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Proceedings of the National Peer Review for Science advice to the Fisheries Protection Program on the effectiveness of spawning habitat creation for substrate spawning temperate fish

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) National peer review process was held January 22nd – 24th, 2019 at the Libraries and Archives Canada, Ottawa, Ontario. DFO's Fish and Fish Habitat Protection Program (FFHPP) had requested the Canadian Science Advice Secretariat to conduct a science review and analysis of the effectiveness of the most commonly applied fish habitat restoration techniques for priority regional fisheries productivity zones of Canada. FFHPP was interested in a peer review of the effectiveness of spawning substrate restoration techniques at restoring or offsetting destroyed and degraded fish habitats and fish productivity losses in regions of varying productivity and across habitat types. FFHPP requested an analysis of the most effective restoration practices for these regions or zones. This meeting focused specifically on spawning habitat creation and used a systematic review of relevant literature. This particular science advisory process is expected to be the first in a series focusing on offset and restoration practices, with later processes focusing on other aspects of the original request for advice (e.g., restoration recommendations across regions of varying productivity and habitat types).

The meeting included discussion around how to best assess the effectiveness of intervention methods and whether or not these practices are effective at restoring or offsetting destroyed and degraded fish habitats. Based on evidence shown in the review, it was agreed that commonly applied spawning substrate restoration techniques can: attract substrate spawning fishes; result in spawning; and result in egg survival and produce age-0 fish. However, this review did not directly explore if these findings translate to population-level productivity improvements.

It was also agreed that long-term monitoring of restoration interventions is strongly encouraged and that there is a need for data collection (existing data and new) and a process for making this data available for research. It became clear from the results of the presented working papers that despite a large amount of restoration efforts in Canada over past decades, there is a lack of published and publically available data. This limited the evidence available to draw conclusions on for this CSAS process.

Participants in this meeting included DFO staff from various sectors as well as external experts. A Science Advisory Report (SAR) (2020/013) (DFO, 2020) was prepared following the meeting.

INTRODUCTION

DFO requires project proponents to offset fish and fish habitat losses as a condition of authorization and also funds several programs to address the historical impacts of development activities through restorative action and partnerships with other governments, fishing/angling groups, Indigenous groups and others in the fisheries conservation field. Science advice was requested to strengthen the ability of the Department to make evidence-based decisions on regulatory decisions and funding allocations to achieve the desired outcomes for improving and restoring fish habitat in Canada.

The purpose of this National peer review meeting was to provide science advice that will support the Department by evaluating habitat offset and restoration proposals and recommending the best restoration practices for differing regional productivity zones to improve the likelihood of success of their restoration efforts. More details can be found in Appendix I (Meeting Agenda) and Appendix III (Terms of Reference).

PRESENTATIONS AND DISCUSSION

OVERVIEW OF THE FISHERIES PROTECTION PROGRAM AND THE NEED FOR OFFSETTING (N. FISHER)

FFHPP gave some introductory context on FFHPP's interest in offsetting and the need for science advice on this topic.

FFHPP provided an overview of the changes to the *Fisheries Act* in 2012 with regards to mitigation and offsetting measures and the uncertainties that resulted thereof in the years following. It was specified that bill C-68 (at the time of this CSAS meeting in hearings with the Senate) introduces proposed amendments to restore lost protections and to incorporate modern safeguards into the *Fisheries Act*.

It was highlighted that the Government of Canada supports considerable amounts of habitat restoration activities (e.g., Coastal Restoration Fund or Endowment Fund) and that proponents of developments affecting fish habitats often have high expenditures when implementing offsetting measures with the goal to restore spawning productivity of fisheries. In contrast, there are few investments that assess if these offsetting measures are indeed effective in restoring spawning habitat. FFHPP emphasized that increased science advice around the effectiveness of these measures is needed to strengthen the ability of the Department to make evidence-based decisions on regulatory decisions and funding allocations to achieve the desired outcomes for improving and restoring fish habitat in Canada.

OVERVIEW OF SYSTEMATIC REVIEW PROCESS, EXAMPLES, AND OPTIONS (S. COOKE)

A Researcher from Carleton University gave an overview of the field of Systematic Reviews and the Collaboration for Environmental Evidence (CEE). He presented on the history of the development of evidence synthesis methods and explained the difference between systematic literature reviews versus other types of reviews (i.e., traditional literature reviews, synopsis of evidence and meta-analysis) and the benefits, disadvantages as well as limitations of each method. Benefits to the use of listed systematic reviews were that they are transparent, objective, repeatable, updateable and robust to criticism and that they minimize bias and critically appraise the quality of evidence. The need for evidence-based decision making and documenting of consequences in conservation actions was highlighted and rationale was provided for the use of systematic review processes as a tool that can support managers in their decision making.

Discussion

Concerns were expressed regarding the incurred expense by conducting extensive systematic reviews versus standard reviews. The question was raised whether or not the results of a systematic review are significantly more robust to justify the cost, leading to discussions around how to decide when to use a systematic review process. It was clarified that the time-consuming (i.e. most cost-intensive) component is the literature review, screening and rigor of the critical appraisal. The importance of including data from grey literature in the review was highlighted which could be missed when information is collected from databases only.

There were discussions regarding the difficulty getting access to certain files/reports depending on the source (i.e., industry partners, academic theses, environmental consultants), but also from within the government (departments and agencies). The need for data storing and tracking within DFO was highlighted, especially keeping in mind the government of Canada's directive on "open government". It was noted that some of the recommendations around the need for standardized data collection, data reporting and data storing has already been captured in the Science Advisory Reports (SARs) of previous CSAS processes (DFO, 2012 and DFO, 2019) and the discussion was deferred to day 2 (under Objective 2).

Questions were raised around the fact that in the natural world controlled experiments and comparators often do not exist and that "one-offs" would not be captured in a systematic review. It was discussed that many hybrid approaches are being developed that combine traditional literature reviews and systematic reviews (e.g. a literature review that is more transparent and lists search terms) to address this concern and to try and capture more information.

PRESENTATION AND DISCUSSION OF THE WORKING PAPER I: WHAT IS THE EFFECTIVENESS OF SPAWNING HABITAT CREATION OR ENHANCEMENT FOR SUBSTRATE SPAWNING FISH? (TAYLOR ET AL. 2019)

Researchers from Carleton University presented working paper I (Taylor et al. 2019), a systematic review (including a quantitative synthesis using formal meta-analytical methods) to assess the effectiveness of techniques currently used to create or enhance spawning habitat for substrate-spawning fish in temperate regions, and to investigate the factors that influence the effectiveness of habitat creation or enhancement.

The methods applied in the systematic review were outlined including the following steps: question, protocol, searching, article screening, data extraction, critical appraisal, synthesis and final review. Of the 75 studies (from 64 articles), 183 data sets and 22 studies (from 20 articles) with 53 data sets were included in the quantitative synthesis. A detailed analysis of the critical descriptive statistics, quantitative synthesis, the meta-analyses and the effects of moderators was provided, followed by conclusions, limitations and recommendations.

Three main conclusions that were drawn from the study were:

1. the addition or manipulation of rock materials was an effective means of enhancing habitat, however the results may only be applicable to salmonids;
2. the addition of plant material (e.g., large woody debris, planting of macrophytes) with or without physical alterations to the waterbody (i.e., riparian modifications or excavation) was also effective in increasing substrate-spawning fish abundance; and
3. that the lack of evidence prevents any further recommendations from being made on other intervention types.

Discussion

There was a question about why fish body size was included as a measure of spawning effectiveness since body size is an indicator of other conditions (i.e. nutrients) rather than a measure related to the intervention.

Discussions were held around control sites (i.e., non-impacted versus degraded sites) and what type of comparators (pre- vs. post- monitoring, same versus different waterbody) were used to see whether or not this had an influence on the effectiveness on offsets. Comparators used as part of this study were as follows: non-intervention comparator; Before-After (BA) (or Trend-by-time), Control-Impact (CI) [or Reference Condition Approach (RCA), Normal Range Approach], Before-After-Control-Impact (BACI), or Randomized Control Trial (RCT).

It was recommended to be noted in the conclusions that the life history and generation time of the fish need to be taken into account when using long-term monitoring data.

There was some discomfort in the group regarding the choice of categorization and grouping of substrates and intervention types on a broad scale. It was noted that within categories, substrates may perform differently in terms of fluvial processes and how they affect the movement of water (e.g., rock versus cobble versus gravel, and plant versus log). In addition, concerns were raised on combining different sized substrates (e.g., cobble versus gravel) because they may be used by different fish species. It was clarified by researchers from

Carleton University that due to the small study sample size it was necessary to combine substrate into categories for quantitative analysis.

There was discussion regarding a statement in the conclusions that multiple types of interventions were effective, without clarifying which exact intervention mechanisms were used. It was suggested to explain why multiple types of intervention are useful and to highlight how to use the intervention mechanisms effectively.

The question was raised if marine studies were included in this CSAS. It was clarified by J. Taylor that most of the marine studies were excluded as they did not include data on eggs/juveniles, and/or that studies were not captured if the purpose of the restoration was not spawning habitat.

PRESENTATION AND DISCUSSION OF THE WORKING PAPER II: HOW EFFECTIVE ARE SPAWNING-HABITAT CREATION OR ENHANCEMENT MEASURES FOR SUBSTRATE-SPAWNING FISH? A SYNTHESIS (RYTWINSKI ET AL. 2019)

T. Rytwinski presented working paper II (Rytwinski et al. 2019). She explained that the objective of this review was to supplement the systematic review by Taylor et al. (2019) with a full synthesis using the whole evidence base, including those studies that were excluded in the systematic review, to assess the effectiveness of spawning habitat creation or enhancements for substrate spawning temperate fish.

The methods were outlined with a focus on the modifications in the methodology applied in this study as compared to Taylor et al.: a) the population criteria were modified to include studies that reported data on only juvenile fish (to capture important information on nursery habitat in addition to spawning habitat); and b) the comparator inclusion criteria were modified to include those studies that reported only post-treatment or impact data. The articles originally excluded in the Taylor et al. (2019) study were retrieved and re-screened with the new criteria resulting in 100 articles and 134 studies included after full text screening. Additional data was extracted including the pre-defined target outcome for the intervention, author's conclusions and statements of caveats, and/or confounding factors or comparator types (i.e., non-impacted vs degraded sites prior to treatment, or whether the control site was a natural waterbody or a nearby reference section within the same waterbody). Of the 134 studies (from 100 articles) included in the narrative synthesis resulting in 359 data sets, 228 data sets were eligible for inclusion in the quantitative synthesis. This is 36 additional articles (59 studies) and 176 additional data sets more than what was included in the Taylor et al. (2019) systematic review.

The narrative synthesis and effectiveness rating was based on the quantitative/qualitative evidence, the outcome measure (direct/indirect) and the post-treatment monitoring. Much of the presentation's focus was on results of the analysis of the effectiveness of the intervention and the specific materials used.

The main conclusions from the study were presented and discussed and can be found in Rytwinski et al. 2019.

The main recommendations based on this study were that all aquatic habitat enhancement activities should include a monitoring component including at least 3 years post-treatment duration, ideally also including a replicated intervention as well as a before and after comparison. In addition, monitoring efforts were encouraged to use outcome metrics that can be taken as direct evidence of successful spawning habitat restoration (e.g., egg-to-fry survival, abundance/density of larvae/alevins/age-0 fishes).

In closing, researchers from Carleton University suggested that both studies can be used to provide a comprehensive, reliable, critically appraised, searchable, and updatable database (that includes pdfs of all articles) as well as an annotated bibliography.

Discussion

It was suggested to consider a power analysis to evaluate how many studies (i.e. smallest sample size) would be needed to draw a conclusion on the effect at the desired level of significance.

There were discussions around the fact that the study design and data validity may have influenced the degree of effectiveness of the interventions. It was recommended to use caution when drawing conclusions on the effectiveness of specific intervention methods and materials due to the limits of the data and the species-specific needs. It was also noted and agreed to by the authors that there should be a weight for the study validity in addition to sample size (i.e. number of studies included in analysis) to clarify the limitations of the data.

Questions were raised on how to appropriately measure the success of an intervention and the effectiveness of offsets. More specifically, discussions were held around the definition of “effectiveness” of offsets and how control sites and reference conditions are defined and chosen (i.e., whether control sites are chosen as a random piece of habitat (stretch of stream) or a natural spawning habitat). It was highlighted that when evaluating success of individual projects, it is important to consider that every study has a different desired outcome and that different metrics evaluate different types of response.

There were discussions around flow and other confounding factors and it was clarified by J. Taylor that they could not be incorporated in this synthesis.

One participant expressed a lower level of confidence in the results of this working paper versus the systematic review due to the potential for publication bias.

Several participants were uncomfortable with the fact that the majority of studies included had data on post-treatment only, and the datasets were not treated as independent as compared to the systematic review. It was suggested to include a normal range or reference condition-type approach as it was deemed valid in the functional monitoring CSAS Science Advisory Report (CSAS, 2018) and to explore whether reference control sites could be included as an independent comparator.

Presentation of external review (N. Lapointe)

The external reviewer brought forward the following main observations and recommendations based on his review of the working paper:

- Recommendation to include some measure of variance in the percent change in response given for each intervention type;
- Recommendation to include uncertainty in the weighted-mean percent changes as the values may be more appropriate for informing offset ratios;
- Suggestion to change the handling of non-significant results so that they are categorized as “potentially effective” or “potentially ineffective”;
- Recommendation regarding the time windows for monitoring time since intervention to use average value across time periods to take into account that that populations fluctuate naturally;

-
- Need to acknowledge sources of bias (e.g., who conducted the analysis, low-validity versus high-validity studies);
 - Need for more clarity around the selection of replicates versus pseudoreplicates and the independence of the comparisons;
 - Recommendations regarding the effects of comparator types;
 - Recommendations on changes in the analysis of intervention categories and types;
 - Concerns about combining species and analysis since species have different spawning requirements and are not expected to respond to habitat manipulation the same way;
 - Inclusion of age-0 and juvenile fish to capture nursery vs spawning habitat is encouraged, however studies of juvenile fish should be analyzed separately;
 - Other questions were raised that could be affecting the study quality such as:
 - Was the substrate appropriate for the species?
 - Was the substrate placed in the right location?
 - Were other habitat conditions appropriate?
 - Was habitat the limiting factor?
 - Were there enough adults to colonize the habitat?
 - Did fish have access (connectivity)?
 - Recommendation to include a discussion of replication of treatments or controls, or of other methods for assessing effectiveness.

There was a discussion around if offset ratios or amounts should be included and if this is science advice or rather a policy question. It was decided as group that science advice should provide guidance on this question to FFHPP. Based on information presented in Rytwinski et al (2019) and the SAR from this CSAS (2020/013), it was concluded that where an offset project enhances existing spawning habitat and the harm was the destruction of spawning habitat (i.e. a like-for-like scenario) then evidence from effect sizes and confidence intervals presented here provide support for a greater than 1:1 offset to impact area ratio. However, while these effect sizes should not be used to directly determine the ratio, broader confidence intervals indicate greater uncertainty, which supports a higher offset ratio. Keeping this in mind, there should be more confidence in applying these results to species and interventions well represented in the reviews.

Other questions on the external review were deferred to the discussions on Objective 3 the following day.

Presentation of internal review (K. Clarke)

The internal reviewer started by pointing out that the work presented in this Research Document is important and valuable.

He brought forward the following main observations and recommendations based on his review of the working paper:

- Cautioned that site- and species-specific information need to be taken into account with regards to habitat compensation. For example, he clarified that brook trout do not always need ground water to spawn depending on the location, contrary to what is stated in the document;

-
- Recommendation to include degraded/impacted sites as comparators instead of natural sites for some parts of Canada where natural sites do not exist and to add a general discussion on what is a proper “baseline” and “comparator” as well as “control” versus a “reference” site, which is difficult to define in natural systems;
 - Recommendation to provide some clarity in the study description and the methodology on what elements were related or different from the Taylor et al. study;
 - Recommendation to clarify the use of “papers” versus “datasets” and “studies” versus “evaluation” in the document;
 - Recommendation to point out that restoration efforts have been ongoing for decades in Canada, however only 64 publications were found or included in the study. This highlights the fact that there is a large number of studies on this subject that have either not been published or that the information has not been captured in this study as it focused on the habitat creation aspect only;
 - Highlighted the observation that studies with better study design will show better results;
 - Recommendation to clarify findings by including confidence intervals in the results of the quantitative analysis and highlighting that the sample size is small; and
 - Recommendation to specifically explain what parameters were excluded from the search (e.g. artificial turf as a substrate).

The internal review stimulated a discussion on which outcome metric (Standardized mean difference (SMD) Hedges’ *g*, or weighted mean percent change) should be used to calculate and demonstrate the effectiveness of the intervention types in spawning-habitat creation or enhancement measures. It was recommended that the purpose of each metric should be clarified, and also to emphasize in the document that it is more important to focus on the confidence intervals rather than the percent change in intervention effectiveness.

The point was brought forward that the evolution of restored sites in the long term needs to be monitored to see if the restoration measures are still effective after 5-10 years, as this is not done in the majority of cases. Some of the discussions related to long-term monitoring in response to the Research document were deferred to discussions on Objective 2.

PRESENTATION AND DISCUSSION OF THE WORKING PAPER III: DOES HABITAT OFFSETTING WORK? A CROSS-CONTINENTAL SYNTHESIS ASSESSING COMPLIANCE AND ECOSYSTEM FUNCTION IN NORTH AMERICAN AND EUROPEAN FRESHWATERS (THEIS ET AL. 2019)

S. Theis presented working paper III (Theis et al. in review) which was a scientific synthesis assessing offset project effectiveness, compliance and ecosystem function in North American and European freshwaters. His review focused on the following components: 1) background on offsetting, 2) methods applied (literature review and analytical process), 3) results (function vs. compliance) and 4) conclusions.

The findings of the study identified several key gaps despite considerable investment in offsetting practices:

- a high compliance score did not guarantee a higher degree of function;

-
- function did improve with larger projects, specifically when projects targeted productivity or specific habitat features, and when multiple complementary management targets were in place; and
 - restorative measures were more likely to achieve full function than creating entirely new ecosystems.

Also S. Theis identified several main constraints in conducting the research presented based on: a) who collected the data (e.g. government agencies), b) how the data was collected and made accessible (i.e. centralized databases), c) language limitations, and lastly, d) the reporting metrics and systems used.

The author concluded his overview with the following recommendations on assessing offset project effectiveness:

- Framework, geographic location, system, scale and overall method & approach will affect project outcome;
- Compliance and Function relationship needs to be strengthened; and
- Alternative approaches (e.g. banking) and systems need to be considered to address the different offsetting requirements.

Discussion

The presentation was followed by discussions around clarifications needed on terms included in the paper (e.g., stream versus river, or “creating an ecosystem”).

One question was related to the size of the projects included per study. It was stated that the 500 datasets included in the study were from 50 reports (e.g. the largest study contained 98 datasets).

It was noted that it would be interesting to look at the effectiveness of habitat banking however that there was no access to data.

OBJECTIVE 1: ARE THE COMMONLY APPLIED SPAWNING SUBSTRATE RESTORATION TECHNIQUES EFFECTIVE AT RESTORING OR OFFSETTING DESTROYED AND DEGRADED FISH HABITATS AND FISH PRODUCTIVITY LOSSES, IN REGIONS OF VARYING PRODUCTIVITY AND ACROSS HABITAT TYPES?

Discussions around objective 1 were held over days 1, 2 and 3 of the CSAS meeting. The day 1 discussions on objective 1 are summarized as follows:

There was an extensive introductory discussion around the fact that several meeting participants were not comfortable with the wording of the question of objective 1, as it was deemed too broad and does not clearly express that spawning is the limiting factor. It was pointed out that the science advice needs to specify that the advice is context-dependent and that many caveats need to be considered.

The question was raised if the marine habitat was included in this review. It was clarified that due to the lack of availability of spawning habitat studies in the marine habitat and lack of data on some fish groups, evidence was not included for the marine environment in this CSAS. It was suggested to address the marine habitat in this context through another CSAS geared towards nursery habitat.

There was a discussion on publication bias (i.e. publishing only positive results) and that it is important to capture negative outcomes and knowledge gaps, and that there is a need for data to support that (and be made available).

It was acknowledged by all meeting participants that there is a strong link between objectives 1 and 3 as effectiveness will only occur or be evaluated if the study is designed with the correct criteria.

There was a suggestion that modifications of flow levels should have been included in this study. However, it was clarified that this study focused on creating or enhancing habitat or substrate and not on fish passage or flow modification, which are covered in two separate, ongoing systematic reviews.

Discussions were held around the lack of access to the many existing files/valuable information on restoration that has been done to date. While there was agreement that a retrospective review would be helpful, it was acknowledged that this would be a huge task. It was discussed whether it is equally (if not more) valuable to invest efforts on data collection in the future and in requesting proponents to monitor and document the results of the restoration measures in a standardized way, making the data readily available going forward.

The discussions on objective 1 were deferred and re-taken on day 2 and 3 as follows:

It was discussed that the scope of objective 1 needs to be clarified and that a distinction needs to be made between nursery and spawning habitat.

A clarification was made in the SAR that the focus of this review was mostly on creation and enhancement, and although the study looked at restoration it was not included in analysis due to the quantitative issues with restoration studies.

There were clarifications made that looking at population level-effects was out of scope.

Discussions were held around the finding that that high quality studies resulted in better results which suggests that better planning leads to better effectiveness. However, there is not enough evidence to validate this further.

There was a discussion on the effectiveness of cobble substrate for species other than salmonids and that there is a need for more data on non-salmonid fish and cobble to provide proper evidence.

Comments were made on the need for monitoring and data management and that monitoring results should be made accessible internally (at minimum) but also be made available to the public.

OBJECTIVE 2: IS THERE INFORMATION THAT SHOULD BE COLLECTED FROM SPAWNING HABITAT CREATION/ENHANCEMENT PROJECTS (OR OTHER RESTORATION PROJECTS) THAT WOULD ALLOW FOR IMPROVED EVALUATION OF EFFECTIVENESS?

There were discussions on the assessment of the study validity and the seven criteria listed in Table 5 of the Taylor et al. (2019) study that should be considered during project design. The seven criteria are: study design, replication at level of intervention, control matching, measured outcome, outcome method, intervention and confounding factors. It was agreed by participants that it should be reasonable to ask proponents to strive for the medium study validity group when requesting monitoring. It was suggested to consider making this table more descriptive (with examples) to facilitate broader use.

Discussions were held around replication and pseudoreplication (among and within sites) as well as the independence of comparator sites. It was noted that there is a need to determine if an independent comparator site should be a minimum requirement to be collected.

OBJECTIVE 3: IS THERE RESTORATION/OFFSET PROJECT ASSESSMENT GUIDANCE (E.G. A HABITAT RESTORATION PROJECT ASSESSMENT TOOL FOR SPAWNING HABITAT CREATION/ENHANCEMENT) THAT COULD BE DEVELOPED FOR FFHPP STAFF TO USE AS FOLLOWS):

- A) TO EVALUATE PROPOSALS FOR AUTHORIZING SPAWNING HABITAT OFFSET/RESTORATION PROJECTS;**
- B) TO EVALUATE PROPOSALS FOR HABITAT RESTORATION PROGRAM FUNDING (PRE-CONSTRUCTION, APPROVAL STAGE) AND;**
- C) TO PROVIDE CRITERIA FOR EVALUATING THE EFFECTIVENESS OF SPAWNING HABITAT TO ACHIEVE THE OFFSET AND RESTORATION FUNCTIONAL OBJECTIVES?**

E. Cooke gave a brief overview of a basic search for existing evaluation criteria and guidelines that she compiled from 14 sources. She placed criteria under one of three sections - Restoration/offset project: Project Context and Objectives, Project Methodology and Monitoring Methods and presented a table with results.

The purpose of a DFO habitat restoration project assessment tool was discussed. It was clarified that the goal of the tool is not to achieve equivalency but rather a consistent monitoring tool that evaluates whether the restoration/offsetting project is appropriate and effective.

The need to provide clear and scientifically reviewed guidance to proponents was highlighted by several participants.

It was noted that offset projects require different monitoring criteria than restoration projects and that different tiers of monitoring are needed depending on the level of impact.

The group discussed and agreed on the need for a system to be established to provide standardized data collection, reporting, management and accessibility.

Discussions were held around Table 10 in Taylor et al. (2019) and the fact that quantitative targets are important when considering the context and objectives. For example, some participants expressed concern over the fact that the table encourages a higher than 1:1 offset

ratio, when these numbers are meant to only inform the decisions for policy makers. The question was raised if a 1:1 offset ratio was needed at minimum. The group decided that the targets are dependent on the context (e.g. enhancement may warrant a ratio higher than 1:1). The group decided that a discussion around using this evidence should be included in the SAR to inform offsetting decisions.

CONCLUSIONS

All three objectives from the Terms of Reference were discussed in plenary. The participants together agreed on summary bullets for the SAR, based on key pieces of advice related to each of the objectives.

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APPENDICES

APPENDIX I: MEETING AGENDA

January 22-24, 2019

Library and Archives Canada, Ottawa, ON

Time	Tuesday January 22, 2019	
8:30-9:30	<ul style="list-style-type: none"> ○ Introduction to CSAS advisory process ○ Introduction of participants ○ Review Terms of Reference ○ Overview of goals and objectives of meeting ○ Overview of the FFHPP program and need for Offsetting 	Chairs FFHPP
9:30-9:45	<ul style="list-style-type: none"> ○ <i>Presentation: Overview of Systematic Review process, examples, and options.</i> 	Steve Cooke
9:45-10:30	<ul style="list-style-type: none"> ○ <i>Presentation and discussion of the Working Paper 1 (Taylor et al. in revision for publication in CEE: What is the effectiveness of spawning habitat creation or enhancement for substrate spawning fish?)</i> 	Jessica Taylor
10:30	Break	
10:45-11:30	<ul style="list-style-type: none"> ○ <i>Presentation and discussion of Working Paper 2 (Elmer et al. - to be published as a CSAS Res Doc- How effective are spawning-habitat creation or enhancement measures for substrate-spawning fish? A synthesis)</i> 	Trina Rytwinski
11:30 - 12:15	<ul style="list-style-type: none"> ○ <i>Presentation and discussion of Working Paper 3 (Theis et al. - in revision for publication in Conservation Biology Does habitat offsetting work? A cross-continental synthesis assessing compliance and ecosystem function in North American and European freshwaters)</i> 	Sebastian Theis
12:15-1:15	Lunch Break (on your own)	
1:15 – 2:45	<ul style="list-style-type: none"> ○ <i>Presentation of Internal Review and Discussion</i> ○ <i>Presentation of External Review and Discussion</i> 	TBD x2
2:45	Break	
3:00 – 4:30	<ul style="list-style-type: none"> ○ Objective 1: Are the commonly applied spawning substrate restoration techniques effective at restoring or offsetting destroyed and degraded fish habitats and fish productivity losses, in regions of varying productivity and across habitat types?. 	All

Time	Wednesday January 23, 2019	
9:00 – 10:30	<ul style="list-style-type: none"> ○ Re-cap of day 1 (progress). ○ Objective 2: Is there information that should be collected from spawning habitat creation/enhancement projects (or other restoration projects) that would allow for improved evaluation of effectiveness? 	Chairs All
10:30	Break	
10:45 – 12:00	<ul style="list-style-type: none"> ○ Objective 3: Is there restoration/offset project assessment guidance (e.g., a habitat restoration project assessment tool) for spawning habitat creation/enhancement that could be developed for FFHPP staff to use as follows: <ul style="list-style-type: none"> a) To evaluate proposals for authorizing spawning habitat offset/restoration projects; b) To evaluate proposals for habitat restoration program funding (pre-construction, approval stage); and c) To provide criteria for evaluating the effectiveness of spawning habitat to achieve the offset and restoration functional objectives? 	All
12:00 – 1:00	Lunch Break (on your own)	
1:00 – 2:30	<ul style="list-style-type: none"> ○ Continued discussion of Objectives 1-3 as needed. Draft SAR points. 	All
2:30	Break	
2:45 – 4:30	<ul style="list-style-type: none"> ○ Discussion and draft SAR points. 	All
Time	Thursday January 24, 2019	
9:00 – 10:30	<ul style="list-style-type: none"> ○ Re-cap of day 2 ○ Review and edit SAR points from Days 1 and 2. 	Chairs
10:30	Break	
10:45 – 12:00	<ul style="list-style-type: none"> ○ Continue drafting Science Advisory Report 	All
12:00 – 1:00	Lunch Break (on your own)	
1:00 – 3:30	<ul style="list-style-type: none"> ○ Complete drafting Science Advisory Report ○ Wrap Up / Next Steps ○ Workshop Ends 	All

APPENDIX II: MEETING PARTICIPANTS

1. Smokorowski, Karen (Co-chair) DFO Science, Central & Arctic (C&A)
2. Winegardner, Amanda (Co-chair) DFO Science, National Capital Region (NCR)
3. Anderson, Shannon DFO, FFHPP, (PAC)
4. Bradford, Mike DFO Science, Pacific (PAC)
5. Cooke, Emma (rapporteur) DFO Science, NCR
6. Cooke, Steven Carleton University
7. Clarke, Keith DFO Science, Newfoundland and Labrador (NL)
8. Depaiva, Alex DFO Ecosystems Management Policies and Practices (EMPP) NCR

9. Doka, Sue DFO Science, C&A
10. Enders, Eva DFO Science, C&A
11. Fisher, Neil DFO EMPP, PAC
12. Fleet, Terry DFO FFHPP, NL
13. Jacobi, Carol DFO FFHPP, MAR
14. James, Joanna DFO Science, NCR
15. Jonnson, Alan DFO FFHPP, PAC
16. Koops, Marten DFO Science, C&A
17. Lapointe, Nicolas Canadian Wildlife Federation
18. Makkay Kristina DFO Species at Risk (SAR), NCR
19. Melanson, Terry DFO FFHPP, Gulf
20. Midwood, Jon DFO Science, C&A
21. Poesch, Mark University of Alberta
22. Ponader, Karin (rapporteur) DFO Science, NCR
23. Roberts, Karling University of Alberta
24. Robichaud, Lisa DFO FFHPP, NCR
25. Runciman, Bruce DFO FFHPP, PAC
26. Rytwinski, Trina Carleton University
27. Stanley, David Ontario Power Generation (OPG)
28. Taylor, Jessica Carleton University
29. Theis, Sebastian University of Alberta
30. Wong, Melisa DFO Science, MAR

APPENDIX III: TERMS OF REFERENCE

Science advice to the Fisheries Protection Program on the effectiveness of spawning habitat creation for substrate spawning temperate fish

National Peer Review - National Capital Region

January 22-24, 2019
Ottawa, Ontario

Chairperson: Karen Smokorowski and Amanda Winegardner

Context

Fisheries and Oceans Canada (DFO) has a regulatory regime in place to avoid, mitigate and offset the negative effects of projects on fish and fish habitat. DFO also funds partnership programs to address the historical impacts of fish habitat destruction and alteration through creation and restoration of aquatic habitats.

DFO's Fisheries Protection Program (FPP) has requested the Canadian Science Advice Secretariat to conduct a peer review of the effectiveness of spawning substrate restoration techniques at restoring or offsetting destroyed and degraded fish habitats and fish productivity losses in regions of varying productivity and across habitat types.

In order to address this request for advice, this science advisory process will largely focus on a single restoration method (spawning habitat creation or enhancement) for substrate spawning fish in temperate systems. This process will primarily make use of a systematic literature review (protocol described in Taylor et al. (2017)) in an attempt to use this type of rigorous analysis in providing applied science advice to management practitioners. Furthermore, to better understand the benefits of using a systematic versus other (conventional) forms of knowledge review and synthesis (or transfer), additional reviews will be incorporated into this CSAS process. We will also use the reviews to better understand and provide guidance on what information is important to collect before, during, and after offset and restoration projects in order to assess their potential and functional effectiveness. This particular science advisory process is expected to be the first in a series focusing on offset and restoration practices, with later processes focusing on other aspects of the original request for advice (e.g., restoration recommendations across regions of varying productivity and habitat types).

Working Papers

Members of the Fish Ecology and Conservation Physiology Laboratory and the Canadian Centre for Evidence-Based Conservation and Environmental Management (CEBCEM; Dr. Steven Cooke) at Carleton University have produced a document entitled 'The effectiveness of spawning habitat creation or enhancement for substrate spawning temperate fish: a systematic review' (Taylor et al. (In review with the journal, *Environmental Evidence*)). The systematic review will serve as the main working paper for this CSAS process, with the primary question: '*What is the effectiveness of spawning habitat creation or enhancement for substrate spawning fish?*'. The purpose of this science advisory process will be to examine the conclusions from this review and attempt to adapt them into science advice that can be given in the context of FPP's operational needs.

A second working paper, prepared by the same Carleton University research group, will focus on literature originally excluded from the systematic review due to quality issues, but that may still contain useful data/information as scientific input for this meeting.

The final working paper reviewed will be a meta-analysis entitled '*Does habitat offsetting work in freshwater ecosystems? A global meta-analysis assessing compliance and function*' (Theis et al. (In review with the journal, *Conservation Biology*). While the scope of this meta-analysis goes beyond the effectiveness of spawning habitat creation or enhancement, it includes analyses and results that speak to larger issues and will be useful in providing additional insight on the general effectiveness of restoration and offsetting in freshwater ecosystems.

The latter two working papers will provide alternative sources of information to the systematic review that will help participants gauge the value-added nature of the systematic review for providing evidence-based science advice to management practitioners.

Objective

Participants will review Working Paper(s) and other information to address the following questions:

1. Are the commonly applied spawning substrate restoration techniques effective at restoring or offsetting destroyed and degraded fish habitats and fish productivity losses, in regions of varying productivity and across habitat types?
2. Is there information that should be collected from spawning habitat creation/enhancement projects (or other restoration projects) that would allow for improved evaluation of effectiveness?
3. Is there restoration/offset project assessment guidance (e.g., a habitat restoration project assessment tool) for spawning habitat creation/enhancement that could be developed for FPP staff to use as follows (If this project assessment guidance can be developed, could it incorporate regional differences in aquatic ecosystems (e.g., lake river, estuary) and fish assemblages?):
 - a. To evaluate proposals for authorizing spawning habitat offset/restoration projects;
 - b. To evaluate proposals for habitat restoration program funding (pre-construction, approval stage) and;
 - c. To provide criteria for evaluating the effectiveness of spawning habitat to achieve the offset and restoration functional objectives?

Additionally, the participants will discuss what information gain (e.g., rigour, quality of evidence) or loss (e.g., exclusion of large proportion of literature) occurs as one moves from conventional forms of knowledge review and synthesis (or transfer) to systematic literature review. This is not a main objective of the process but will occur as a byproduct of discussion of the objectives, and may help inform future syntheses of science for evidence based decision making.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document(s)

Expected Participation

- Fisheries and Oceans Canada (Ecosystems and Oceans Science, Fisheries Protection Program)
- Academia
- Other invited experts

References

Taylor, J.J., Rytwinski, T., Bennett, J.R., Smokorowski, K.E., and Cooke, S.J. (2017). The effectiveness of spawning habitat creation or enhancement for substrate spawning temperate fish: a systematic review protocol. *Environmental Evidence* 6:5 DOI 10.1186/s13750-017-0083-1

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