Harvest Plan for Red Lakes Walleye Stocks
2015 revision

Background

The first Harvest Plan for Red Lake Walleye Stocks (RLFTC 2006; hereinafter, Harvest Plan) was drafted in 2005 and approved by the Red Lake Fisheries Technical Committee (RLFTC) just prior to reopening the walleye fishery in May of 2006. The 2006 Harvest Plan replaced the Recovery Plan for Red Lakes Walleye Stocks (hereinafter, Recovery Plan) that was officially approved by the managing jurisdictions through a signed Memorandum of Understanding in April 1999.

The Recovery Plan specified that spawning stock biomass (SSB) must exceed target levels for three consecutive years before harvest could be resumed. This criterion was met in 2005 following a seven-year walleye harvest moratorium and three recovery stocking events. The RLFTC determined that the walleye population could safely support conservative harvest beginning in 2006. This determination was based, in part, on wild fry density estimates from two small-scale stocking events in 2004 and 2005 that confirmed SSB estimates were producing wild fry densities that not only met recovery goals, but exceeded recovery fry stocking densities. The RLFTC clarified that the Red Lakes walleye population had not fully recovered and added a mature female age diversity metric as a second threshold to define full recovery and long-term sustainability (Figure 1).

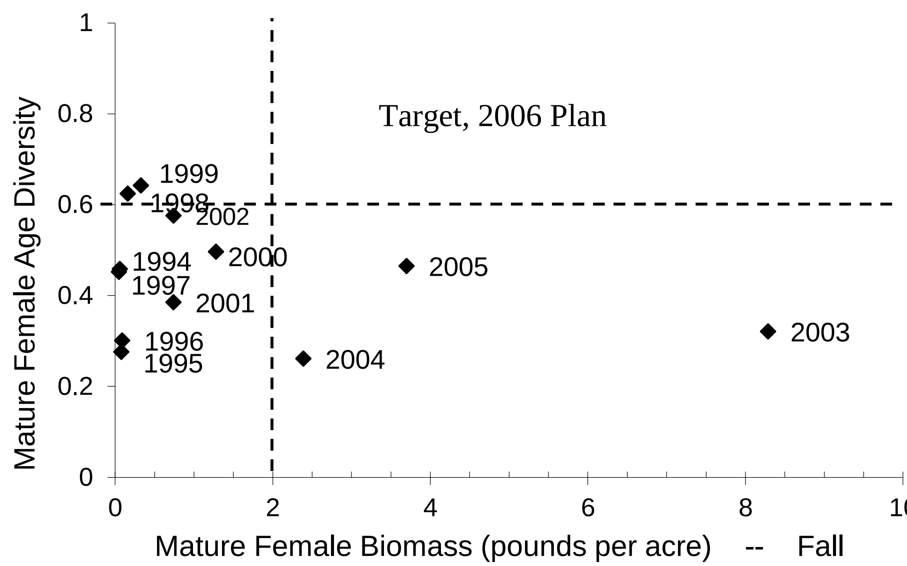

Figure 1. Primary population criteria for walleye of the Red Lakes, MN, 2006 Harvest Plan.

The 2006 Harvest Plan focused on maintaining mature female spawning stock biomass (SSB) above the minimal level (2 lbs/surface acre) that provided excellent recruitment during the recovery phase. Additional SSB above the Optimal Condition (2-3 lbs/surface acre) was considered Surplus (>3 lbs/surface acre). Although the harvest framework provided slightly more latitude for harvest below the closure cap when in the Surplus Condition, the Target Harvest Zones for the Optimal and Surplus Conditions were identical (Table 1). This reflects the cautionary approach of the Harvest Plan and the uncertainty of how the population would respond when in the Surplus SSB condition. SSB was not expected to remain in the Surplus Condition but rather periodically reach this level and then return to the Optimal Condition (RLFTC 2006). There was no management action prescribed to actively reduce SSB when in the Surplus Condition.

Table 1. Harvest Framework, 2006 Harvest Plan

SSB lbs/acre	SSB Condition	Harvest Zones (lbs/acre)			
		Opportunity	Target	Caution	Cap
>3	Surplus	0-1.75	1.75-3.5	3.5-5.0	5.0
2-3	Optimal	0-1.75	1.75-3.5	3.5-4.5	4.5
1-2	Marginal	0	0-2.0	2.0-2.5	2.5
<1	Closed	0	0	0	0

Much has been learned since reopening the walleye fishery ten years ago. Population data available to the RLFTC in 2006 included a pre-collapse period of instability (1970-80's), the period of collapse characterized by extreme low abundance (1990's), and a recovery period of rapidly increasing abundance (early 2000's). Fry marking during recovery not only provided estimates of wild fry production in stocked years, but the relationship established between SSB and wild fry production provided a means to project wild fry densities in years when estimates are not available. Most informative may be the recruitment response to a wide range in fry densities as the population transitioned to a fully recovered state (Figure 2).

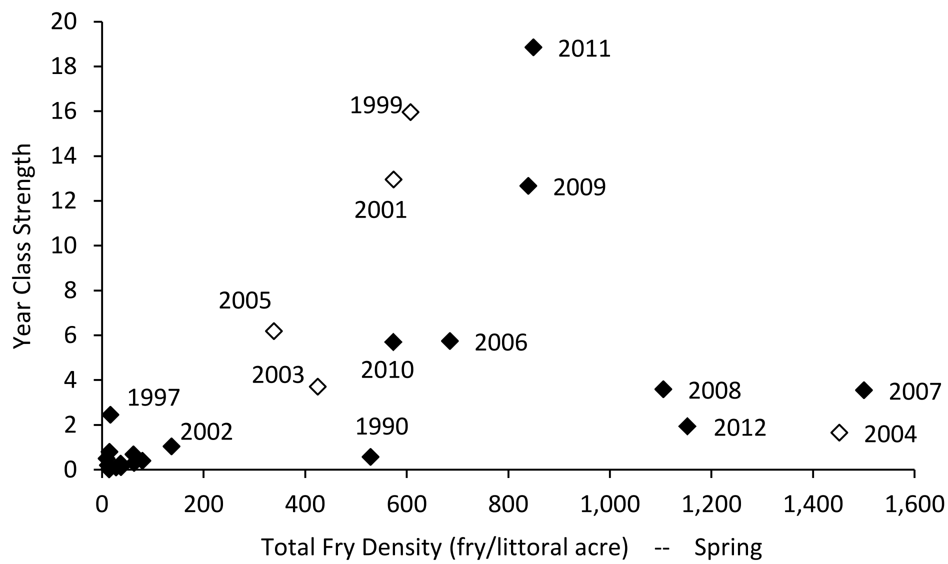

Figure 2. Total walleye fry densities and subsequent year class strength, 1988 - 2012. *Fry density is used for this stock recruitment curve rather than SSB because recovery fry stocking strongly influenced recruitment in years with low SSB. Open symbols represent*

walleye fry densities measured using mark-recapture techniques and solid symbols represent fry densities projected based on SSB estimates.

The 2006 Harvest Plan identified 400 to 600 fry/littoral acre as the range of fry densities needed to produce a strong year class. With the additional data points obtained since the walleye population has fully recovered, it now appears that the peak of the stock recruitment relationship may occur at slightly greater densities (450-850 fry/littoral acre). This increase in optimal fry density after recovery is somewhat intuitive due to increased predation from an established population. However, these data also strongly suggest that excessive fry production from elevated SSB reduces the probability of producing strong year classes.

The most substantial elements of this 2015 Harvest Plan revision are an adjustment to the Optimal SSB condition and the intent to avoid elevated fry densities produced by Surplus SSB by actively managing for the Optimal SSB condition.

2006 Harvest Plan Objective

Develop a plan that outlines methods to identify and allocate safe harvest levels for Red Lakes walleye stocks, and allows the continued establishment and long-term maintenance of a fully recovered, self-sustaining walleye fishery.

2015 Harvest Plan Revision Objective

Revise the existing harvest plan to refine safe harvest levels for Red Lakes walleye stocks that optimize walleye recruitment potential and facilitate the long-term maintenance of a fully recovered, self-sustaining walleye fishery.

Plan Components

1. Primary Population Criteria
2. Harvest Zones
3. Pre-season Management Strategies
4. In-season Management Actions
5. Fall Population Evaluation
6. Annual Harvest Evaluation
7. Decision Making Process
8. Time Frames

1. Primary Population Criteria

The two original measures of sustainability, age diversity of the female spawning stock coupled with spawning stock biomass, have been useful in describing reproductive potential and stability and will be maintained (Figure 1). Key adjustments to these criteria are an increase in the minimal SSB level to 2.5 lbs/acre, and defining an optimal range for SSB rather than a minimum above which it should be maintained (Figure 3). The revised SSB target (2.5-4.5 lbs/acre) is approximately equivalent to the adjusted optimal fry density range (450-850 fry/littoral acre) identified from the stock-recruitment relationship (Figure 2). This SSB target will now define the Optimal Condition in the revised harvest management framework.

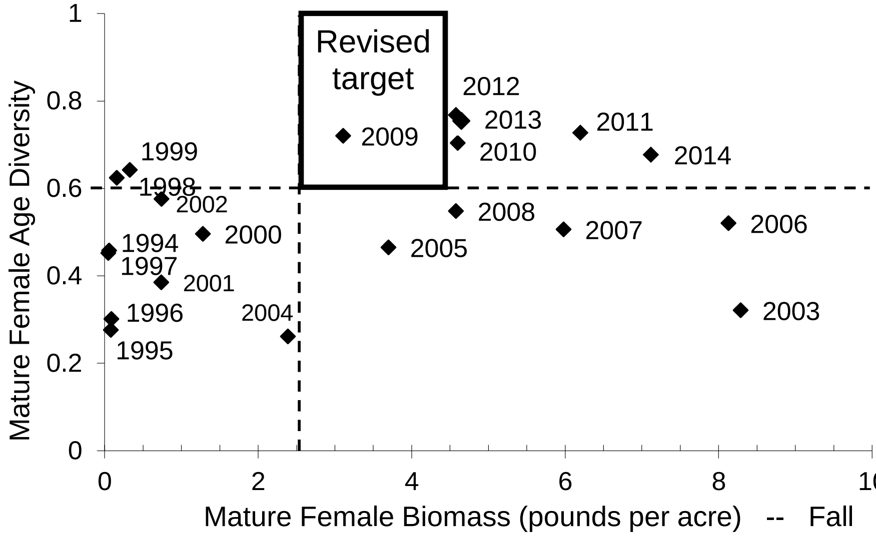

Figure 3. Revised primary population criteria for walleye of the Red Lakes, MN.

Annual estimates of spawning stock biomass will be generated from the fall assessment via the Q_{abg} model (Excel version – by D. Logsdon, 11/19/2002) applied to the total catch of mature female walleye in the 68 standardized experimental gill net samples collected through the joint monitoring program (see Fall Population Evaluation). Individual basin estimates will be added together for a total SSB estimate expressed in pounds per surface acre. The annual SSB estimate will be categorized prior to each harvest year (December 1 – November 30) into one of the following revised SSB Conditions.

Surplus (>4.5 lbs/acre): It is expected that SSB will exceed optimal levels periodically as strong year classes recruit to the spawning stock. The Surplus Condition will now trigger more aggressive harvest to reduce SSB back to the Optimal Condition. Adjusting the Surplus Condition threshold from 3.0 lbs/acre (2006 Harvest Plan) to ≥ 4.5 lbs/acre ensures that this level of SSB is surplus, based on stock-recruitment observations, and provides additional conservatism before more aggressive harvest is prescribed. When determining harvest management actions for the Surplus Condition, managers should consider broadening the size range of harvested fish to specifically target some mature females.

Optimal (2.5-4.5 lbs/acre): The Optimal SSB condition has been adjusted upward to better represent optimal fry densities for the current recovered population as indicated by the stock-recruitment relationship (Figure 2). The observed variability of SSB after recovery has also proven to fluctuate wider than previously expected. The width of the Optimal Condition was doubled from the 2006 Harvest Plan to better reflect natural variation and it is expected that managing SSB within this range will be more achievable.

Marginal (1.0-2.5 lbs/acre): This condition represents a SSB level at which harvest at a reduced level can be safely maintained. The upper threshold of this range was increased from 2.0 lbs/acre (2006 Harvest Plan) to 2.5 lbs/acre to provide some additional conservatism to the harvest framework. When determining harvest management actions for the Marginal Condition, managers should consider regulations that protect mature females to facilitate management of SSB back into the Optimal Condition.

Closed (<1.0 lbs/acre): This level of SSB is considered critically low and no harvest should occur under this condition. Catch-and-release walleye fishing would be permissible under this condition because even during years with high fishing pressure and walleye catches hooking mortality is low. This condition is unchanged from the 2006 Harvest Plan.

2. Harvest Zones

Table 2. Revised harvest zones for each of the various SSB Conditions[1].

SSB lbs/acre	SSB Condition	Harvest Zones (lbs/acre)			
		Opportunity	Target	Caution	Cap
>4.5	Surplus	0-5.0	5.0-7.0	7.0-8.5	8.5
2.5-4.5	Optimal	0-2.5	2.5-5.0	5.0-6.0	6.0
1.0-2.5	Marginal	0	0-2.5	2.5-3.0	3.0
<1.0	Closed	0	0	0	0

Revisions to the Harvest Zones in the various SSB conditions are based on the observed response of the walleye population at harvest levels within the previous harvest framework, as well as Forecast Model predictions for elevated harvest levels. Since reopening the fishery in 2006, SSB has remained consistently in the Surplus Condition, even though harvest has gradually increased. Total harvest near the upper limit of the Target Harvest Zone (THZ) has not reduced SSB. Model forecasts suggest that substantially higher harvest levels would be required to reduce existing SSB and future recruitment to SSB. Harvest levels have been increased in this revision for all but the lowest SSB condition where harvest would be closed.

Opportunity: Harvest levels that fall within this zone are an indication that there may be an opportunity to increase annual harvests. A single annual harvest estimate that falls within this zone is unlikely to trigger a regulation change the following year. Two consecutive years in the Opportunity Zone may indicate a need to relax regulations.

Target: The Target Harvest Zone is the range in which harvest should be maintained, preferably on an annual basis, but definitely on a three year running average[2]. Proposed regulations will be modeled to project harvest within the THZ, or when necessary to adjust for three year averaging. Note that the THZ is now substantially higher when in the Surplus Condition with the objective of reducing SSB. When harvesting at these levels, it is advised to use regulation options that

[1] Specific poundage relating to jurisdictional acreage is listed in Appendix Table 1.

spread harvest over a variety of size ranges (understanding that strong year classes will likely still dominate the catch and harvest).

Caution: Harvest levels that fall within the Caution Zone will be tolerated within a given year without a harvest closure. Regulation adjustments may be necessary prior to the following harvest year in order to bring the average annual harvest back within the THZ.

Cap: The defined Harvest Cap for the SSB condition will function as a safety net and represents a level that annual harvest should not exceed. In-season projections of harvest exceeding this level will trigger regulation adjustments or a harvest closure before the Harvest Cap is exceeded.

3. Pre-season Management Strategies

Prior to the onset of a new harvest year (1 December), the SSB Condition must be determined so that the appropriate Target Harvest Zone can be identified. Each jurisdiction will then attempt to tailor its fishing regulations to yield a total annual harvest within the THZ. There are two possible strategies to manage harvest within the THZ.

1. Initiate harvest with liberal regulations and a programmed closure at or near the upper limit of the THZ.
2. Formulate restrictive regulations intended to result in a total annual harvest that is near the midpoint of the THZ, with the intent of operating the fishery throughout most of the harvest year.

East Upper Red: The preferred method for setting recreational angling regulations will be Strategy 2. Various regulation options will be modeled to predict total annual harvest. A recreational angling regulation that has a high probability of resulting in a total annual harvest near the midpoint of the THZ will then be selected. This strategy acknowledges the difficulty and uncertainty in predicting angling pressure and catch rates, but increases the probability that actual harvest will fall within the THZ. Because this strategy lacks the precision of simply closing a fishery once target harvests have been achieved, reasonable levels of harvest outside of the THZ (i.e., in the Caution Zone) will be tolerated, but harvest regulations may need to be adjusted the following year to manage the three-year running average back to within the THZ. A mid-season harvest closure is the least desirable measure for managing recreational harvest but provides a backup if harvest under the regulation greatly exceeds projections. Setting seasonal harvest targets and/or caps may be desirable to allocate harvest between winter and open-water seasons. Annual harvest caps will be adhered to and need to be clearly defined and communicated to the public, clarifying the level of harvest in any individual year or season at which harvest will need to cease.

Recreational angling regulations will likely include both restrictive bag and length limits to control total harvest. Length restrictions will be formulated to protect and maintain existing

[2] Three year averaging is straightforward when SSB conditions remain unchanged. When SSB condition changes within a three-year period, the cumulative harvest for the period should not exceed the sum of the upper end of the target harvest zone of each individual year.

spawning stock when in the Optimal Condition, or relaxed when the reduction of SSB is a desired management objective in the Surplus Condition.

Reservation Waters: The Band will determine allocation between recreational and commercial harvest. Both harvest methods will be managed using Strategy 1, because the majority of the harvest will be captured by the commercial fishers, with a small, often <10% of total harvest being attributed to the personal use catch. Commercial harvest will be regulated to meet a predetermined commercial quota. The commercial quota will be determined by taking the upper limit of the THZ and multiplying it by 237,000 acres, and then multiplying by the allocation (approximately 90%) for commercial fishing. The size structure of the commercial catch will be managed with gear, size, and daily bag regulations to protect and maintain spawning stock. The recreational harvest allocation will be determined by subtracting the commercial quota from the upper limit of the THZ. Recreational harvest will be regulated with size and bag limits. Harvest estimates from recreational harvest will be determined using angler interviews at the commercial processing plant coupled with access and roving creels surveys depending on the season. At the end of the season, harvest from both methods (commercial and recreational) will be summed to provide an estimate of total walleye harvest on reservation waters.

4. In-season Actions

East Upper Red: Harvests from recreational angling will be estimated through creel surveys. Specific creel survey designs are outlined in Appendix A. The monitoring protocol will include methods to estimate related sources of mortality (e.g., angler release mortality). Preliminary harvest estimates will be generated on a bi-weekly or monthly basis in order to project total harvest through the end of the respective fishing season.

Total harvest projections falling within the THZ require no in-season action. Total projections exceeding the Harvest Cap may initiate a mid-season regulation adjustment and will require a harvest closure before the Harvest Cap is exceeded. Minnesota DNR has sought Legislative authorization to ease the process of mid-season regulation changes to better react to fluctuating catch rates and fishing pressure. Total harvest projections falling within the Caution Zone will not require a regulation adjustment within the season, but will likely result in an adjustment for the following season or year. Two consecutive years of harvest within the Caution Zone will require a regulation change the following year to manage harvest back within the three-year average for the THZ. Total harvest projections falling within the Opportunity Zone are not likely to stimulate in-season regulation changes but may result in relaxing regulations in future harvest years.

Reservation Waters: Commercial harvest will be directly measured as outlined in Appendix A. Harvest will be monitored daily, and monthly summaries will be recorded for all commercially important species during the harvest season. Harvest will be controlled on a daily, weekly, and seasonal basis to maximize efficiency and profitability. This will be accomplished by setting daily bag limits and size limits on walleye captured by anglers and determining the number of gillnets to be set by Red Lake Fisheries' net crews.

Recreational angling will be estimated as described in Appendix A. When higher than anticipated recreational harvest is projected to exceed the predetermined allocation, this will result in reallocation of unused commercial harvest to attempt to remain under the upper limit of the THZ. Total harvest (commercial and recreational combined) projected to remain within the Caution Zone will not require an in-season regulation change, but may require harvest adjustments the following year. Two consecutive years of harvest within the Caution Zone will require a regulation change the following year to manage harvest back within the three-year average for the THZ. Total harvest projections falling within the Opportunity Zone may not stimulate in-season regulation changes but may result in relaxing regulations in future harvest years.

5. Fall Population Evaluation

The annual fall population evaluation is a critical component of the harvest plan. Results of the combined gill net assessment are used to determine the SSB condition for the following harvest year. It will also function as an error checking process and safety net to ensure that the walleye population is not being over-exploited, even if harvest estimates appear to be within the THZ. Over-harvest could still be occurring under one, or any combination, of the following scenarios:

- Harvest ranges within the Target Harvest Zone are set too high.
- Under estimation of legitimate harvest and associated fishing mortality.
- Undetected illegal harvest mortality.

A description of the methodology used for the cooperative walleye population assessment is included in Appendix B. A variety of biological indicators will be measured and updated from the fall assessment results. Specific indicators include the following:

- Current SSB
- Estimates of total population biomass and/or harvestable biomass
- Spawning stock age diversity
- Mean age of mature females
- Gill net CPUE
- Length and age distributions
- Condition
- Total length at age three
- Maturity rate
- Harvest year mortality (from Q_abg estimates)
- Year class strength index
- Age 0 abundance (recruitment predictions)

Basin and Sector Differences: It is the intent to manage the entire Upper and Lower Red Lakes as a combined system because there is documented interchange of adult walleye between basins, and fry stocking evaluations have documented that the Upper Basin will export considerable fry production to the Lower Basin. It is agreed that the lakewide SSB estimate will be used to define the SSB condition. This simplifies allocation issues and avoids the potential scenario of differing SSB conditions and harvest levels for the two basins. However, it is recognized that considerable biological differences exist between the basins as determined by predictive yield models, as well as observed differences in growth, maturity and density. In addition, harvest methods may vary widely between jurisdictions. As agreed by the RLFTC when standardizing RLDNR and MNDNR monitoring programs, all data will continue to be collected, analyzed and reported separately for the Upper and Lower Basins. Some population indicators will also be combined to represent the entire system (e.g., SSB). Similarly, some analyses will need to distinguish jurisdictional sectors of the Upper basin. This approach will retain basin and jurisdiction resolution, and help to detect trends related to differing harvest methods. The forecast model (Appendix C), which assumes the Red Lakes walleye population functions as a single population, will also be run separately for the Lower Basin, Upper Basin-east and Upper Basin-west due to differences in the type of fishing in each of these three sectors.

Trend Analysis: Many of the biological indicators are useful in monitoring trends over time and will aid in decision-making when adjustments are being considered. However, most of these indicators lack the short-term resolution to recognize excessive harvest in any individual year. Trends over time in one or more population indicators may support increases or decreases in future walleye harvest.

Yearly Change: Some biological indicators can be useful in evaluating the impact of the previous year's harvest. Those indicators can be based on relative or absolute change from the previous fall assessment period, essentially documenting the impact of the previous year's harvest on the existing population. While these indicators need to be sensitive to yearly change, they are also subject to the effects of normal sampling variability. Extreme caution should be exercised when making any decision based on change in a single year.

Harvest Year Mortality: The total annual mortality estimate for the previous harvest year will provide a benchmark against which to compare the harvest estimates. Though it is difficult to partition natural mortality from fishing mortality, or separate additive from compensatory effects, total mortality, or annual survival, determines long-term sustainability. Harvest year mortality will be calculated from the previous year's Q-abg population estimate of age-2 and older walleye minus the current year's population estimate of age-3 and older walleye. The difference divided by the previous year's estimate (age-2 and older) represents a rate of total annual mortality for the current harvest year. Note: since walleye fishing resumed on the Red Lakes in 2006 total mortality rates are very similar to the period when walleye fishing was closed (1999-2005). This suggests that walleye harvested under the 2006 Harvest Plan framework may be mostly compensatory within total mortality.

Population Forecasting: Numerous revisions have been made to the original forecast model that is described in the 2006 Harvest Plan. Most useful has been the ability to do retrospective analysis with nine years of actual harvest and population data since fishing resumed. The model allows for various levels of yield to be simulated and output projects SSB levels and spawner age diversity for each of the following three years. The most current population parameters from fall assessments provide model input, including the current population estimate, size distribution, growth rate, and rate of maturity. Details outlining revisions to the Forecast Model structure can be found in Appendix C.

Forecasting with probability-based modeling will continue to be a critical component of population monitoring under the 2015 revision. This revision intends to expand harvest across a broader size range, but juvenile walleye will still be a major component of the harvest. Forecasting will be limited to three-year projections to reduce the uncertainty of variable recruitment. Three-year projections are adequate because ages 3-5 are still expected to make up the majority of the harvest and will recruit to SSB over the next few years. Harvest regulations since the fishery reopened have been designed to protect mature fish, with harvest primarily concentrated on juvenile walleye, resulting in delayed effects on SSB.

6. Annual Harvest Evaluation

A full harvest year will be defined as December 1 – November 30. System harvest is total annual harvest by all methods, including estimates of associated mortality (release mortality, commercial culling, etc.) expressed in pounds per surface acre. Jurisdictional harvest is total annual harvest by all methods including estimates of associated mortality (release mortality, commercial culling, etc.) expressed in pounds per surface acre for each jurisdiction Several different methods will be utilized to estimate total annual harvests in each jurisdiction. Specific survey designs are outlined in Appendix A.

Biological indicators of population health may not be sensitive to over-exploitation within one jurisdiction if total harvest within the entire system is not excessive. Harvest in one jurisdiction that exceeds the THZ may result in regulation changes even though overall system harvest may be low and biological indicators positive.

A conservative approach to harvest under the 2006 Harvest Plan resulted in a gradual ramping up of harvest by both jurisdictions (Figure 4). Uncertainty in angler response to the emerging sport fishery, and development of a new hook and line commercial fishery contributed to the gradual increase in annual harvests. A complete listing of the specific regulations used to manage the sport, subsistence and commercial fisheries since fishing resumed is available and will be updated annually in the Red Lakes Walleye Management Program Annual Report to the Red Lakes Fisheries Technical Committee.

The 2014 harvest year is an example where sport fishing exceeded the Target Harvest Zone for the first time (Figure 4), but system-wide harvest remained just under 3.5 lbs per acre (Figure 5). Biological indicators remained positive and even though this represents the highest annual harvest since walleye fishing resumed. Despite this level of harvest, harvest loss was estimated at just 4.8% of the population $\geq$ age 2.

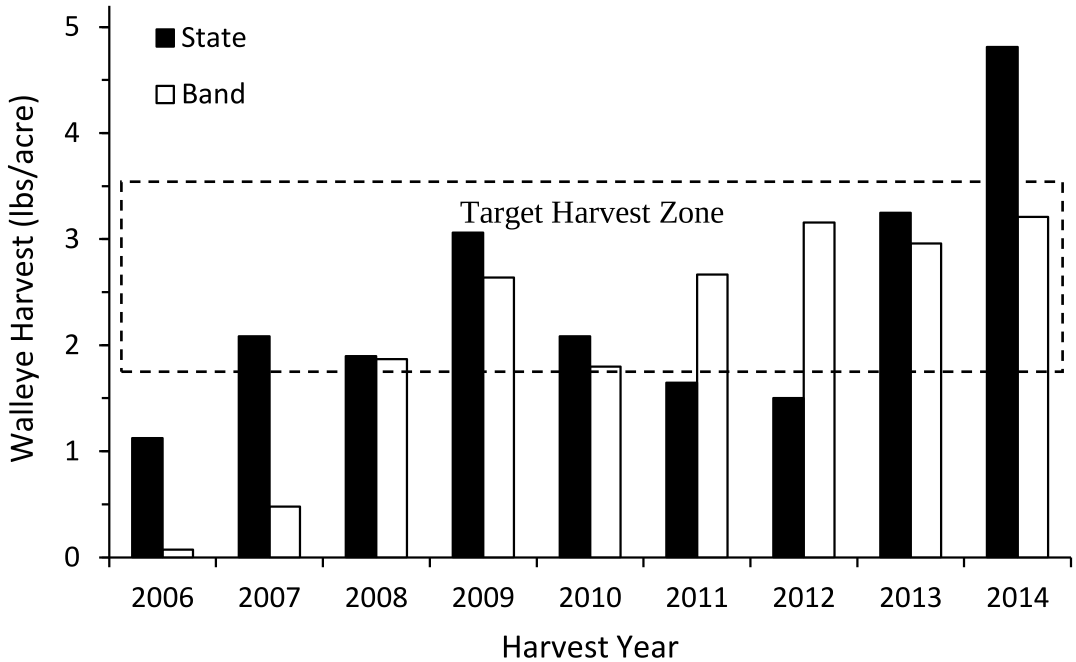

Figure 4. Annual walleye harvest by each jurisdiction since re-opening the walleye fishery in 2006.

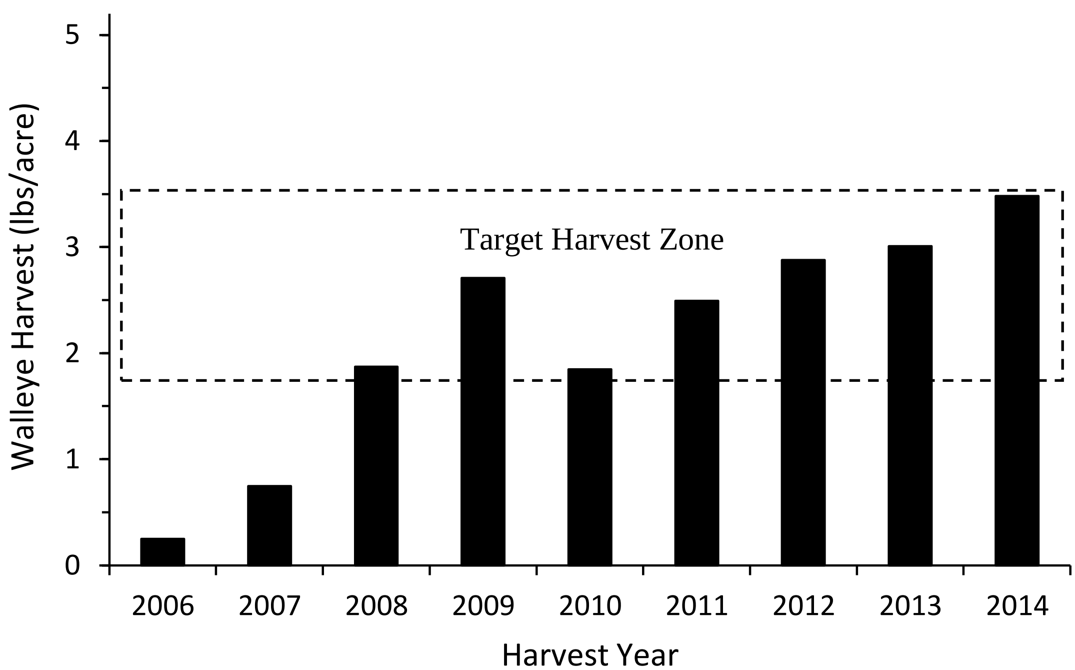

Figure 5. Total walleye harvest for both jurisdictions combined (i.e., lakewide harvest) since re-opening the fishery in 2006.

Harvest within the Opportunity Zone: Consistent harvest estimates that are less than the lower limit of the THZ may indicate an opportunity for additional safe harvest. Additional harvest may even be beneficial to the population if it resulted in increased growth rates and recruitment. However, population criteria must also support such a change (e.g., SSB projections maintained in Surplus or Optimal Conditions).

For example, after four consecutive years with State harvest within the THZ, annual harvests in 2011 and 2012 dropped into the Opportunity Zone (Figure 4). Angling regulations were relaxed in 2013 to utilize additional safe harvest. The rapid increase in harvest was the effect of both less restrictive regulations that allowed more harvest and increased angler effort in response to the additional harvest opportunity.

Harvest within the Target Harvest Zone: Total annual harvest within the THZ for the programmed SSB condition will be considered ideal. However, such harvest will be evaluated to verify that it is sustainable as a safeguard against unreported, illegal, or underestimated sources of fishing mortality. Adjustments to specific values representing the various harvest zones will be required if total annual harvests are consistently within the THZ, but population indicators reveal biological signs of over-exploitation. (e.g., SSB projections dropping into the Marginal or Closed conditions).

Lake wide annual harvest has been maintained within the THZ for seven consecutive years since 2008 (Figure 5) and biological indicators have remained positive. However, SSB has remained consistently in the Surplus Condition, a situation not anticipated when drafting the 2006 Harvest Plan. This is an indication that the initial Target Harvest Zone may be too conservative.

Harvest within the Caution Zone: Total annual harvest exceeding the THZ will likely result in regulation adjustments for the following season, especially if population indicators reveal biological signs of over-exploitation (e.g., SSB projections dropping into the Marginal or Closed conditions). If harvest estimates consistently exceed the THZ, but population indicators do not reveal biological signs of over-exploitation, adjustments to specific values representing the various harvest zones may be warranted (e.g., SSB projections maintained in the Surplus or Optimal Conditions).

Lake wide harvest has never reached the Caution Zone as of the 2015 revision, but Forecast Model output suggests that substantially more harvest would be required before any impact on SSB is expected. Increasing and broadening the harvest opportunity when in the Surplus Condition as defined within this 2015 Harvest Plan revision is intended to accommodate the harvest levels needed to effectively manage SSB back to the Optimal Condition.

Exceeding the Harvest Cap: It remains the intent of this plan for each jurisdiction to avoid exceeding the Harvest Cap by projecting harvest within a season and implementing a harvest closure before the Harvest Cap is reached. Should unanticipated harvest beyond the Harvest Cap occur, significant regulation changes will be required to adjust harvest back within the THZ the following year.

7. Decision Making Process

Within the framework of this plan there are distinct areas where decision-making processes differ:

Predetermined triggers: Specific threshold values or "hard triggers" within this plan such as the Harvest Cap or SSB Condition have been defined and agreed to by the full Technical Committee. These triggers were established in 2006 and refined in 2015 to dictate specific actions.
Examples:

- Current SSB will be calculated from fall assessment netting.
- THZ and Harvest Cap are set by the SSB condition.
- Harvest projections exceeding the Harvest Cap will dictate a harvest closure before that Harvest Cap is exceeded.

Jurisdictional decisions: Selection of regulation options to manage harvest within the Target Harvest Zone are jurisdictional decisions. Methodology of harvest projections and rationale for specific regulation setting will be shared between jurisdictions, but do not require formal RLFTC approval.
Examples:

- Specific fishing methods and regulations.
- Allocation between fishing methods.
- Allocation between seasons.

Harvest plan adjustments: Adjustments to Harvest Zones, Harvest Caps, SSB conditions or other specific indicators in this document require RLFTC approval. No single "hard trigger" dictates a specific action. A variety of indicators such as BPI's or model output will provide data for Technical Committee consideration.
Examples:

1. Harvest stays within the Target Harvest Zone but predictive models project future SSB problems. Target Harvest Zone may need to be adjusted.
2. Harvest estimates are consistently in the Caution Zone, but predictive models look good. The Target Harvest Zone could possibly be adjusted upward.
3. Harvest stays within the Target Harvest Zone but harvest year mortality estimates indicate leakage. Harvest estimates may need to include leakage, or Target Harvest Zone adjusted, or enforcement efforts redirected.

The 2015 Harvest Plan Revision is the first Harvest Plan adjustment requiring RLFTC approval. The adjustment best fits example 1 above, from the 2006 Harvest Plan. However, the SSB problem being addressed is excessive SSB, a concern never anticipated in the 2006 Harvest Plan. In this case the recommendation is an upward adjustment to the ranges of the Harvest Zones.

8. Time Frames

- September-October
    - Fall population assessment.

- November 1
    - Fall assessment data will be compiled and SSB Condition determined.
    - Harvest Zones and/or Harvest Caps are set for the next harvest year as defined by the new SSB Condition.

- December 1
    - Start of new harvest year.[3]
    - Q-abg estimates run by age and sex.
    - Finalize harvest statistics from previous harvest year.

- December RLFTC meeting
    - Joint population assessment draft report reviewed.
    - Final harvest year statistics reviewed.
    - Evaluate previous harvest year.
    - Review Enforcement measures.
    - Jurisdictions provide preliminary plans for harvest adjustments in response to current SSB condition, or exceeding the THZ.[4]

- March 1
    - Walleye aging completed
    - Calculate harvest year mortality.
    - Forecast Model output generated.

- March RLFTC meeting
    - Joint population assessment final report reviewed.
    - Jurisdictions report final regulation adjustments for open water season.
    - Compare reported harvest + predicted natural mortality, to harvest year mortality estimate.
    - Discuss potential sources of significant unaccounted mortality.
    - Present output from population forecasting model.
    - Recommend adjustments to THZ or Harvest Caps, if any, for the following harvest year.

[3] Preliminary harvest statistics will be generated monthly throughout the harvest year and shared between jurisdictions within two weeks of the end of a month.
[4] Implementing regulation changes may not be logistically possible before the winter portion of the coming harvest year, but changes in the Harvest Cap level or three year averaging may result in an earlier winter harvest closure.

Appendix A

Annual Harvest Estimates

Annual harvest information from the Red Lakes will be required to implement the Harvest Plan aimed at cooperative management of the shared resource that supports multiple fisheries in two jurisdictions. Walleye yield estimates from each jurisdiction will be used in conjunction with population estimates and the Forecast Model to determine the amount of surplus production available for harvest on an annual basis. Yield estimates will also be used to allocate allowable harvest among various harvest methods or between harvest seasons.

East Upper Red

Waters falling under the jurisdiction of the State of Minnesota will support a recreational angling fishery. To estimate total annual walleye harvest of this fishery, an annual creel survey covering both the open-water and winter periods will be conducted. The primary objective is to generate minimally biased and precise estimates of angling pressure (effort) and associated harvest and size structure of all species caught. Secondary objectives include estimating catch and release rates (all species), release mortality (walleye only, using release mortality model developed by Keith Reeves, MN DNR). For within-season harvest monitoring, preliminary harvest estimates will need to be generated monthly during the winter season and every two weeks during the open-water season to ensure that the respective Harvest Cap will not be exceeded.

Open-water Creel Survey: An angler creel survey will be conducted from mid-May through September of each year. One creel clerk will be employed to collect information from various access points around the lake. The clerk will work within a spatiotemporal sampling framework determined by a stratified random, two-stage, non-uniform probability design. Creel clerks will make counts of boat landings at each access point and will interview anglers to obtain information such as party size, trip length, species sought, number of fish harvested and released, and fish lengths. Monitoring of lake water temperatures will be conducted throughout the open-water season to provide data inputs for the release mortality model.

Winter Creel Survey: An angler creel survey will be conducted from early December through at least the end of walleye season each year. One to two creel clerks will work within a spatio-temporal framework determined by stratified random, two-stage, uniform probability sampling. The creel clerk will make counts of angler parties leaving the lake via ice roads after completing their fishing trips. The clerk will interview angler parties to obtain information such as party size, trip length, species sought, number of fish harvested and released, and fish lengths.

Reservation Waters

Waters falling under the jurisdiction of the Red Lake Band will support both a commercial and recreational fishery running simultaneously. Total annual harvest will be estimated by calculating harvest for each method separately and then summing the two estimates together. To estimate total annual harvest on the reservation, we will use both direct and indirect methods. We will use direct methods at the processing plant to determine total commercial harvest of each species. Angler harvest will be estimated using various indirect methods, such as angler interviews at the processing plant, roving creel surveys during the winter months and access surveys during the summer months. These methods will assist in adequately predicting the harvest on the reservation and assisting the Tribal Wardens in protecting the natural resources of the Band. Reservation harvest will be estimated monthly and reported to the Red Lake Tribal Council and members of the RLFTC.

Commercial Fishery**:** The commercial angling season will be from December 1 to the following November 30th. Ice fishing is suspended each year in late March or early April, when ice conditions become too dangerous for fishing, and does not resume until the first Saturday in May. The Band will attempt to catch the majority of the quota using hook and line fishing, however several gillnets crews, hired by the processing plant, will be utilized when angler harvest is unable to meet the needs of the processing plant. Daily catch records will be recorded for all commercial operations and weekly summaries will be computed and subtracted from the annual quota. Fishing may be suspended once the upper limit of the THZ for commercial fishing is reached depending on the amount of recreational harvest quota remaining. Daily records will include total pounds and number for each species caught and total number of fishers and/or nets lifted daily (including mesh size) for each basin. A weekly random sub-sample of the commercial catch will be processed from each basin. One hundred randomly selected walleye will be measured (TL; mm) from each gear type (anglers and various gillnet mesh sizes) to represent the total catch for each gear type.

Recreational Fishery**:** Tribal members are only able to fish using hook and line to catch walleye to take home and eat. The current daily bag limit is 10 walleyes a day and a possession limit of 30 walleyes. Ten percent of the upper limit of the THZ has been set aside for this type of fishing. Angler interviews will be used to help determine the harvest of this type of fishing, because many of the anglers are also turning in fish at the processing plant. When anglers are turning in fish at the processing plant, they are asked how many walleyes they kept to eat, the size of the fish kept, the length of their trip, and which lake they were fishing. Not all fisherman turn their fish into the processing plant, so additional creel surveys will be conducted to determine this harvest and is described in the following section. Weekly totals will be subtracted from the recreational quota, and once the predetermined quota is reached this season may be suspended, depending on the amount of the commercial quota available.

Summer and Winter Angling Creel Survey: A roving angler creel survey will be conducted during the winter months, and an access point survey will be conducted during the summer months on the reservation. A clerk will work within a spatiotemporal sampling framework determined by a stratified random, two-stage, non-uniform probability design. The clerk will make counts of boats or fishing parties, trip length, fish harvested and released, and total lengths.

If parties are observed completing their trip, the clerk will attempt to make contact and update records to include the completed trip. Random, two-stage instantaneous counts will also be conducted weekly to assist in assigning sampling probabilities in the future.

Appendix B

Walleye Population Evaluation

Fall Gill Net Sampling

In September of each year, 68 standard 250-foot (76.2 m) experimental gill nets will be fished at established locations throughout the Red Lakes (48 sets in Reservation waters and 20 sets in State waters). Nets will be set overnight (approximately 24-hours). All captured fish will be identified and enumerated. Data should be recorded separately for each of the five mesh sizes. All fish will be individually measured to the nearest millimeter and weighed to the nearest gram. Sex and maturity will be documented for each individual walleye. Otoliths and scales will be collected from all walleye sampled, and associated length, weight, sex, and maturity will be recorded. Individual fish ages will be determined from otoliths. Maturity of female walleye is a very critical determination from fall netting, ultimately determining SSB. Female maturity for SSB calculations will be defined as visible gamete development indicating probable spawning the following spring. Mature fish with no egg development will be noted separately.

Annual SSB Estimates and Q_{abg} Modeling

Annual estimates of SSB will be generated from the fall gill net data using the Q_{abg} model (Excel version – by D. Logsdon, 11/19/2002) applied to total catch of mature female walleye in the 68 standardized experimental gill net samples collected through the joint monitoring program. Individual basin estimates will be added together for a total SSB estimate expressed in pounds per surface acre.

A version of the Q_{abg} model developed by Melissa Treml within the statistical program R will also be applied to all walleye caught in gill nets each year by jurisdiction/lake basin, sex, and age. Resulting sex-specific population estimates along with along with vital statistics calculated with a separate R program and used as input data into the Forecast Model (Appendix C).

Other Sampling

Shoreline Seining: Thirteen stations (8 in Reservation waters and 4 in State waters) will be sampled weekly for a 6-week period from July through mid-August. A single haul will be conducted at each station using an untreated, 100 foot (30.5 m) long, 5 foot (1.5 m) deep, 1/4 inch (6 mm) mesh, bag seine. Because of the extensive shallow nature of Upper Red Lake in near-shore areas, parallel- or perpendicular-to-shore methods will be used, rather than the traditional fixed-pole method. All adult fish, excluding most cyprinids and other small species, will be enumerated and released immediately after a haul. The remainder of the sample, including all young-of-the-year (YOY) walleye, will be preserved on ice for subsequent laboratory processing. For large catches, including rare instances when several hundred YOY walleye are caught in a single haul, a sub-sample may be taken and all remaining fish bulkweighed and released. Total catch should then be extrapolated from the sub-sample by weight. In the laboratory, fish will be identified, enumerated, measured to the nearest millimeter and weighed to the nearest gram.

Bottom Trawling: Since 1998, annual trawling has been conducted at 30 stations each on Upper and Lower Red Lake during mid-August. An otter trawl equipped with a 16-foot (4.9 m) headrope and 1/4 inch (6 mm) mesh cod end liner is used. A five-minute haul was conducted at each station at a trawling speed of 1.2 miles per hour (2.0 km/hour). Captured fish are identified and enumerated. All captured walleye are measured to the nearest millimeter.

Zooplankton Sampling and Aquatic Invasive Species (AIS) Monitoring: The Red Lake and Minnesota Department of Natural Resources are cooperatively collecting zooplankton samples to measure secondary productivity and early detection of AIS. Samples are collected once a month in May, September, and October and twice a month in June, July, and August at 3-fixed locations in both Upper and Lower Red Lakes. A single v-haul is made with a 30-cm mouth diameter, 80-µm Wisconsin Plankton net and collection bucket. Date, location, and depth (feet) are recorded on the sample jars and a duplicate tag is placed in each preserved sample. All samples are preserved using 90%-ETOH. Sample volumes are adjusted to a known volume by filtering through 80-μm mesh netting and rinsing specimens into a graduated beaker. Individual zooplankton specimens are identified, counted, and measured using a dissecting microscope and a computerized analysis system. A compound microscope was also used to aid in the identification to species (or the lowest taxonomic group possible). All samples were examined for the presence of spiny water fleas (*Bythotrephes longimanus)* prior to dilution. During July and August, the entire sample from each site was also examined for zebra mussel (*Dreissena polymorpha*) veligers. Density (number/liter), biomass (μg/liter), percent composition by number and weight, mean length (mm), mean weight (μg) and total count of each taxon identified was generated by analysis system and recorded in the MNDNR zooplankton database. Currently, analysis is conducted by MNDNR Ecological and Water Resources staff under the guidance of Jodie Hirsch.

Water Quality Sampling: Water samples will be collected annually from State waters at three standardized locations on or near August 1 of each year. The Minnesota Department of Agriculture Chemistry Laboratory in St. Paul, Minnesota will analyze these samples for total phosphorus concentration, chlorophyll *a*, pH, total alkalinity and total dissolved solids. The Red Lake Department of Natural Resources collects water samples from Lower and Upper Red Lake as well as the major tributaries, from both Tribal and State waters. Samples are taken two times per month from June through September, and include 5 standardized stations in each basin. Samples are analyzed by an EPA-certified facility and include at a minimum, dissolved oxygen, temperature, turbidity, conductivity, pH, total and ortho phosphorus, TKN and nitrate+nitrite-nitrogen.

Other lake data to be compiled and reported annually will include mean monthly water temperature and water surface elevation.

Appendix C

Population Forecasting

This appendix explains how we will forecast the impacts of various amounts of fishery yields on spawning stock biomass and age diversity in the Red Lakes.

Purpose: To determine the effects of specified fishery yields on the two key management performance indicators: female SSB (with a goal of 2.5-4.5 lbs/acre) and female spawner age diversity in numbers (with a goal of 0.6 or greater).

Model structure: The forecasting model is a deterministic age structured model (ages 2-10+) that simulates the Red Lake walleye fishery for 3 years. Each fishing year is divided into two periods: winter and summer. Two types of mortality were applied to the fishery: natural and fishing. Fishing mortality is a function of fishing effort, catchability, selectivity, hooking mortality, and compliance. The model uses an optimization function to determine the fishing mortalities needed to achieve the target fishery yields for each sector. The effect of that mortality is then forecasted over the population.

The following assumptions and details from the management framework form the basis of for how the forecasting system is constructed.

Assumptions:

1. Fish can move between sectors. We know that there is some movement of adult fish throughout the system, but we do not know how much. All fish movement is assumed to occur after the open water fishery and before the winter fishery. Currently, 80-90% of the fish are assumed to remain within a sector.
2. Ratios between winter and summer seasons for fishing effort are constant over time
3. Age-specific growth, maturity, and natural mortality is constant over time
4. Catchability of males and females is the same. If needed, sex-specific selectivity will be added to further scale catchability.
5. Given the short forecasting range (3 years), new recruits are assumed to have little effect on model results, at least on mature female spawner density. Nominal numbers of new fish enter the system in years 2 and 3. For years 2 and 3, new age-2 fish are calculated as a user specified fraction of age-2 fish in year-1. For year 3, new age-3 fish are calculated as a user specified fraction of the average number of age-3 fish in years 1 and 2.

Basic inputs:

1. Qabg is used to estimate male and female abundance by age and sector using gillnet assessment data
2. The following vital rates are estimated by sex and sector using gillnet assessment data
    a. Von Bertalanffy growth curves to estimate length at age
    b. Length-weight regressions to estimate weight at age
    c. Maturity rates via logistic regression to estimate maturity at age
3. A composite measure of selectivity, compliance, and hooking mortality were derived from observed creel data and abundance estimates. To date, there is little annual

variation, so these age-specific estimate were assumed constant over time. If the selectivity of a significant portion of the fishery changes, this will need to be revisited.

4. Natural mortality by age was estimated using the Lorenzen method (J. of Fish Biology (1996) 49: 627-647) and mean weight at age for Red Lake walleye.

Model structure:

1. The basic forecast model uses Baranov's catch equation for estimating yield based on estimated population abundance by age, and an estimated age-specific natural mortality: $C_i = u_i \times N_i = \frac{F_i \times A_i \times N_i}{Z_i}$, and $Z_i = F_i + M_i$, where C is catch in numbers, u is exploitation rate, N is the number in the population at the start of the fishing season, F is instantaneous fishing mortality rate, A is annual total mortality rate, Z is instantaneous total mortality rate, M is instantaneous natural mortality rate, and the subscript i indexes age for all rates. Fishing mortality (F) is the product of fishing effort (f), maximum catchability (q), selectivity (s). Selectivity estimates by age incorporate compliance and hooking mortality. Age-specific selectivities scale apical F (where apical $F = f*q$), the highest age-specific fishing mortality. For a given age of fish, fishing mortality will therefore be: $F = f*q*s$.
2. The fishing season will start in December. This is convenient for a number of reasons. Our netting in September will be near the end of the open water season, and new recruits to the fishery will occur after the big pulse of fishing mortality that occurs in the spring, and before a new winter fishery starts.
3. The model uses the *Optimize package* in *R* to determine the force of fishing needed to achieve the desired amount of yield in each sector of the fishery. This is done sequentially by year.
4. Forecasts are conducted separately for the three sectors of the two lakes: Upper East, Upper West, and Lower. Forecast output is combined for comparison with system-wide management goals.
5. Key model output includes: female spawning stock biomass and age diversity by zone and year and kill by age and year.
6. The model can also be used to conduct a retrospective analysis on predictive performance. To do this, observed yield rather than target yields are input into the model.

Appendix Table 1.

SSB condition	Harvest Scenarios	State Waters pounds	Band Waters pounds
Surplus	Harvest in any individual year will not exceed the cap of 8.5 lbs/acre.	408,000	2,014,500
	Harvest will be maintained below 7.0 lbs/acre on a three-year average.	336,000	1,659,000
	Harvest of less than 5.0 lbs/acre for two consecutive years may trigger relaxing of regulations to allow additional harvest.	240,000	1,185,500
Optimal	Harvest in any individual year will not exceed the cap of 6.0 lbs/acre.	288,000	1,422,000
	Harvest will be maintained below 5.0 lbs/acre on a three-year average.	240,000	1,185,000
	Harvest of less than 2.5 lbs/acre for two consecutive years may trigger relaxing of regulations to allow additional harvest.	120,000	592,500
Marginal	Harvest in any individual year will not exceed the cap of 3.0 lbs/acre.	144,000	711,000
	Harvest will be maintained below 2.5 lbs/acre on a three-year average.	120,000	592,500
	There will be no opportunity for relaxing regulations while SSB is in the Marginal Condition.	0	0
Closed	Harvest will be closed.	0	0

Final acreage calculations agreed to by Red Lake Nation DNR and Minnesota DNR GIS specialists, February 27, 2006.
Upper Red Lake- 119,274.43 acres.
Lower Red Lake- 164,989.60 acres.
Total- 284,264.03 acres.
Minnesota portion of Upper Red Lake- 47,725.02 acres.
Red Lake Nation portion of Total- 236,539.01 acres.

Acreage rounded for harvest management purposes.
State of Minnesota- 48,000 acres.
Red Lake Nation- 237,000 acres.