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Review of the Flathead Lake Draft Environmental Impact Statement

Proposed Strategies for Lake Trout Population Reduction
to Benefit Native Fish Species Flathead Lake, Montana

Project #1991-019-01

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Background

In response to the Northwest Power and Conservation Council's August 10, 2012 request, the Independent Scientific Review Panel (ISRP) reviewed a draft Environmental Impact Statement for *Proposed Strategies for Lake Trout Population Reduction to Benefit Native Fish Species Flathead Lake, Montana* (hereafter Flathead Lake draft EIS or draft EIS).

The draft EIS "analyzes the environmental consequences of a proposal to reduce the abundance of non-native lake trout in Flathead Lake to benefit native fish populations…The proposed action would use a combination of fisheries population-management tools—including angling and netting—to reduce the population of lake trout."

This is a follow-up review to the ISRP's evaluation and the Council's recommendation for the Confederated Salish and Kootenai Tribes (CSKT) Project #1991-019-01, *Hungry Horse Mitigation/Flathead Lake Restoration and Research, Monitoring and Evaluation (RM&E)* as part of the Resident Fish, Data Management and Regional Coordination Category Review. The intent of this submittal and review is to address a condition placed on the project by the Council as part of the Category Review. Specifically, the Council recommended "Do not implement Lake Trout reduction program (Deliverable 3) until the ISRP has reviewed the Flathead Lake Environmental Assessment and has favorable Council review to proceed with full implementation."

In addition to submitting the draft EIS, the Tribes responded to a number of ISRP concerns raised in the proposal review process (ISRP 2012-6). The review below contains the ISRP's comments to improve the draft EIS and evaluation of the Tribes responses to ISRP comments from the Category Review.

ISRP Review Summary and Recommendation

Recommendation: Incomplete. Several important aspects of the proposed lake trout suppression program need to be clarified before the program proceeds to implementation.

In the draft EIS, the CSKT have developed a useful working document that conveys many of the key issues regarding lake trout abundance, Flathead Lake fishery management, and the potential need for suppression in relation to native species recovery in the lake. The *a priori* selection of the four possible lake trout suppression alternatives in the draft EIS is supported by

Appendix documents, in particular the Trophic Interactions Document (Appendix 4) the Lake trout Population Dynamics Document (Appendix 6), and the Estimation of Lake trout Abundance Document (Appendix 9). Each of these documents contains sufficiently detailed and clearly presented information for a scientific review by the ISRP. However, despite many positive aspects to the draft EIS, the document remains incomplete. The ISRP concludes that several important aspects of the proposed lake trout suppression program need to be clarified before implementation. Comments on the draft EIS and on the appendices are provided below.

1. Co-management: The issue of co-manager cooperation, specifically with the Montana Department of Fish, Wildlife and Parks (MFWP), the other primary fishery co-manager, remains unclear. Although the CSKT indicated that it is "too soon to say, they [CSKT and MFWP] are not united," it was also stated that MFWP withdrew from the EIS process in March, 2012. The alternatives considered in this draft were evidently decided upon by the Bureau of Indian Affairs (BIA) and Tribal Council. It is thus unclear to the ISRP if any of the alternatives are acceptable to the co-managers or if there are other potential alternatives that have not been adequately considered or evaluated. The previously expressed ISRP qualification regarding the need for cooperative co-management (in the Resident Fish Category Review) remains a concern. The ISRP continues to believe that the co-managers of Flathead Lake must work together if they are to successfully address the lake trout suppression issue.

2. Confidence limits: The CSKT attempts to evaluate the four alternatives based on the results of a population dynamics model (Appendix 6), but information is not provided on how the confidence limits are derived. Given that the population model is largely deterministic, it is essential to determine sensible and reliable confidence limits. The presented confidence limits give an unwarranted indication that the Flathead Lake system will respond in a fairly predictable, well-behaved manner. The actual response is likely to be much more variable than predicted by the simulation model. If this proves to be the case, then the implementation of any of the proposed alternatives may create unintended and potentially irreversible consequences.

3. Sensitivity analysis: A more thorough sensitivity analysis of overall model responses is warranted. For long-lived fish, even small changes in annual recruitment or mortality can be magnified over a few decades and greatly affect the actual population trajectory of the lake trout, even if a consistent netting regime proposed under the alternatives can be implemented. It is important to address how the model will behave with variations in mortality. This evaluation is especially needed because the actual benefits of the removals are slow in developing (may take years) and it may not be possible to remove as many fish as anticipated under some alternatives. In addition, it is not clear if the simulations adequately reflect the extent of any compensatory changes that may occur in the lake trout population as harvest removal proceeds.

4. Integrated model: The development of the population model proceeded in a piece-wise fashion with the mark-recapture data being estimated separately from the gillnet data. An integrated model would seem to be preferable as it would capture some of the synergy between these components. An integrated model would also be able to use data that are currently ignored, e.g., captures of PIT-tagged fish in years subsequent to the year of release. Additionally, the mark-recapture results could be presented by length classes and used for detecting age-specific trends. The mark-recapture data could also be used as a general monitoring tool to assess removal benefits and the effects of implementing a chosen alternative.

5. Monitoring: The ISRP has substantial concerns about the ability of the proposed sampling program to detect changes in the lake trout population status in the first decade of the program, especially under alternatives with a lower level of suppression (A-C). The description of the post-implementation monitoring is too brief. It is not possible to determine if the proposed monitoring will be able to detect actual, gradual changes in the population yearly or even for intervals of a few years.

6. Targeted lake trout suppression: Absent from the document is a description of if and how lake trout suppression might be best targeted toward those groups of fish that are most likely eating bull trout and cutthroat trout. It was mentioned that smaller lake trout tend to remain in deeper water than larger lake trout. Are there particular sizes of fish living in proximity to tributary mouths? Lake trout movement patterns should be presented in the document. Are all fish highly mobile or are some sedentary? Are there differences by size or age?

7. Desired future condition: A clearer and more complete definition of the "desired future condition" is needed. Goals and objectives are listed in the introduction, but they do not give a clear description of the ecological and social conditions that are anticipated or desired after implementing any of the proposed alternatives. One example of this lack of definition is that it takes some time for the reader to realize that there is no apparent intent to eliminate lake trout altogether. Doing that "would be inconsistent with the Co-Management Plan" (p. 27) although that issue is never fully discussed or clarified. A 90% lake trout reduction is classified as a non-option, but this alternative deserves formal consideration. Can this level of reduction be achieved? Is it desirable but unachievable? A second example is that the duration of lake trout suppression is not made clear. The Description of Proposed Action (p 4) states that "Project activities could then occur year-round indefinitely into the future…" but it is never emphasized that financial resources must be found to continue efforts of suppression for decades. These and similar issues related to desired future condition need to be more clearly articulated in the document.

8. The 73% reduction alternative: The draft EIS did not include model estimates for the population or diet changes for the 73% reduction alternative. It would be important to provide the scientific basis for this alternative.

9. Food web variability: In projecting the benefits of suppression and lake trout harvest potential, it would be useful to provide a discussion of the range of annual variability in the food web of Flathead Lake. There may be significant inter-annual shifts in lake trout diet and distribution that affect their susceptibility to harvest. Abundance of age-0 yellow perch, for example, seems to vary extensively from year to year. While this directly affects lake whitefish more than lake trout, causative factors and potential impacts on harvest removal need to be understood. Is it possible to manage lake trout without a well-grounded understanding of the ecology of lake whitefish and yellow perch? The document provides some information for the whitefish, but not for yellow perch.

10. Lake whitefish harvest: Is the role of lake whitefish in providing a sport fishery minimal or is it being understated in the document? In 2007, the whitefish catch was more than double that of lake trout (Figure 3.39) and many anglers were targeting the relatively large whitefish. Could a major fishery develop, or be developed, or is it already significant? Would an expanded whitefish fishery be an effective partial replacement for a reduced lake trout fishery?

The ISRP recommends that an opportunity be provided for a review of the revised EIS document, including the appendices, after a preferred alternative is selected. The revision might include detailed methods and monitoring and evaluation improvements for the EIS alternatives as suggested below.

ISRP Comments

Response to Previous ISRP Review Comments

The ISRP's recommendation for the project in the Resident Fish Category Review included the following bulleted, italicized qualifications relevant to the draft EIS. The Tribes responded point by point to several of these items in their cover letter to the ISRP as well as in the draft EIS.

- *Transparency of linkage with Montana Fish Wildlife Parks needs clarification. The absence of listed project relationships probably does not reflect those that are in place with state and federal agencies, and others. The CSKT and MFWP have a shared* *mitigation and implementation plan as well as roles outlined in the Flathead Subbasin Plan. For the Flathead Lake component of the proposal, it appears to reviewers that success in suppressing lake trout will be impossible if there is not a unified program by both co-managers of the lake. The proposal under Deliverable 3 indicates some unspecified level of coordination with MFWP as part of the ID team during the creation of the Environmental Assessment in 2012. It would be helpful to increase transparency of the linkages between this proposal and those in 199101903 (MFWP).*

The ISRP failed to see how this qualification was addressed or clarified in either the Draft EIS or the cover letter. Although the CSKT indicated that it is "too soon to say they [CSKT and MFWP] are not united," it was also stated that in Chapter 1, Page 10 of the draft EIS that the Montana Department of Fish, Wildlife and Parks, the other fishery co-manager in Flathead Lake, withdrew from the EIS process in March, 2012. The alternatives considered in this draft were evidently decided upon by the BIA and Tribal Council. It is thus unclear to the ISRP if any of the proposed alternatives are acceptable to the co-managers, or if there are other potential alternatives that have not been considered or evaluated. The qualification regarding the need for cooperative co-management remains a concern. The ISRP continues to believe that the co-managers of Flathead Lake must work together if they are to successfully address the lake trout issue and the need for suppression.

- *The lake trout reduction program needs continuing assessment as to how it will be accomplished and a timeline for meeting a stated goal incorporated into the proposal. The predator problem is too big for an individual project to solve. It needs a basinwide approach and study with an adequate design. As discussed in the ISRP's programmatic comments included in the front section of this report, a more unified effort is needed in dealing with lacustrine predators. This effort might include getting together appropriate groups of fishery biologists and modelers dealing with lake trout and other exotics, such as walleye, for a conference. One conference goal could be to discuss and design studies that cover multiple locations that complement each other, especially for eradication issues. Further, there are emerging predators other than lake trout, such as smallmouth bass, that require monitoring, especially if temperatures increase from climate change or local land use. It seems worthwhile to engage in preliminary modeling to gain insights into systems and biotic communities going forward.*

The response partially addressed this qualification. The CSKT indicated that they are preparing for a conference focused on Flathead Lake problems. However, they did not indicate in the cover letter or the EIS that they are planning or conducting monitoring for any emerging non-native predators such as smallmouth bass.

The draft EIS does, however, have some timelines included based on the population dynamics (Appendix 6) and trophic interactions (Appendix 4) simulations.

- *The data management system requires careful scrutiny. This aspect of the program needs a better description. It is not clear that an efficient data management system is in place. Considering the scope of the projects, there needs to be a clear and open system for entering and analyzing data, and for assessing data quality. Further, many of these data are acquired with public funds and therefore should be readily available to the public. What facilities and equipment, including software, are in use? What are the planned upgrades to the data management system, for example cloud computing?*

No additional information is provided in the cover letter. Appendix 5 or Appendix 8 should include a section regarding data protocols and management, but neither includes such a section. For example, PIT-tagged fish have been released into Flathead Lake for several years—are the data associated with those fish stored in a single database?

Scientific Support for Alternative Actions

Proposed Alternatives

The draft EIS includes four alternatives:

- **Alternative A -** NEPA-defined, no action alternative (maintain the status quo).
- **Alternative B -** Reduce the population of adult lake trout (age 8 and older) by 25% using targeted gillnets, trapnets, Mack Days, and by allowing angers to legally keep fish of all sizes (there would be no “slot” limit).
- **Alternative C -** Reduce the population of adult lake trout (age 8 and older) by 50% using targeted gillnets, trapnets, Mack Days, and by allowing angers to legally keep fish of all sizes (there would be no “slot” limit).
- **Alternative D -** Reduce the population of adult lake trout (age 8 and older) by 73% using targeted gillnets, trapnets, Mack Days, and by allowing angers to legally keep fish of all sizes (there would be no “slot” limit).

Based on Appendix 6 model estimates (if we are to assume that the 73% reduction alternative falls mid-way between the 50 and 90%), Alternative D is the most aggressive removal alternative of the four under consideration but is still not as aggressive as the 90% Alternative that was eliminated. Lake trout may still eliminate bull trout from Flathead Lake under the 73% alternative because model projections may have high levels of uncertainty. Why was the 90% alternative not fully considered? The 90% reduction Alternative should be re-considered.

It seemed unnecessary to start the draft EIS with a figure (Page 8) purporting to show bull trout trends and lake trout trends when there appears to be no obvious trend except for some high points in early years for bull trout and some low points during the same period for lake trout.

The other years look stable. Why was a regression not run? Are there age structure factors not shown by this figure, i.e., stockpiling of older fish?

In the gillnet/trapnet approach identified and simulated, the short-term benefits of even high levels of removal are not very great; long-term benefits differ greatly with scenario. However, there has not been an effective assessment of these four alternatives versus other methods of population depletion such as commercial fishing. It is not clear why those methods have been dismissed, but the idea of commercial fishing has not been sufficiently considered. Also, the report is lacking information regarding the respective viewpoints of the co-managers and the extent of their cooperation on these critical fish removal and method issues.

Estimates of harvest for the various alternatives (Chapter 2) are based on a simulation model described in Appendix 6. The ISRP can find no basis for the confidence limits reported on the number of fish to be harvested for the Alternatives in the report. Furthermore, the simulation model is deterministic (except for recruitment), so it is not clear how it can be used to derive confidence limits on the harvest for the Alternatives. The actual response of the system to the Alternatives is likely to be much more variable than presented in this report.

The recommendations for harvest by gillnet are stated in terms of increasing the length of gillnets. Presumably harvest by nets depends on the area of gillnets being deployed which is a function of their length and width times the number of days they are used. To increase harvest, one can increase the size of the gillnets and fish them for the same length of time, as is currently done, or increase the number days the nets are fished. The report was unclear how long the present gillnet program is run annually and why the gillnetting “season” cannot be extended? Was extending the season considered?

Two Eliminated Alternatives (Appendix 7)

Appendix 7 of the draft EIS includes two alternatives that were considered but eliminated:

- Do nothing except general harvest
- Reduce the population of adult lake trout (age 8 and older) in Flathead Lake by 90% relative to the 2012 levels

The CSKT indicated that they eliminated the 90% reduction alternative because in the long term (~50 years) it would eliminate the lake trout fishery. However, data presented in Appendix 7 seems to support the 90% alternative as the most aggressive approach to restore native trout populations based on the best available data/model projections. Is the 90% option achievable?

Other Potential Alternatives

Is there any specific indication that large female fish may be congregated at certain locations and times so that they can be targeted? Do the catch data get recorded by sex? It would seem that any way to reduce females may have advantages over and above a reduction in males.

The Affected Environment and Environmental Consequences Section

No comments.

Trophic Interactions (Appendix 4)

The bioenergetics models were useful in projecting different prey consumption scenarios under each of the lake trout reduction alternatives.

Harvest Methods (Appendix 5)

In general, this section lacked adequate detail for an effective ISRP review. A data reporting and management system was not included as the ISRP had requested.

Under commercial fishing, no mention was made of potential issues with contaminants in large, old lake trout, and whether such issues would affect the marketability of the fish. However, this was mentioned clearly in Figure 3.19. The CSKT have an advisory on the consumption of larger fish. Is this a problem widely recognized in lake trout populations, and are the observed levels such that a commercial fishery is not a viable option? If so, this should be mentioned in this section. Have both younger and older fish been thoroughly tested in a scientifically reproducible way? Are the CSKT standards different from standards elsewhere?

Also, since commercial harvest is potentially a low-cost method, it would have been useful to have a more thorough assessment of how effective contract commercial fishing has been regionally or nationally to deal with similar problems. There was also little information on how the lake trout program across the border in Idaho has performed. There still seems to be a need for the co-managers to develop a more effective, unified front in choosing a range of possible alternatives and in ultimately selecting the best alternative. There is also no evidence provided in the document or cover letter that this unified vision is in place.

For the possible approaches of bounties and commercial fishing, there seems to be a concern that because of legislative issues in Montana, they cannot be considered for the northern portion of the lake until 2013 or beyond. This seems like a short delay given that the modeling analyses under the various alternatives often show no beneficial effects of increased gillnet harvest for at least 5-10 years. The same patience in seeing results of the netting could be beneficial in developing commercial fisheries interest. Also, is there tribal interest in commercial fishing? Is there a possibility of a co-manager-commercial joint venture? What is the estimated harvest of 75,000 fish per year based on?

A 73% reduction would require 2,334 sets of 200-foot-long nets in a year. Would a commercial operator be more cost effective?

Is it possible or likely that catch rates may go down in subsequent years as a response to the fish becoming less susceptible to netting?

Lake Trout Population Dynamics (Appendix 6)

The Population Dynamics model is an age-structured, (partially) stochastic population model. This development of this model and subsequent runs are fairly standard, and the ISRP had few concerns about this part of the report. It is noteworthy, however, that the only stochasticity in the model is in the recruitment of age 0 trout – all other changes are deterministic because natural and fishing mortality rates were fixed. Hence the confidence limits presented in the paper refer to AVERAGE long-term abundance (assuming that the model is correct) and not to variation in actual abundance of specific years (which is much larger). Actual year-to-year changes in the population will be much more variable. The model was thus a useful exercise to project future lake trout populations under different reduction alternatives. But as with any model, there are many assumptions required and the actual outcomes can differ widely from predictions.

As in any assessment involving a very long lived species such as lake trout or sturgeon, the specific outcomes to be achieved depend heavily on some small changes in annual survival rate and harvest rates of older fish. A small percentage difference in mortality over enough years can substantially increase or reduce benefits of a specific removal program. Although these issues are discussed, no formal sensitivity analysis was performed. Until that occurs, it will not be possible to determine whether the estimates used in the analysis were substantially too high or too low based on minor differences in actual harvest removal. In Figure 3.4, the von Bertalanffy growth curves are presented for the three periods and discussed in the methods: It was not clear that these curves were developed for fish of each sex separately, or not. Data on sex seem to have been collected along with length, weight, etc. It would seem necessary and preferable for the growth curves to be presented separately by sex since there are clear differences in age at maturity. Were there no sex-specific differences in growth?

More interpretation of Figures 3.3 and 3.5 is needed. Why did *Mysis* numbers drop in later years when lake trout numbers seemed reasonably stable? Was this result caused by larger fish with greater food requirements?

How variable are year class strengths in this population? Is there a great potential for strong and weak year classes? How good is the assumption that recruitment variability is "relatively constant within a species"? There would seem to be some legitimate environmental reasons why it would not be.

The simulation model assumes that biological parameters will remain constant over time after management action. No sensitivity analysis was performed to see the impact in changes in the underlying parameters (e.g. natural mortality) or which parameter has the most influence on the subsequent results. This would inform subsequent monitoring efforts on which aspect is most important to monitor.

The simulation model also made assumptions about how the population would change due to management actions. For example, it is assumed that there is no compensatory mortality. Do the sponsors have a basis for concluding that no compensation would occur as a result of harvest removals? There is currently little information on how to model this, but this type of response would then require that adequate monitoring is needed post-implementation.

The Population Dynamics model has a series of components to estimate parts of the population structure and dynamics, but these results are only loosely integrated. Consequently, estimates from each component have poor precision. Further comments about specific component parts of the model are presented below.

Details: Section 1. Mark-recapture estimates of abundance.

Five separate Petersen-estimates of abundance were formed based on three marking events and five recapture events:

- marking Fall 2007 to Spring 2008; recapture fall 2008;
- marking Fall 2009 to Spring 2010; recapture Spring 2010 and then in Fall 2010;
- marking Fall 2010 to Spring 2011; recapture Spring 2011 and then in Fall 2011;

Each marking event (angling and netting) extended over about a six month period, and each recapture event (fishing derbies) over about a 1-2 month period. Marked fish were PIT tagged and adipose-fin clipped; recaptured fish were checked for ad-fin clips and (presumably) scanned with a detector to read the PIT tag (but this is never explicitly mentioned in the Appendix). Length was measured at both release and recapture.

To account for heterogeneity in catchability by length (i.e. gear selectivity), fish were stratified into three length classes (10-50 cm; 50-65 cm; 65-75 cm). Fish less than 10 cm have not recruited to the population; fish greater than 75 cm were protected by the slot-limitation on harvest. To account for fish growth between mark and recapture events, fish lengths at the time of recapture were interpolated backwards to their length at the end of the respective marking period.

A total of 5 separate temporal x 3 length class estimates were formed using the standard Petersen estimator. Confidence intervals for abundance were formed using exact intervals for a binomial proportion method as outlined in many texts.

Dealing with assumption violations.

This was nicely dealt with by the authors. As noted by the authors, the assumption of closure was not likely valid for these estimators, but immigration from outside populations was considered negligible; immigration by recruitment was handled by the back-calculation of length at the time of marking; and mortality that is equal for marked and unmarked fish still results in unbiased estimates of the population size at the time of marking.

The authors claim that they were unable to estimate tag-loss despite fish having two marks (ad-fin clip and PIT tag) because the ad-fin clip was used for other studies and so fish with an ad-fin clip and no PIT tag cannot be assumed to have lost their PIT-tag. It was not clear if holding studies were conducted to examine immediate tag loss.

Because different methods were (mostly) used for the marking and recapture events, it is hoped that behavioral changes as a result of marking will be minimal.

Estimation.

The report does not fully extract all of the information from the data and so ends up with estimates that are very imprecise. There are several areas where improvements can be made.

(a) Stratification. To deal with heterogeneity in catchability, the authors stratified fish into three length classes. Ideally, a finer stratification by length would be better, but the data are then too limited in each length class. Chen and Lloyd (2000) show how to use a kernel-smoothing method to estimate the selectivity function (by length) at each event and the population distribution by length. Basically, a moving window locally pools data centered on a given length and a simple-Petersen estimate is computed. As this window moves across the length distribution, a series of Petersen estimates for each length are obtained. This would directly give a profile of the abundance by length similar to Figures 1.2 adjusted for the selectivity curve at the two events.

(b) Combining estimates. Figure 1.3 gives the five Petersen estimates. But as noted in the section about assumptions, the two estimates based on the 2010 marking event are both estimating the same quantity – the population size at the corresponding marking event. A similar comment applies for the 2011 estimates. There are many ways to combine Petersen marking events – refer to the monograph from White and Garrott (1990). By combining estimates from two recapture events from the same marking event, precision should be improved.

(c) Using recoveries from subsequent events. The paper does not discuss what happens with the recaptures from later recapture events, e.g., marks applied in 2008 and recaptured in 2011. The report is not clear that such data were collected (presumably yes, as the fish were scanned for PIT tags). These data can again be combined with the previous recapture events as in (b) to update the precision of the 2008 population estimate.

In general, this study is an example of a mark-resight study (see McClintock et al. 2009) of which much development has taken place in recent years. In studies such as these marking events are combined with resighting events (such as the derbies) were no marks are applied (but animals can be removed). These models should be investigated to use mark-recapture dataset as a whole, i.e., an extension of a Jolly-Seber model to monitor the entire population over time in one analysis. Increases in fish length over time can be dealt with by adding a growth model or through the use of multi-state models where states refer to length classes. This is similar in flavor to age-structured Jolly-Seber models. As marking continues over time, more and more marks are available to be captured, but in the current analysis most of the recapture information from subsequent years is simply ignored.

Details: Section 2. Standardized gillnetting index of abundance.

In this section, the standardized gillnet survey from 1998 to 2011 is used to look at trends in abundance. Multi-sized mesh gillnets of constant length were fished in a consistent way during this period. No information was provided on the soak-times of the surveys. Were they overnight sets? How many days were the surveys run? The pattern of catch over time may serve as an index of abundance, that is, depletion if the assumption of constant CPUE over time is true. The applicability of this critical assumption was never formally mentioned or critically assessed in this section, for example, CPUE could decline due to gear saturation as the population increases.

All fish captured were measured and stratified to fish < 30 inches and 30 inches or longer (protected by the slot-regulation). Based on a simple regression of standardized catch over time, the authors conclude that there is evidence that the larger segment of the population is tending to increase over time, but they found no evidence that the small size segment is tending to increase over time. It is not clear why such a coarse stratification was used. For example, stratification by finer limits could reveal if pulses of post-age-0 recruitment and thus any substantial variations in year class strength are passing through the system?

The gillnet data were analyzed in isolation from the mark-recapture dataset. These two sources of information should be analyzed together in a single model, called integrated population modeling, similar to what was done for walleye in Mille Lacs, Minnesota by the Minnesota Department of Natural Resources. Here a catch-at-age model that followed cohorts over time and the mark-recapture study was used to "anchor" the catch-at-age model.

Details: Section 3. Growth of Lake Trout.

Back-calculated length at age.

Back-casted lengths from cumulative individual unvalidated otolith annuli were first computed. Then a separate von Bertalanffy (VB) growth model was computed for each individual and the individual fish VB estimates were used to assess changes in growth. The estimated parameters for each fish of the VB models were then used to assess changes in growth over time.

The interpretation of the comparison of the growth curves is not clear because of the overlapping growth history of individual fish. For example, a fish that is captured at age 30 in 2008, or age 27 in 2005, or age 17 in 1995 all have the same growth history for the first 17 years of their life. Consequently, the growth curve for an individual fish is a combination of potentially different growth regimes all of which influence the estimated parameters of the VB growth curve.

The back-calculations are also measurements of length at age with measurement error, that is, the back-calculated lengths are not the true lengths. This fact was never incorporated into the analysis. This analysis seems unnecessarily complex. The back-calculations implicitly assume a linear relationship between growth and otolith increments. Consequently, it may be just as useful to use the raw otolith increments as a proxy for growth for fish at a particular age in a particular growing year. Then analyze these otolith increments to detect effects of age, calendar year, etc.

Length-at-age using length-at-capture.

In this analysis, 3 periods of data (pre-1995, 2005, and 2008) were combined using the length of fish and age at capture as estimated from otoliths to examine if the growth curve changed over the period in question. The authors claim to use maximum-likelihood methods followed by likelihood ratio and t-tests.

The equations on (physical page) 236 of the document are incorrect as there are extra *n* terms appearing in the division when finding the standard error of the difference in the estimates – the individual standard errors already include the effect of sample size. The correct formula is $s_{X_1-X_2} = \sqrt{se_1^2 + se_2^2}$ and there is no simple way to compute the degrees of freedom. Consequently the results from this section are suspect.

More seriously, it is not clear exactly what is being tested in the analysis, again, because of the overlapping growth history of individual fish. For example, a fish that is captured at age 30 in 2008, or age 27 in 2005, or age 17 in 1995 all have the same growth history for the first 17 years of their life. Consequently, the 2005 and 2008 period data has older fish that were influenced by the pre-1995 *Mysis* expansion as were fish in the pre-1995 group.

In this case, because the 2008 data do not have individual otolith increment data, a segmented VB model will have to be fit for each fish with the different segments of the VB curve representing the different regime effects. One could then fit a model where the segments belong to a single model or where the segments vary by *Mysis* abundance.

Growth index.

A growth index was determined using the back-calculated lengths for ages 1-5 in a regression model with age and calendar year as covariates. This model was then used to predict the length at age 3 for each calendar year in the study, and the predicted values were standardized to the overall grand mean.

This analysis ignores the fact that the multiple back-calculated lengths are taken from the same fish and so the inferential statistics assume a sample size much larger than the true one. Reported standard errors are likely incorrect. Again, a much simpler analysis would use the otolith sizes at age 5 as the response measurement and see how these changed over calendar years.

The large jump in the growth index around 1966 (Figure 3.5) is unexplained and not biologically reasonable, as outlined by the authors. Further investigation is required to identify whether the cause is an instrument change or did something happen to the lake such as environmental change. Being unable to account for the unexplained jump in a value that was consistent for so many years calls into question the entire results.

Details: Section 4. Population model.

The initial age distribution was inferred from a synthesis of the length at catch from the angling and gillnet surveys. These lengths were standardized to the overall population size estimated from the mark-recapture and then converted to an age distribution using a length-age key developed from the otolith data. An *ad-hoc* fix up was added to ensure that the age-distribution followed the familiar exponential decline from age 0 onwards.

An assumed (fixed) instantaneous natural mortality was chosen at M = 0.1544. Fishing mortality used the selectivity curves estimated by the gillnet surveys and angler catches (Figure 4.3) scaled by the proposed changes in management. No stochasticity in the effects of mortality or fishing was assumed.

Recruitment was simulated from a Ricker-curve based on a similar curve from lake trout in Lake Superior scaled to match the assumed age 4+ population in Flathead Lake. Stochasticity was allowed in the stock-recruitment curve based on the results from Lake Superior.

The model was then run starting at the same point for up to 200 years and various performance measures were derived.

The removal levels recommended in the alternatives were found by trial-and-error by gradually adjusting a multiplier applied to the selectivity curves for the various modes of removal until the long-term average of age 8+ fish was reduced by the targeted percentage. For example, refer to Table 4.4 (of Appendix 6). The second line of the table indicates that an effort multiplier of 1.5 is required to obtain a long-term reduction in the 8+ population by 25% which corresponds to a harvest of 83,000 fish, although Alternative A says 88,000 fish. No confidence limits can be found for this multiplier as a particular value for the multiplier always leads to the identical results, except for stochasticity in the recruitment.

No information is presented in Appendix 6, or elsewhere, on how the confidence limits for the amount of harvest in the Alternatives are found. No confidence limits are presented in Table 4.4 of Appendix 6 on the total harvest and none can be computer as the simulation is deterministic, except for recruitment. The confidence limits reported in Table 4.4 are not really confidence limits in the usual sense as the uncertainty is only due to running 1000 simulations to estimate the final average abundance and not uncertainty in the parameter estimates for natural mortality, fishing mortality, etc.

The Chen and Lloyd (2000) methods applied to the mark-recapture data should be able to provide estimates of the population distribution and selectivity curves within the catchable ranges directly and reduce the amount of initial pre-processing required.

As far as could be seen, no sensitivity analysis was performed. For example, what happens if natural mortality varies from its assumed value?

Monitoring and Adaptive Management (Appendix 8)

Table 1 provides a good general overview but stops far short of providing the details needed to describe a sound monitoring and evaluation program. For example, Table 1 appears to be lacking benchmarks for any of these proposed measures.

Much more work is needed to describe monitoring of the lake following the proposed actions (Table 1, Appendix 8). No information is presented that shows whether the protocols have sufficient ability to actually detect the effects of interest with high power. For example, the harvest protocol will use an aerial-access survey to estimate angler harvest, but no information is presented on the likely precision of the estimates that will be obtained. Similarly, both a mark-recapture study (Appendix 9) and the standardized gillnet survey will be used to monitor population abundance over time, but no information is provided on the power of the proposed designs to detect trends over time. After implementing a program, the potential ability to detect population benefits is absolutely necessary. It is not adequate to implement a program for 5 or 7 years with a monitoring program that turns out to be inadequate to detect benefits. The methods for monitoring and evaluation need to be shown up front to have a high probability to detect changes in the population.

Where is the data management system? How will it be used to effectively monitor population trends?

Estimation of Lake Trout Abundance (Appendix 9)

Appendix 9 describes a series of mark-recapture studies to estimate abundance of lake trout between 1994 and 2012. It consists of a series of Petersen-type experiments with a single marking event and a single recapture event.

As noted by the authors, size selectivity is an issue for these types of experiments. It is not clear in Table 1 (Appendix 9), what part of the population is being estimated. An *ad-hoc* adjustment for selectivity gave a total population estimate of 1.5 million fish, but no estimate of precision was possible. More rigorous methods, for example Chen and Lloyd (2000), may be helpful to explicitly model and estimate the selectivity function of both samples, and an integrated population modeling approach that combines the mark-recapture and gillnet data will also be helpful.

The requirements state that catchability cannot change, for example with age, sex, or social status. Is this true? How can it be evaluated?

Editorial Comments

The entire document should be paginated, including the appendices.

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