A Third Party Scientific Review

of Alberta Environment and Park's North Central Native Trout Recovery Program

A third party Science Report commissioned by the Office of the Chief Scientist

Alberta
Environment and Parks
Office of the Chief Scientist

A Third Party Scientific Review of Alberta Environment and Park's North Central Native Trout Recovery Program

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Alberta’s Environmental Science Program

The Chief Scientist has a legislated responsibility for developing and implementing Alberta’s environmental science program for monitoring, evaluation and reporting on the condition of the environment in Alberta. The program seeks to meet the environmental information needs of multiple users in order to inform policy and decision-making processes. Two independent advisory panels, the Science Advisory Panel and the Indigenous Wisdom Advisory Panel, periodically review the integrity of the program and provide strategic advice on the respectful braiding of Indigenous Knowledge with conventional scientific knowledge.

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- *Openness and Transparency.* Appropriate standards, procedures, and methodologies are employed and findings are reported in an open, honest and accountable manner.
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The Office of the Chief Scientist and Third Party Science Reviews

The Chief Scientist, Alberta Environment and Parks, provides scientific oversight for the provincial environmental science program, which includes the use of independent peer review processes to evaluate the scientific foundations of work undertaken and used to inform Alberta Environment and Parks. The peer review process is a fundamental pillar of the practice of science in order to build a credible and reliable body of knowledge which stands up to the scrutiny of the experts in a particular field of science and can be trusted to inform policy and management actions.

Upon request from the Minister, the Science Advisory Panel, the Department, or if the Chief Scientist deems it necessary, the Office of the Chief Scientist will engage independent expertise to undertake third-party scientific reviews. The Office of the Chief Scientist acts as a neutral broker to bring together relevant experts from across scientific and Indigenous knowledge systems to evaluate, review and recommend improvements to the scientific foundations of ongoing science and monitoring programs or issue-focused applied research or monitoring activities. In upholding the principles of the environmental monitoring and science program, with the aim of building public trust in the credibility of scientific inputs to evidence-informed decision making processes, all third-party scientific reviews will be publically available.

The Fisheries Stakeholder Advisory Committee

A Fisheries Stakeholder Advisory Committee (FSAC) was formed in May of 2018 to provide perspective, advice, and recommendations on fisheries management in Alberta to Alberta Environment and Parks, specifically for the implementation and delivery of the following:

- Scoping and enabling an independent third-party science review of Alberta's fisheries management approach and the science behind the proposed angling closures in specified places along the east slopes;
- Developing a science-based information sharing seminar to bring together anglers, stakeholders, scientists, and staff to share their expertise and foster an improved understanding of fisheries management;
- Providing an inventory of the most critical places where industrial activity and recreational activity is impacting streams (areas of the worst linear disturbances), and developing a budget to address these concerns;
- Working with the stakeholder groups on an angler education program;
- Engaging with the stakeholder groups to assist in fixing habitat-related problems; and
- Working with the stakeholder groups on citizen science projects.

The first priority of the committee was to support the completion of a third-party science review, through the Office of the Chief Scientist, Alberta Environment and Parks. This technical document represents the third-party science review completed through the Office of the Chief Scientist and has been completed in accordance with the contract.

Alberta Environment and Parks will continue to collaborate with the Fisheries Stakeholder Advisory Committee to develop a strategy to prioritize and address the recommendations in the report. Alberta Environment and Parks acknowledges the importance of independent third party reviews in providing objective, evidence-based knowledge on important environmental issues that require management action by government. As such, it should be acknowledged that the conclusions and recommendations contained in the reports are those of the author(s) and may not represent the views or opinions of Alberta Environment and Parks or the Fisheries Stakeholder Advisory Committee.

Third Party Scientific Review of Alberta Environment and Park's North Central Native Trout Recovery Program

Conducted under contract for the Alberta Government

Submitted to the Office of the Chief Scientist

March 19, 2019

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TABLE OF CONTENTS

ACRONYMS

CEM = Cumulative Effects Model

DOC = document submitted by AEP to the TPSR team (with identification number)

FMA Committee = Fisheries Management Advisory Committee

PAC = Provincial Advisory Committee (for the bull trout management plan)

NCNT = North Central Native Trout

NCNTRP = North Central Native Trout Recovery Program

TPSR = Third Party Scientific Review

EXECUTIVE SUMMARY

As understood by the TPSR team, the specific objectives of the NCNTRP are to: **1.** implement standardized fish monitoring of NCNT populations in Alberta's East Slopes (prior to and after management actions) (DOCs 31, 48, 57); **2.** quantitatively establish (historical) reference benchmarks for NCNT populations using the Fish Sustainability Index (FSI) (DOCs 31, 48, 57); **3.** quantitatively assess population threats using species- and watershed-specific cumulative effects models (CEMs) (DOCs 14, 16, 48, 57); **4.** implement adaptive management measures in chosen watersheds consisting of fishery closures and habitat remediation activities to A) improve the status (i.e. FSI) of fish populations (DOC48), and B) test hypotheses about the relative importance of population threats generated by watershed-specific CEMs (see DOC 57). A central tenet for the establishment of the NCNT is that it is a response to Species-At–Risk (SAR) legislation and policy implementation, which differs from a stakeholder-centric focus primarily on recreational fisheries management. As a legislative requirement, this tenant influences how resource managers must evaluate the magnitude and timing of management options and the timelines when they are deployed. The listing of some of Alberta's cold-water native trout species suggests that effects of anthropogenic activities, and potentially climate change, pose a risk to the persistence of some species.

Strengths of the program:

- The AEP team leading the NCNTRP includes many natural resource professionals committed to a science-based approach to management and conservation. It is our understanding that most are anglers and all are passionate about ensuring that NCNT populations in Alberta's East Slopes persist and recover despite anthropogenic threats.
- The NCNTRP is a timely and valuable effort to assess and to begin to address the status of NCNT populations and the relative importance of environmental threats in Alberta's East Slopes using a quantitative approach.
- In theory, the use of CEMS to formulate hypotheses about the relative importance of environmental threats is a useful process to inform adaptive management. Acknowledging and considering parameter uncertainty is an important component of the modelling process.
- Model outputs are adequately treated as hypotheses to inform management, which require validation through testing.
- The NCNTRP follows an adaptive management approach such that recovery measures can be adapted and refined as new information becomes available.
- The proposed management experiment involves spatial replication at scales (subwatershed) that have rarely been conducted and has the potential to produce very informative data for future recreational fisheries management in Alberta and elsewhere.

Weaknesses of the program:

- A single reference document that synthesizes the NCNTRP is lacking – such a document should provide the scientific and technical foundations for the program with the associated management experiment that is derived from the science synthesis.
- There is a lack of clarity and transparency as to how the CEMs were parameterized (i.e. to what extent was local knowledge and broad stakeholder input considered in the development

of dose-response curves and the determination of watershed-specific doses?) and what specific criteria were used for the selection of watersheds.

- The multiplicative nature of the CEMs and some of their assumptions and inputs are problematic.
- Certain aspects of the NCNTRP (e.g. mortality estimates from catch-and-release angling, extent of habitat restoration required, efficacy of angling regulations and angling closures) would benefit from a broader (systematic) review of the literature and insight from both successful and unsuccessful management initiatives in other Canadian and US jurisdictions.
- There are inconsistencies between the stated objectives of the modelling process (i.e. produce hypotheses that require testing via experiments and adaptive management) and the planned management activities as they currently stand. The large scale experiment designed to test management hypotheses from the CEMs is unbalanced and was set to begin before sufficient watersheds were designated to the different treatment groups (including the control).
- AEP's top-down approach to management when fisheries are deemed to have 'collapsed' (i.e. level 1) was ineffective in that it has failed to garner the necessary support from local stakeholders. Literature from the fields of conservation and resource management clearly shows that active participation of stakeholders in necessary to formulate and implement effective policy and management action, even when there is urgency to act.

Recommendations:

Based on a careful review of the documents submitted by AEP to the TPSR team, conversations with AEP biologists, and written and verbal input from members of the FMA Committee, we submit the following six recommendations:

1. A single document synthesizing the NCNTRP should be created to allow effective communication, participation and evaluation of the NCNTRP by AEP staff themselves, stakeholders and third parties. This document would also serve ensure that the "legacy" from such an experiment is not lost or forgotten.
2. AEP should explore alternative models of recreational fisheries management with an emphasis on how the public can be meaningfully engaged to enhance stewardship. This should include making the FMA Committee "permanent", broadening its membership (to include agencies or organizations that relate to non-angling related threats – such as Agriculture and Forestry, Transportation), and considering the development of similar regional committees that engage local stakeholders on regional issues.
3. The structure, assumptions and inputs of the bull trout and Athabasca rainbow trout CEMs should be re-examined and their implications carefully evaluated.
4. A genuine commitment to transparency and openness on behalf of AEP operations and policy/planning is needed to restore public trust in Alberta Fisheries Management.
5. An end-date to the management experiment should be explicitly stated and a long-term management plan for NCNT populations developed in anticipation of fishery closures being lifted.
6. AEP should consider building capacity related to human dimensions research as an effective means of informing management action.

SCOPE OF THE THIRD PARTY SCIENTIFIC REVIEW

The primary goal of the Third Party Science Review of Alberta's NCNTRP is to review the scientific foundations for the proposed angling closures in upper portions of select watersheds, and habitat enhancements of river reaches in some rivers and streams in the East Slopes by:

1. Participating in a meeting of the FMA Committee held in late July 2018 to understand the scope of the review process, the role of the reviewers, and to receive feedback from committee members on what they require that the review consider.

2. Reviewing all written materials presented to the TPSR team that describe the scientific basis of proposed angling closures in select regions of the East Slopes and proposed habitat enhancements. These materials include those created and provided by the Office of the Chief Scientist and AEP biologists who have led or supported the development of the scientific foundations behind proposed changes to angling and habitat management.

3. Completing a written technical report (i.e. the TPSR) based on written materials provided by AEP and written and verbal feedback on the stakeholder engagement process by members of the FMA Committee.

4. Presenting the draft TPSR, in the format of a written technical document, to the Chief Scientist who shall forward it to the FMA Committee for their review.

5. Participating in a second meeting of the FMA Committee to present the main findings of the review and to solicit input from the FMA Committee on the draft report.

6. Converting the draft TPSR document into a final document by making select revisions identified by the FMA Committee and presenting that final document to Chief Scientist Wrona.

The TPSR team engaged with AEP biologists to request additional information on written materials and/or missing documents when necessary. The TPSR team also engaged with members of the FMA Committee to ensure that the TPSR considered the opinions and perspectives of diverse stakeholders and to better understand the ways in which the Committee has been engaged in the NCNTRP and how it would like to be engaged/consulted in future fisheries management activities in Alberta. That said, the review did not include a formal consultation component with the broader stakeholder community. Moreover, the review did not include conducting formal data analyses or model runs beyond what was needed to understand the science underpinning the proposed management actions. Similarly, the goal of the review was not to provide alternative management plans.

To ensure that the review remained focused, the Office of the Chief Scientists sent the TPSR team four focal questions, each of with included 2 to 8 sub-questions (see *Table of contents*). The questions and sub-questions are a synthesis of approximately 200 questions submitted to the Office of the Chief Scientists by members of the FMA Committee. The TPSR document is therefore structured on the basis of these questions.

N.B. On 05 Oct 2018, the TPSR team was informed that the CEM for Westslope cutthroat trout (DOC 15) should be ignored because this species is not included in the NCNTRP. We were also instructed to ignore the summary model outputs for Arctic grayling and mountain whitefish presented in DOC48 because these models are in development and not ready for review.

We wish to emphasize that the TPSR's mandate was to evaluate the *science* and appropriateness of stakeholder engagement underlying the decision to close certain fisheries in the context of the NCNTRP proposed management experiment. The decision whether to proceed with the planned management rests in the hands of Albertans and their government. Scientists are well known for wanting to understand a system at its fullest, a process which always require additional time to collect more data. However, decisions regarding when to monitor and when to act are particularly difficult because they require information not only on the current state of a system, but also on the uncertainties involved in monitoring itself (Runge et al. 2011; Bennett et al. 2018). Very often, decisions must be made quickly and with incomplete information. The consequences of delaying action under the pretense that the science is incomplete can be extinction of a population or species (Martin et al. 2012). In such cases, adaptive management can be a good strategy that allows acting quickly but changing course based on new information.

One important point to note, which is beyond the scope of this review, is that Athabasca rainbow trout was classified as "Endangered" by COSEWIC in 2014 (the highest designation for a population still present in an area) – see https://wildlife-species.canada.ca/species-risk-registry/species/speciesDetails_e.cfm?sid=1258). It is currently under consideration for protection by the Canadian Species at Risk Act (SARA). If Athabasca rainbow trout is listed under SARA, then it will become protected, and targeted or incidental catch may be prohibited in accordance with Federal legislation. Therefore, the status of Athabasca rainbow trout requires close monitoring by AEP.

PREFACE

We wish to reiterate that the aim of the TPSR was not to formulate a path forward or decide whether the NCNTRP should proceed in its current form or not – this decision is in the hands of Albertans, their elected government, the staff of AEP, and key stakeholders. In this document, we have considered the science that underpins the proposed management experiment. Our task was to conduct what we term a "peer review". Peer review remains a tenet of contemporary science although it is also imperfect (see Smith 2006). This was a highly complex task and we trust that we have given fair consideration to all of the associated science documents, input from members of the FMA Committee and knowledge shared by the AEP team. The length of this document should not be viewed as being abnormal or damming. Our task was to dig in and critique (in a constructive manner) the science underpinning the NCNTRP - we took this task seriously. We recognize the many socio-economic benefits derived from recreational fishing, yet we also recognize (as do all of the stakeholders we interacted with) that conservation of biodiversity is equally necessary. With this in mind, it is important to understand that the public servants who manage natural resources in Alberta have to wear both hats – attempting to achieve fisheries management objectives which often connect to angler satisfaction – and being advocates for biodiversity, ecosystem integrity, imperiled species, and the next generation of resource users and citizen. Finding the necessary balance in these tasks is an inherently arduous task (Cowx et al. 2010). A central tenet for the establishment of the NCNT is that it is a response to Species-At–Risk (SAR) legislation and policy implementation. As a legislative requirement, this tenant has broad ranging implications including the lens through which resource managers evaluate the magnitude and timing of management options and the timelines when they are deployed. This SAR perspective differs from a stakeholder-centric focus primarily on recreational fisheries management. We encourage resource managers to continue to emphasize this key message to stakeholders as it provides important context for action proposed to be taken in support of the NCNT. The listing of some of Alberta's cold-water native trout species suggests that effects of anthropogenic activities, and potentially climate change, pose a risk to the persistence of some species. Large-scale, replicated management experiments as the one proposed here are extremely rare and have the potential to be highly informative. Indeed, none of the stakeholders we interacted with ever questioned the idea of a well though-out experiment to inform management. Rather, the questions that arose largely dealt with a (valid) lack of understanding regarding what was being proposed and the basis for it. For that reason, it is important to reiterate here the importance of having a single document that represents the science and the management plan (proposal) co-created *with* key stakeholders. There is a vast literature on the importance of engaging stakeholders in large-scale management experiments (see Gregory et al. 2006; Allen and Gunderson 2011).The path (process) taken to arrive at the point where we are today is not one that represents best practice in stakeholder engagement. Yet, we have seen during this process much to be excited about. The leadership in AEP is genuinely (and publicly – see this video) committed to meaningful stakeholder engagement moving forward, which is promising. Of equal importance is the fact that there is a talented (although under-resourced) group of resource management professionals working on behalf of the fish and citizens of Alberta. The FMA Committee is well positioned (once populated with several missing sectors) to work with AEP to refine the plan and ensure that the knowledge generated from the experiment is in the best interest of the natural resource and its users in the long term.

1. Is <u>the structure</u> of the cumulative effects model scientifically robust such that it identifies the main drivers of variance in fish populations and supports meaningful scenario modelling?

Preamble

Ecological modeling to inform decision-making can be complex, and subject to considerable uncertainty. Typically there are too few quantitative data. Where data exist, they are often noisy and complex. Making sense of the data, and making (often time-sensitive) decisions can be very tricky.

In light of these issues, there are several positive aspects of the proposed CEM approach. First, the model attempts to incorporate the interactions among various threats, which is important when there are multiple stressors impacting populations. Second, it is at least theoretically precautionary. Given that the species are listed provincially or being considered for federal listing, there is some cause for concern. Indeed, there is also some need to clarify the legalities around a potential SARA listing (see *Scope of the TPSR*). Third, the potential incorporation of adaptive management, whereby some areas are closed to fishing and others not, is also theoretically a good idea, because information is obviously lacking for many aspects of this problem. Fourth, the proposed model attempts to simplify a complex problem and complex information in order to facilitate stakeholder involvement and formulate management recommendations that are understandable. Importantly, the impact of some drivers can be inputted based on "informed guesses" rather than data or published information/relationships. This would make the model serve the purpose of developing hypotheses to be tested about the impact of drivers on population, as highlighted by the authors, but not as tool to determine what has impacted the populations.

Despite several positive aspects of the CEM approach employed by AEP, we have several important technical concerns regarding the model(s). These concerns fall into the following categories: 1) assumptions regarding the model(s) scale and inputs; 2) the multiplicative nature of the model(s); 3) incorporation of stakeholder information; and 4) incorporation of uncertainty. We detail these points in the sections below.

1.1 Does the structure of the model allow identifying and prioritizing threats from multiple stressors on fish populations?

In theory, yes. However, the current model(s) require improvements. The purpose of the CEM approach employed in the NCNTRP is to assist biologists in estimating the relative importance of different threats. However, model outputs are only informative if the model structure is sounds and model assumptions and parameters (i.e. 'dose-response curves' and 'doses') approximate the true functional form of these relationships and states of the system.

Multiplicative nature of the model

The multiplicative model has mathematical implications that are very important, and need to be acknowledged. The fact that the model relies on a multiplication of fractions (each denoting the purposed effect of a putative impact) will greatly exacerbate the effects of multiple impacts even if each individual impact is thought to have a small effect on the population. This is inconsistent with the authors' statements that the model assumes individual impacts to act independently, which is how *additive* cumulative effects would be interpreted. Further investigations and interactions with technical staff from AEP revealed that there were some inconsistencies in terminology used in various documents (especially DOC 57 – page 17). Based on interactions in March of 2019 we have since concluded that the model is additive in the log-scale and multiplicative on the proportional scale. Nonetheless, regardless of how one refers to the model, we interpret the combined model as being synergistic (a term that itself has been much debated in the literature) as multiplying proportions will presumably exacerbate individual effects.

In DOC 57, the authors sometimes indicate that the model assumes that the effects interact (synergistically in the way the model is formulated, although antagonistic interactions are also possible), and at other times, that the effects are independent (i.e. additive). For example:

- "Multiple impacts are modelled as both cumulative and potentially interactive, using the model in a static format (i.e., one point in time) to prioritize hypotheses that quantify plausible key limiting impacts to the current status." (DOC 57 p. 7)
- "Each model consists of a series of dose-response curves where each impact is treated as independent, with the identified impact as the dose and the FSA rank of Current Adult Density as the response." (DOC 57 p. 17)
- "Although this sounds somewhat complicated, it simply describes an additive cumulative effects model on the multiplicative or proportional scale, which is the sensible biological scale if each impact influences survival." (DOC 57 p. 17)

Currently, the use of a multiplicative structure is not fully justified, and some components are unclear. For example, the multiplication by 5 at the end of the multiplicative model does not algebraically remove the denominator, as seems to be implied in the text of DOC 57. More fundamentally, the multiplicative model makes some very important assumptions. First, all components are treated equally. Second, their effects are synergistic, in the multiplicative sense. An example will hopefully illustrate the implications of multiplying fractions. Location A has 8 potential impacts, one of which is very strong (1/5) and seven of which are not a concern (5/5). The equation described in DOC 57 results in an overall FSI of $(1/5)*(5/5)^7*5 = 1$. Location B has 8 potential impacts, all of which are relatively minor (e.g. 4/5). The same equation results in an overall FSI of $(4/5)^8*5 = 0.83$. However, in reality, location B may (or may not) be much less threatened than Location A. In Location A, the single high impact parameter may actually act as a "show-stopper" that makes the location highly unsuitable for the species, whereas the combined effects of the eight low-risk impacts in site B may not be nearly as grave as the multiplicative technique implies.

NatureServe's ranking system (see below) recognizes such issues, allowing for thresholds and "show stoppers" among the various criteria to rank species. We would encourage the adoption of analogous techniques, after careful consideration of model parameter importance.

As a side note, it is possible that the authors assume independence because, in the context of probability (which is how the fractions could be interpreted), the probability of independent events *occurring at the same time* is given by the product of individual probabilities. For example, if one took each fraction derived from dose-response curves as the probability of an impact *not* affecting the populations (note that this is not how the fractions are interpreted in the current models), the probability that all impacts together *do not* affect a population would be given by their product (again, assuming that the impacts are independent). Importantly, this product would represent the probability of *all* impacts together not affecting the population, and would be lower the more impacts one considers. This straightforward calculation is very different from computing the combined magnitude of impacts from different threats, which appears to be the objective of the current model(s). Computing the combined magnitude of impacts from different threats is a more complicated process than the simple product of fractions outlined in DOC 57.

To be clear, the idea of independence in a cumulative effects context implies that effects are *additive*. However, this is inconsistent with the authors' application of "independence" in their CEMs, which instead follows how the combined *probability* of independent events is calculated. As a result, the combined effect of different threats is magnified, implying full synergy.

Assumptions regarding model scale and inputs

The 1-5 scale for model parameters and final ranking is an understandable simplification; however, this simplification is not sufficiently justified in existing documents. For instance, DOC 57 states that AEP's scale follows NatureServe's methodology for assigning conservation status rank (Faber-Langendoen et al. 2009). However, it is actually much simplified compared to what NatureServe uses and it is unclear whether differences in final rankings should be interpreted as linear or not (i.e. a score of 4 is twice the value of a score of 2).

Individual parameters for the CEMs are described in several documents. Unfortunately, for all of them, there is inadequate documentation and justification, and several may have flawed assumptions. For example, Figure 10 in DOC 14 presents a model for FSI vs. phosphorus index. Panel A shows a fitted relationship sated as using '90th quantile regression'. All points except one are actually below the line. This could perhaps be explained by the 90th quantile method (it's hard to tell), but the standard regression line should also be shown. In addition, if the conservative 90th quantile regression was indeed used to draw this line, the line should actually be much lower than it is. As such, the line drawn is not precautionary, and could severely underestimate the impact of phosphorus index on FSI. The same is true of Figure 11 in DOC 14 and Figure 11 in DOC 16. Finally, it is clear from Panel B in Figure 10 (DOC 14) that the relationship in panel A is being extrapolated far beyond the reasonable bounds of the model (and nearly two times beyond the last data point).

Additional examples include several of the inferred linear relationships, which are likely non-linear. In particular, the habitat loss and fragmentation relationships are well-documented in the ecological literature to be saturating curves (i.e. with slow initial losses followed by precipitous declines), rather than linear (e.g. MacArthur and Wilson 1967).

We stress that the examples given above are not exhaustive, but indicative of a need to carefully consider all of the parameters used in the CEMs. This is a crucial point, because the relative importance of the various parameters referred to in the recovery program tactical plan (DOC 48) appear to be simply the inferred 1-5 FSI levels of the threats from these models.

Without specific knowledge of the local threats, we cannot recommend detailed adjustments to model parameters. However, we would encourage the use of structured approaches, better stakeholder consultation and exhaustive literature searches to properly derive parameters.

Incorporation of stakeholder information

In DOC 57, it is noted that the modeling process is designed to include input from stakeholders. It is also noted that the biologists "have found it useful to build out the preliminary model in a workshop-style setting" (p. 20). While it is clear that stakeholders were consulted in drawing up the lists of threats and dose-response curves for the bull trout (DOC 14) and Athabasca rainbow trout (DOC 16) CEMs, it is not clear how this stakeholder information has been incorporated into the models themselves. Currently, there is very little information in the description of individual parameter derivations that suggests any substantial stakeholder input. Furthermore, it is worth considering that the apparent stipulation that stakeholders draw up dose-response curve could have limited some responses, for example by stakeholders who did not feel that a dose-response curve adequately captured the complexities of the ecosystem (except for historical adult density). Additional information on the incorporation of stakeholder information into the CEMs (both for dose-response curves and doses) is needed and could be generated from stakeholder correspondences with AEP and minutes taken during workshop-style meetings (see DOC 35 p. 1, DOC 59 p. 2).

1.2 Are the uncertainties and limitations of the model and its output adequately described?

Not sufficiently. The process of quantifying model uncertainty and assessing data reliability is described in DOC 57 p. 30-34. Here, the authors state that "A highly useful aspect of the Joe modelling process is the ease of explicitly defining ranges of uncertainty in the dose-response relationships as well as in the ranges of uncertainty inherent in the state variables." We commend the AEP for using a quantitative approach to estimating uncertainty in the model outputs, the three steps of which are outlined in bullet points on p. 31 of DOC 57. Members of the TPSR team were also given a live demonstration of these steps during a webinar on Oct 5 2018.

We note that, while the description in DOC 57 and the short demonstration provide a good overall understanding of the sensitivity analyses undertaken, the incorporation of uncertainty into model outputs and final FSI estimates requires more extensive documentation. For example, there is insufficient detail regarding why normal distributions were apparently assumed for all parameters; which criteria were used to select key drivers from the model for the sensitivity analysis; whether model runs with different combinations of dose-response curves and input parameters ('doses') were carried out systematically or randomly; how the data reliability ranking procedure (DOC 57 p. 32-34) was incorporated into the modelling, if at all; and how uncertainty was incorporated into the general conclusions (it does not appear to be numeric). There is also no sensitivity analysis presented in the draft bull trout and Athabasca rainbow trout CEMs (DOCs 14 and 16), nor is there any other rigorous consideration of uncertainty. Propagation in interactive models is tricky, and must be carefully considered. Full sensitivity analysis (including presentation of uncertainty bounds in final estimates) would be highly desirable. Possible additional techniques to explore include Monte Carlo analysis (Burmaster and Anderson 1994) and Bayesian belief networks (Pollino et al. 2007), preferably in collaboration with statistical consultants who specialize in these approaches (we acknowledge that the AEP has a history of reaching out for such expertise and encourage that moving forward).

Future efforts to estimate uncertainty could also consider asking each stakeholder to draw-up their own dose-response curve independently from others. Combining the different dose-response curves would then create a distribution of responses for each dose (the more stakeholders, the better), which would better represent uncertainties in the simulations. Having stakeholders independently work on dose-response curves would have the added benefit of avoiding some cognitive biases mentioned, such as anchoring (i.e. the tendency to rely too heavily on one piece of information when making decisions).

1.3 Is the cumulative effects model an appropriate tool for its identified purpose?

We refer the reader to the preamble for *section 1*, and *section 1.1*.

1.4 Does the model provide outputs that can be used to compare and prioritize alternative recovery actions?

Yes (in theory). However, see caveats in preamble for *section 1*, and *section 1.1*

In DOC 57 (p. 16) and elsewhere, the authors clearly state that "Modelled results are treated as hypotheses needing testing, rather than predictions." "Alberta's cumulative effects Joe models are not designed to be complex ecosystem-level models that capture every synergistic or antagonistic interaction among impacts and definitively predict fisheries status and responses. They are also not meant to replace localized action plans requiring tactical, fine-scale, specific-site data. Rather, these are strategic, population-level models using the best-available science to create reasonable, quantitative hypotheses of cumulative effects and management actions. As such, the output from these models are treated not as predictions, but as best-available hypotheses needing to be tested and validated." (DOC 57 p. 19)

As such, model outputs are a useful means of assessing the relative importance of various threats and informing management decisions, which must be revised based on new evidence following an adaptive management approach. Currently, given the multiplicative structure of the CEMs, one assumes that multiple impacts are highly synergistic (i.e. their combined effect is greater than their additive effects) and could perhaps use model outputs to support a precautionary approach to management. However, the reservations we expressed regarding the modelling approach outlined in *section 1.1* might impact the model outputs as they currently stand. One notable point that requires clarification (and perhaps refinement) is how different threats are ranked/prioritized in the NCNTRP Tactical Plan (e.g. Figures 3, 6, 11, 14, 17 and 18 in DOC 48). Currently, it appears that the ranking in these figures simply reflects the FSI for each threat based on the 'dose' identified for each threat's 'dose-response curve' (i.e. the input into the model), not an actual model output with some quantitative measure of uncertainty.

2. When identifying management actions related to closure of recreational angling or habitat enhancement, was the model applied in a scientifically rigorous way so that predictions were based on appropriate data including state parameters and coefficients, and that uncertainties in predictions are adequately described?

Preamble

In many ways, question 2 is an extension of question 1, so additional context is not necessary in terms of a preamble.

2.1 Are historical data required to understand temporal trends in native trout populations related to the selection of watersheds where angling closures were proposed?

Yes. DOC 57 (p. 13-16) and DOC 56 (p. 6-12) outline AEP's approach to establishing a reference or benchmark condition when faced with limited historical data to determine temporal trends in NCNT populations: "In science-based natural resource management, measurable population-level objectives provide a benchmark against which to measure fish population status and the performance of recovery and maintenance actions (e.g. DFO 2006, Artelle et al. 2018). Without quantitative benchmarks, declines in fish populations that happen over decades will be largely misinterpreted or misunderstood, as shifting baselines mask the actual changes (Pauly 1995). Following AESRD (2012) and similar to approaches used by other conservation agencies (e.g. Williams et al. 2007; NatureServe 2009), Alberta Fisheries Management has adopted the use of broad risk categories to describe fish population status relative to a provincial reference condition (see AEP 2018a). This reference condition is the key quantitative metric that reduces the potential bias associated with the shifting baseline syndrome."

This approach relies on the Fish Sustainability Index (FSI), which is reviewed in *section 2.8*. The temporal data used in determining reference conditions for bull trout, mountain whitefish, Athabasca rainbow trout, and Arctic grayling are outlined in Appendices A, B, C and D of DOC 56, respectively (p. 12-28). Further species- and watershed-specific information on population status compared to provincial FSI standards for the Kakwa River, Berland River, North Saskatchewan River, Clearwater River, Red Deer River is provided in DOC 31. According to the text in DOC 56, much of the data records for the preparation of these documents were extracted from the provincial Fish and Wildlife Information System (FWMIS). When the TPSR team asked about the public availability of these data via FWMIS during a conference call with stakeholders and a representative of AEP (17 Sept 2018), we were informed that these records are not readily accessible and must be requested from government. Stakeholders voiced frustration to the effect that requests for information were often left unanswered or denied. Stakeholders also expressed concern that not all relevant data sources were assessed by AEP when establishing historical and current population statuses, such as survey data by non-government biologists and angling associations.

The TPSR team is not in a position to comment on whether sufficient historical and current data were used to determine reference and present conditions for specific NCNT populations. The answer to this question should be reached as a consensus among relevant parties (AEP staff and

FMA Committee members). As such, the data underpinning these assessments should be made publicly available on an online platform (FWMIS or other) and presented in formats that 1) allow reuse and reanalysis by third parties with the necessary scientific expertise (i.e. the raw data and accompanying metadata); and 2) allow non-specialist audiences such as anglers and members of the public the opportunity to assess temporal trends in fish numbers and size (e.g. summary data of CPUE and size measurements at relevant spatial and temporal scales).

2.2 To what degree were data required and used to quantify angling pressure in these watersheds where angling closures were proposed?

In the context of the NCNTRP, data on angling pressure were required to determine the angling mortality rates used in the bull trout CEM (see DOC 14 p. 5, 2nd paragraph) and Athabasca rainbow trout CEM (see DOC 16 p. 12, 4th paragraph). Angling pressure was also a consideration for determining reference conditions (i.e. an FSI) for NCNT populations (DOC 57 p. 13-16, DOC 56 p. 6-12).

DOC 60 describes the process by which angling pressure (for bull trout) was determined based on the proximity of human settlements and the amount of access (e.g., road density, road type, road location) to flowing waters in each HUC, and later converted to an estimated angling mortality using a ranking system. GIS and FWIMT (Fish and Wildlife Internet Mapping Tool) were used by AEP in this process. Results (i.e. angling mortality estimates) and justifications (i.e. 'Overharvest Protection Need') are presented for the Kakwa River, Berland River, Clearwater River, and Ram/North Saskatchewan River but not other watersheds.

Angling pressure (effort) is an important component of fisheries assessment and management but is also dynamic and complex (see Post et al. 2008). However, fishing effort is notoriously difficult to measure in instances where there is not a common entry point for anglers, such as a boat ramp on a lake. For instance, recreational fisheries pressure in streams and rivers is inherently diffuse although at times it can be aggregated in specific locations. This is not to say that creel surveys cannot be used (and indeed they have been used by AEP on streams in Alberta, see DOC 18 p.2) but they are expensive and encounter rates may be low. As such, proximity to human population centres (often quantified in terms of travel time; Hunt et al. 2011) and road access can be a useful proxy for angling pressure in the absence of fine-scale (on-the-ground) data (see Post and Parkinson 2012), particularly when large areas must be assessed. Ideally, this proxy would be validated in subsets of the areas under consideration using alternative methods of estimating angling pressure.

Simple technology such as remote traffic counters (see van Poorten and Brydle 2018) and cameras set to record images at pre-determined intervals or upon triggering (see Greenberg and Godin 2015; van Poorten et al. 2015) even at night (i.e., using thermographic imaging; see Taylor et al. 2018) provide creative options for assessing effort once properly calibrated. There have also been innovations in using angler-provided data via phone-based applications (Venturelli et al. 2017), including work done in Alberta (Papenfuss et al. 2015). We are confident that the staff of the Alberta government are aware of these opportunities (and may already be using them). We encourage efforts to further validate, and where appropriate, apply these tools to enhance assessments of fishing effort (and other aspects such as catch).

2.3 To what extent are descriptions of natural ranges in variability in fish abundance and biomass required to assess whether fish populations are above or below historical levels?

This is among the most difficult of the questions to answer. There are financial and time limitations to any monitoring program. From our investigations, it appears that AEP tends to monitor population status in a given system/reach no more than once a year, and not always during the same months/seasons although that is the aim (DOC 31 p. 1). This was a criticism raised by some of the stakeholders during our interactions with them. There is some suggestion that there are other data sources but they have not been collected using standardized methods. The issue of non-standardized surveys is raised in DOC 56 – e.g. “Standardizing the assessment of species status has resulted in a more consistent, rigorous approach to fisheries management in Alberta”; “Until recently, provincial Bull Trout surveys did not follow standardized sampling protocols, which resulted in significant challenges for detecting population trends across space and time.”; “When watershed surveys are standardized and are consistently monitored through time, there will be more reliable long-term population data to inform thresholds.” There are also several mentions of “NCNT Standard Operating Procedures” in DOC 48. Other mentions of the importance of standard surveys occur in DOC 57 p. 9-15.

We do acknowledge that standardized sampling methods are critical for trend-through-time monitoring or any attempts to use monitoring data to inform state of the resource reporting or management (see Bonar and Hubert 2002). There appears to be an appetite among some of the stakeholder groups to participate in assessment, so it is important to ensure that standardized assessment methods are shared. However, that does not address the issue of historic data to establish population baselines. We (the members of the TPSR) do not have a good understanding of the historic data available in Alberta. As discussed in *section 2.8* below, historic conditions are extremely important and need to be agreed upon by stakeholders involved. It is unclear the extent to which historic conditions were estimated in a manner that involved stakeholders and considered the broadest suite of available data and knowledge.

2.4 How were the five watersheds chosen to receive proposed closures to angling, and also, why were five watersheds and not a lower or higher number chosen?

Information regarding the criteria for the selection of watersheds to be included in the NCNTRP management experiment were vague in the initial documentation submitted to the TPSR team (i.e. DOCs 1-58). Similarly, public information on AEP’s website describing how watersheds were selected for the program is rudimentary, listing biological, economic and social factors in very broad terms (http://aep.alberta.ca/fish-wildlife/fisheries-management/north-central-native-trout-recovery/default.aspx). The specific criteria considered by AEP in the choice of watersheds for the management experiment were clarified in DOC 59 (“Response to Third Party Review Questions Oct 2018 FINAL”; p. 3-5) upon request from the TPSR team. It is our understanding that the detailed (written) information regarding these criteria is not currently available to the broader public.

Similarly, limited information on the management experiment was available in the original documentation submitted to the TPSR team other than an experimental design outlined in Figure

1 of DOC 48 and the identification of eight waterbodies to be included in the experiment: Kakwa River, Berland River, Pembina River, North Saskatchewan River/Lower Ram River, Clearwater River, Upper Red Deer River and Pinto Lake. The design of the planned NCNTRP management experiment was verbally explained to the TPSR in greater detail during a webinar with AEP staff on Oct 3 2018. This explanation is consistent with DOC 59, which outlines a Before-After-Control-Impact (BACI) experimental design with 4 treatment groups: ~2 watersheds that will undergo extensive habitat restoration, ~2 watersheds that will have highly restrictive sport fishing regulations or fishing closures, ~2 watersheds that will undergo both habitat remediation and angling closures, and ~2 watersheds that will act as controls with a "business as usual" approach to fisheries and land management. This is a sensible experiment that is consistent with the stated goals of the NCNTRP: testing hypotheses generated by the CEMs for bull trout (DOC 14) and Athabasca rainbow trout (DOC 16). However, Figure 1 in DOC 48 (below) currently indicates that *five* watersheds will undergo angling closures and habitat remediation, *two* will be open to fishing and undergo habitat remediation, *one* is closed to fishing without habitat remediation, and *none* are identified in the control group (i.e. open to fishing and not undergoing habitat remediation).

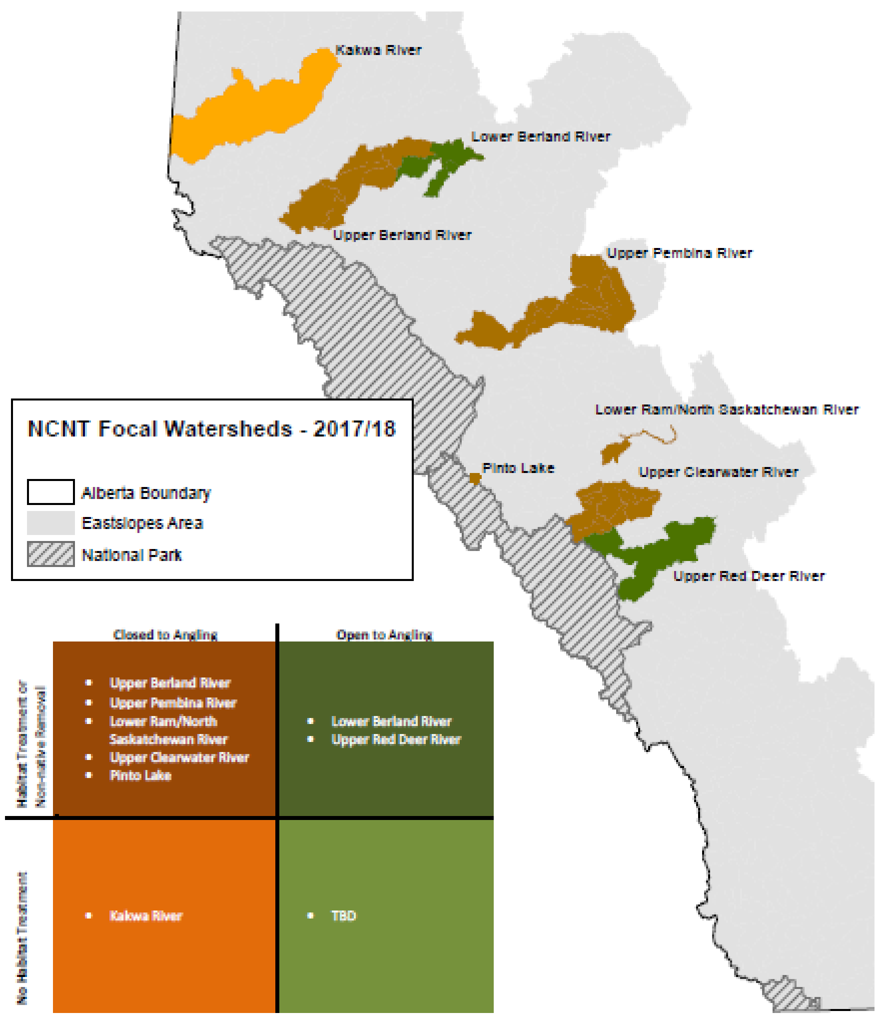


Figure 1 from DOC 48

As it stands, the experimental design is strongly unbalanced (i.e. the sample size in each treatment group is highly uneven). It is also noteworthy that the experiment was planned to begin in the summer of 2018, with the control group containing no replicates as of yet. Having different starting dates/years for different treatment groups is problematic from an experimental point of view because the results are likely to be confounded by starting year and/or time (i.e. duration), particularly over the short time span (five years) of this experiment.

Lastly, the AEP should be commended for contracting a statistician to conduct power analyses and determine an adequate sample size to detect trends in CPUE over time with regards to baseline monitoring for the NCNTRP. However, a similar power analysis should also be conducted to determine an adequate sample size for the planned management experiment. The existing power analysis (DOC 51 a-e) does not take into consideration the four treatment groups in the experiment. Consideration should be given as to whether watersheds are treated as the unit of replication (i.e. one measure per watershed each year), or whether multiple yearly measurements are made at different locations within each watershed, such that measurements must be blocked by watershed to account for their non-independence (e.g. by treating watershed as a random factor nested within treatment groups).

2.5 Were other changes to angling regulations that could reduce angler-mediated mortality of fish evaluated (e.g., reduced length of the angling season, barbless hooks) other than closure to angling?

Yes. During a webinar meeting on Oct 05 2018 (Appendix V), AEP biologists informed the TPSR team that an angling sub-model had been carried out to explore potential effects of angling restrictions on NCNT populations and evaluate alternatives to angling closures. Written information about these sub-models was subsequently communicated to the TPSR team on Oct 23 2018 (see DOCs 61 point B and 63). For specific information on the angling sub-model, refer to *section 3.2*.

Fisheries managers have a suite of options to attempt to modify fishing mortality in catch-and-release recreational fisheries. For example, regulations can be applied that restrict gear type (e.g., only flies, no treble hooks, barbless hooks, no live bait, circle hooks), reduce fishing catch/effort (e.g., use of special stamps, temporal/seasonal restrictions), shift fishing effort to more benign periods (e.g., closures during warm temperatures), or alter angler behaviour (e.g., prohibit air exposure – see Landers (2016) for an example with Washington State wild steelhead). However, in recreational fisheries governance, voluntary actions are sometimes preferable to regulatory actions (Cooke et al. 2013). For example, efforts to educate anglers regarding best handling practices or social movements such as #keepemwet can also be effective (https://www.keepemwet.org). However, none of the aforementioned strategies will eliminate fishing mortality. Even when optimal handling methods are used by conservation-oriented anglers, a (usually small) proportion of the catch will fail to survive catch-and-release fishing.

Within the ~430 peer reviewed studies that have been conducted on catch-and-release, the most clear driver of mortality is hooking location on the fish (Batholomew and Bohnsack 2005; Cooke et al. 2011; Huhn et al. 2011). Specifically, fish hooked in locations such as the gullet, tongue or gills tend to do comparatively poorly relative to fish hooked in more superficial locations such as the jaw. Air exposure has also been regarded as a driver of mortality. It is of course intuitive that there are species-specific thresholds for air exposure and that these can vary relative to water temperature (among other things; see Cook et al. 2015). There are thresholds for air exposure that result in immediate mortality as well as thresholds that might lead to behavioural impairments that enable post release predation (thus, an indirect form of mortality). Sensitivity to air exposure is modulated by water temperature; the warmer the water, the more sensitive most fish (including salmonids) are to fisheries-related stressors (reviewed in Cooke and Suski 2005; Gale et al. 2013). Barbless hooks are also commonly used in an effort to reduce mortality but the science on the topic is equivocal (Taylor and White 1992), such that barbless hooks are regarded as a social issue (Schill and Scarpella 1997).

Although the aforementioned ideas could be used to reduce fishing mortality, it could take significant time before reduced mortality is realized. We are just now starting to learn about compliance with catch-and-release regulations and the extent to which education does yield outcomes that benefit fish. The angling community is heterogeneous such that single approaches to education are unlikely to be successful. This is an emerging research area that may provide more options in the future but for now it is unlikely that other approaches will ensure the level of desired mortality (i.e., low) notwithstanding the discussion in *section 2.6* regarding the assumptions with fishing mortality numbers used in the CEM exercise. The proposed NCNTRP management experiment is intended to identify whether elimination of fishing mortality is sufficient to enable recovery of fish populations. This is a different question than asking whether reducing (but not eliminating) mortality is sufficient to enable recovery.

2.6 What levels of hooking mortality and annual fish mortality were used and are they appropriate?

In the context of the NCNTRP, the premise for catch-and-release mortality being a potential limitation to population recovery is that fish handling is suboptimal. As noted in *section 2.5*, hooking location is often regarded as the primary driver of mortality. For various reasons, that is not regarded as being important in the East Slopes. Handling includes aspects of air exposure and how the angler interacts with the fish with their hands or other surfaces (net, shoreline). Although there have been several studies that have assessed how use of landing nets can contribute to dermal injuries, there is little evidence that such nets contribute to mortality (Lizee et al. 2018). As such, it is thus presumed that air exposure is the primary diver behind mortality in the context of NCNT fisheries.

Air exposure has been well studied as a stressor in catch-and-release since the early 1990s. A classic paper by Ferguson and Tufts (1992) set the stage for understanding the physiological consequences of air exposure. However, the paper is most notable for what it says in its abstract – specifically "… survival after 12h was 100%* in control fish and 88% in the exercised fish but fell to 62 and 28% in fish which were air exposed for 30 and 60s, respectively, after exercise." This statement has served as the basis for much of the contemporary thinking regarding how high levels of mortality can arise from even short durations of air exposure. However, a more nuanced reading of the entire paper reveals that all of the fish were cannulated – that is, a tube was sutured into place that fed directly into the dorsal aorta. The tube is used to withdraw small blood samples to assess physiological status. So – fish that were used to assess mortality were also subject to blood withdrawal. That alone is not of great consequence to a resting fish (e.g., control fish had 100% survival). However, when fish are exercised or handled (air exposed) there is potential for the dorsal aorta cannula to become dislodged. The longer a fish struggles, the greater the likelihood of the dorsal aorta cannula becoming dislodged. If a cannula becomes dislodged from the aorta, a fish most certainly bleeds to death. It is probable (and consistent with other literature) that longer air exposure is more likely to lead to death in fish but mortality associated with the short-duration air exposure periods provided in Ferguson and Tufts (1992) are simply not relevant to field/management scenarios. This is not a critique of the science in that paper but rather how it has been used. This is important context in that the findings from that paper influenced the selection of mortality levels used in the NCNTRP management experiment (see page 3 of DOC 18 – as well as Figure 5 reproduced from Ferguson and Tufts on page 4 of DOC 18).

In DOC 18, it is argued that since early modeling of bull trout (where Post et al. (2003) used 10% mortality for catch-and-release and 10% for poaching), recreational fishing has changed such that air exposure is longer (due to digital camera technology being more prevalent) and fishing for trout in the East Slopes has become more common. As such, there is a need to revisit these mortality values (as per DOC 18). A value of 50% mortality was used in early iterations of the modeling (Presentation by M. Sullivan to FMA Committee in late July) for fish that are photographed and released (note that this was subsequently lowered to 33% as per DOC 55). This early estimate (50%) is not consistent with the majority of the air exposure literature for a range of species (aside for some marine fishes where there are hyperabundant predators such that any behavioural impairment may enable post-release predation; see Raby et al. 2014). Air exposure is certainly not beneficial for fish but it also does not mean that it always (or 50% of the time) leads to mortality. Many factors influence sensitivity to air exposure – species, population, size, sex, stage of maturation, fight duration, and water temperature, among others (reviewed in Cook et al. 2015). These have been variably explored but what is clear is that context matters (Cook et al. 2015; Raby et al. 2015). Beyond obvious species-specific differences (related to different physiological tolerances), water temperature is probably the most important factor mediating the lethality of air exposure. A study of bluegill (see Gingerich et al. 2007) clearly shows how water temperature and air exposure interact. Most of the catch-and-release work done thus far on bull trout has been done at water temperatures below 15˚C (see below).

So – What is the real number? The short answer is "it depends" but there is really little bull trout specific data to draw upon. One of the few studies of bull trout catch-and-release mortality occurred on a reservoir in British Columbia (Gutowsky et al. 2011). The authors trolled various lures and reported immediate mortality of <1% (1 out of 126 fish). Air exposure times were not recorded but the authors recall that they were in the vicinity of 30 seconds (for landing, hook removal, and placing fish into a water-filled cooler). Fish were subject to chemical anesthesia and surgical implantation of telemetry transmitters (both of which are inherently stressful) yet only a single fish failed to swim away and that fish was one that was significantly impaired as a result of massive blood loss (hooked in the gills). That study was conducted in the spring when surface water temperatures ranged from 2 to 15˚C. Andrusak and Thorley (2014) studied bull trout on Kootenay Lake in British Columbia and reported mean short-term mortality rates of ~4% for fish captured on single hooks, irrespective of body size. The authors then used the 4%

value (for handling-related catch-and-release mortality) in subsequent modeling. Another bull trout study was not conducted explicitly to generate a catch-and-release mortality estimate but that was a convenient outcome. Clayton (1998) conducted a telemetry study of bull trout in a lotic system in Alberta. Because fish were captured by angling before tagging, Clayton (1998) was able to generate a mortality estimate of ~5%. Of course it is not possible to tease out the tagging effects, so it is possible that mortality was elevated by tagging. No information on handling (i.e., air exposure) was provided. There are likely other telemetry studies from which data could be extracted but it is unlikely that any of them include data on air exposure. There is one recent study (i.e., Roth et al. 2018b) on the effects of air exposure on bull trout (it also contains good data on rainbow trout and cutthroat trout), which provides much needed data on the topic. The authors captured fish with rod and reel (mostly flies) from several rivers and then exposed them to air for 0, 30, or 60 s during which time they were tagged and released. Subsequent single-pass backpack electrofishing was used to recapture tagged fish and estimate relative survival. The authors captured 278 bull trout (0 s: n = 92; 30 s: n = 94; 60 s: n = 92) and observed no difference in relative survival among the three groups (same finding for the other two species). The study was conducted in the midsummer with water temperatures ranging from 6 to 14˚C. Because of the study design, only relative differences were reported so it is not possible to generate an actual mortality estimate from their data.

To supplement the data generated by Roth et al. (2018b), AEP conducted a study in summer 2018. To our knowledge, the data have not been formally "written up" but were shared with the FMA Committee in the form of a presentation and made available as a briefing document (see DOC 55). The study was conducted in a small lake in Alberta using single barbless hooks. Water temperature was not reported in the document but was recorded. Short-term (24 hr) mortality was assessed by holding fish in a net pen. Two groups of fish were used in the study: 20 control and 30 treatment fish. The control fish were captured and then moved to the net pen while fish in the "treatment" group were exposed to air for 112 sec (mean) with a range of 75 to 162 sec.

At the conclusion of the study (DOC 55), there were 3 dead fish in the control group (15% mortality) and 10 dead fish in the air exposure treatment group (33% mortality). The researchers reported that most fish mortalities were "recognizable" within 2 hours of release (i.e., limited opercular movement and loss of equilibrium) but it was unclear if this was restricted to the air exposed fish. Because fish were held in net pens, it is not possible to determine if mortality of the control fish represents catch-and-release mortality or if it is a consequence of net pen retention. If one assumes that the 15% mortality of control fish was an artefact of retention, then that would suggest that the actual hooking mortality value for the treatment fish is closer to 18%. The duration of air exposure and level of handling used in this study merit some comment. For example, recent work in Idaho, where anglers were surreptitiously observed, has revealed that air exposure periods for anglers fishing for salmonids rarely exceed 30 seconds (Lamansky and Meyer 2016; Roth et al. 2018a) – a time period that is likely closer to what fish in the control treatment experienced rather than those in the air exposure treatment (where the minimum air exposure time was 75 sec – or more than twice as long as what has been observed in Idaho). Although the authors of DOC 55 state that they used methods that were representative of how anglers fish in Alberta, it is unclear whether that statement is based on formal observations such as those conducted by Lamansky and Meyer (2016) or Roth et al. (2018a), which represent more than just anecdotes or best guesses. We fully agree with one of the conclusions of the report –

that mortality is above zero – but that is the case for all catch-and-release scenarios. We also agree that the air exposure treatment applied here resulted in mortality that exceeded that of controls. However, the relevance of the experimental air exposure durations and handling treatments are unclear. It is important that experiments designed to generate data to inform management are "realistic" – something essential if data are to be relevant to decision making (see Cooke et al. 2017b – for a general discussion of this topic as well as several examples specific to recreational fisheries).

The 50% mortality estimate (note – in DOC 62 the number 33% is used but prior to generating those data this summer, the number of 50% was being used as noted above) used in the modeling for fish exposed to air is at least 17% (in actual levels) higher than what would be a fair estimate to use based on the 33% mortality value generated by Alberta government staff in summer 2018. If one uses the more conservative mortality value for air exposed fish (i.e., 18% mortality) then the current value of 50% or even the 33% (which as of the memo from Oct 9 2018 – DOC 62 – is now 33%) is much higher. However, the data from Roth et al. (2018b) are also somewhat compelling and suggest no difference between treatments.

We appreciate the notion of breaking down the angler segment by their catch-and-release behaviour and having "behaviour-specific" inputs to the model but it may be premature to do so. Compartmentalizing anglers into different groups is not easy to do and requires educated guesses. It may be more reasonable to simply assign a mortality value across the board for all catch-and-release angling behaviours recognizing that there will always be some good performers and some poor performers (with respect to fish handling). Based on the available data, that number should range between 1 and 18%. In that context, the 10% mortality level identified and used by Post et al. (2013) remains reasonable. The numbers for catch-and-release mortality provided by the Alberta government are also within that ballpark (see DOCs 61 and 62). Quoting DOC 62 "The modelling of threats to Bull Trout in east slopes watersheds used a range of potential values of three types of catch-and-release mortality, with the resulting cumulative mortality having a central tendency of 10%, and a range of approximately 5% to 15%. These values and ranges were derived from simulation modelling and field-based analysis of the following three categories of catch-and-release mortality."

Several of the volunteer biologists directed us to the following statement (from p. 51 of Mushens et al. 2003) with which we agree: "Reliable estimates of natural mortality and hooking mortality rates of bull trout are critically important when developing models of sustainable exploitation for the species." The reality is that there has yet to be a decent study of bull trout release mortality in the streams of Alberta (or surrounding environs) using appropriate controls, best scientific practices, and angler-informed treatments to ensure relevancy. This should include a seasonal component and occur in systems with various levels of thermal "stress" to establish how water temperature mediates catch-and-release stressors. We also encourage efforts to better characterize the range of angler behaviours and use that to inform study design so that it is as relevant as possible.

During the course of our review, we had the opportunity to ask questions to the science/management staff of AEP regarding poaching. We had identified some potential concerns (either through our assessment or via issues raised by members of the FMA

Committee). The information provided during the webinar of Oct 5 2018 with AEP staff was useful to clarify this point, and additional information was provided in the form of a memo (DOC 61). Some concerns were raised regarding the level of poaching that was used in the models as being too high. The details provided during the call and subsequently in DOC 61 provide additional (nuanced) details that bring more clarity to the issue and, in our opinion, justify the numbers used. We wish to note that the research conducted by AEP staff related to compliance (or lack thereof) with recreational fisheries represents the majority of our collective published knowledge of this topic and is regarded as globally unique.

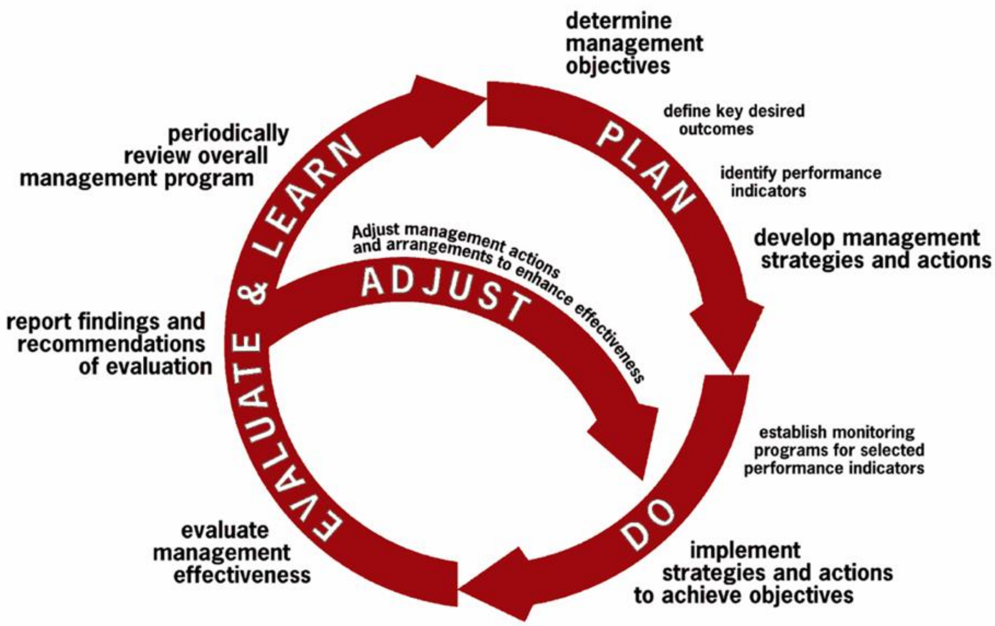
Ultimately, given the challenges of accurately determining mortality rates and current research needs in this area, values estimated for modelling purposes (and their uncertainty) should be agreed upon by consensus among AEP biologists and the FMA Committee. A review of the science can inform the "number" but there are many uncertainties and it is well known that catch-and-release mortality is context specific (Raby et al. 2015), so efforts to engage key stakeholders in the process will be important to generate consensus.

2.7 How were uncertainties in model outputs evaluated and communicated?

We refer the reader to *section 1.2*.

2.8 The FSI is an integral component of modeling exercises. How is constructed, is it appropriate, and are other descriptors, including metrics also required?

State of the resource reporting is essential in contemporary resource management as it provides trend-through-time information and helps to identify areas in need of management interventions. Examples of such reporting at the level of the watershed or subwatershed include efforts by Conservation Ontario (they call them report cards; http://conservationontario.ca/policy-priorities/science-and-information-management/watershed-reporting/) or the World Wildlife Fund Canada watershed reports (http://watershedreports.wwf.ca/page/about/#canada/by/threat-overall/profile/?page=about). An assumption with such reporting efforts are that they are a realistic reflection of the current state relative to historical conditions. It goes without saying that biological assessment is an essential component of the management cycle (fee figure below from CSIRO – http://www.cmar.csiro.au/research/mse/; Lorenzen et al. 2016). Therefore, if the biological assessment and associated state of the resource reporting fail to reflect reality, then management actions may be misguided. This can be costly to the resource itself, the users (current and future), and the tax payer.



http://www.cmar.csiro.au/research/mse/

In Alberta, the provincial government relies on the Fish Sustainability Index (FSI) to synthesize the state of fish populations in a given management unit. Quoting (verbatim – to bring readers to a common state of background knowledge) government resources on the FSI "The FSI was developed to bring consistency to individual fish stock assessments and provide a province-wide evaluation of the status and sustainability of Alberta fish species. We use data and information from a variety of sources, including: Fisheries surveys; Scientific literature; Local and traditional knowledge; Expert opinion. In total, seventeen different metrics are summarized and integrated to classify population integrity, the productive potential of the habitat, and threats and their mitigation. We also evaluate the reliability of the data used to score each metric based on the amount of data/information, the age of the data, and its consistency. Together, these metrics provide a description of the current status of a fish population, their habitat and the threats they face. Each metric is scored on a scale from 0 to 5 (0 is a fish population has already disappeared or one that is no longer sustainable; 1 is a population that is least sustainable; 5 is the most sustainable population). For the majority of FSI metrics, these rankings are easily translated into an evaluation of risk, where a FSI score of 1 is a population at very high risk, and a rank of 4 and 5 represent a population at low risk."

According to AEP, the results of the FSI can be used to support the following actions:

- Allow for broad comparisons to changes in fish species sustainability over time.
- Allow for comparisons between fish sustainability and management actions.
- Direct effective future recovery and management actions.
- Educate decision-makers, conservation partners, private industry and the public on the status and risk of fish species compared to historical levels, how the condition of surrounding watershed is influencing fish population health, and threats that may jeopardize population persistence.
- Provide information to assist in the development of specific watershed restoration plans and integrated watershed strategies.

In the context of the TPSR, the FSI requires some discussion given that it is the outputs of the FSI that have been used to conclude that the fish populations in the East Slopes region are sufficiently “unsustainable” that management intervention is necessary. In other words, the FSI outputs are being used to justify the management experiment. Moreover, the FSI is being used to help identify target watersheds, evaluate the level of intervention that may be needed (and type of intervention relative to threats), and to assess outcomes (i.e., testing the hypothesis that various management interventions can push populations to levels that are more sustainable – or in the context of the FSI, to a higher number). Referring back to the fisheries assessment-management cycle, knowledge of the state of the resource is simply essential to be able to engage in effective management.

We are highly supportive of the use of a system like the FSI and our issues with the scoring system are already raised in Question 1.1. In general, the FSI metrics are logical and comprehensive; we failed to identify any metrics that should/could be added. We do note that the role of climate change (Lynch et al. 2016) is not explicitly recognized as a threat but is presumably captured in the drivers of productive capacity. The current protections (needs and protection availability) for climate change and associated adaptation strategies may be different from those used to address habitat impairments or overfishing (see Paukert et al. 2016). This should be rectified in the future.

With any good reporting system, the biggest issue is data quality. For the FSI, data quality refers to both the current state and the historic state. Correctly identifying the historic state is critical. For example, if the historic conditions were in fact rather poor (say a score of 2) but were incorrectly determined to be high (say a score of 5), then it would be unlikely that any level of management intervention (save turning it into a put and take fishery) would succeed in achieving anything higher than a score of 2. It is also important to be cognizant of shifting baselines (see Humphries and Winemiller 2009 for a discussion of shifting baselines in river fisheries and its relevance to restoration), something identified by AEP in DOCs 56, 57. For example, if the historical conditions are based on stakeholder input but from within the last few decades, it is possible that a system may be given a score of 4 or 5, yet relative to true historic baselines (say from pre-European settlement) which may have been a “real” 5, the 4 or 5 assigned recently may in fact be a 2 or 3. This could lead to management efforts being halted prematurely with the assumption that historic state had been reached. These scenarios have been identified by various FMA Committee members in our interactions and represent valid concerns.

On a watershed/subwatershed perspective, it is unclear what evidence has been used (or intentionally ignored) when using the FSI to generate scores. As noted above, it is reported that the FSI relies on fisheries surveys, scientific literature, local and traditional knowledge and expert opinion. Yet, there is little transparency regarding which sources were used for a given system. This lack of transparency is of concern in that stakeholders indicated that, in some cases, the reported FSI values fail to align with their beliefs regarding the status of a given system. We also heard from several FMA Committee members additional sources of data exist (e.g., from fisheries surveys/technical reports), which had not been considered in this process. So – again – although we are conceptually supportive of the FSI, the specific inputs for a given watershed determine the overall validity of the method. We acknowledge that there are attempts to understand and report uncertainty, which is useful, but that alone fails to reassure stakeholders about the process.

Future efforts regarding classification should be more transparent and include open discussion with stakeholders with respect to identifying historical states and incorporating their knowledge into current population statuses when appropriate. For instance, every time a FSI score is updated, AEP should summarize the basis for *each* metric rating and share this information transparently on an open forum.

3. TO WHAT EXTENT ARE THE RECOMMENDED MANAGEMENT ACTIONS (E.G., CLOSURE OF FISHERIES IN SELECT WATERSHEDS, HABITAT RESTORATION MEASURES) SUPPORTED BY THE PREDICTIVE MODELLING?

Preamble

It is important to note that the CEM approach employed by AEP is a *hypothesis-generating* exercise rather than a *predictive tool*. This is explicitly stated by AEP biologists throughout DOC 57, the main document detailing the modelling approach, and in the documents outlining the CEMs for bull trout (DOC 14) and Athabasca rainbow trout (DOC 16).

3.1 Are the prescribed management actions consistent with modeling assessments specifically related to proposed angling closure and deployment of habitat enhancements?

With regards to angling closures, we refer the reader to *sections 1 and 2*. Insufficient information was provided to determine whether habitat enhancements are consistent with model outputs.

When habitat has been degraded, it is quite common to engage in various forms of ecological restoration. We recognize that this term (i.e. ecological restoration) is almost always used incorrectly (Jackson et al. 1995) but to remain consistent with terminology adopted by the AEP (and the broader community) we will also adopt that same terminology. True "ecological restoration" implies that one has set a target that is based on historical conditions which requires one to know what such conditions were like (see Jackson and Hobbs 2009), which is often not the case. The efforts proposed as part of the experimental management program are really focused on trying to reduce some of the level of habitat impairment (e.g., improving connectivity, reducing erosion) but without any explicit assumption that the target is to re-establish pre-disturbance (noting that this is undefined) conditions.

Ecological restoration is resource intensive and may not always be beneficial. Several recent meta analyses have been useful in that they assemble the many disparate examples (specific to trout in fluvial systems) and look for the "big picture" signal regarding the effectiveness of various habitat restoration interventions. For example, Sievers et al. (2017) reported that revegetation did not consistently benefit trout populations but that trout populations did respond positively to increasing woody debris and livestock exclusion (+87.7 and +66.6%, respectively). The authors postulated that positive riparian changes may just attract fish (i.e. increased local abundance or density) rather than enhance actual population production (i.e. individual size and growth) but additional work is needed in that space. This should be considered when monitoring restoration activities. An earlier meta-analysis by Stewart et al. (2009) revealed that evidence regarding the effectiveness of in-stream devices (e.g., flow deflectors, boulders, rip-rap, gabions) is equivocal. The authors conclude that "[…] widespread use of in-stream structures for restoration is not supported by the current scientific evidence base, particularly in larger streams". This is not an exhaustive summary of the literature but rather intended to point out that often restoration interventions are conducted with good intention but they fail to yield ecological benefits that translate to improvements in trout production. We share this information as we were not provided with a restoration plan, so we are attempting to provide some guidance moving forward.

One of the greatest issues we have identified with respect to the experiment is that the documents provided make it very unclear whether the level of habitat restoration planned has the potential to meaningfully reduce/reverse the impairments related to water quality and fragmentation. We acknowledge that to some extent this is the “point” of the experiment. However, the level of detail provided on the type and scale of habitat restoration activities makes it quite difficult to provide commentary regarding whether this has potential to achieve its objective. It is similarly unclear if the level of resources (funds, staff time, volunteers) exist to conduct habitat restoration at the scale needed. What if the funding needed to restore a given reach is $4 million yet only $40,000 is available? This is not a “science question” but it does speak to the ability to implement restoration at a scale needed to potentially be a meaningful comparator. Moreover, it is unclear if there are issues with landowner permissions or other government bodies (e.g., authorities that deal with roads for instances where there are hanging culverts). The restoration element of the plan (which is one of two primary comparators) is very much presented as a “trust us” approach. We acknowledge that AEP and its partners (like Trout Unlimited, Cows and Fish) have a long history of engaging in hands-on restoration activities, which is promising. But, without details on the specifics of what is planned (see below for what was shared with us), it is impossible to provide a formal scientific review of this aspect of the proposed management experiment.

There is no doubt that functional fish habitat (including water quality and physical aspects) translates into productive fisheries (or at least the potential for such productive capacity; Lapointe et al. 2014). However, if the habitat restoration activities are not conducted at the scale needed to actually improve water quality and physical aspects of the habitat (including hydraulic connectivity), then one may erroneously conclude that the only driver of trout populations is fishing mortality. Perhaps that is the case (however unlikely given the habitat impairments that we have seen in various documents provided by AEP) – but if the experiment fails to test a meaningful level of restoration, one will be unable to have the certainty one needs to make informed management decisions. The full closure of the recreational fisheries could be argued to be heavy handed (rather than trying various educational strategies or trying to reduce impact through regulations that say reduce fishing effort during warm periods), which means that the habitat restoration approach needs to be equally “heavy handed”. One could argue that a fair comparison to “total fisheries closure” is “total restoration”. We recognize that is unrealistic but we have no basis to determine if the proposed habitat management actions are a valid comparator.

Restoration plans – As noted above, the details regarding restoration are vague. Here we present the entirety of the plan as described in DOC 28, 29 and 30 (which are summary documents provided for public consumption). DOC 48 spans more watersheds than the individual DOCs 28-30 but the same level of vagueness is provided. We were not provided with a specific “science-based” plan that details the restoration activities beyond what we share here (which are bullet points – the same as presented in the documents shared with us).

Example from DOC 28:

- Address habitat fragmentation: Habitat related management actions may include remediating fish movement barriers, such as hanging culverts.
- Address water quality: Mitigation of point sources of sediment and phosphorous runoff, which may include areas of OHV disturbance and impacted shorelines as well as runoff associated with roads and road stream crossing.
- Specific actions depend on the results of fish habitat assessments in 2017 and 2018.

This material is vague with use of qualifiers like "may". It appears that specific actions will be based on habitat assessments but if those have been conducted and used to develop appropriate plans, they were not shared with the review team.

Example from DOC 29:

- OHV trail damage at Rocky Creek: A log crib wall, soil wrap, coconut matting and willows were used to rebuild the bank and reduce sedimentation. Over time, natural processes will transform this crossing back into properly functioning riparian habitat.
- Restriction of illegal motorized access into the watercourse by downing trees, tree planting and installing enforcement signage at key access points.
- Increased enforcement presence
- Installation of educational signage at high visitor-use areas in the watershed, project brochures, print materials, etc.

Here, most of the information regarding what might be possible for other sites is based on a photo caption (top bullet). We appreciate that the restoration includes efforts to address one of the apparent "root causes" of the problem (i.e., OHVs) through education, enforcement and creative attempts to physically deter access. Unfortunately, we do not have detailed aspects of the plan. How many such crossings/sites are there in a given experimental reach? Do the resources exist to implement these actions at all of them? Will this shift OHV effort to another site?

Example from DOC 64:

This presentation notes that one must "restore 20% of a degraded stream to achieve 25% increase in smolt production". This statement is derived from a study by Roni et al. (2010) focused on coho and steelhead smolt production. This is a single study based on a different location with a different species (coho salmon) and life history strategy (steelhead if making comparison to rainbow trout) such that there is much uncertainty with making extrapolations to the NCNT fisheries in Alberta. It would seem that such a study is desperately needed in Alberta to inform restoration planning.

3.2 Why were angling closures and associated habitat enhancements selected as the initial management actions as opposed to a suite of other potential remedial actions?

As described during the FMA Committee meeting in Edmonton in late July 2018 and reinforced in AEP documents (DOCs 59, 61 point B, and 63), management interventions other than fishery closures were explored via an angling 'sub-model' based on Alberta's CEM framework. We refer the reader to *section 3.1* for information about habitat enhancement. “The [angling] sub-model allowed biologists to simulate the potential effect of a variety of angler-suggested gear restrictions and season restrictions on recovery of populations. The model was developed primarily for Westslope Cutthroat Trout and Athabasca Rainbow Trout, but the information gained is broadly applicable for management of other east slope stream fishes such as Bull Trout, Mountain Whitefish, and Arctic Grayling.” – DOC 61 p. 2. The details of this sub-model are presented in DOC 63. The results suggested that the only way to sufficiently mitigate fishing mortality to the point where detectable population recovery (at least over a 5 year period) was possible was through a complete fishing closure. As with the main bull trout and Athabasca rainbow trout CEMs (DOCs 14 and 16), consideration of the inputs and structure of this angling sub-model is important when interpreting the output. We refer the reader to earlier sections where we discuss limitations of the current CEM approach.

Regarding model inputs, an important message missing is that there is a general lack of replicated and well conducted management scale experiments in fisheries science that systematically evaluate the effectiveness of different management interventions. This is not to say that governments and their research/management divisions have not previously closed fisheries or implemented different types of angling restrictions to manage threatened fish populations. However, rarely are these measures implemented and studied with sufficient replication and appropriate controls to enable meaningful assessments of their efficacy. The same is true of habitat restoration efforts. For example, a recent systematic review conducted by the Cooke Lab (Taylor et al. in review) focused on evaluating spawning habitat creation or enhancement for substrate-spawning fish. The authors reported that of 96 individual projects, the majority (62.5%) were assigned ‘low’ study validity whereas 37.5% were assigned ‘medium’ validity with 0 studies of ‘high’ validity. Critical appraisal (where one determines if the experimental design is appropriate for testing the specific hypothesis) is fundamental in systematic reviews as part of evidence-based conservation and environmental management (Pullin and Stewart 2006). The reality is that the vast majority of “one off” management interventions do not generate data of sufficient quality to inform future actions. As such, determining adequate parameters for the angling sub-model is a challenging endeavour. Importantly, if it were to also include angling restrictions (not just a complete closure), the proposed management experiment would have the potential to systematically generate data that are “high quality” and that would thus support future evidence-based conservation and management approaches that rely on angling restrictions and/or closures. So – the reality is that although there are other management measures, rarely have they been explored systematically to truly inform management.

3.3 To what extent are the modeling exercises required to identify timelines through which reductions in angling mortality and accompanied enhancements in fish habitats would be forecasted to result in gains in fish populations?

As stated by AEP staff (e.g. DOCs 14, 16, 57), the aim of the CEMs is to formulate hypotheses, not predictions. As such, the models are not intended to identify timelines through which reductions in angling mortality and enhancements in fish habitats will lead to gains in fish populations. Instead, the proposed experiment, which is based on the results of the modeling exercise, will provide the necessary data to estimate population recovery times as a function of which management options are implemented. During a webinar meeting on Oct 05 2018, AEP biologists informed the TPSR team that angling closures and specific habitat remediation activities were chosen to produce results that would be statistically detectable within 5 years.

4. TO WHAT EXTENT WERE STAKEHOLDERS ENGAGED IN THE PROCESS TO EVALUATE POTENTIAL CHANGES IN MANAGEMENT OF FISHERIES IN EAST SLOPE WATERSHED?

One of the most pressing needs in recreational fisheries governance is to identify, understand and manage 'people conflicts' because such conflicts can hamper any progress towards sustainability. (Arlinghaus 2005)

Preamble

From our first interactions with the FMA Committee, it was apparent that some aspects of the engagement and consultation failed to engender the support needed for the implementation of the management plan. The fact that a TPSR was mandated is partly a testament to the fact that there was a lack of trust, understanding, and buy-in of the proposed management experiment. This is not to say that there was no engagement of stakeholders on behalf of AEP; several public meetings were held around the province to share what was proposed (see DOC 35). However, it is well known within the environmental, resource management, and conservation spheres that simply "telling" stakeholders what is happening is often regarded as too little, too late. This is regarded as an archaic model of stakeholder engagement in that it fails to incorporate what we now know as the tenets of meaningful stakeholder engagement that contribute to meaningful management actions that are supported (or if not supported, at least understood) by stakeholders. There are a number of papers that discuss and explore the idea of stakeholder engagement in fisheries management (e.g., Hughey et al. 2000; Mikalsen and Jentoft 2001; Soma 2003; Arlinghaus 2005; Arlinghaus et al. 2007) as well as others that explore the topic more broadly (e.g., in environmental management; Reed 2008). Below, we summarize some of what are regarded as "best practices" for meaningful stakeholder engagement and also highlight an example of another Canadian jurisdiction where this has now become the norm following a decentralized model. However, first we present our findings related specifically to Q4. To do so, we reviewed the resources that were provided (DOCs 35, 39-42), interacted with AEP biologists via telephone calls, interacted with stakeholders on the FMA Committee during phone calls, and gathered their written perspectives.

4.1 Did AEP fulfill its common practice by informing the public of proposed angling closures?

Yes. Based on background information provided by the office of the AEP Chief Scientist, the TPSR team understands that AEP biologists must follow established protocols for consulting and engaging with First Nations and other local stakeholders. These protocols and the consultation process that occurred with regards to the NCNTRP are detailed in DOCs 35, 41 and 42.

Engagement with First Nations

In DOC 35, AEP states: "Native trout populations within the focal watersheds of the North Central Native Trout Recovery Program have been assessed as high to moderate risk of extirpation (FSI). Currently, these fish are managed using a zero harvest regulation and there is no amount of those species that can currently be harvested for food by Aboriginal or non-Aboriginal fishers due to conservation reasons. Additionally, there is no evidence that the treaty right to harvest fish has and is being exercised on the waters being considered for regulation changes as part of the North Central Native Trout Recovery Program. Therefore, the First Nations Consultation Level was assessed as Level 3 and notification steps followed the “Level 3: Extensive Consultation” process outlined in “Government of Alberta’s Proponent Guide to First Nations Consultation Procedures for Land Dispositions” (DOC 39).”

The consultation process of First Nations with regards to the NCNTRP as detailed in DOC 35 appears to have carefully followed AEP protocol: “In total, 24 First Nations and Metis Communities received notification letters and follow-up correspondence from August 2017 to November 2017. There was no recorded opposition to the North Central Native Trout Recovery Program or proposed angling closures. Of the contacted communities, only Paul Band First Nation requested a meeting. The Paul Band representatives were supportive of the North Central Native Trout Recovery Program and proposed angling closures and indicated they would be interested in developing a partnership with AEP to help with native trout recovery. In 2018, AEP (Fisheries Management and Whirling Disease) and Paul Band First Nation collaborated to collect water temperature information and sediment samples to help prioritize recovery actions and contribute to whirling disease risk assessment.”

Engagement with other stakeholders

According to the framework outlined in Alberta’s Fish Conservation and Management Strategy (see DOC 35), AEP follows three levels of stakeholder empowerment, depending on status of the fishery. Stakeholders are consulted and involved in the decision-making process only when the status of a fishery is deemed above the baseline threshold required for conservation (i.e. when the fishery status is level 3 [trophy, quality, stable] or level 2 [vulnerable]). If a fishery is deemed to have collapsed (i.e. level 1), AEP biologists are instructed to “advise stakeholders regarding desired outcomes and management actions to recover the fishery”.

In its overview of the communication and engagement of stakeholders with regards to the NCNTRP (DOC 35), AEP states: “At a provincial and local scale, the status of these fisheries is ‘collapsed’. Therefore, stakeholder empowerment is Level 1, with the goal of advising, or notifying stakeholders, of actions required to recover the fishery. The empowerment level will shift appropriately once fish populations have recovered.” In effect, “The form of consultation reflects the status of fish populations within the fishery. As fish populations and fishery status improve, and options for use increase merely beyond recovery, the power to define Fisheries Management Objectives and select management options shifts towards stakeholders.” As such, AEP biologists must inform stakeholders of actions required to recover the fisheries. They must also provide opportunity for involvement and collaboration by stakeholders in implementing the management plan developed by AEP.

Due to the changes in the NCNTRP (i.e. “Peace to Pass Project” converted into the NCNTRP) and the program’s tight links to other AEP initiatives (e.g. Bull Trout Recovery Plan), it was challenging for the TPSR team to determine exactly what engagement and communication and/or education efforts were made in the specific context of the NCNTRP as it currently stands. Some stakeholders were clearly involved in the development of dose-response curves for the Bull Trout CEM (the so-called “Provincial Advisory Committee” or PAC; see DOC 35 p. 1-2) and the Athabasca rainbow trout CEM (see DOC 16 p. 8). The Bull Trout PAC consisted of 10 stakeholder groups representing industry (e.g. forestry, petroleum), NGOs, and national and federal government bodies, which engaged in writing or via meetings on several occasions between Nov 2015 and June 2017. Only three of these stakeholder groups are members of the current FMA Committee, which consists of 15 associations/groups not affiliated with the Alberta government. Based on the information at hand, it is unclear to what extent stakeholders have or will participate in the development of the CEMs for mountain whitefish and Arctic grayling.

According to information in DOC 35, AEP undertook 39 presentations to regulators, industry groups, fishing clubs, OHV clubs, counties, and at scientific conferences between Feb 2017 and Jan 2018. An online survey was sent to 360,000 licensed anglers via email and advertised via AEP's Twitter and Facebook social media accounts. 1,200 anglers (0.33% of all anglers contacted) completed the survey and 60-68% of these reported supporting 5-year fishing closures according to AEP data. Two public information sessions were held in Edmonton and Calgary on Dec 12 and 14 2017, respectively. These were advertised via AEP social media accounts and AEP's conservation, university/college and fishing club network. A total of 73 participants attended the two information sessions. Other modes of outreach/education employed by AEP are detailed on p. 8-9 of DOC 35, and included: online products, external media products, brochures, communication with commercial fishing guides and email or letter correspondences sent by stakeholders to AEP. Examples of such products (brochures, magazine articles, Powerpoint presentations) were submitted to the TPSR team. The breakdown of these correspondences and their content is detailed on p. 9-10 of DOC 35. Most of the stakeholder email inquiries received a standard (1+ page) response from AEP providing key information about the NCNTRP (see p. 10-12 of DOC 35).

Conclusion: The AEP appeared to follow the framework outlined in Alberta's Fish Conservation and Management Strategy, which is to inform and educate stakeholders of actions required to recover fisheries deemed to have collapsed. Opportunities were also provided for stakeholder involvement in the management program developed by AEP. The suitability and potential efficacy of AEP's top-down approach to resource management in the context of the NTNCRP is discussed in *section 4.2*. Feedback from stakeholders on the FMA Committee regarding the suitability of outreach, engagement and education efforts by AEP is also provided in *section 4.2*.

4.2 Were additional activities to promote public awareness and involvement of a knowledgeable public in fisheries management successful in communicating the proposed activities of the NCNT program?

Overall, no. From interacting with the stakeholders on the FMA Committee, there was a general perspective that the consultation failed to occur at a time when they had the ability to influence and be a part of the process. There is appreciation for the opportunity to take a pause and participate in the TPSR but it will not make up for lack of early engagement.

Seven stakeholder groups provided written feedback and identified their priorities as being shared between conservation and recreational fishing (see Figure 1 at the end of this document). Three of the seven stakeholders felt that they had been provided with a satisfactory opportunity to participate in the development and implementation of the Bull Trout Recovery Plan and the

NCNTRP. The remaining four groups indicated that they were offered limited or no opportunities to engage (Figure 2). Overall, stakeholders clearly indicated that their level of satisfaction with the NCNT engagement approach was worse than with previous AEP programs or initiatives (Figure 3). In line with this assessment, stakeholders rated specific aspects of the NCNTRP communication and engagement approach as less than adequate, on average (Figure 4). However, there was considerable variation in these scores, with some stakeholders (i.e. 14-42%) indicating that aspects of the communication approach ranged from adequate to very satisfactory (Figure 4). Finally, stakeholders indicated that, on average, the communication of key topics including fisheries inventory methods, the Fish Sustainability Index, CEMs, habitat remediation, angling regulatory measures, and angling closures rated as less than satisfactory (Figure 5). Again, these scores ranged from almost fully satisfactory to completely deficient, with most scores tending towards the latter (Figure 5).

Below, we synthesize the main concerns and recommendations conveyed to us by all stakeholders on the FMA Committee in writing (n=7) and/or in conversations (n=14). See *Appendix V* for information on the stakeholders consulted, phone conversation dates and durations, and dates at which the stakeholders were asked to provide written feedback.

Summary of stakeholder concerns

N.B. Bullet points below are a summary of key concerns voiced by stakeholders to the TPSR team.

- There is a disconnect within AEP at a regional, operations and policy level, resulting in management decisions that are poorly planned, misunderstood by the public, and lack stakeholder support.

- Stakeholders from the angling and conservation community provided written feedback, suggestions and requests to AEP with regards to the NTNCRP. Most of these communications were unanswered and appear to have been ignored.

- Only one group representing the angling community was involved in the Bull Trout Recovery Plan and the process of determining dose-response curves for this species. The impression of this group and the broader angling community is that their voice was largely dismissed despite their ability to contribute extensive knowledge and information on the matter as well as being the stakeholders most directly affected by the proposed management actions. The argument was made that the presence of anglers on streams provides a strong constituency for, and ongoing public monitoring of, habitat management issues.

- A lack of public information on the status of Alberta fish populations that have been closed to fishing (sometimes for decades) prevents stakeholders from assessing the effectiveness of this management tool, resulting in a lack of support for fishery closures. The status of fish populations is also disputed in many watercourses. In other words, there is doubt among many anglers regarding the actual status of NCNT. This dispute cannot be resolved because data used by AEP in the modelling process has not been shared transparently. As such, there is a general perception that the NCNTRP relies heavily on angling restrictions, without providing the underlying data or information to justify these restrictions.

- There is a reluctance of AEP to consider and integrate data from the angling community in the decision making process. Conversely, stakeholder requests for data (e.g. baseline population counts) were apparently denied by AEP.

- Efforts via e-mail communications to the Premier and Ministers to expand cooperation of other Ministries in implementing the habitat aspects of the NCNTRP have not produced meaningful results. There are no specific commitments from the ministries of Agriculture and Forestry, Transportation, Energy, and from the Solicitor General on how they are prepared to support the NCNTRP in areas related to their mandate. Despite the importance of threats to fish populations from roads, agriculture and forestry activities, the absence of these key players at the discussion table hampers effective management decisions by AEP and contributes to the perception that the angling community is largely responsible for fish population declines.

- Public information sessions for the NCNTRP were held *after* the online survey closed. These information sessions could have been a good opportunity for AEP to share information about the program and help Albertans answer the survey. Information about other initiatives (e.g. Castle, land use planning) was available before the surveys were launched for these programs. Additionally, the final plan that was presented at the open house in Calgary (and possibly also in Edmonton) was clearly identified as not open for debate. No alternative management options were discussed or other biological/social/economic perspectives entertained at these meetings. Information on the NCNTRP (webpage, fact sheets) was made available at the same time as the survey was rolled out but likely came as a surprise to many anglers.

- Engagement with the angling community was very restricted in comparison to other, previous AEP initiatives. A limited survey was rolled out via Facebook rather than AlbertaRelm, which would have been a more suitable dissemination pathway. The survey resulted in only ~1,200 responses out of 300,000+ licensed anglers and did not clearly identify what management measures were being considered by AEP (i.e. angling closures and habitat remediation).

- Public information sessions were hosted by another organisation (not AEP) in Calgary and Edmonton, which are not in the areas affected by the proposed closures. Other information sessions should have occurred in regional areas that will be directly affected by the NCNTRP, such as in central or west central Alberta. Most of the presentations and discussions at the two information sessions that occurred were centered on the proposed fishing closures whereas more should have been done to communicate the habitat components of the plan (i.e. progress on stream crossing inspection and remediation, habitat assessment and rehabilitation).

- The proposed complete angling closures will likely displace angling pressure to other, vulnerable streams and may cause a gold-rush reaction when lifted, with the result that any benefits will be quickly undone.

- Recent mainstream river bull trout inventory and angler effort metrics are paramount to setting the baseline before any fishing closures occur. None of these have apparently been completed to date or shared with the public.

- There does not appear to have been any formal communication (e.g. e-mail to participants) or a meeting of stakeholders involved in the Bull Trout Recovery Plan since early summer 2017. The Bull Trout recovery team was presented an idea of a proposed "Peace to Pass" initiative towards recovering native salmonids. This was changed to the NCNTRP but why the change was made was not effectively communicated nor was the team of stakeholders actively engaged in the change.

- Strong commitments to limit industrial development or protect habitat appear to be absent from the NCNTRP.

Summary of stakeholder recommendations

N.B. Bullet points below are a summary of key recommendations shared by stakeholders with the TPSR team.

- Fisheries Management should engage in greater outreach to anglers and other stakeholders (who might not be actively seeking out information from AEP) through social media, engagement on outdoor forums and regular regional public consultations.

- Greater transparency on how and why various angling restrictions are being proposed for each watershed, and how the negative risks will be managed, is paramount if anglers are to understand and support any angling restrictions. Transparency by the AEP, and willingness to explain underlying data (not just the modelling approach, but the data used in the models) would go a long way in regaining trust from the angling community. Additionally, a largescale map of all proposed angling restrictions would have helped stakeholders understand the extent of restrictions on a landscape level. This map should also include tangible indications of habitat restoration and protection measures that the government commits to undertake.

- Coordination with other government departments (Energy, Infrastructure, Transportation, Agriculture and Forestry) is required to establish effective recovery plans that restore both habitat and fish populations. There needs to be a multi-ministry approach with broad public representation where underlying issues are dealt with and trade-offs transparently disclosed.

- AEP should adopt a consensus-based approach where the action plan is developed by participants rather than the agenda of the proponent (open book approach).

- Engagement with the public/stakeholders by AEP needs to: include a better media campaign to raise awareness and include traditional and non-traditional modes of communication (e.g. Instagram, Twitter, newsprint, radio, television); occur in areas directly impacted by any proposed measures in the case of open house meetings; make use of the already existing Alberta Relm platform to reach out to anglers in an effective manner; ensure educational materials are available to all Albertans not just special interest groups; be a two-way process rather than unidirectional.

- Silos must be broken down within AEP such that operations, policy and regional level management are all present and participating at the discussion table. Discussions must be a round table format that includes cross-ministry representation with considerable public and stakeholder participation. Decisions must be consensus-based and transparent, with trade-offs clearly enunciated.

- There needs to be an important angler education component to the NCNTRP. For example, a program that mandates that all anglers pass a test on fish identification, species habitat requirements, and proper fishing and handling procedures, as a condition of being issued any Eastern Slopes fishing license should be implemented. Stewardship programs in partnership with the angling community will also likely be a key component for creating and sustaining support for recovery measures and on-the-ground restoration efforts.

- AEP should report back to members of the public and stakeholders that provided feedback or requested information to confirm that they were heard. Examples of desirable initiatives include an online forum or a specific e-mail address where people can share their concerns and obtain a timely response.

- AEP should consider: providing readily available public information and data on the status of fish resources, fish habitat, and angler use in a state of the environment report; use anglers to provide information on the status of the fish stocks; continue to allocate fish resources with low risk harvesting methods and adapt management as necessary while discussing fish management plans with the users; ensure no net loss of fish habitat and enforce fish habitat protection legislation; implement increased opportunities with habitat improvements and supplemental stocking.

- AEP should organize regular, regional public consultations both in person and online, which need to be widely advertised. A summary of the meeting and its outcomes should be provided soon after for public consumption and repeat sessions implemented where necessary. Consider wider, timelier sharing of information related to the work and assignments of fisheries biologists, hatchery updates, etc so that anglers become more knowledgeable about the management issues requiring stakeholder engagement.

RECOMMENDATIONS OF THE TPSR

We want to be very clear – the shortcomings we identified in this review are not the fault of any particular individual involved in the development and implementation of the NCNTRP. Institutional culture sets norms for when and how engagement occurs. As such, our critiques and ideas here are intended to provide the Alberta government with options for changing that culture and providing structures and support mechanisms for its team members when such engagement is needed. We understand that the extent of stakeholder engagement in Alberta fisheries management has varied over the last decades. For example, there has previously been a provincial-level fisheries advisory group or 'round table' but it is our understanding that the group had not met for some time (~2014) and was revitalized only after it became apparent that there was significant opposition to the proposed management experiment. We would submit that the timing of engagement failed to occur at a time period when it would have been meaningful. This is not disconnected from what is perceived by stakeholders to be a "top-down" approach. Stakeholders failed to feel empowered or have an interest in taking ownership of the management experiment.

1. Produce a management plan

A single document synthesizing the NCNTRP is necessary to allow effective communication, participation and evaluation of the NCNTRP by AEP staff themselves, stakeholders and third parties. This document should target an audience with the same level of scientific background as its authors (i.e. AEP biologists), and outline the background (i.e. history, evolution, links to other AEP programs), underlying science (including stakeholder input), rational for management decisions, and proposed management actions of the NCNTRP. In an effort to help generate such a document, the TPSR team has indexed the 64 documents received from AEP and suggested, for each document, whether parts or all of its content should be included in the main text, referenced, or included as an appendix (see Appendix IV).

In parallel to this document, a second, much shorter report should be compiled using the same format as above, but targeted at a non-scientific audience. The purpose of this second document should be to communicate the process, content, proposed management actions and expected outcomes of the NCNTRP in layman's terms such that key aspects of the program are understandable to non-specialists. In effect, this document should resemble a more extensive version of some of the NCNTRP brochures already created by AEP (e.g. DOCs 28, 29, 30), which include informative figures such as detailed maps of planned fishery closures and habitat remediation activities.

Both documents should be made readily available to the public on the Alberta government's website. Regular online updates should accompany these (static) documents to inform the Alberta population of the program's progress (e.g. in the form of blog posts, updated maps and alerts of major changes to the program if any).

2. Adopt a participatory approach to fisheries management

Explore alternative models of recreational fisheries management with an emphasis on how the public can be meaningfully engaged to enhance stewardship. We encourage the Alberta government to do so by learning from what has worked (and failed) in other jurisdictions. The Directors Committee of the Fish and Wildlife Managers in Canada, the Association of Fish and Wildlife Professionals in the USA, and the Fisheries Administrators Section of the American Fisheries Society all provide avenues for discussions with colleagues from other jurisdictions.

Recognize that simply “telling” the community what is planned is different from meaningful engagement. Efforts to engage in co-production of management plans is essential to achieve desirable levels of stakeholder engagement and support, even when species are deemed highly threatened and urgent action is needed as in the example of the NCNTRP.

Develop mechanisms for ongoing stakeholder engagement at the provincial and regional level with key stakeholder groups. Such engagement is needed not only when dealing with complicated files (i.e., reactive) but rather on a more continual basis (i.e., proactive). We repeatedly heard from members of the FMA Committee that they hoped the committee would persist in the future with other regional committees developing to ensure more opportunity for engagement (see example from Ontario presented above).

3. Consider the implications of the CEMs in their existing form

As stated in the preamble of *section 1*, the CEM approach adopted by AEP has several advantages, namely its simplicity, which facilitates stakeholder participation and the communication of the models’ functioning and outputs to non-specialist audiences. However, the implications of a multiplicative model and assumptions regarding model scale and inputs for management decisions should be carefully evaluated. Furthermore, uncertainty should be explicitly incorporated into model outputs in the form of uncertainty bounds around final estimates.

4. Be transparent

A genuine commitment to transparency and openness on behalf of AEP operations, policy and regional management is needed to restore public trust in Alberta Fisheries Management. The difficulty of accessing AEP documents and data and an apparent mistrust of the science conducted by AEP were common themes conveyed by many stakeholders to the TPSR team. Several stakeholder groups on the FMA Committee have the resources to conduct research and the necessary knowledge and training to evaluate and contribute to the science being conducted by AEP. Clearly, AEP management understands that trust requires transparency. This is apparent in an email to a member of the public requesting information on the NCNTRP, in which Chief Scientist FJ Wrona states the necessity to “ensure we [AEP] maintain public trust in the scientific information generated and used to inform management actions undertaken by AEP staff. […] My expectation is that AEP operate in an open and transparent manner for all scientific activities undertaken from the early stages of determining study objectives and designs, to data evaluations and assessments, and lastly in the sharing and understanding of results.” Such transparency goes hand in hand with the participatory approach to resource management detailed in *recommendation 2* above. Specific to the NCNTRP, it is worth noting that management experiments that involve closure of fisheries must have a clear "end date" which is communicated with stakeholders and observed (as reinforced by recent a position paper from the Canadian Sportsfishing Industry Association; see http://www.keepcanadafishing.com/wp-content/uploads/2018/06/GovernmentDocument2018-FINAL-FOR-WEB3.pdf).

5. Plan for the long-term

Currently, none of the documents we have examined mention whether planned angling closures in the East Slopes will be lifted at the end of the 5-year management experiment. An end-point to the experiment should be explicitly stated and clearly communicated to stakeholders with consideration given to what might happen to protected NCNT populations once angling closures are lifted. Some stakeholders expressed valid concerns that closures might simply displace angling pressure to other watersheds and cause a 'gold-rush reaction' when lifted, such that protected populations will be quickly depleted again. AEP and Albertans would benefit from developing a long-term vision of how NCNT populations will be managed in the absence of angling closures. A multi-pronged approach could be effective by combining angler education programs, evidence-based angling regulations that limit fishing mortality in other creative ways (e.g., Hoot owl restrictions), and the creation of regional committees to assist AEP and the FMA Committee in the decision-making process.

6. Build capacity related to human dimensions research

People are at the centre of most natural resource management problems *and* solutions. A primary lever available to fisheries managers is to manage people but rarely is that done with a full understanding of stakeholder's perspectives. Use of human dimension surveys conducted by trained individuals can be an effective means of informing management actions. We acknowledge that information was collected during the consultation phase (see DOC34) but we suggest that there is opportunity for human dimensions work to be conducted prior to this form of engagement to be able to proactively identify issues. At the end of the day, a big part of recreational fisheries management (and resource management more broadly) is modifying human behaviour (Schultz 2011). Individuals with expertise in that realm (ideally we are envisioning a PhD level researcher in the area of human dimensions of fish and wildlife – see Decker and Enck 1996 for a discussion on how fundamental human dimension work is in contemporary resource management) would be a great addition to AEP. Note – we asked repeatedly if such capacity existed but that question was never answered so we have to assume that there is no such capacity.

Relatedly, it is important to recognize that there is an entire science behind stakeholder engagement. Consider building capacity in that area – people who understand and are trained in knowledge co-production, stakeholder engagement, conflict resolution, and the sociology of knowledge. It may be worthwhile to consider holding training courses and/or workshops on the tenets of stakeholder engagement, co-production, and stewardship to build understanding and capacity within the organization.

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FIGURES

N.B. In figures displaying box plots, blue circles represent scores given by individual stakeholders and solid red dots represent the mean score across all stakeholders (with error bars indicating the standard error of the mean). Blue dots are jittered to avoid overlap. The blue line inside each box plot represents the median score. Figures only display the responses of stakeholders other than the Alberta government.

Figure 1. Stakeholder feedback (n=7). Answers to the question: "The Fish Conservation Management Strategy identifies the following priorities in order of importance: Conservation, Indigenous, Recreational Fishing and Commercial Fishing. What is the top priority of your organization in relation to the Fish Conservation Management Strategy?"

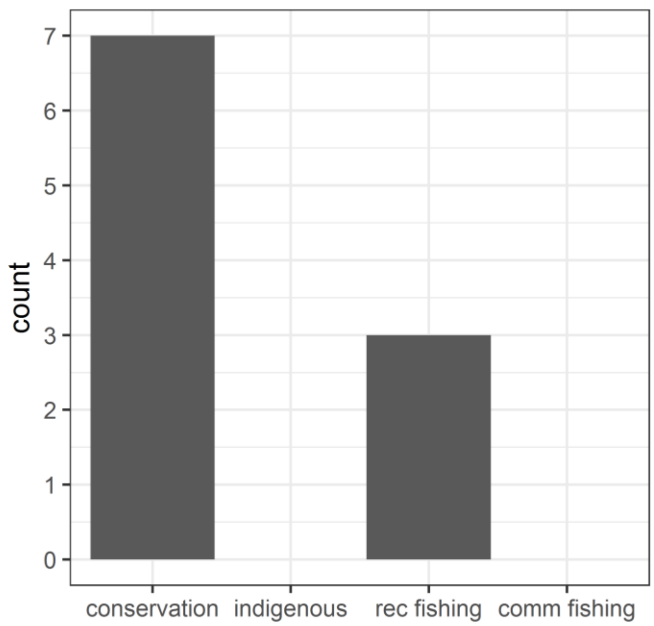


Figure 2. Stakeholder answers (n=7) to the question: "To what extent did your organisation and/or members participate in the development and implementation of i) the Bull Trout Recovery Plan, and ii) the NCNT Recovery Program on a scale from 0 to 10. 0 indicates that you were provided with little or no opportunity to engage; 10 indicates that you were provided with a satisfactory opportunity to engage?"

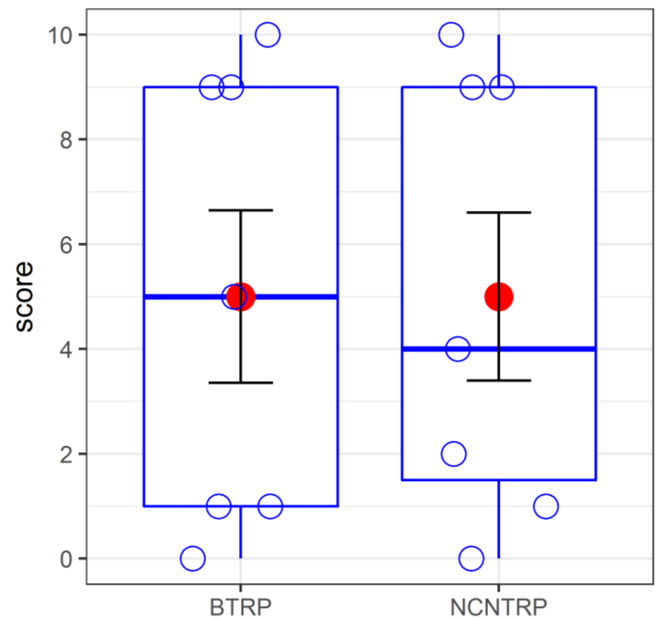


Figure 3. Stakeholder answers (n=6) to the question: "Relative to other AEP programs or initiatives (e.g. chronic wasting disease, whirling disease, land use planning, air quality, Castle, others) that you are aware of, rank your organization's satisfaction with the NCNT engagement approach (0 = much worse, 5 = similar, 10 = much better). Skip this question if you are not aware of any other AEP programs".

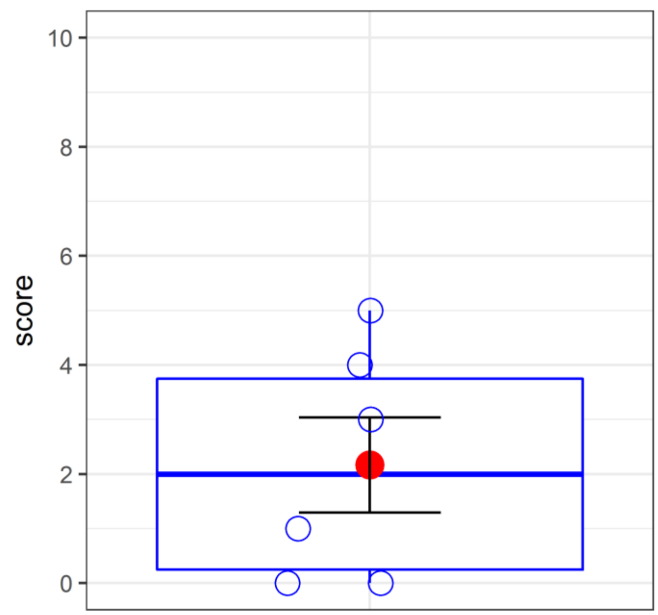


Figure 4. Stakeholder answers (n=7) to the question: “With respect to the NCNT communication and engagement approach, how would you rank the following elements: (0 = very poor, 5 = adequate, 10 = fully satisfied).” Labels: frequency = frequency of communication and engagement activities; formats = diversity of formats (online, in-person meetings, brochures, radio, survey, print media, etc.); timing = timing relative to implementation of NCNT Recovery Program; accessibility = accessibility of information (ease of understanding); relevance = relevance of information; location = suitability of location of in-person events; audiences = diversity of audiences reached.

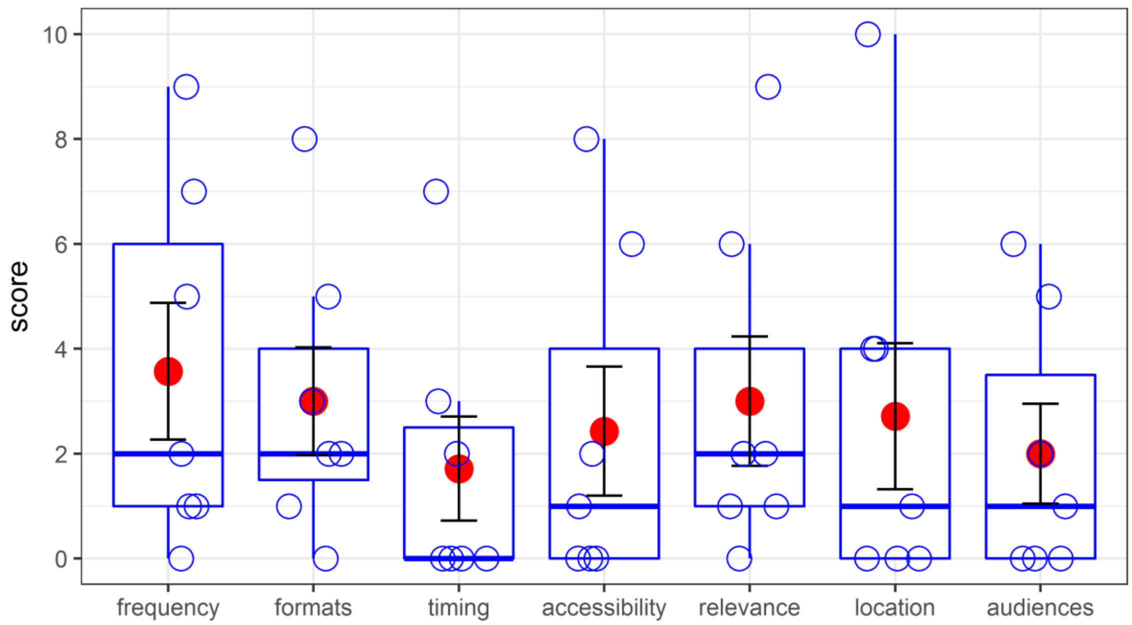
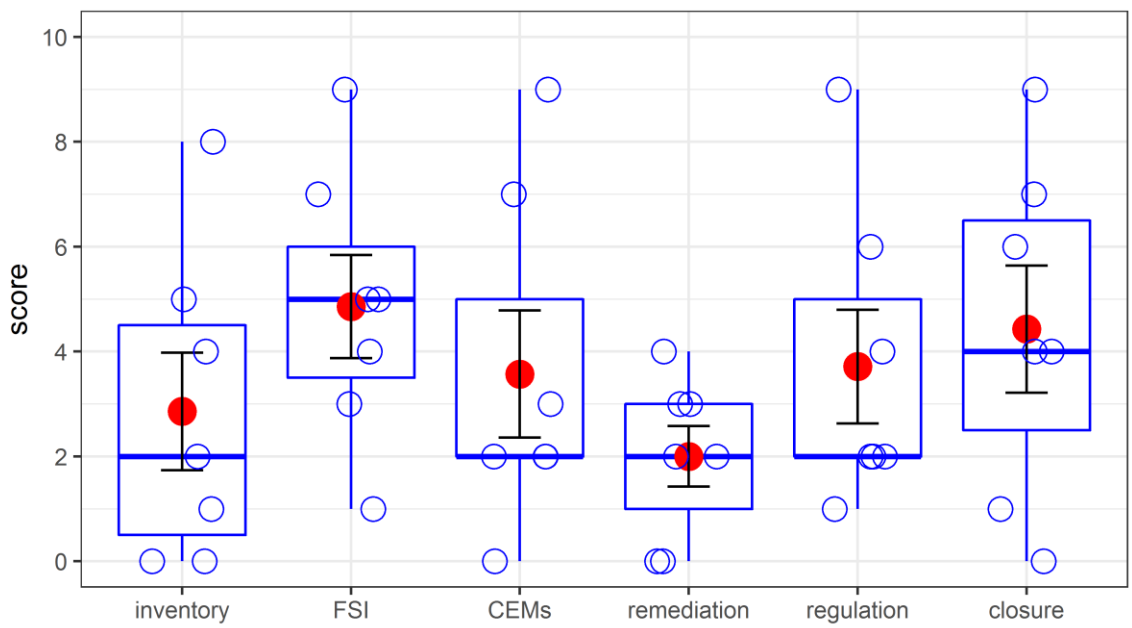


Figure 5. Stakeholder answers (n=7) to the question: "Score how the following topics were communicated 0 (not at all) to 10 (satisfactory)." Labels: inventory = fisheries inventory methods; FSI = species status (Fish Sustainability Index); CEMs = threat assessment (cumulative effects [Joe] models); remediation = habitat remediation; regulation = angling regulatory measures; closure = angling closures.



APPENDIX I. COMMENTS ON THE REVIEW PROCESS

As with many management program assessments, reviewing the NCNTRP has been a challenge, largely because the scientific information underlying the program is scattered across numerous documents and parts of the program have been carried over from pre-existing AEP initiatives such as the Bull Trout Recovery Plan, which has its own set of associated documents and stakeholder engagement process. Upon accepting the mandate, the TPSR team was handed a first set of 58 documents in two tranches. The Office of the Chief Scientists informed us that these documents had been brought together for the specific purpose of the TPSR. An overarching view of the program via the consolidation of these documents into a single place was not only essential for the TPSR, but will also benefit AEP scientists and Albertan stakeholders who wish to understand the NCNTRP's many components and how they are linked (e.g. rational for the program, FSI, historical and present fish abundance data, modelling approach, stakeholder engagement process, considered and proposed management measures [angling restrictions, angling closures, habitat remediation activities], experimental design, power analysis, etc.).

The original 58 documents were later supplemented by other documents upon requests for clarifications by the TPSR team (DOC 59 on Oct 3 2018 and DOCs 60-64 on Oct 23 2018). Numbers for these documents were assigned by the TPSR team for referencing purposes and are listed in Appendix IV.

It is worth noting that, of the original 58 documents, many were PowerPoint presentations, brochures, PDFs of scientific articles, magazine articles, etc., which are typically not the focus of a scientific review. Scientific papers are easily referenced in a report, brochures often contain information of little scientific value, and PowerPoint presentations are generally unintelligible to the reader because they contain little text and lack context without the explanations of the presenter. Some documents were also superfluous (and misleading), such as the CEM for Westslope cutthroat trout (DOC 15), a species which is not included in the NCNTRP. Others appeared to be missing, such as documents outlining CEMs for mountain whitefish and Arctic grayling – it later became apparent that these documents are incomplete and therefore not ready for review.

Overall, we appreciate the assistance of AEP staff in helping us navigate the documents and providing further information on request. However, the lack of a single document synthesizing the NCNTRP undoubtedly complicated and delayed the review process. We indicate in Appendix IV which documents should be included in such a synthesis, in whole or in part, and which ones should not. We wish to emphasize that there were no attempts to restrict access to such information. Rather, in many cases, it simply had not been synthesized in written form in a manner that could be easily shared.

APPENDIX II. TENETS OF STAKEHOLDER ENGAGEMENT

Issues involving fisheries are often termed “wicked problems” given their inherent complexity and dynamic nature (Rittel and Webber 1973). This reality demands flexible and transparent decision-making that embraces a diversity of knowledge and values which is the basis for stakeholder participation in decision-making (Reed 2008). Failure to listen to or engage stakeholders in a meaningful way has impeded conservation and management on many occasions (e.g., Christie 2004; Keppel et al. 2012).

Although there have been many papers on the topic, the literature review by Reed (2008) on stakeholder participation in environmental management (not just fisheries) has been particularly informative. For context, it has been cited some 3000+ times, which makes it a citation classic by any standard but also emphasizes that this is not some fancy new approach – active stakeholder participation *is* regarded as the norm in effective environmental management. That is not to say that stakeholder participation is always effective or without its challenges. However, a well-designed, well-structured, well-intentioned, and well-implemented stakeholder participation program will almost always pay huge dividends. Importantly, a recent article in nature suggested that co-production (when stakeholders are inherently involved in an activity to the point where they take ownership) done well generates outcomes that extend well beyond the tangible to include many things that are intangible (see Willyard et al. 2018).

There is still some disagreement regarding which models of stakeholder engagement are most effective, yet there are certainly some key tenets that seem to apply rather generically as summarized by Reed (2008). Here we list the tenets (verbatim) and then annotate each tenet with our thoughts specific to the NTNCRP.

Tenet 1. *Stakeholder participation needs to be underpinned by a philosophy that emphasises empowerment, equity, trust and learning*

Reed (2008) argues that these philosophical underpinnings are foundational to meaningful and respectful stakeholder engagement. With respect to empowerment, this means ensuring that participants have the power to influence the decision as well as the technical capability to understand and engage effectively with the decision. Reed (2008) states that “If a decision has already been made or cannot really be influenced by stakeholders, then participation is not appropriate.” This is reminiscent of the stakeholder engagement (or lack thereof) that occurred with the NTNCRP. Likewise, if there is insufficient technical capacity or knowledge, it will not be possible for stakeholders to engage in a meaningful way even if they want to do so. It may take much time and effort to help educate the stakeholders on the general topic before getting into actual management discussions so they have the confidence and knowledge to engage. With diverse stakeholders (age, gender, experience, position) come the potential for power imbalances that must be addressed (there are mechanisms to do so – see Tippett et al. 2007) to ensure that the process is perceived to be both fair and valid. Reed (2008) emphasizes the need for mutual respect both among stakeholders and between the stakeholders and the facilitators (government or their agents). Finally, there is need for expectation by all parties that they are there to learn – to listen to what others have to say and to approach the issues with an open mind. Such an approach is key within any stakeholder engagement model where bi-directional communication is much more effective than simply one party telling the other something as if only one (the regulator/manager) has all the knowledge and answers (Cooke et al. 2017a). Note: This Tenet links to Tenet 4 in that these expectations need to be clear and transparent from the first stages or engagement (i.e., recruiting and/or selecting stakeholders).

NTNCRP: We appreciate that significant efforts were made by AEP to help the members of the FMA Committee understand certain scientific aspects of the NTNCRP, such as the CEM approach, but again it is our impression that much of that was done well after the management action had been proposed. Only three of the 15 stakeholder groups currently sitting on the FMA Committee were part of the Provincial Advisory Committee which assisted AEP in developing the CEM for bull trout between Nov 2016 and June 2017.

Tenet 2. *Where relevant, stakeholder participation should be considered as early as possible and throughout the process*

It is well known that co-production is most effective when done from the beginning and sustained throughout the entirety of the process (Reed and Abernathy 2018). This can be done in a variety of ways and has successfully been done in a number of fisheries contexts. For example, Bower et al. (2016) summarize an approach used with the recreational angling community in India to generate a suite of research priorities for an important group of sportsfish. That initial engagement served as the foundation for more extensive engagement during field studies (which included embedding stakeholders within the research program) and subsequent discussions regarding the management implications. A survey of stakeholders engaged in marine spatial planning revealed that they felt it important to be engaged in an open and transparent process that brings together diverse participants with the engagement extending throughout the duration of the project (Gopnik et al. 2012).

NTNCRP: In the context of NCNTRP management experiment, it would have been useful to engage the community at the stage where research needs and priorities were being identified. It is also possible for stakeholders to be actively involved in monitoring and evaluating the outcomes of the decision-making process (see Estrella and Gaventa 2000), which would seem like a good idea should the proposed management experiment (or some version therein) move forward to implementation. Clearly, some partnerships between AEP and stakeholders have already been established to this effect – eight concrete examples were provided by AEP in response to a question from the TPSR team in early October (see answer to Q12 in DOC 59).

Tenet 3. *Relevant stakeholders need to be analysed and represented systematically*

This Tenet is focused on the idea that there are structured approaches that can be used to determine the types of stakeholders that should be engaged in a given activity. Time and resources are limited so it is important to be able to identify key voices that represent the various interests. It would, for example, be inappropriate to simply select stakeholders that were the “loudest” about a given topic. Having different interest groups, especially ones that may be perceived to have fundamentally different perspectives is important.

NTNCRP: We did not explore the mechanisms by which the groups (and their representatives) were selected for participation in the FMA Committee but it was discussed at a Committee meeting in late July 2018 (where Cooke was present) that some industry groups (e.g., forestry, oil and gas) and indigenous representatives were notably absent. One organization on the fisheries management committee mentioned that the stakeholder representation on this committee is generally adequate but highlighted the need to have important government ministries such as Transportation and Agriculture and Forestry also sitting at the discussion table. Roads, agriculture and forestry all contribute to habitat degradation and having them actively participate in the NTNCRP would help avoid pointing fingers at angling pressure as the (perceived) driving source of population decline.

Tenet 4. *Clear objectives for the participatory process need to be agreed among stakeholders at the outset*

Setting ground rules is essential in an effort to provide clarity re what stakeholders may expect. This typically includes establishing a code of conduct to which participants must adhere. In some cases this may extend to some form of limits (e.g., non-disclosure agreements) regarding what can be shared with others outside of the process unless done so in an agreed upon manner (e.g., via a public meeting where the consensus perspective is shared by also noting any alternative perspectives as appropriate). Engagement done well means that the process does not belong to any single stakeholder or sector or the regulator/manager, but rather to the collective.

NTNCRP: DOC 35 (Communication overview) states: "At a provincial and local scale, the status of these fisheries [i.e. fisheries of NCNT] is "collapsed". Therefore, stakeholder empowerment is Level 1, with the goal of advising, or notifying stakeholders, of actions required to recover the fishery." The effectiveness of such top-down approaches to management are discussed elsewhere in this review. However, the extent to which stakeholders knew they were being *informed* of management decisions rather than *consulted* is unclear to us. Several stakeholders felt that their suggestions/recommendations/concerns were not adequately addressed and incorporated into the management plan by AEP. Additional clarity as to the purpose of the information sessions and consultation process by government could have prevented some of the frustrations experienced by stakeholders. There are some hopeful signs within the FMA Committee that members are working collaboratively and in good will towards a common goal, but as noted above, this is after the management experiment involving fishery closures and habitat remediation had been proposed so it is not a surprise that there is some level of opposition.

Tenet 5. *Methods should be selected and tailored to the decision-making context, considering the objectives, type of participants and appropriate level of engagement*

There are many forms of engagement and mechanisms for doing so. The approaches selected should consider the objectives and diversity/type of participants and be revised as needed based on ongoing reflection.

NTNCRP: AEP employed a diversity of engagement mechanisms ranging from "in-person presentations and discussion, an online survey, program-specific information sessions, online products, external media products, paper products, to phone conversations with commercial fishing guides" (see DOC 35 and feedback from interactions with stakeholders). Moving forward, it would be desirable to consider the many approaches identified by Tippett et al. (2007) in their review of methods for supporting participatory ecological planning and management.

Tenet 6. *Highly skilled facilitation is essential*

Reed (2008) summarizes how different facilitators can use the same tools but end up with quite different outcomes. Having a skilled facilitator who understands and respects process will be able to handle the various challenges (especially conflicts) that arise. The facilitator should simply not be the person who puts up their hand to volunteer or the person who is told to do it – they should be selected because of their skills and familiarity with facilitating stakeholder participation. For example, individuals with specific training in this area can be recruited from outside organizations. Alternatively, it is possible to develop capacity within an organization. The benefit of a third party facilitator is that it can enable more independent thinking that may otherwise be constrained if facilitated by the management organization. Facilitators are less important at meetings that serve more as information updates (such as the FMA Committee meeting in July 2018) but are exceptionally important during phases of stakeholder engagement where there efforts are being undertaken to co-produce and refine ideas.

NTNCRP: It may be necessary to engage professional facilitators or have AEP staff provided with such training. We also recognize that such engagement (early on) does have financial costs and does have the potential to slow down the process but the dividends can be huge.

Tenet 7. *Local and scientific knowledges should be integrated (Local, traditional, and scientific knowledge should be respected and considered)*

There are many different forms of knowledge that may have relevance to a given context or suite of management actions. By using a bi-directional knowledge exchange approach, and assuming diverse stakeholders, it is possible to bring those different (perhaps local or traditional) knowledge sources to the table. This is the entire premise of stakeholder engagement.

NCNTRP: It was difficult for the TPSR team to understand the extent to which different knowledge forms were used to support the development of the management experiment. Clearly, scientific knowledge generated by AEP and a subset of stakeholders (listed in DOCs 35 and 59) was used in the development of CEMs (i.e. determining dose-response curves) for bull trout and Athabasca rainbow trout. We also learned that individual biologists/managers are physically based in various areas within the East Slopes such that they bring some level of local knowledge. However, it does not appear that there was significant opportunity for non-governmental stakeholders to contribute local or traditional knowledge during the planning of the management experiment, which appears to still be ongoing (i.e. the specific watersheds designated to undergo the different treatments have not been fully identified). Note: In the Alberta/Canadian context, we would further extend this to traditional knowledge. For comments on how local and traditional knowledge were considered in other components of the NCNTRP (e.g. the development of CEMs), see *sections 1.1 and 4.1*. Further, the idea of "integration" is often regarded as being disrespectful to Indigenous peoples such that this is better framed as respected and considered. We have thus rewritten the Tenet from Reed (2008) and put it in brackets.

Tenet 8. *Participation needs to be institutionalised*

The notion of stakeholder participation in contemporary environmental management is well understood as being essential, yet it is still not uniformly embraced. To be truly effective, stakeholder participation needs to be institutionalised – simply regarded as the way that business is done – and supported. There needs to be structures for doing so along with the necessary resources and capacity.

NTNCRP: Based on our interaction with stakeholders and AEP team members, as well as the simple fact that there appears to have been very limited stakeholder engagement during the critical phases of the management experiment development, it is quite apparent that stakeholder participation is not "institutionalised" in the Alberta government to the extent that it could be. There is need for developing capacity in this area through training while empowering staff to consider how stakeholders can be engaged in various aspects of AEP business.

APPENDIX III. LEARNING FROM OTHERS – THE ONTARIO EXAMPLE

For decades, natural resource management agencies in North America and beyond have been exploring different models of stakeholder engagement in an effort to enhance stewardship. It is simply not possible to review all such models but a notable example is that of Ontario. Our familiarity with this example is partly because Cooke is involved in one of the zone management councils (Zone 18) in Ontario but also reflects our opinion that it is indeed an example of an effective model. For instance, at the first ever UN FAO workshop on inland fisheries, Ontario's landscape approach to biological assessment, stakeholder engagement, and management was highlighted as an example of a model that could be exported to other regions. Around 2006/2007, the Ontario Ministry of Natural Resources (now the Ontario Ministry of Natural Resources and Forestry; MNRF) released their Ecological Framework for Recreational Fisheries Management.

The core principles of the framework are:

- A landscape approach
- Adaptive management
- Monitoring and reporting
- Enhanced public participation

Just like Alberta, Ontario is a vast province with different fisheries underpinned by inherent eco-regional differences. The sheer quantity of water bodies making water-body specific management impossible, coupled with a desire to simplify regulations, led to a shift towards a landscape approach. Twenty "Fisheries Management Zones" (FMZs) were defined based on eco-regions. Representative monitoring and an adaptive management approach are important components of this model. However, relevant to this review (and *section 4*) is Ontario's approach to "Enhanced public participation". Each FMZ has a zone council with ~10 to 20 participants representing diverse stakeholders within a given region (e.g., various fishing clubs and associations, guides, tourist outfitters, bait dealers, academics, cottage associations, Indigenous representatives, etc). The FMZ members are appointed by the Zone Manager. Each Zone Council has a non-government Chair and the Councils meet as needed (ranging from monthly to quarterly) to consider various topics related to zone-level recreational fisheries management.

Each council works collaboratively to develop fisheries management objectives that eventually are used to guide the development of zone-specific fisheries management plans. The councils are provided updates on stock status and are able to engage in discussions regarding monitoring and reporting procedures. Various management strategies are considered and debated such that the council members understand the uncertainties and limitations with the scientific knowledge and the management strategies. The Council members also work and liaise with other local groups, particularly as it relates to consultation regarding the zone management plan or specific management actions. Because the Council members were involved in the process that led to a given outcome, they take ownership and are able to assist the MNRF in sharing the plan with the broader community. In doing so, it becomes apparent to the broader community that diverse stakeholders were involved in the process and that options have been considered not only from the perspective of the regulator but also that of the anglers, business owners, and conservationists. Council members also promote public involvement (e.g., encouraging the broader public to participate in public meetings) and also serve an important role in educating the public about management changes. This *bottom-up* approach has been highly effective at dealing with a number of high profile and thorny issues such as the implementation of bag limits on sunfish in eastern Ontario (which was initially perceived to have been a major detriment to tourism).

Cooke has sat on the FMZ 18 Council as the sole "academic" for 8 yrs. It took time for the council to coalesce and for council members to begin to understand the complexity of fisheries assessment and management, but also the varied perspectives on a given issue. The MNRF continues to maintain a provincial-level advisory board with thought leaders from relevant organizations but the majority of the management decisions now arise at the zone level. At times, there is need for different zone councils to interact when dealing with common issues (e.g., to consider harmonizing a regulation across a broader spatial scale). The provincial level advisory committee focuses on issues that cut across all management zones (e.g., bait bucket release regulations) but there is still updates and engagement at the zone level. The level of understanding that has been developed by the Council members is impressive as they now understand the biases associated with say an angler diary program, they understand the costs associated with implementing a creel survey, they recognize that it takes much effort to estimate population size in a given waterbody such that water-body specific management is nearly impossible, and they appreciate that the public servants are committed to managing aquatic resources for the good of all users.

APPENDIX IV. INDEX OF AEP DOCUMENTS

Index of the documents submitted by AEP to the TPSR team. The document number (DOC), type (DocType), and a brief description are provided along with information regarding whether the document was relevant for the TPSR (TPSRrel; 0 = no, 1 = yes) and a suggestion of how it should be integrated into a synthesis of the NCNTRP (Use; I = included in the main text, C = cited, A = included as an appendix, E = excluded).

DOC	**DocType**	**Description** (provided by AEP)	**TPSRrel**	**Use**	**Notes**
1	AEPreport	East Slopes Review	1	I	old version of DOC 46
2	AGreport	FishConservationManagementStrategyAlberta-Sep2014	0	C	
3	AEPreport	AB FSI Thresholds Native Salmonids	1	A	old version of DOC 56
4	maps	Historic and Current Adult Density Maps for Native Salmonids	1	I	
5	AGreport	BullTroutConservationManagementPlan	1	C	
6	AGreport	Status of Bull Trout in Alberta_2009	0	C	
7	report	COSEWIC_Rainbow Trout_2014	0	C	
8	AGreport	Alberta Athabasca RainbowTrout RecoveryPlan	1	C/A	
9	AGreport	Status of Athabasca Rainbow Trout in Alberta_2009	0	C	
10	AGreport	WestslopeCutthroatTrout-RecoveryPlan	1	E	
11	report	Status of Westslope Cutthroat Trout in Alberta_2006	0	E	
12	PPTpres	Fish SAC Model Presentation	0	E	
13	AGreport	Fish Sustainability Assessment Draft	1	A	old version of DOC57
14	AEPreport	Developing and Testing Hypotheses for Cumulative Effects of Land Use on Bull Trout	1	I	
15	AEPreport	Adaptive Management of Westslope Cutthroat Trout Cumulative Effects Modelling	1	I	
16	AEPreport	Athabasca Rainbow Trout Cumulative Effects Model V6	1	I	
17	PPTpres	Fish SAC Angling and Summary Presentation	0	E	
18	memo	Is CR a potential threat to BLTR recovery	1	I	
19	PPTpres	1955 Angling Regulations	0	E	
20	AGreport	ASRD 2012 Survey of 2010 Alberta sportfishing	0	C	
21	report	Jacques Lake BLTR Report Addendum 2014	0	E	
22	report	Assessment of the Keystone Species Mountain Whitefish in Jasper National Park	0	C	
23	sciPaper	Assessment of Alternative Harvest Regulations for Sustaining Recreational Fisheries Bull Trout	0	C	

24	sciPaper	Illegal Angling Harvest of Walleyes Protected by Length	0	C	
25	sciPaper	Ferguson and Tufts 1992 air exposure RNTR	0	C	
26	sciPaper	Bull Trout Population Responses to Reductions in Angler Effort and Retention Limits	0	C	
27	sciPaper	The demography of recovery of an overexploited bull trout population	0	C	
28	brochure	Trout Recovery Overview and Watershed Brochures	1	I	
29	brochure	Fall Creek Reclamation Project Brochure	1	I/A	
30	brochure	Rocky Creek Reclamation Project Brochure	1	I/A	
31	AGreport	NCNT Watershed Assessment Results 2017	1	I	
32	AGreport	NCNT Watershed Assessment Results 2017			DOC was initially missing Duplicate of DOC 31
33	AEPreport	North Central Native Trout Consultation and Engagment Tracker			DOC was initially missing Marked as confidential
34	AEPreport	North Central Native Trout Sportfishing Consultation Report			DOC was initially missing Marked as confidential
35	AEPreport	Communication Overview	1	I	
36	PPTpres	Bull Trout PAC FSI Presentation	0	E	
37	PPTpres	Bull Trout PAC Situational Analysis and CE Model	0	E	
38	PPTpres	Bull Trout PAC Adaptive Management Proposal	0	E	
39	AGmanual	Government of Alberta's Proponent Guide to First Nations Consultation Procedures for Land Dispositions. 2015	0	C	
40	AGmanual	Government of Alberta. 2015. Operational Procedures for First Nations Consultation: Fisheries Management Branch	0	C	
41	AEPreport	NCNT Strategic Commuications Plan	1	I	
42	AEPreport	NCNT Engagement Plan	1	I	
43	media	AO article NCNT	1	A	
44	media	AO article Rocky Ck	0	E	
45	PPTpres	Public Info Session NCNT pres	0	E	
46	aEPreport	UPDATED: East Slopes Review	1	I	updated version of DOC1
47	data	Raw data inputs for Bull Trout CE Model HUC8	1	A	
47a	data	CUT Raw Data inputs	1	A	
47b	data	BULL Raw Data inputs	1	A	
47c	data	RAINBOW Raw Data inputs	1	A	
48	report	NCNT Tactical Plans	1	I	

49	e-mail	Reply to D. Radford regarding photo-then-release study on Bull Trout	1	A	
49a	sciPaper	Bull trout (*Salvelinus confluentus*) occurrence and abundance influenced by cumulative industrial developments in a Canadian boreal forest\watershed	0	C	
50	memo	Tri-creeks Technical Memo	0	C/A	
51a	AEPreport	NCNT Monitoring and evaluation plan: Statistical Study Design Summary 14 Aug 2018	1	I/A	
51b	AEPreport	NCNT Monitoring and evaluation plan: Estimating power and sample size to detect trends in CPUE	1	C	
51c	AEPreport	NCNT Monitoring and evaluation plan: Details Of Bayesian Analysis	1	C	
51d	AEPreport	NCNT Monitoring and evaluation plan: Creating a draft Watershed Assessment Report	1	C	
51e1	duplicate	Clearwater River Watershed Assessment 2017	1	E	duplicate of DOC31
51e2	duplicate	Kakwa River Watershed Assessment 2017	1	E	duplicate of DOC31
52	missing				not associated with a PDF
53	sciPaper	Landscape -level stream fragmentation caused by hanging culverts along roads in Alberta's boreal forest	0	C	
54	sciPaper	Cumulative Industrial Activity Alters Lotic Fish Assemblages in Two Boreal Forest Watersheds of Alberta, Canada	0	C	
55	AEPreport	Word doc - Summary of Marie Lake Catch and Release Mortality Assessment 2018	1	A	
56	AEPreport	AB Thresholds approach FINAL DRAFT	1	I	updated version of DOC3
57	report	Fish Sustainability Assessment Draft_ FINALDRAFT	1	A	updated version of DOC 13
58	PPTpres	Third Party Review Document Map	1	I	
59	AEPreport	Response to Third Party Review Questions Oct 2018 FINAL	1	I	received Oct 3 2018
60	AEPreport	Angling Dose Steps excerpt from BLTR FSA protocols 18 Oct 2018	1	I	received Oct 23 2018
61	AEPmemo	EnvParks 18 Oct 2018 Memo East Slope fisheries science review questions of 5 Oct 2018	1	I	received Oct 23 2018
62	AEPmemo	EnvParks Oct 2018 Memo Estimating sources of mortality at C&R fisheries	1	I	received Oct 23 2018
63	AEPreport	Fish Sustainability Assessment Joe Modelling Angling Sub-Model 18 Oct 2018	1	I	received Oct 23 2018
64	PPTpres	ThirdParty_TacticalPlans2018	0	E	received Oct 23 2018

APPENDIX V. STAKEHOLDERS AND AEP STAFF CONTACTED BY THE TPSR TEAM

List of AEP staff and stakeholders on the FMA Committee contacted by the TPSR team to obtain information and input on the NCNTRP. An email request for written and verbal feedback was sent to stakeholders on Oct 4 2018.

Group	Representative(s)	Meeting type	Date	Time (EST)
Next Step Team and Volunteer Biologists Group	Ray Mackowecki, Duane Radford, Ken Crutchfield, Don Meredith, Jim Stelfox	conference call	17_09_2018	15:00_16:30
Alberta Environment and Parks	Jessica Reilly	phone call	21_09_2018	15:30_17:10
Alberta Environment and Parks	Micahel Sullivan, Jessica Reilly, Lisa Avis, Mike Blackburn, John Tchir, Dave Park	webinar	05_10_2018	15:00_16:00
Alberta Fish and Game Association	Darryl Smith	phone call	17_10_2018	15:00_16:00
Northern Lights Fly Fishers Chapter Trout Unlimited	Peter Little	conference call	18_10_2018	14:00_15:30
Trout Unlimited Canada	Lesley Peterson, Sylvia D'Amelio	conference call	18_10_2018	14:00_15:30
Cows and Fish	Lorne Fitch	conference call	23_10_2018	15:45_17:00
Alberta Wilderness Association	Joanna Skrajny	conference call	23_10_2018	15:45_17:00
Alberta Fish and Game Association	Darryl Smith	conference call	23_10_2018	15:45_17:00
Alberta Hunter Education Instructor's Association	Robert Gruszecki	conference call	23_10_2018	15:45_17:00
Dickson Fish and Game Association	Kelsey Kure	phone call	23_10_2018	17:10_18:00
Angling Outfitter and Guide Association of Alberta	Nancy Storwick	conference call	25_10_2018	08:00_09:00
The Association of Summer Villages of Alberta	Morris Nesdole	conference call	25_10_2018	08:00_09:00
Pure Fishing	Dave Majeau	conference call	25_10_2018	08:00_09:00
The Fishin' Hole	Kevin Johnston	conference call	25_10_2018	08:00_09:00
Let's Go Outdoors	Michael Short	phone call	25_10_2018	13:50_14:00
DFO	Bev Ross, Stephanie Martens	Not reached. Emails sent on 04, 19, 25 Oct.		