SCIENCE REVIEW OF STANDARDIZED MONITORING AND SUCCESS CRITERIA REPORTS FOR LAKE CONSTRUCTION, CHANNEL CONSTRUCTION, AND AQUATIC HABITAT WORKS

Context

In 2011, Fisheries and Oceans Canada (DFO) Fish and Fish Habitat Protection Program (FFHPP) requested science advice on developing cost-effective and science-based monitoring programs as part of habitat offsetting plans, to determine the effectiveness of habitat offsetting projects. Three hierarchical levels of monitoring were briefly described (compliance, functional, and effectiveness monitoring), but for that advice process the focus was on effectiveness monitoring (DFO 2012). The science advice on effectiveness monitoring was deemed applicable to projects with offsetting measures that warrant detailed monitoring (e.g., typically projects expected to have a large impact on fish and fish habitat, or high uncertainty in outcome). A technical report (Smokorowski et al. 2015) was produced following the 2012 advice and focused on developing the design and metrics for comprehensive effectiveness monitoring. In 2018, a follow-up science advisory process was held to focus on 'functional monitoring', recognizing that not all projects warrant full-fledged effectiveness monitoring, but that understanding the performance of the constructed habitats requires more than determining if the proponent has complied with conditions set out in an authorization under the *Fisheries Act*. The resulting Science Advisory Report (DFO 2019a) provided operational guidance on functional monitoring, exploring when it might be appropriate to implement, and providing monitoring design and indicator options to move towards standardization. Since then, there has been no DFO science advisory process to recommend requirements for compliance monitoring. The type of monitoring to be implemented and resulting level of effort depends on the goals/objectives of the monitoring, the scale of the potential impact, the relative understanding of the performance of specific types of constructed habitats, and corresponding indicators or surrogate metrics chosen. While science advice exists for the selection of monitoring approaches and design, none of the products from these past Canadian Science Advisory Secretariat (CSAS) processes were prescriptive enough to provide specific guidelines (i.e., step-by-step instructions) to implement an effective, standardized monitoring program.

Currently, FFHPP Ontario and Prairie Region (O&P Region) does not have standardized monitoring protocols and no standardized physical, chemical, or biotic collection techniques for both proponents and DFO to use in monitoring most habitat offsets. Recently, DFO FFHPP O&P Region contracted the development of proposed standardized monitoring approaches for several types of offsets or restorations, including lake construction, restoration/relocation/construction of watercourses to enhance or construct fish habitat (channel construction), aquatic habitat works which modify watercourses and lakes to enhance or construct fish habitat. Also included were supporting physical, chemical, and biotic collection techniques. These contracts followed-up from previous monitoring-related CSAS processes to specifically produce standardized monitoring protocols. Prior to incorporating these protocols into operational activities, DFO FFHPP had requested DFO Science review them and provide advice on the contractor-proposed, standardized monitoring programs/approaches for the aforementioned offset activities. All standardized monitoring programs/approaches are proposed for application in freshwaters, but inclusion of marine versions of similar protocols could be considered for future work.

The objective of this review was to assess whether the proposed standardized monitoring approaches for lake construction, channel construction, aquatic habitat works, and supporting biota collection techniques are scientifically sound, to help FFHPP build consistency in their monitoring and data requirements for their program and proponents. More specifically, the objectives were to:

1. Assess the quality and adequacy of information presented so that it is in line with previous advice, and determine if any relevant information was missing in the approaches;
2. Determine if appropriate study design, indicators and metrics, methods, sampling intensity, and best scientific practices in monitoring were used;
3. Determine if the monitoring approaches, including study design, data collection, metrics, and data accessibility, were structured in a manner for DFO Science to conduct a meta-analysis of the results in the future so monitoring protocols can be reassessed and to evaluate the 'success' of constructed habitats, and;
4. If necessary, recommend additional or alternative monitoring measures and approaches.

This Science Response Report results from the regional peer review of November 21-24, 2022, on the Science Review of a Standardized Monitoring and Success Criteria Report for Lake Construction; Channel Creation and Aquatic Habitat Works.

Background

Over the past number of decades there have been thousands of scientific books and articles dedicated to promoting and improving ecological monitoring globally (Lindenmayer and Likens 2010). In Canada, the need to improve habitat project monitoring was emphasized by Quigley and Harper (2006) as necessary to both improve compliance and to better understand the implications of decisions made under the *Fisheries Act*. Other, more recent studies have also highlighted deficiencies in monitoring program design and implementation as the failure to evaluate effectiveness of past habitat offset and restoration activities, or track changes in fish populations more broadly (Bradford et al. 2017, Krall et al. 2019, Radinger et al. 2019). Efforts have been made by DFO to achieve monitoring improvements over time (e.g., Pearson et al. 2005, Lewis et al. 2013, DFO 2012, 2019a, 2020, Smokorowski et al. 2015). Even so, the step-by-step instructions presented in the contractor reports, reviewed via this CSAS process, operationalize past advice on monitoring (i.e., see DFO 2019a, Figure 4, Step 4), but guidance on successful monitoring programs requires reiteration and incorporation into FFHPP programming. Specifically, items for careful consideration when developing any monitoring program include (adapted from DFO 2012, 2019a, 2020, Smokorowski et al. 2015):

- The objective(s) of the monitoring program are well-defined, scientifically-based questions identified at the outset, and thus will determine the level of sampling required (e.g., compliance, conformity, functional or effectiveness – defined in Appendix 1).
- The appropriate sampling design must be carefully considered after establishing monitoring objectives. The sampling design must have a comparator (e.g., the site before manipulation, a control site, baseline or reference conditions). Note different designs have different

comparators that are carefully selected to be suitable for comparison to the management measure site (e.g., control sites have similar biophysical conditions). At a minimum, the collection of “pre-project” data is recommended as a comparator. Ideally, multiple comparators are used to help clarify causation.

- Indicators and metrics selected must be appropriate for the monitoring objective (including considerations of system type, species, target life stages, habitat types, etc.). Metrics should be the same for both the comparator (pre-project, control, etc.) and intervention sites (post-management measure, habitat project site).
- The design must be able to yield a reliable estimate and variance of each metric measured, and consideration during the design phase should be given to statistical analysis and statistical power needs, including caution against pseudoreplication (Hurlbert 1984).
- Measurements should be quantitative (numerical) and not qualitative descriptions, whenever possible. For example, anecdotal observations are not useful but can provide context for metadata. However, expert classification, such as defining categories via a Delphi process, may be accepted. Well-defined categorical data can also be used.
- The duration, timing, and frequency of monitoring is appropriate to the species-life stage, setting, management measure, and objective of the management measure (e.g., assessing permanent vs. temporary functions).
- Monitoring data must have proper quality control checks and be stored electronically in a format that will endure and is accessible, as appropriate.

While this monitoring advice has previously been published as formal CSAS documents, it is important that any tool developed to operationalize standardized monitoring incorporate the above points. Collecting data in a standardized way without considering these important science-based concepts would still fail to yield tangible benefits, like: 1) DFO FFHPP understanding the implications of their decisions, 2) proponents’ monitoring programs contributing to greater understanding of the benefits of their offsetting or restoration activities, or 3) Canadians better understanding whether fish habitats are being protected for future generations.

Analysis and Response

The comments presented in this Science Response Report are related to contractor reports listed in Table 1. These three reports were produced by two separate contractors and were submitted to DFO FFHPP in fulfillment of contracts to produce standardized monitoring protocols for both DFO and proponent use on specific works, undertakings, or activities (WUAs) in and around water. This Science Response Report document compiled reviews conducted by a suite of invited experts including scientists and practitioners, both from within and external to DFO (see section 5.0 – Contributors).

Table 1. List of standardized monitoring documents reviewed as part of this CSAS process.

Document title (Short title/Abbreviation) Date	Author	Sections in SSR
User Manual for a Survey123 Application that Supports the Monitoring of the Restoration/Relocation/ Construction of Watercourses to Enhance or Construct Fish Habitat (Channel Construction/CC) December 23, 2020	5 Smooth Stones Restoration Inc., Kitchener, ON	Sections 3.1, 3.3, and 3.5
User Manual for a Survey123 Application that Supports the Monitoring of Aquatic Habitat Works which Modify Watercourses and Lakes to Enhance or Construct Fish Habitat (Aquatic Habitat Works/AHW) April 4, 2021	5 Smooth Stones Restoration Inc., Kitchener, ON	Sections 3.1, 3.2, and 3.5
Effectiveness Monitoring of Whole Lake / Large Scale Lacustrine Habitat Constructions (Whole Lake Construction/WLC) November 27, 2020.	Hatfield Consultants LLP, Vancouver, BC	Sections 3.4 and 3.5

Two of the three contracted documents (Channel Construction and Aquatic Habitat Works; referred to herein as CC and AHW respectively) were written by one contractor, based on the same proposed monitoring software application, but for different types of offsets, thus, much of the text was the same between the two documents. The third (Whole-Lake Construction; referred to herein as WLC) was prepared by a different contractor. All three documents were reviewed collectively via this Science Response process since they were all produced with the same goal in mind: to develop standardized monitoring programs/approaches for both proponent and DFO use, and ultimately to improve knowledge gained of effectiveness from offset monitoring to improve decision making.

There were a large number of minor editorial suggestions and where these did not change the intent of the sentence, they were compiled and retained outside of this Science Response Report to be considered if any future revisions of the original contracted documents are needed.

In instances where the suggested edit changed the intent, context, or meaning of the statement (including more substantial clarifications), these were included in the Science Response Report as part of the scientific review. For these more broad, substantial, and higher-level concerns, this Science Response Report followed a standardized format whereby the section of the document/issue of concern was raised first, the science analysis and assessment came next, followed by the science recommendation to address the concern.

The extent of all comments received was substantive; ranging from higher level concerns to technical sampling methodological recommendations. Through this peer-review process, it was determined that a stepwise, iterative approach should be taken to continue the development of the standardized monitoring protocols for use at all offsetting, habitat banking, enhancement, or restoration projects (collectively, regardless of the scale or purpose of the project, hereinafter referred to as ‘aquatic habitat works’). As such, this Science Response Report focuses on the broad, substantial, higher-level concerns identified in the review of the three contracted documents, in addition to providing recommended next steps. The issues raised during review have been grouped into five sections: issues common to all documents, AHW and CC common points, and unique points concerning each of the three contractor documents. The issue of concern is described, followed by an analysis and assessment of the issue, and science recommendations for consideration.

3.1. Issues Common to All Documents

3.1.1. Issue of Concern – Monitoring Tier Terminology

Three hierarchical levels of monitoring have been used historically through past CSAS science advisory documents (compliance, functional, and effectiveness monitoring), but discussions at the meeting demonstrated that FFHPP and DFO Science were not using these terms consistently.

Analysis and Assessment

Science branch has been using the terms compliance, functional, and effectiveness monitoring as a hierarchy, or continuum of intensity, where levels of monitoring of aquatic habitat works increase from lower to higher effort. FFHPP, however, uses the term compliance monitoring to include whether the requirements of the prohibitions of the legislation and the regulations have been met, which goes beyond monitoring the aquatic habitat works at any level. Discussions at the meeting clarified that the term 'conformity' was more appropriate to describe the level of effort required to determine if an aquatic habitat work was built as it was designed, without mistakes or faults. Furthermore, the FFHPP program has been using the term conformity monitoring to also include whether the aquatic habitat work is functioning as intended (Figure 1, Appendix A); this blends components of functional monitoring as defined by DFO Science previously (DFO 2012).

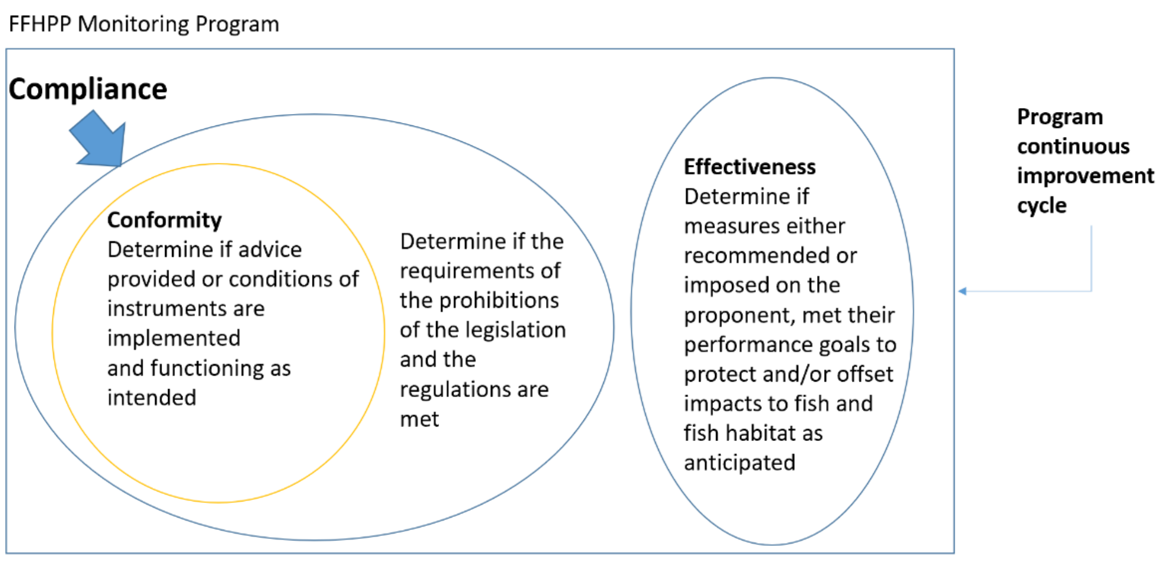

Figure 1. Venn diagram demonstrating how the FFHPP currently uses the terms Compliance, Conformity and Effectiveness monitoring in terms of their objectives for the program.

Science Recommendation

Going forward, DFO Science should use the terms conformity, functional, and effectiveness monitoring to describe the three levels or tiers of monitoring for aquatic habitat works. Further clarification on the distinction between conformity, functional and effectiveness monitoring and a demonstration of how FFHPP can use these terms for their program should be addressed at the next CSAS process advancing the standardized monitoring program.

3.1.2. Issue of Concern – Harmonization of Methods

The three documents reviewed were written by two separate contractors, and thus two were nearly identical (AHW and CC), but the third (WLC) took a different approach.

Analysis and Assessment

With the main purpose of this exercise being standardization of methods across the Department, there needs to be a harmonization of the methods used among all monitoring programs established by the Department for use in aquatic habitat works evaluation. For example, in WLC there was a section on monitoring constructed inlet and outlet streams, but it was missing some important parameters such as channel form (e.g., cross-sectional characteristics, longitudinal profile, etc.). This impairs the ability to modify the design if failures or changes occur. The eventual standardized methods developed to monitor channel construction projects would be as applicable to riverine offsetting as to the constructed channels that are part of a large WLC project. Two different 'standardized methods' for the same ecosystem component should not exist.

Furthermore, the AHW and CC documents proposed a way to capture, secure, and allow for the analysis of data collected from monitoring programs. Any analytical tool adopted by the Department should be used and applied universally across monitoring conducted on all aquatic habitat works.

Science Recommendation

- It is recommended that the three separate protocols be combined into one overarching 'framework' document' that applies to all monitoring conducted or required by the Department. As science-reviewed monitoring standards are developed for different components of the aquatic ecosystem, these methods should be applied universally to the appropriate components. Once a software system is reviewed and adopted by the Department to facilitate standardization, this system should be used in all aquatic habitat works monitoring programs.

3.1.3. Issue of Concern – General Terminology

A large number of concerns were raised about a lack of consistency and completeness of terminology use throughout all three documents, including the need for provision of improved or DFO-adopted definitions for a number of frequently-used terms.

Analysis and Assessment

Concerns about terminology have been extracted from the individual reviews and compiled. It is recognized that understanding and standardizing terminology is an important exercise when developing standardized monitoring protocols that cross DFO sectors. Specific terminology issues were not discussed at the meeting or addressed in this Science Response Report but a list has been retained for future steps and science advisory processes associated with the continued development of standardized monitoring protocols. Some definitions have been included in a glossary (Appendix 1).

Science Recommendation

- It is recommended that DFO develops peer-reviewed standardized terminology that is consistent with past science advice and definitions as part of their continued efforts to develop standardized monitoring protocols. These standardized terms could also be used in other science advisory processes to ensure consistency within the Department.

3.1.4. Issue of Concern – References

All three reports cite few references to support statements, and many references that are cited are older. Some specific references related to sampling techniques or metric calculation could not be included due to copyright protection.

Analysis and Assessment

There was a lot of reliance on few and old references, and some references were heavily used, but not necessarily applicable to all uses. Thus, some sections may not provide a complete review of current methods, which may be more appropriate to the new *Fisheries Act*, or may be more modern, effective, and/or efficient means of sampling.

In the case of WLC, it was identified that more real-world experience should be included by citing reports and primary literature where possible. For WLC, specific references should include existing lake construction offset authorization and monitoring reports. Documentation of the ecological progression of an excavated lake is particularly important to allow for consideration of issues when comparing constructed lakes to natural lakes, especially at the start of WLC succession.

In the AHW and CC reports, there was a general lack of connection to existing advice on the new *Fisheries Act* (e.g., offsetting, equivalency currencies) and monitoring standards. Including full reports as guidance in the Survey123 application was considered cumbersome. Summarizing methods and citing relevant reports or primary literature would also avoid any copyright issues. Where necessary, copyright permission can be obtained from the publisher to use specific figures or tables in the application. Many specific instances of where references are needed, or where references were mis-applied, are included in tables of minor edits to the contractors.

Science Recommendation

- Include more up-to-date references and/or reference specific items where they are lacking but needed. Published methods (including those from the grey literature as relevant) should be summarized and cited for ease of use in the field. Numerous specific instances are provided in the tables of minor edits to the contractors.
- Need to consider incorporating more references from existing real-world, whole-lake constructions in Canada, not only from published literature (e.g., Ruppert et al. 2018), but also from internal monitoring reports.

3.2. Aquatic Habitat Works and Channel Construction – Common Points

3.2.1. Issue of Concern – Document Duplication

Both the AHW and CC reports were produced by the same contractor, based on the use of the Survey123 application, and used much of the same text, so many of the concerns raised by reviewers were common to both reports. In some cases, a reviewer started with Aquatic Habitat Works (AHW), in other cases they started with Channel Construction (CC). The first review captured many edits, changes, and concerns to the common sections, but the second review simply said ‘see first review’ for edits to the common sections of the second document being reviewed. Thus, sometimes common elements in AHW were reviewed more thoroughly, and sometimes CC was reviewed more thoroughly. The WLC document was reviewed separately and is largely treated as such in this Science Response Report.

Analysis and Assessment

Considering the extent of overlap between the AHW and CC documents, it was suggested that the two be combined into one, with different sections for AHW and CC when appropriate. After reviewing WLC separately, it also became apparent that a number of issues were common among the three documents. Considering that the intent is to standardize all monitoring conducted or required by DFO FFHPP, the production of one common approach would facilitate this goal with specificity about monitoring different project types included.

Science Recommendation

- It is recommended that the three documents are not to be used in their current format; content from the three existing documents would be used as appropriate to develop one common, standardized but flexible approach. A stepwise, iterative approach is recommended at the end of this Science Response Report to achieve this goal.

3.2.2. Issue of Concern – Document Organization

The AHW and CC documents state: “*The monitoring system uses Esri’s ArcGIS Survey123 software. …The Survey123 application can also be used to guide pre-modification (baseline) or reference site monitoring, to provide a basis for comparison and determination of the net change associated with an offsetting or banking project.*” (AHW p. 6 and CC p. 5).

Analysis and Assessment

The Survey123 application is barely introduced before the document jumps right into how it is used. Several reviewers were concerned with the organization of the documents and the heavy focus on the Survey123 software. While it was agreed that the use of such (or similar) software was useful for standardization and important to the data entry and accessibility component of the monitoring program, the heavy emphasis on the software as written implies that standardization could not be achieved without the software, which is not the case.

Science Recommendation

- While a number of written reviews provided recommendations on how to reorganize the AHW and CC documents, given Science Recommendation 3.2.1, the original recommended reorganization is no longer applicable.

3.2.3. Issue of Concern – Appendices

Both AHW and CC contain extensive appendices designed to provide more detailed guidance on what and how to sample. While it was agreed that this level of detail was valuable to the process and implementation of a standardized monitoring program, the presentation and format of the appendices, particularly if they are to be incorporated into the Survey 123 platform, posed some concerns.

Analysis and Assessment

Current appendices are a blend of contractor-developed tables and existing user manuals, and parts of some appendices are redundant to others. For example, in CC the appendices describing sampling for different channel types are repetitive and could be streamlined into one, with defaults for all types and additional sampling added for different sampling levels, as this would increase standardization. In AHW, elements of Appendix B are redundant to Appendix A and a master reference list would be more user-friendly and improve standardization. Habitat and fish parameters are treated differently and there should be consistency in steps and detail in the appendices (e.g., there is a fish sampling workflow and this could be useful for all steps; similarly, a coding list for fish sample descriptors in C7 would be useful for habitat parameters). Tables 2 and 3 in Appendix C7 (AHW) were considered good examples of standardization. Some items in the main body (e.g., habitat parameters organized by category) reference the appendices, but the list between the two sections are not the same. Including full user manuals was considered inefficient for use in the field.

Science Recommendation

- The written reviews suggested that the appendices need simplification and focus (e.g., a master sampling list, with additions for more intensity as needed) to improve ease of understanding and consistency. Including full documents as appendices was considered inefficient, and the main points should be extracted as needed with a citation to the original reference document. Where copyright issues are not a concern, the document can be provided in a separate repository for ease of access, if needed. Producing a summary of key points with references to the originals would avoid most copyright issues, but where a specific table and/or figure is deemed important, efforts should be made to obtain copyright permission to include that key component when appropriate.
- Given the stepwise, iterative processes for monitoring advice, now recommended at the end of this Science Response Report, the specific details of various protocols are still to be decided by technical teams. Templates (i.e., common headings and outlines) for the development of the tiered monitoring protocols are to be developed as part of the overall monitoring and evaluation framework, and these will be reviewed at subsequent CSAS processes.

3.2.4. Issue of Concern – Narrow Focus of Sampling.

Both the AHW and CC documents thoroughly discussed habitat and fish sampling, with brief mentions of sampling benthos, but aquatic ecosystems include more than these components that should be monitored.

Analysis and Assessment

The heavy focus on only physical habitat and fish components of aquatic ecosystems excludes many other components of aquatic habitat that are of relevance to the *Fisheries Act*, including abiotic factors (e.g., chemistry, turbidity, dissolved oxygen, groundwater flow) and other biotic factors (e.g., aquatic and riparian vegetation, zooplankton, food webs beyond benthos).

Science Recommendation

- When relevant to the intensity of sampling warranted by the scope of the project, consideration needs to be given to incorporate more than just physical habitat, fish, and cursory benthos sampling, to include other aspects of how ecosystems can respond to both aquatic habitat works or channel construction (i.e., limnology, water and sediment chemistry, biota/food webs).
- Monitoring tiers should be tied to previous advice re: conformity, functional and effectiveness monitoring.

- Core monitoring measures would include those related to conformity monitoring and potentially aspects of functional monitoring by category of aquatic habitat works.
- When at the conformity level, the design of the works determines what is monitored.
- When at the functional level, the objectives of the project need to be considered to drive what is measured.
- When a project warrants effectiveness monitoring, broader ecosystem level measures should be included based on specific, measurable, achievable, relevant, and time-bound (SMART) performance objectives.

- Monitored (sampling) parameters need to be relevant to meet monitoring objectives for the specific type of work and be consistently applied to all works of this class. Modifications may be needed regionally, as needed.

3.2.5. Issue of Concern – Links to Previous CSAS Monitoring Advice

The AHW and CC documents state "*The application identifies habitat parameters that are used to determine if the project was constructed as intended and is performing effectively.*" (AHW, p. 10 and CC, p. 8).

The AHW and CC documents further state "*Fish monitoring is divided into four tiers, representing increasing levels of intensity and complexity.*" (AHW, p. 13 and CC, p. 10).

Analysis and Assessment

Both the AHW and CC documents advocate for tiered fish sampling, which is complementary to previous advice, but it should be made explicit how the fish sampling tiers relate to levels, intensity, and breadth of monitoring (e.g., as described in DFO 2019a). Terminology used is also not consistent with previous advice, for example, 'constructed as intended' sounds akin to conformity monitoring, and 'performing effectively' could be either functional or effectiveness monitoring.

Science Recommendation

- Ensure appropriate links are made to previous CSAS advice (i.e., DFO 2012, 2019a, 2020, Smokorowski et al. 2015), and use the terms as previously defined and accepted by DFO, as per Objective 1 to this CSAS.

3.2.6. Issue of Concern – Scope of Documents

The AHW and CC documents state "*That is, proponents are required to undertake design, construct, and carry out post-construction monitoring of works (e.g., habitat enhancement, restoration or construction) intended to offset the harm to fish and fish habitat caused by their development projects. There are four types of projects that can be undertaken to enhance, restore or construct fish habitat:*

1. Projects that modify lakes.

2. Projects that modify watercourses.

3. Projects that restore/realign/construct watercourses.

4. Projects that restore/construct lakes.

The habitat banking annex contains information that is similar to that contained in an authorization for offsetting. Monitoring of habitat banking projects presents another opportunity to generate data that can be used to improve the quality of projects that construct or enhance fish habitat." (AHW p. 5 and CC p. 4).

Both documents further state "*Fish monitoring is divided into four tiers, representing increasing levels of intensity and complexity… Tier 4 applies to complex projects or to research initiatives that would typically require preparation and review of a detailed monitoring program design. Thus, Tier 4 is beyond the scope of the monitoring system.*" (AHW, p. 13 and CC, p. 10).

Analysis and Assessment

There was some confusion around the four identified types of projects and wording used in the different categories (e.g., difference between modify vs. restore, or watercourses vs. lakes). These documents have been written with the monitoring of habitat offsets or banks in mind, and in many instances a habitat banking project is the same as an offset but are built before the impact of a development project, thus in most instances monitoring treatment of offsets and banks are the same. However, offsetting and restoration may not always be the same. The restoration literature is very large, with many good overview/review papers already in existence, the same cannot currently be said for offsetting. Yet, a number of reviewers questioned why the standardized monitoring approach to be developed would not apply as well to projects intended to restore or replace unauthorized works or other degraded habitats. Similarly, there was interest in the approach being used for riparian restoration or offsets, or to evaluate mitigation measures.

Furthermore, given the expertise required in conducing standardized monitoring using specialized software, reviewers questioned whether low-risk WUA's or projects using standard offsetting practices might not require this approach. If not, there should be some consideration given to a consistent threshold for when this monitoring should be required, especially as standard practices yield predictable monitoring outcomes in future. At the other end of the spectrum, examples of what would be considered a Tier 4 project, and thus proposed to be excluded from standardized monitoring, should be provided because it was not clear why or when this approach could not be used for more complex or research-level monitoring projects.

Science Recommendation

- The project types identified require delineation and examples to clarify their classification. Reviewers suggested presenting this material in a table.
- It is recommended that for any offset, habitat banking, restoration, or enhancement project (i.e., the all-encompassing 'aquatic habitat works'), the same monitoring approach should apply, but the level of monitoring would be adjusted accordingly based on set rules applied to all types.
- After discussion, it was agreed that even the most minute offsetting project would require conformity monitoring, with some aspects of functional monitoring included (i.e., a few indicators and minimal effort). Small offsets (i.e., those with minimal impact) would generally not require full-scale effectiveness monitoring unless a comparative study was developed with multiple small offsets as replicates.
- Whether or not this monitoring program is implemented for any aquatic habitat works (offset, bank, restoration, enhancement, riparian or impact projects) is largely dependent on regulatory requirements, but the option to use the approach more broadly exists and the potential information gained would be more informative than just monitoring offsets.
- If monitoring is required or chosen, it should follow the developed standardized approach so that all monitoring collectively provides information towards improved decision-making.

3.2.7. Issue of Concern – Sampling Design

The AHW and CC documents state "*The Survey123 application can also be used to guide pre-modification (baseline) or reference site monitoring, to provide a basis for comparison and determination of the net change associated with an offsetting or banking project. That is, the overall amount of habitat modified or constructed is based on a comparison with baseline conditions*." (AHW p. 6 and CC p. 4).

Similarly, the documents state "*However, given that pre-construction sampling is anticipated to be less frequent, and habitat project specific, defaults are not provided*." (AHW p. 15 and CC p. 12).

Analysis and Assessment

There are a number of places in these reviewed documents that mention baseline, reference reaches and/or pre-modification sampling to serve as the comparator, but nowhere is the overall design of the monitoring program discussed to determine what type of design, and thus comparator, will be used to determine success (e.g., before sampling, reference or control sampling, both, regional benchmark, etc.). For using a pre-modification condition as a comparator, consideration should be given to going beyond a focus on current conditions to assess whether the pre-modification condition is the appropriate goal, incorporating a range of information including local populations, Indigenous knowledge, etc.

In addition, there were numerous concerns raised regarding the lack of use of existing CSAS and other DFO publications that define, explain, and recommend designs related to the types of monitoring that could be conducted for aquatic habitat works, and the lack of direction related to the design of the monitoring program in general. This past advice should be used to understand the context of DFO-mandated monitoring, to provide guidance towards proper sampling design, and for setting targets.

Science Recommendation

- Any new monitoring protocol document must focus first on the design of the monitoring program to ensure it is scientifically sound, or the data collected could be of little use, regardless of the standardization of metrics or accessibility of the data. The discussion of sound scientific sampling design should come early in the document and could be presented as a table of different study design options depending on needs (e.g., Table 4 in Braun et al. 2019) and some minimum sampling criteria (e.g., as in DFO 2020 and the Background section above) to incorporate into any design used. Once the design is established, some guidance should be provided regarding features of an appropriate comparator (i.e., how to establish the baseline). There should also be standardization of the terminology used (e.g., baseline vs. pre-modification sampling vs. before sampling, and/or reference reach vs. control vs. benchmark) (see section 3.1.2).

3.2.8. Issue of Concern – Proprietary Software

Both reports rely heavily on the Survey123 application for success, including the standardization of what is collected and how, data collection in the field, and the ability to upload the data to a secure cloud held by DFO. Specifically:

In AHW and CC, the documents state *"If the proponent does not have a license for Survey123, DFO will make arrangements for the proponent to use the application under DFO's license. While all data uploaded by the field staff will go to DFO's secure cloud, DFO can allow the proponent to access the data for the evaluation phase of the process*." (AHW p. 6 and CC p. 5).

The documents further state *"The adoption of the Survey123 monitoring system offers many benefits. The single largest benefit will be the creation of a monitoring database..."* (AHW p. 7 and CC p. 6).

Analysis and Assessment

There was general agreement that the use of software with the abilities of Survey123 could be highly beneficial to a standardized monitoring program, particularly to consolidate, access, and potentially analyze data to gain insights into the effectiveness of different aquatic habitat works. Establishing a solid database foundation will ensure the long-term functionality and value of the data repository and its outputs. However, there were concerns about the software's costs (including annual fees), proprietary use and licensing issues, and the dependence on IT to assist with issues in a timely manner. The assumption that proponents could use the software under a DFO license was raised as a specific concern to address prior to adoption of this particular software, as well as the costs, administration, and support that this may require to deliver. Similarly, where the data are uploaded was of concern, specifically to a DFO server or not (security vs. accessibility issues). Thus, the assumptions made on the ability to use the software as described in this report need to be clearly articulated and assessed for accuracy, including consideration of the long-term viability, maintenance, and accessibility of the resulting database and supporting applications for analysis.

Science Recommendation

- The monitoring protocol needs to specify that data collected as part of any monitoring program are eventually loaded into an electronic database.
- The ultimate application to be used, however, depends on the issues raised above. It is also recommended that DFO get a critical review of the database by an expert to ensure that: it can be used as intended under DFO license, it is not cumbersome, that uploads from proponents are secure, that the data can be efficiently manipulated to analyse, and that it has the flexibility to incorporate future modifications to ensure longevity of the data availability and updates.
- Consider exploring existing widespread data collection examples (e.g., Environment and Climate Change Canada Environmental Effects Monitoring [ECCC EEM]) to serve as a model to promote data interoperability and accessibility, with appropriate meta-data.
- Ensure that whatever database platform is used is flexible to allow the upload of data easily, regardless of how the data are collected with appropriate metadata.

3.2.9. Issue of Concern – Standardization

In AHW and CC the documents state "*The data from multiple …projects used for offsetting and habitat banking can be aggregated and analyzed to determine what works and what does not. This should help improve the quality of habitat projects which is a benefit to both DFO and project proponents*." (AHW p. 7 and CC p. 6).

The documents further state "*Although it is discouraged, field staff may, with justification, elect to use a different measurement method than the one prescribed when the monitoring program was designed.*" (AHW p. 12 and CC p. 9).

Analysis and Assessment

One main purpose for developing these protocols was to achieve as much standardization as possible among monitoring projects such that meta-analyses can be conducted on data from multiple projects. The only way that this is achievable is if projects have a sound scientific design and collect data that are comparable among and between altered and comparator sites, regardless of how data to generate that metric was collected in the field (which may necessarily be different depending on habitat and system type). For example, some metrics will differ depending on the sampling method (e.g., Catch-Per-Unit-Effort [CPUE] measured by different fish gear types), but as long as the projects are asking the same question (e.g., effect of an offset reef on fish biomass), the design includes a comparator, and the main metric is the same (e.g., fish biomass or abundance, but not comparing between the two), different studies can be combined by converting these metrics to a standardized mean difference for meta-analysis. Furthermore, there are standard analytical methods in meta-analyses that, with sufficient data, can explore the influence of sampling differences (e.g., gear type) on effect-size estimates. It would be useful to outline what is required for sound meta-analyses from the literature on this topic and incorporate those criteria to clarify how this is done, perhaps with a real-world example to demonstrate.

Considering how the data are expected to be analyzed in advance of actually collecting those data is critical to be able to conduct analyses, particularly when, for example, ancillary data need to be collected to ensure that the appropriate ecological context is known when combining various fish responses to a habitat change. This would also facilitate the development of a sound database structure. The actual meta-analyses would not be expected to be conducted by proponents or FFHPP staff, but by science on some periodic basis after adequate data have been collected.

There are a lot of instances where the manual refers to a preferred approach but describes reasons for alternatives. This makes the manual very wordy, and the reader can easily lose track of what is required/prescribed over preferred. At a minimum, the principles of maintaining a consistent approach should be stressed, and a hierarchy of approaches with decision criteria made clear.

Science Recommendation

- Principles of meta-analyses and criteria for being able to combine data from different projects into a common analysis need to be outlined (e.g., see Arnqvist and Wooster 1995, Harrison 2011). There should be a hierarchy of approaches provided that stress maintaining consistency when feasible. A theoretical example should be included for clarity.
- Database design is critical to ensure its utility in supporting extraction for meta-analysis. How data are reported in electronic format needs to be carefully considered and planned (e.g., text boxes without categorization are not useful for analyses).

3.2.10. Issue of Concern – Flexibility vs. Rigidity of the Survey123 Forms

In CC the document states "*While it is essential that sampling methods are consistent on all occasions that a specific project or associated reference reaches are monitored, the most effective and efficient monitoring methods will vary widely among channels and therefore no detailed protocols have been developed for monitoring restored, realigned or constructed channels.*" (CC p. 11). The AHW document says the same thing, but with 'features' instead of 'channels' (AHW p. 14).

Both documents continue on to state "*The person establishing the monitoring protocol can override any or all the defaults. The defaults, however, have been provided to encourage greater consistency within the data and improve DFO's ability to analyze the data from multiple* *projects to improve future projects. Therefore, the defaults should not be overridden without a good reason.*" (AHW p. 17 and CC p. 13).

In addition, they state "*When complete, the person will have created a tailor-made field survey form for the project, for each year of monitoring for the offsetting proposed within the authorization or the project proposed within the habitat banking annex. The form will show only the parameters that need to be sampled*." (AHW p. 18 and CC p. 14).

Analysis and Assessment

There was broad concern about the high amount of flexibility to add and remove parameters for monitoring. While it is true that the most effective and efficient monitoring methods will vary among system and project types, and may change over time, it does not preclude adopting an approach for comparability across similar projects in scale or site characteristics. Table 1 is a good example that could be generalized for different habitat parameters or features in standardizing data to be collected. Having a core set of parameters that are always monitored for a given project and system type would greatly improve the ability to conduct future meta-analyses. It is considered particularly important to standardize approaches and effort between the comparator (pre-data, control site, etc.) and the altered sites. Recommended methods and core sampling by system type need to be clearly defined as there should be no situations where a proponent is not prescribed most of the sampling protocols *a priori*.

On the other hand, while it was universally agreed that a degree of standardization was critical for the purposes of meta-analyses, there were related concerns that too rigid a process would not allow for the flexibility required to sample different system types in a country as eco-diverse as Canada where unique situations may arise. To address this concern, there should be a core set of habitat parameters, which should be a minimum for information input and common to all watercourses, and then specific guidelines that accommodate different ecosystem components and standardization of effort by system size. The addition of custom parameters could be accommodated on the electronic form, but this should be minimized.

Science Recommendation

- The documents should be clear on both the limitations of consistency and realistic on what these data will provide. Core recommended parameters and sampling approaches by project and ecosystem type should be developed, as should standardization of effort by system diversity and size. This goal may be best achieved via the establishment of expert committees that develop sampling protocols by ecosystem component (i.e., physical, chemical, and biological methods).
- Limitations due to sampling precision and thus the ability to detect differences between comparators do exist, and can be a particular challenge for some metrics (e.g., measures of fish population dynamics). If it is deemed acceptable for field staff to alter recommended methods with justification, some examples of such acceptable justification need to be provided. If any defaults are changed then a justification text box should be mandatory, and consideration given to requiring DFO approval.

3.2.11. Issue of Concern – Data Quality Assurance and Quality Control

In AHW and CC the documents state "*If the field staff have access to the web while in the field, they can upload the data to the cloud for permanent storage from the field.*" (AHW, p. 25 and CC p. 21).

Analysis and Assessment

There is concern that data uploaded from field would not have undergone important quality assurance and quality control (QA/QC) checks that should happen prior to being considered ready for analyses. Uploading from the field can provide some initial data security (back-up) but this version of the data will need to undergo QA/QC before it is considered final for use. Furthermore, there was concern about ancillary data that take longer to process (e.g., data on fish ages, fish mercury concentrations, stomach content analysis, etc.), and how this will be provided to DFO for upload later.

Science Recommendation

- QA/QC steps and data management standards should be developed and followed as part of this monitoring protocol.
- Data collected by a variety of means should still follow the same QA/QC steps, and only then can be uploaded to a common database for further use.
- Data backup/security steps should be part of the protocol.
- As part of the review of the software application(s), there needs to be an investment in database design and structure to allow for data security, QA/QC steps, and post-field data processing to be finalized for secure long-time storage and future meta-analyses.

3.2.12. Issue of Concern – Level of Fish Sampling

In AHW and CC the documents state "*Fish monitoring is divided into four tiers, representing increasing levels of intensity and complexity. Tier 1 does not entail any structured monitoring program. It is simply the recording of opportunistic observations of fish made by field staff while carrying out the habitat monitoring or observations reported by indigenous persons, local residents, anglers or others. Tier 1 can be reported in the text box provided in the habitat monitoring form. Tier 4 applies to complex projects or to research initiatives that would typically require preparation and review of a detailed monitoring program design. Thus, Tier 4 is beyond the scope of the monitoring system*." (AHW p.13 and CC p. 10).

The documents continue to state "*Tiers 2 and 3 entail monitoring (i.e., sampling) of one or more life stages (spawning, nursery, foraging, migration) of one or more fish species. Tier 2 evaluates presence/absence. Tier 3 involves quantitative sampling. A target can be selected for each species/life stage. For Tier 2 sampling, the target will usually be **presence**, however **absence** would be the target if the goal is exclusion of one or more species (e.g., Round Goby;* Neogobius melanostomus*). Targets for Tier 3 sampling are quantitative and can be simply a number for a channel (e.g., 10 adult Brook Trout captured within the reconstructed reach) or a catch per unit of sampling effort (CPUE) measure (e.g.,1 adult Brook Trout captured per 100 m^2 electrofished within the channel).*" (AHW p.13 and CC p. 11).

Analysis and Assessment

The use of the term 'tier' should be restricted to overall sampling effort (i.e., functional or effectiveness monitoring). Thus, for fish-specific sampling, the use of 'level' is more appropriate. It needs to be clarified how the different levels of fish monitoring relate back to monitoring objectives. Linking the fish sampling levels to previous CSAS advice (i.e., conformity, functional, effectiveness monitoring) will clarify their intent, but there were numerous concerns regarding what was included, or not, in each proposed level of fish sampling, and when each would apply. Examples should be provided for the types of aquatic habitat works that may require different levels of monitoring. Specific concerns and potential solutions related to fish sampling included the following:

- Level of fish sampling needs to link to the objective of the project. If the objective is to restore habitats or habitat-forming processes, then fish sampling may not be required. If the objective includes fish, then some level of fish monitoring is required, even if it is Level 1.
- Observations of fish can be noted, if they are made, regardless of the objective of the project.
- Others felt that due to the variability of fish monitoring results, for Level 1-3 emphasis should be placed on measurable success targets for habitat, and that the use of fish monitoring should be more supportive information, and overall be carefully considered.
- Highlight situations when fish sampling may not be necessary (e.g., shoreline stabilization) as well as when it is (e.g., construction of spawning shoals, installation of fishways).
- For Level 2 fish sampling, the criteria for establishing ‘absence’ are different than presence, and these should be outlined, including accounting for detection probability. Consideration should be given to adding eDNA to Level 2 since it is well established for presence/absence measures (including in complex habitats for rare species).
- As new techniques are developed and validated (e.g., connecting eDNA to abundance), these should be considered, but then may need to use multiple techniques (including traditional gear types) to further validate new methods, if needed.
- For Level 2 - presence may be appropriate for functional monitoring but if the objective is related to a particular fish use, then a metric demonstrating fish use of habitat (for its intended purpose) is important to note beyond presence.
- For Level 3, standardized CPUE should be considered a minimum for quantitative fish monitoring. Furthermore, Level 3 should not be limited to relative abundance – relative biomass should also be considered.
- Some advocated that standard methods for population estimation (or abundance estimates) are commonly used with appropriate assumptions and confidence intervals and should not be discounted for Level 3 fish sampling. Others suggested that the use of any fish abundance/productivity data for assessment of project success should be limited to Level 4 programs. From past CSAS advice, effectiveness monitoring was considered necessary for complex projects expected to have a large impact on fish and fish habitat, and/or where the risk and uncertainty regarding the efficacy of the offset habitat is great. Metrics considered appropriate for effectiveness monitoring included fish population abundance, species richness, or fish community composition, productivity, and biomass. The detailed fish sampling protocol development team should provide examples as to where population estimation may be required.
- Whole-lake/stream/river destruction and/or whole-lake/stream/river construction are their own classes of sampling and should be considered at the ecosystem scale by the protocol development teams.
- A Level-5 fish sampling protocol should be developed to capture specific monitoring related to assessing fish passage. Passage criteria for fish ladders/passage structures as laid out in Cooke and Hinch (2013) should be considered. It should be explored if DFO’s fish passage tool (for culverts) that is in development could be integrated into this application. Grades

within fish-passage assessment exist and need to be clarified (e.g., monitoring related to assessing fish passage efficiency, effectiveness, and passage structure type) as protocols are further developed.

- That fish life-stage, species-specific information (e.g., spawning times, sizes, swim speeds, etc.) when available be collated and included in the application for ease of reference.
- That standardized default recommendations for sampling at each level were not and should be provided to users.

Science Recommendation

- The levels of fish sampling should be described in a table format where it is clearly delineated how these levels tie back to the tiers of monitoring from previous CSAS advice, what is included in each level as a default/minimum, and optional additions to monitoring depending on the objective of the sampling that may be situational. Consideration should be given to developing a flow diagram to facilitate decision-making among levels of sampling.

3.2.13. Issue of Concern – Timing of Sampling

The AHW and CC documents state "*The Survey123 application provides defaults for the timing of post-construction habitat sampling. More specifically, it specifies the season, frequency (number of times per year) and duration (how many years) of sampling for each project. …The timing of fish sampling will depend upon the species and life stages that are monitored. If there are no highly specific timing requirements (e.g., a spawning survey) it is assumed that the fish monitoring would be undertaken at the same time as the habitat monitoring.*" (AWH p. 15 and CC p. 12).

Analysis and Assessment

Timing of sampling is critical, particularly for biotic sampling, but even for habitat sampling (e.g., vegetation surveys). Inappropriate timing can affect the quality of the data; inconsistent timing can affect interannual comparability. Some habitat sampling may be best suited for high flows (e.g., river bathymetry), but most habitat sampling is best suited for low flows. Capturing seasonal variability in habitat measures is also important. The timing of fish sampling is crucial, especially for within-season and among-year comparisons of fish abundance. Abundance is affected by the emergence of young-of-year (YOY) and is much lower in spring than it is in fall in almost every temperate system, although can be variable depending on life history (e.g., spawning aggregations or migrations). Within-year comparisons are potentially highly confounded by this if it is not accounted for in the original study design (e.g., sampling too close in time, or separately accounting for YOYs in abundance estimates if they recruit to the gear between sampling events). Interannual variation would not necessarily be affected, as long as samples were taken at the same time of year/under similar conditions. Biomass is less likely to be affected by the emergence of YOY (or less strongly affected) but could certainly change seasonally with the arrival of migrants such as salmon or wetland-spawning fishes. The current timing options are very broad in Appendix D (i.e., open water, plant growing season, spawning season, other), and their delineation is not clear (e.g., what is the difference between open water and growing season?).

Science Recommendation

- Guidance on timing of both habitat and fish sampling, and how timing affects interpretation and comparison of metrics should be developed. For fluvial habitats in particular, timing of physical habitat sampling is often during low flows or differs depending on the parameter (e.g., vegetation or bathymetry). Consideration should be given to sampling across seasons to capture seasonal variability when relevant, including developing protocols for the winter (ice dynamics and cover) and transitional seasons. Timing of biological sampling should be linked to a key life process to ensure there is some connection between timing of the survey and key ecological processes. Defaults for fish monitoring should likely be as rigorous and standardized as habitat monitoring. As recommended in Section 3.2.12 (Level of Fish Sampling), collating and making available information on fish life-stage, species-specific information (e.g., spawning times, sizes, swim speeds etc., by region as needed) would facilitate prescribing the timing of sampling.

- Monitoring during winter, ice cover or transitional periods should be considered for both freshwater and marine habitats when relevant to the objectives of the project and its monitoring.

3.2.14. Issue of Concern - Targets

In AHW and CC, the documents state "*The application provides valuable guidance to DFO staff when writing conditions for Authorizations or Letters of Advice or negotiating habitat banking annexes; it encourages DFO to ensure that these documents specify the targets needed to effectively determine success and the monitoring required to determine if those targets are achieved. The targets should be achievable and measurable. Those involved in establishing targets should, however, take into account the inherent uncertainty in predicting future biological states and be appropriately flexible in how success is determined*." (AHW, p. 7-8 and CC p. 5).

Analysis and Assessment

While the setting of targets aligns with previous science advice (e.g., DFO 2012 clearly states that quantitative targets are required for effectiveness monitoring), the discussion of how to establish them needs to be expanded and made more clear. The use of the term target implies a single value (average, with or without a variance) but, in some cases, a range or multiple values may be appropriate, or perhaps the use of a benchmark (value or range) might be appropriate. Specific examples of monitoring-target flexibility should be discussed to allow for variability, uncertainty, and time lags. Furthermore, depending on the objectives of the sampling, and/or the level of certainty in the linkage between those objectives and the target, a quantitative target might not be necessary or appropriate. Uncertainty, including potential changes in future biological states, will need to be managed such that future comparison of monitoring results are meaningful. Consideration also needs to be given to standardizing targets across types of ecosystems, despite regional differences. There is potential to learn from other target setting exercises (e.g., Great Lakes Areas of Concern) to develop the prescriptive guidance needed for target setting for aquatic habitat works.

Science Recommendation

- The document needs to expand the direction given on the use of targets and how to establish them based on the objective of the monitoring program. Targets should be set based on ecological value and function of the aquatic habitat, not on how common a technique is (i.e., scoring metrics for use of wood was set low because wood is not commonly used for restoration in Canada–CC p. 23). Parameters measured should have clear links back to monitoring objectives, and there should be a discussion of the scale (temporal and spatial) at which targets are set so that the noise of fine scale variability does not detract from determining progress towards an objective.

- It is recommended that target-setting guidance be developed in conjunction with developing scoring and success criteria (see next step recommendation #3 in Section 4.0).

3.2.15. Issue of Concern - Scoring

In both the AHW and the CC documents a scoring system is presented (Section 3.3) that is intended to determine the success or failure of an aquatic habitat works project based on deviation from set targets.

Analysis and Assessment

Numerous participants expressed concern regarding the scoring system. Specific issues raised included: that the increments seemed arbitrary, that there was no upper limit allowing for a potentially undue high-rating of multiple habitat features, that evaluation of year-to-year change presents a moving target that can be difficult to evaluate, and that the scoring approach does not appear to be based on any established protocol, nor is it supported by literature. The determination of success and/or failure of a project was suggested to be within a certain percentage of a target(s), but a small percent deviation from a target was considered potentially unrealistic given natural variability in many metrics (e.g., 10% deviation from a target for benthic invertebrate metrics). This suggests a high level of project failure could result. Similarly, the issue of the level of precision possible for any particular metric and how that interfaces with the scoring system was a concern.

Science Recommendation

- While scoring of a project relative to a target is critical for evaluating its success, the scoring systems as presented is a challenge to evaluate. It is recommended that these documents focus on study design, data collection methods and metrics, and data accessibility, as per the ToR. Fully evaluating and recommending a new scoring approach is beyond the scope of this process and thus is recommended for a more detailed assessment in the future.

3.2.16. Issue of Concern – Determining Success/Failure of a Project

In AHW Section 3.3.3.3 (p. 30) and CC Section 3.3.3.2 (p. 26) there are steps outlined for determining if a feature or project was ultimately a success or failure.

Analysis and Assessment

This section is outside of scope with the intent of the documents. There was agreement that some discussion of next steps is appropriate for when measures don't work, but there may be other options possible besides those listed in these reports. Furthermore, with the recommended removal of the scoring system from this document, this final step is not possible within this process.

Science Recommendation

- Recommendation is to remove this section and replace it with a more general discussion of next steps as have been outlined at the end of this CSAS process. There was agreement that it is important to get scientific guidance on determining the success or failure of a project, which can be the focus of a future CSAS process that guides the scoring system development. This should focus on linking the monitoring design to performance outcomes, and highlights the need for SMART (specific, measurable, achievable, relevant, time bound) performance objectives in monitoring plans.

- Guidance on how to evaluate success if some of the objectives are met but others are not would be helpful, though ideally this would be anticipated and incorporated into the monitoring plans and objectives themselves. Comments made regarding the scoring system and determining success/failure of a project in these documents should be kept for consideration for future CSAS processes.

3.2.17. Issue of Concern – Training

The AHW and CC documents state "*While the Survey123 application provides clear instructions as to how the sampling and scoring should be carried out, its use requires considerable expertise in fisheries management, habitat assessment, vegetation assessment and fluvial geomorphology. This expertise is particularly important for scoring, which relies to some extent on professional judgement. It is assumed that a project proponent would access this expertise through consultants.*" (AHW p. 6 and CC p. 5).

Analysis and Assessment

While some proponents may possess the required expertise in actual monitoring techniques, few DFO staff would have the skills and experience to undertake this monitoring, and it is not likely that all (either consultants or DFO) would be familiar with Survey123 or similar/related applications. It was noted, however, that any proponents undertaking a monitoring plan for a large aquatic habitat work project would require considerable monitoring expertise, regardless of whether Survey123 is used or not.

Science Recommendation

Persons conducting the monitoring program and using data capture and management software require a considerable amount of expertise. If this expertise is not available, then training is required. Suggested types of training include, but are not limited to:

- Data management software
- File management and storage
- Biological monitoring
- Field survey techniques (i.e., topographical)
- Geomorphological monitoring
- Hydrometric monitoring
- Physico/chemical monitoring
- Meteorological monitoring

3.2.18. Issue of Concern – Table of Suggested Sampling Changes for AHW and CC

Some expert reviewers identified deficiencies in the sampling program and recommended changes or additions specific to what or how to sample.

Analysis and Assessment

The considerable number of specific items identified in the sampling protocols that were of concern to reviewers were too plentiful to list here. The level of detail required to identify both core and ancillary sampling for each tier of monitoring (i.e., conformity, functional, and effectiveness) requires more time than was available during this CSAS process. Specific suggestions or detailed sampling changes were transferred to a table and categorized (water chemistry, physical habitat, forage base, fish), but were specifically not reviewed at the meeting. Expert working groups (including: DFO Science, DFO FFHPP, consultants, academics) should be formed to further develop the specifics of the monitoring protocols and the detailed comments are to be addressed and reviewed during subsequent CSAS and technical team processes.

Science Recommendation

- Specific sampling changes captured as part of this review should be considered by the expert working groups as they develop their core and ancillary sampling for each tier of monitoring (i.e., conformity, functional, effectiveness). Specific templates and instructions will be provided to each expert working group to facilitate amalgamation and review. DFO Science should ensure some common member(s) among future monitoring science advisory work to ensure oversight and consistency.

3.3. Aquatic Habitat Works – Unique Points

3.3.1. Issue of Concern – Feature Types

In AHW, the document states "*Each modification is referred to as a* ***feature****. The features that are commonly used in habitat projects involving modifications to lakes are presented in Table 1. The features commonly used in habitat projects involving modifications to watercourses are presented in Table 2. To be comprehensive, four older and less desirable features (i.e., brush fascines, crib wall, riprap, gabion baskets) have been included. Their inclusion should not be considered as an endorsement. In fact, their use is discouraged…. . The features have been aggregated into groups, referred to as* ***feature types****, based on their fish habitat function. In addition to commonalities of function within feature types, there are commonalities with respect to how they are monitored. An "other" category is included in each feature type to allow inclusion of features that are not listed.*" (Section 2.3, p. 8).

Analysis and Assessment

There was some uncertainty with the use of the term 'feature' to describe the categories of Aquatic Habitat Works, given that the term is also often used to describe components of rivers and lakes (e.g., riffle, pool, meander, shoal, sandspit). Features listed in Tables 1 and 2 of AHW are a mix of techniques, structures, and objectives, and are not clearly linked to fish habitat function. For example, "add structure" or "increase shoreline length" describe what would be physically undertaken, but do not speak to how that additional structure or shoreline length may support a function for a specific species or life-stage. Type ii and iii listed in Table 2 ('modify to stabilize channel' and 'modify to stabilize banks) can be interpreted in diverse ways; restoring channel-forming processes (channel geomorphology) or bank functioning is the goal. The approach in general, however, has merit; by keeping the feature or action to a generalized group of techniques allows for more creativity in techniques to meet the goal that is trying to be achieved (e.g., add structure could have the goal to increase habitat complexity). While there may be commonalities in terms of how features are monitored in some cases, if the intent of the feature differs (e.g., to provide structure for spawning or cover or food base), thus the type of monitoring requested may differ, emphasizing the need to link back to fish habitat function and the species, community, or life-stage targeted. The feature types listed also exclude any mention of food resources for fish, which is also a vital aspect of fish habitat. Also, some specific features were questioned for their inclusion at all.

Science Recommendation

- The language needs to be clarified, including definitions of each and/or renaming these to characterize more accurately what function they represent. To allow for creativity in designing a solution or a feature to meet an objective, it is recommended to summarize "structures" as specific functions to meet a specific goal (e.g., add complexity may be a structure type, and any materials suitable to the waterbody and biotic objectives could be used to provide that complexity). In other words, a structure type should be explicitly linked to a specific function(s) the altered habitat will provide. Monitoring would then have to determine if that specific function (e.g., addition of complexity for fish habitat) improved habitat for various aquatic species and then was considered an effective habitat alteration.
- When categorizing function, separate categories should be included. For example, a feature category for river/stream function (e.g., diffuse energy for stability of the ecosystem) separated from its fish habitat function (e.g. cover). The objective and metrics monitored would be related to all functions. For example, if a structure was constructed for a dual purpose that included providing functional fish habitat, then biotic metrics may also be required in addition to stability metrics.
- If the technique is novel, greater intensity of sampling will be required (i.e., effectiveness monitoring). If it is well established, then functional monitoring may be adequate.
- All lake, wetland, and channel modifications listed should be examined for inclusion on the list (e.g., is there a need to remove gabion baskets or 'construct channels through wetlands'), completeness (e.g., barriers are also a habitat fragmentation concern; consider adding modifications that improve food resources for fish), and categorization (e.g., Table 2, Type ii and v have similar functions).

3.4. Channel Construction – Unique Points

3.4.1. Issue of Concern – Channel Type and Risk Level

In CC, the document states "*The application is designed to handle four different types of channels. The risk level and the characteristics of the four types of channels are outlined below."* (p. 7).

The CC document also states, "*While most parameters apply to all four types of projects, the **thermal classification** parameter applies only to type iv projects which rely on groundwater discharge." (p. 8).*

Analysis and Assessment

The four channel types described are defined by risk, yet nowhere is the risk actually defined. Risk is an ambiguous term that could refer to ecological function, infrastructure, or compliance and legal risk. The criteria for low and high risk are provided, but medium risk has no characteristics identified. There was a question about why the risk categories were not in numerical order. Criteria to define 'not significantly altered' for Type i channels are needed. Type iv channels could effectively be captured under high risk (Type ii) with thermal classification and presence of groundwater (or glacial) inputs being another factor to consider as opposed to having a separate category altogether. Understanding the physical channel form type is useful since different channel types behave differently under specific conditions or restoration approaches. Using established channel form classifications (e.g., Rosgen 1996, or other physical form types such as riffle:pool; step:pool) should be considered. Usage of the channel is also an important consideration (e.g., Indigenous harvest, cultural or ceremonial purposes, recreation, fishing, etc.), as are other risk modifiers (e.g., species at risk, specific local fisheries or habitat management objectives or plans).

There was also concern that introducing a new concept of channel classification without supporting references could conflict with existing stream classification systems (e.g., Alberta or Manitoba Stream Classification models). Regional variability across Canada was highlighted in comments such that the delineation of channel types is not appropriate nationally. For example, in Nova Scotia a 'low-risk channel' would be in a much smaller watershed (<1.0 km^2), not 10 km^2. It was also suggested that a breakdown of channel type was not necessary and that the same monitoring protocol be used for each aquatic habitat work project, regardless of channel type, since maintaining consistency removes the opportunity for bias in the data, but caution was raised in that not all channels behave the same and classifications can help determine the appropriate parameters to monitor.

Science Recommendation

- Similar to 'feature type' above, there is a need to define, clarify and provide examples of channel types. 'Risk' needs to be explicitly defined and the criteria for each category included in table format. Consider including stream type from a geomorphic condition, type by relative risk, and incorporating existing classifications and other risk modifiers. Supporting references need to be included.
- Type of Channel (e.g., Rosgen 1996 or other geomorphological bases) should be tied back to monitoring needs (i.e., tier of monitoring). The name for 'risk' level should be changed (e.g., 'Channel Risk Category') for clarity, thus linking risk level to channel type, and avoiding confusion related to risk due to other factors (e.g., impact on biota or property).
- The channel-type categories should be general enough that existing stream classifications used in other jurisdictions can be applied appropriately.
- Ensure those involved in developing channel classifications include fluvial geomorphologists and biologists.
- It would be useful to identify known highly-specialized habitat requirements as part of the previously recommended Survey123 appendix that identifies species-specific life-stage information.

3.5. Whole-Lake Construction (WLC) – Unique Points

3.5.1. Issue of Concern – Background Information

The WLC report provides background information on the *Fisheries Act* and relevant legislation related to the monitoring of offset projects, but provides minimal background related to constructing lakes as offsets.

Analysis and Assessment

In general, it was felt that this report did an excellent job of reviewing legislative context for WLC but didn't adequately describe lake construction. There was confusion as to how lakes were constructed, and the extent to which the watershed area immediately surrounding a newly-constructed lake contributes and connects to the new lake, including direct runoff which can be important to short and long-term lake ecological processes. The different options in terms of excavating a lake vs. installing a water control structure to flood existing land, or a combination of both, and some clarity on the different options would be useful for readers.

Science Recommendation

- Background should be split into a section on the legislative context and then one to briefly explain the different constructed lake types and features as are relevant to developing a standardized monitoring process.

3.5.2. Issue of Concern – Scope of Document

In WLC, the document states "*The purpose of this document is to provide a standardized monitoring approach for assessing effectiveness of large-scale lacustrine habitats that are constructed for the purpose of satisfying offsetting requirements within* Fisheries Act *Authorizations, as well as for fulfilling future offsetting obligations through the establishment of a habitat bank. ...…with offset planning beginning at the Environmental Impact Assessment stage of a proponent's project cycle. Alternatively, conservation projects include habitat construction and/or restoration of fish habitat in advance of adverse impacts to fish and fish habitat.*" (p. 7).

The WLC document further states "*Often, constructed lakes are selected as an out-of-kind approach to offsetting*." (p. 9).

Analysis and Assessment

There was confusion as to the scope of application of this manual in terms of identifying: what is 'large-scale', what constitutes lacustrine in terms of constructing connecting channels, if an Environmental Impact Assessment (EIA) is required for this document to apply, if it applies to lakes constructed only by excavation or also by other means (e.g., impoundment), how it applies to existing versus constructed lacustrine habitat (i.e., enlarging existing aquatic habitats vs. flooding non-aquatic habitat), or if it would apply to large restoration/conservation projects that are not offsets or banks as well. There was also a question related to how often WLC has been applied as an offset in Canada, and that applying a case-study approach throughout the document would provide clarity.

Science Recommendation

- With improved background, the authors should clearly delineate where this manual applies in the real-world setting.
- It would be useful to identify how often lake construction has been used as an offset (including specific number(s) and locations), and that actual examples be used to illustrate the scope and application of this manual, including how often an aquatic system is formed via other activities (e.g., aggregate extraction), and is subsequently proposed for offsetting.

3.5.3. Issue of Concern – Tiered Monitoring

The WLC document states "*This report encompasses all three levels of monitoring, the use of which are dependent on the stage of offsetting development (i.e., pre-construction, construction, and post-construction) and equivalency metric employed for determining success (i.e., habitat suitability or productive capacity). For the purposes of this report, it can be assumed that functional monitoring will be used when determining success through the application habitat suitability metrics, while direct measures of productivity (or an appropriate surrogate) will be assessed using effectiveness monitoring.*" (p. 8).

The WLC document further states "*For the purposes of this document the term 'monitoring plan' will be used regardless of the level of monitoring being conducted (i.e., compliance, functional, or effectiveness); however, the appropriate level of monitoring (Section 1.2) will be referenced when discussing specific equivalency metrics or success criteria (i.e., functional monitoring when assessing habitat suitability and effectiveness monitoring when assessing productivity).*"

Analysis and Assessment

The WLC document does a good job of linking its recommended monitoring program to previous CSAS advice and does advocate for a tiered approach to their monitoring, whereby habitat measures are identified as functional monitoring, and fish productivity measures are identified as effectiveness monitoring. However, the full details recommended for a WLC monitoring program appear to reflect complete effectiveness monitoring design. More clarity is needed in what would be monitored as solely a compliance (conformity) or functional monitoring levels when it comes to WLC. Given that effectiveness monitoring is considered particularly important for complex projects expected to have a large impact on fish and fish habitat, it was questioned if there would ever be an instance where a whole lake was constructed, and some components of the monitoring required actually stopped at compliance or functional levels.

Science Recommendation

- Whole-lake constructions are complex projects that are expected to have a large impact on fish and fish habitat, and therefore effectiveness monitoring programs should always be required. Clarity should be provided for elements of monitoring that may be considered conformity or functional monitoring. This recommendation could apply to whole or partial river/stream construction projects as well.

3.5.4. Issue of Concern – Design

The WLC document states "*Characterizing underlying physical, chemical, and biological habitat conditions (pre-development) is required when evaluating proposed locations for lake construction projects to answer two key questions:*

1. *What are the existing terrestrial and/or aquatic habitat values that may be impacted by the offset project?*
2. *Are the underlying conditions (e.g., groundwater, inlet and outlet sources) conducive to supporting the intended function of the constructed lake?"* (p. 19).

The WLC document also states "*In the case of whole lake construction projects, statistical monitoring designs such as the Before-After-Control-Impact (BACI) method are typically not used given the impacted site is not monitored after the HADD occurs (i.e., it is expected to be lost as a result of works, undertakings, or activities) and offsetting is often conducted using out-of-kind measures in a different location.*" (p. 21).

Analysis and Assessment

In general, the WLC document is lacking details about study design. Regarding the overall design, it was felt that it was important to not only survey the habitat to be affected by the constructed lake, but also to quantify the biotic community of the habitat that will be destroyed at the site of the development project to quantify what was lost as a basis for comparison to what was constructed. While a two-site BACI may not be feasible given that there may be no habitat to assess at the impact site after the works, undertakings or activities (WUAs), having data from all affected aquatic habitats either pre- or post- would improve the possible suite of comparisons.

The document describes general monitoring methods and sampling intensity well, but lacks specific details and study design, especially for habitat and fish sampling. For example, will there be a stratified sampling design scaled relative to lake size and available habitat types so that similar effort is afforded to all habitat types irrespective of lake size? This type of information is critical for fulfilling Objective 3 in this process, which states the need for standard collection practices such that a meta-analysis can be conducted across the various constructed lakes. What is important is a sound sampling design that allows one to properly assess limnological, physical and biological variables in constructed lakes through time.

Science Recommendation

- Providing a schematic of all the possible pre-, during, and post-habitats to monitor (i.e., habitat to be destroyed by both the project and the construction of the offset lake, unaltered comparator systems before and after, post-construction offset lake, etc.) would clarify the potential overall design options. Details regarding the design of the fish habitat and fish sampling are required to facilitate meta-analyses across a range of constructed lakes (including all aquatic habitat works).

3.5.5. Issue of Concern – Comparator

The WLC document states “*However, identifying a suitable comparator is often not possible as natural lakes comprised of similar physical, chemical, and biological characteristics may be limited or non-existent in the watershed, which can be a major consideration for selecting whole lake construction as an offsetting measure. …… The advantage of the normal range approach is that once the investment has been made to establish the normal range of conditions or benchmarks, project-specific monitoring need only sample the constructed lake to determine if conditions are within the range of expected values. The disadvantage is that establishing the normal range of conditions or benchmarks can be data-intensive, region or ecosystem specific, and must be completed before the monitoring design can be implemented.”* (p. 21).

The WLC document further states “*There is a disadvantage associated with using a comparator lake that should be considered. Comparing a constructed lake to local waterbodies or other lakes from further afield that are mature or in a different state of succession will find statistical differences simply due to the different morphologic, chemical, and hydrologic characteristics of the two systems…. Additionally, natural within-site variability plays a large role in defining habitat suitability.*” (WLC p. 22).

Analysis and Assessment

There were lots of questions and concerns regarding the limitations identified for the comparator system(s). It was questioned why the comparator lake must be located within the same watershed (and the need to define the scale of the watershed in the context of an appropriate comparator) given that there is much value in having long-term data from reference system(s), where possible, and this should not be narrowly defined based on geographical location. Ongoing assessment of the normal range of condition/benchmarks can begin before the offset is constructed and can continue once monitoring of the constructed feature begins. This will provide additional data on the normal range of variation with which the conditions of the offset can be compared and help to identify whether and how baselines are shifting. Capturing the natural range of variation is particularly important given that the constructed lakes are likely to have a very wide range of "normal" conditions such that the underlying variability makes it more challenging to determine effectiveness. What is important are long-term trends, not year-to-year statistical differences between a newly-constructed lake and reference system(s). The key is that the new lake and the reference system should become more similar over time.

It is unclear if it was suggested that only one comparator lake would be used. Replication was mentioned, but it is unclear whether this was within-comparator replication or replication of comparators. Having multiple comparator lakes (e.g., n = 4 or 5) would help to address many of the concerns identified. If the comparator lakes all vary together, and the offset lake is the outlier, then differences can be attributed to the offset. In contrast, if all lakes including the offset vary considerably, and the variation in the offset lake is within the normal range of variation observed among the comparators, then differences can be attributed to natural variation. This is a standard design in BACI experiments (Underwood 1994).

It was also suggested that the design used by Ruppert et al. (2018) who assessed the first compensation (offset) lake in the oil sands region in Alberta is worth referencing and discussing here. In contrast with statements made in the report that inherent ecosystem variability makes comparisons among sites difficult, and the discussion of the normal range approach, Ruppert et al. (2018) provided a community ecology approach for comparing the constructed lake to natural lakes in the region using existing data, minimizing the need for extensive field work at comparator systems. Careful consideration needs to be given to comparability of data and parameters used among studies.

Science Recommendation

- For WLC offsets, the incorporation of a minimum of one, but ideally more, comparator lake(s) monitored before, during and after the lake construction is critical to assessing if the constructed system is approaching the conditions and variability of natural systems. The same metrics and effort should be sampled at both the comparator and constructed system.
- Similarly, pre-construction monitoring of the habitat(s) to be destroyed would be important to validate equivalency of the offset system(s).
- The design of Ruppert et al. (2018) (i.e., capturing range of natural variability in multiple lakes in the region, using largely existing data when available) should be explored as a potential way to minimize the intensity of sampling required to obtain adequate comparator data. Using existing regional monitoring databases (e.g., oil sands monitoring databases) could facilitate such comparisons. A hybrid approach between using existing data or normal-ranges and collection of new monitoring data is also an option.
- Consideration should be given to the likelihood that local comparator lakes would be less productive by nature than a constructed lake, at least in the first few decades post-construction, and that expectations for their succession are different than what would exist in regional lakes.
- Consideration should also be given to frequency of sampling at newly constructed systems vs. comparators since the latter may not require as frequent effort to capture variability as a newly constructed system.

3.5.6. Issue of Concern – Data Standardization and Accessibility

In WLC the document states "*It is important to note that there are numerous site-specific factors that can affect biological colonization and stabilization (Thornton et al. 1990), including watershed position (species access through connection to other waterbodies), surficial geology, lake level fluctuation, shoreline stability, water and sediment quality, and fish habitat enhancements.*" (p. 10).

The WLC document further states "*The following sections provide standardized monitoring endpoints and metrics required to assess effectiveness of lake offsetting projects; however, a number of considerations will require some flexibility in the selection of appropriate site-specific endpoints (e.g., geographical setting of the lake, traditional knowledge and Indigenous peoples considerations, and selected equivalency metrics) while other endpoints will require more rigidity in design and should be standardized across projects.*" (p. 23).

In addition, the WLC document states regarding Year 3 of sampling: "*Fish population surveys are expected to include a greater level of effort, incorporating methods to provide data that are directly comparable to any HSI focused studies that were undertaken to characterize pre-disturbance aquatic habitat.*" (HSI = Habitat Suitability Index, p. 36).

Analysis and Assessment

While there was agreement that some factors would necessarily be site-specific, it was emphasised that it was important to standardize metrics across sites, habitats, and features to gain understanding of the factors that contribute to success of lake construction as offsetting or aquatic habitat works more broadly. Given that the design of the lake and its bathymetry will vary from project to project, it was considered important to standardize the locations of sampling by both transect as well as by feature, with a specific method of determining number of samples to provide good estimates. Fish sampling should be standardized based on system type and use newer, nonlethal methods when possible. Ultimately, there would be more statistical power if monitoring was standardized across projects as much as possible, with custom adaptations kept to a minimum as needed. While it would be helpful to expand on how site-specific factors can affect biological colonization and stabilization in this document, it was also recognized that over time, the collection of comparable data would allow for more understanding of how site-specific factors affect these processes. The principles of meta-analyses as described above for AHW and CC also apply here.

Science Recommendation

- A set of core standard monitoring techniques for habitat and fish parameters that can be adopted across differently constructed systems needs to be compiled, including standardizing intensity of sampling depending on system size and feature characteristics (including standard transects and points for sampling multiple metrics).
- All data from these sampling plans should be standardized as much as possible, and data need to be provided in electronic format. The steps for data security, data QA/QC, data standards that are developed from these recommendations should be common across all monitoring programs.
- Data entered into the database should be documented and vetted before it is entered into the database.
- Consideration needs to be given to the use of appropriate data/geospatial software (e.g., Survey 123) across monitoring programs to the extent possible, and as is reasonable, to encourage standardization.
- Consideration should be given to the type/level of data uploaded into the database (e.g., raw data vs. calibrated and processed) and certain data types (continuous, discrete), standard units, etc.
- The database should conform to FAIR principles (Findability, Accessibility, Interoperability, and Reuse).

- As with AHW and CC above, principles of meta-analyses should be outlined in this document, and criteria for combining data from different projects into common analyses need to be outlined (e.g., see Arnqvist and Wooster 1995, Harrison 2011).
- There should be a hierarchy of approaches provided that stress maintaining consistency when feasible. A theoretical example could be included for clarity.

3.5.7. Issue of Concern – Sampling Frequency and Duration

Regarding the flooding of Lake Diefenbaker, the WLC document states *"…experienced three trophic periods, including an initial 4-year period of eutrophication, a decade of mesotrophy, and a gradual shift to a steady state of equilibrium (Hall et al. 1999). Productivity will decline above-natural to near natural conditions 10 to 20 years after flooding, when the store of nutrients…"* (p. 16).

Additional timelines are suggested in WLC, Table 1: Suggested target timelines for the establishment of various ecosystem components of constructed lakes (p. 17).

Furthermore, in WLC the document states **After Year 5** "*surveillance monitoring is the next step for long-term management to ensure the lake is stable, self-sustaining, and providing the offsets predicted in the offsetting plan (or reaching targets of a conservation project as part of a habitat banking agreement). The surveillance monitoring approach will ensure that data are collected at an appropriate frequency and resolution to make informed management decisions, while less informative tasks are identified and reduced in frequency or discontinued.*" (p. 33)

Analysis and Assessment

The document provides some suggestions for sampling frequency and duration, but these suggestions don't reconcile with what is known about the time it takes for newly flooded systems to reach an equilibrium. Table 1 represents the time estimates for establishment of each component to a self-sustaining level, but no references are used to support these timelines, or to clarify how 'self-sustaining' is different from system stability or equilibrium. The suggested maximum duration of intensive sampling is 5 years, with reduced surveillance monitoring thereafter conflicts with the stages of succession highlighted in the same document. System stability will take longer than 5 years and should be tied to the life cycle of the target fish species. The timeline set for sportfish is between 10-15 years, but this would be for the natural (colonized) wild populations. Should stocking of the lake be conducted, the impact of the stocked fish on establishment of wild fish would need to be accounted for, and could affect the timeline.

There is no consideration of timeline for monitoring the establishment of the riparian zone, which is known to provide important fish habitat function such as filtration, erosion protection and shading. No details are provided regarding sampling components, frequency, and duration of surveillance monitoring (after year 5). Since aquatic habitat works are designed to be self-sustaining, proponents are required to ensure they are functioning for the life of the project, and remedial action may be required beyond the 5-year, initial monitoring period.

Science Recommendation

- The duration of 5 years of intensive monitoring is too short when considering WLC. Duration should be tied to the life cycle of the target species and be connected to the literature documenting the trajectory of constructed aquatic systems. Impact of stocked fish needs to be considered. A target timeline for the establishment of riparian zones should be included, based on succession phase. Standards need to be provided regarding the expected intensity and duration of long-term monitoring to ensure ongoing function of the system (beyond regulatory sign-off).

- Need to consider setting sampling duration standards for all categories of works.
- Duration and intensity should be tied to tier of monitoring, which should reflect the level of uncertainty and impact of the project. For construction of aquatic systems (channels, lakes, saltmarshes) longer than 5 years is typically required across regions.
- For constructed channels, bankfull flows are required to ensure stability, and therefore in years without such flows, stability is not yet tested. 'Futureproofing' against climate change impacts by ensuring a well-designed floodplain is important, and appropriate expertise in habitat construction is needed. Monitoring the floodplain should be part of the design.
- Sampling frequency should be higher when variability and/or uncertainty are high; frequency can be reduced as variability and uncertainty are reduced.
- Contingency sampling may need to be considered whereby frequency and intensity are revisited under major event/failure-repair scenarios.

3.5.8. Issue of Concern – Figure 1, Conceptual Model

There were concerns regarding Figure 1 in WLC, the conceptual model for assessing the progression of lake construction projects. (p. 15).

This figure is further cited later in the WLC document: "*If key ecological benchmarks have been met after the first five years of monitoring, as determined using the model for assessing the progression of lake construction projects (Figure 1) and the key success criteria scoring system described in the Assessment of Conformance section of this document (Section 4.0), surveillance monitoring is the next step for long-term management to ensure the lake is stable, self-sustaining, and providing the offsets predicted in the offsetting plan (or reaching targets of a conservation project as part of a habitat banking agreement).*" (p. 33).

Analysis and Assessment

Concerns were raised regarding the conceptual model and the lack of specificity in the decision points. For example, it would be a challenge for any waterbody to have an absence of zooplankton, phytoplankton or benthic invertebrates, yet their simple presence doesn't mean these essential components of an ecosystem are well-established, functional, and able to support higher trophic levels. There is also a lack of any measure of component interactions, demonstrating a functioning ecosystem, and no feedback link from the surveillance or long-term monitoring box back into the process. It is not clear how this diagram provides ecological benchmarks and how this compares to regional benchmarks mentioned elsewhere in the document.

In addition, each of the interventions on the right-hand side (aside from water quality) involves introducing organisms, presumably based on the assumption that the organisms would colonize naturally but did not, or that initial stocking attempts failed. In either case, the cause of the failure should be investigated. If it was simply a lack of propagules, then the proposed intervention makes sense. However, if colonization or establishment failed, it may be because biotic or abiotic conditions precluded this, and those deficiencies should be investigated, identified, and rectified before further stocking occurs.

Science Recommendation

- Written comments included suggestions such as tying the decision points along the left side of the flow chart to include biomass or other metrics, not just presence/absence. Some measure of system component interactions should be incorporated (e.g., food web interactions via stable isotopes). Include a feedback link from the surveillance monitoring box (after changing the name to long-term monitoring) back into the process. Include investigation of the cause of failure of colonization to ensure that further stocking/seeding attempts are successful/warranted.
- A detailed discussion of the conceptual model did not occur at the meeting. It was determined that fine-tuning this model would be left to future steps in the development of this standardized monitoring program. Suggestions for improvement were retained for future consideration as needed.
- It was suggested that the technical committee handling WLC could revisit this model and consider metrics needed to establish ‘success’ of a WLC, which should be tied to the objective of the altered system, including if it is functioning effectively.
- Core needs to track over time and what to compare the WLC measures to are key. Similar concerns arise with any unique system (e.g., constructed wetlands, large rivers).

3.5.9. Issue of Concern – Targets

The WLC document states “*Although performance targets should be set during the design and planning phase (e.g., modeled predictions for water quality or percent littoral zone cover of macrophytes), success cannot be defined as some point where an offset habitat reaches a pre-defined statistical state for biota or other physical or chemical characteristics, because differences from the predictions do not necessarily mean that the offsetting requirements are not achievable. Therefore, evaluation of constructed habitat progression will entail significant professional judgment and a weight-of-evidence approach when assessing fish habitat requirements and biotic responses. Offset habitats will evolve to their own unique dynamic equilibrium state and the monitoring design should be developed to identify ranges of success criteria whereby a safe operating space (e.g., water quality guidelines for the protection of aquatic life) defines thresholds where intervention through adaptive management is required (Carpenter et al. 2017)*.” (p. 14).

Analysis and Assessment

More guidance needs to be provided on how to set the ranges of success criteria or targets, based on the objectives of the offset lake. Metrics to be sampled are identified as ‘endpoints’, yet no actual endpoints are identified. Benchmarking or incorporating a normal-range approach (discussed above under ‘Comparator’) might be an option. The use of power analysis should be considered. Similar to the discussion of guidance for setting targets for the AHW and CC documents above, examples of monitoring target flexibility for future acceptable states (i.e., incorporating uncertainty and time lags), and considering how to standardize targets across regions are necessary. There was concern regarding the idea that differences from predictions did not imply lack of success and that this needed clarification. There is potential to learn from other target-setting exercises (e.g., Great Lakes Areas of Concern) to develop the guidance needed for target setting for all aquatic habitat works.

Science Recommendation

- The document needs to expand the direction regarding the use of targets and how to establish them based on the objective of the monitoring program. Target setting guidance should be similar across monitoring protocol documents.
- It is recommended that target setting guidance be developed in conjunction with developing scoring and success criteria (see next step recommendation #3 in section 4.0).

3.5.10. Issue of Concern – Equivalency and HSI Models

There were numerous references in the WLC document to using Habitat Suitability Index (HSI) modelling, and how to establish equivalency between what is lost and what is gained in a whole-lake offsetting project. The quotes of relevance are as follows:

- “Offsetting is generally provided in one of two “currencies”, either in habitat units as defined in the Habitat Evaluation Procedure developed by the United States Fish and Wildlife Service (USFWS 1980) or in production and measured in units of biomass by area and time. Other offsetting currencies such as ‘equivalent adult units’ (DFO 2015 and Randall et al 2017) or approaches like chemical and biological manipulations or complementary measures (e.g., scientific research) may be considered but are less common.” (p. 8).
- “... however, the use of HSI models requires periodic refinement and validation, ... (p. 10).
- “HSI modeling has been selected as a common tool for comparing habitat losses and gains as a surrogate for productivity in these two habitat types. Accordingly, a great deal of baseline characterization has focused on using HSI models to evaluate stream habitats, particularly those slated for development.” (p. 11).
- “As previously discussed, HSI modeling is a common tool for comparing productivity in these two habitat types and uncertainty is reduced by establishing clearly articulated criteria for measuring success (i.e., equivalency metrics) with benchmarks and timelines for measuring progress.” (WLC p. 13).
- “Characterizing aquatic and terrestrial biota within underlying habitat and the surrounding area is essential for the development of an offsetting plan.” (WLC, p. 21).
- ... “using fish population and biomass data from monitoring to verify HSI models.” (WLC, p. 27).

Analysis and Assessment

There needs to be some clarity in the document as to how the Habitat Evaluation Procedure (HEP), originally developed by the U.S. Fish and Wildlife Service (USFWS 1981) in the late 1970s and early 1980s, has been updated, adapted, and used to calculate habitat units between fluvial and lacustrine habitats. There may be other modeling techniques or geospatial decision-support tools that have value and could be explored (e.g., Habitat Suitability Index (HSI) modelling approaches (USFWS 1981), a Habitat Suitability Matrix (HSM) model approach (Minns et al. 2001), web-based decision support tools/software for habitat assessment and/or visualization (e.g., HEAT (Lake Habitat/Ecosystem Assessment Tool), and integration use of geospatial decision-support system, Geographical Information Systems (GIS), remote sensing, and spatial habitat mapping/graphs to assist in implementing decision-making frameworks/strategies). Variables measured in the field that can be used to evaluate engineering drawings (post construction of the offset) are needed. HSI modelling is mentioned often, but not how habitat suitability is converted into habitat units for the purposes of DFO offsetting. While a detailed description is beyond the scope of these reports, there needs to be a brief introduction to the method, plus more guidance, including references, as to how available habitats are modeled to transfer habitat units between lentic and lotic systems in the case of WLC, because this speaks to data needs. It was also unclear how using fish population and biomass data from monitoring can verify HSI models (clarify the need for localized habitat:fish population relationships), how habitat units (lost and gained) are incorporated, and if it is assumed that habitat units have a consistent relationship to carrying capacity.

The two main equivalency currencies identified (HEP and fish production) are predominantly used by DFO, but others are possible, particularly to assess offsetting needs for the death of fish (e.g., biomass + production foregone, Habitat Productivity Index, Population models, DFO 2022). Even though these monitoring protocols are being developed to address a harmful alteration, disruption, or destruction (HADD) of fish habitat and not to account for the death of fish, it was felt that solely relying on HEP-type modelling was not enough, and that there should be some evidence that the offset is functioning to replace what was lost, including measures of fish to validate the habitat modeling.

Finally, presumably stream habitat is lost for both the WUA in question and for the area to be occupied by the constructed lake, so both of these lost habitats need to be considered in equivalency calculations, thus requiring monitoring at multiple sites. Consideration also needs to be given to the fact that lake and fluvial habitats are generally not mutually exclusive but connected to provide the entire lifecycle the necessary habitats for population production for those species that require it. In addition, both habitat and fish responses evolve over time after offset construction, but often not at the same rate or time, so these temporal aspects need to be considered in monitoring timelines.

Science Recommendation

- The discussion of how to establish equivalency needs to be expanded, potentially with a case-study example to demonstrate how this can be done, particularly when comparing lentic and lotic systems. However, this description should be kept brief and focused on how it is relevant to monitoring.
- The difference between habitat suitability (largely reflecting use) and habitat units (reflecting suitable area) needs to be clarified. In the calculation of the HADD, productivity or biomass is typically not used, whereas presence/absence/relative abundance and historical distribution of fish are often used. Habitat and fish metrics included in the models define the sampling that is required.
- In the case of WLC, habitat modelling techniques and/or geospatial decision-support tools are considered valuable to test scenarios of habitat-site suitability, predict limiting factors, or to direct monitoring designs to help provide information within a decision-making framework.
- When using a habitat-based modeling approaches for a large-scale lake construction project, measures of that habitat function and effectiveness (i.e., measures of fish) are required to validate the approach. However, no uniform standards exist for the data collection, calibration, and validation of the models. Furthermore, while some validation could be addressed with proponent-led monitoring, some may be more of a science-monitoring activity. A protocol was developed by Hatfield Consultants and Ecofish Research (2018) and should be explored as a potential starting point.

3.5.11. Issue of Concern – Adaptive Management

The WLC document states "*Offset habitats will evolve to their own unique dynamic equilibrium state and the monitoring design should be developed to identify ranges of success criteria whereby a safe operating space (e.g., water quality guidelines for the protection of aquatic life) defines thresholds where intervention through adaptive management is required (Carpenter et al. 2017)*." (p. 14).

The WLC document also states "*If the various offsetting targets are not met in the prescribed time frames, the proponent should work with DFO to determine whether any intervention may be warranted. Intervention may not always be desirable or even possible, depending on the situation*." (p. 17).

In Section 3.0 (Adaptive Management) in the WLC document, it states "*Alternatively, contingency measures may need to be considered*." (p. 27).

Analysis and Assessment

The term 'adaptive management' technically means scientific process of implementing management interventions as formal experiments (see Walters and Hilborn 1978, McLain and Lee 1996, Williams 2011), but in this document it is being used to refer to when additional interventions are required in response to a failure or shortfall. While it is possible to develop adaptive management experiments to evaluate the effects of various interventions, simply adjusting interventions as needed over time, or implementing additional aquatic habitat works or other measures, is not adaptive management. A list of possible ongoing interventions is provided that coincides with Figure 1, but then 'contingency measures' are mentioned as an alternative that may need to be considered, without clarifying what these contingency measures might be. It should be noted that 'active management' options or ongoing interventions may need to occur beyond the initial 5-year monitoring period, but this is not 'adaptive management'.

Science Recommendation

- Clarify terminology to reflect that what is proposed is not formal adaptive management as defined in the scientific literature. This term is frequently and erroneously used and understood by management (e.g., in formal Impact Assessment processes, DFO's offsetting policy as outlined in DFO 2019b) as describing the ongoing improvement of individual environmental management actions by evaluating their outcomes and identifying or implementing new or modified measures to improve project outcomes. Appropriate terminology should be used for this management approach such as ongoing interventions or active management. A specific term and definition should be proposed and considered during the recommended next steps as described in the conclusion section of this Science Response Report.
- Provide some examples as to what 'contingency measures' might be appropriate if colonization does not occur as expected, even with the additional interventions identified.

3.5.12. Issue of Concern – Determining Success/Failure of a Project

The WLC document states "*Success criteria will be determined by the overarching objectives of the lake as described in the Offsetting Plan and informed by DFO guiding principles (Section 2.1). Offsetting objectives and success criteria will need to be clearly articulated in the monitoring plan. Once approved, the monitoring plan will be embedded as terms and conditions in the* Fisheries Act *Authorization, including a conformance reporting schedule*" (p. 38).

Analysis and Assessment

No details were given regarding the scoring threshold system to be used to determine such success criteria or how are objectives and criteria are related. Establishing the ultimate success or failure of a project is beyond the scope of the ToR for this process, which needs to focus on establishing clear guidance for the standardized setting of objectives, design, metrics, methods, data quality, security, and accessibility for future learning.

Science Recommendation

- Similar to the AHW and CC documents, the recommendation is to provide a general discussion of next steps as are determined at the end of this CSAS process. There was agreement that it was important to get scientific guidance on determining the success or failure of a project, but that can be the focus of the future process that will help guide the scoring system. This should focus on linking the measured data to performance outcomes and highlights the need for SMART performance objectives in monitoring plans. Guidance on how to evaluate success if some of the objectives are met and not others would be helpful, though ideally this would be anticipated and incorporated into the monitoring plans and objectives themselves.

3.5.13. Issue of Concern – Weight-of-Evidence Approach

The WLC document states "Annual reports should incorporate a weight-of-evidence (WOE) approach, considering multi-disciplinary conclusions rather than a specific line of evidence when evaluating success criteria or areas of poor performance that require intervention. If the WOE approach identifies a limiting variable (e.g., absence of young-of-year fish) then specific functional monitoring of that variable (e.g., spawning habitat) will be initiated as part of the adaptive management process. T*he WOE ecosystem-based approach allows for latitude in the monitoring plan, whereby more intensive habitat-specific functional or effectiveness monitoring can be initiated as needed*." (S. 4.1.1, p. 38).

Table 4 in the WLC document is also relevant to the discussion of the weight-of-evidence approach (p. 39).

Analysis and Assessment

Given that this process will not proceed to the step of ultimately determining success/failure of a project, the adjustment of this section is not required for this report. However, for the sake of future processes, there were deficiencies identified in the suggested process. Specifically, a 'weight-of-evidence approach' typically involves evaluating and weighting all evidence considered relevant to the process. In this case, it is not clear if the expectation is that all criteria are weighted equally or if some would be considered more important than others, and thus weighted more heavily in the consideration of all evidence. What is outlined in this report is more of a multiple line of evidence approach that could be weighted given more guidance. The mention of a 'limiting variable' needs further elaboration and discussion. Table 4 was considered a clear way to capture metrics to be used in evaluations, but the method on how to combine the information is required. It was suggested that a Great Lakes Area of Concern (AOC) approach could be a useful example (Doka et al 2018, Barnes et al 2020, Midwood et al. 2022) among others internationally (Woodward and Hollar 2011, Campanaro et al 2019).

Science Recommendation

- It is beyond the scope of this CSAS process to evaluate and establish success criteria and how to ultimately determine the status of the constructed lake in terms of being a success or failure. However, recommendations included because of these reviews should be carried through to future CSAS processes that will establish a framework and evaluation system for how to determine the success/failure of an aquatic habitat works project.

3.5.14. Issue of Concern – Table of Suggested Sampling Changes WLC

Some expert reviewers identified deficiencies in the sampling program and recommended changes or additions specific to what or how to sample.

Analysis and Assessment

The considerable number of specific items identified in the sampling protocols that were of concern to reviewers were too plentiful to list here. The level of detail required to identify both core and ancillary sampling for each tier of monitoring (i.e., conformity, functional, and effectiveness) requires more time than was available during this CSAS process. Specific suggestions or detailed sampling changes were transferred to a table and categorized (water chemistry, physical habitat, forage base, fish), but were specifically not reviewed at the meeting. Expert working groups (including: DFO Science, DFO FFHPP, consultants, academics) will be formed to further develop the specifics of the monitoring protocols and the detailed comments are to be addressed and reviewed during subsequent CSAS or technical team processes.

Science Recommendation

- Specific sampling changes captured as part of this review will be considered by the expert working groups as they develop their core and ancillary sampling for each tier of monitoring (i.e., conformity, functional, effectiveness). Specific templates and instructions will be provided to each expert working group to facilitate amalgamation and review. DFO Science should ensure some common member(s) among future monitoring science advisory work to ensure oversight and consistency.

3.6. Other Considerations

- All monitoring protocols focused on sampling in freshwater environments, but a similar exercise could be focused on marine environments, especially where habitat changes come under DFO's purview. Many habitat and biotic sampling methods should be similar across systems, but customizations will be needed, as with wetland, lentic and lotic systems.
- There is a need to ensure that requirements for different types of projects use consistent criteria if possible (e.g., offsetting can have different tiers of monitoring whereas for habitat banking, monitoring at the effectiveness level has typically been required), as is recommended in previous DFO monitoring guidance documents (e.g., DFO 2012, 2019, 2020, Smokorowski et al. 2015). It was noted that tiers of monitoring should depend on the scale and uncertainty as to the benefit of the action for fish and fish habitat, not whether the aquatic habitat work is completed before or after the impact.
- Qualified experts from various fields should be considered in developing the standardized monitoring protocols including fluvial geomorphology, engineering, and habitat construction and design, in addition to biological.
- Knowledge of past successes and failures are equally important and can provide good learning opportunities. Provision of monitoring data is important but making project reports also more widely accessible (e.g., in a registry) could also be highly informative.

- There is a need for dedicated assessors to examine the effectiveness of offsetting, banking, enhancements and restoration efforts, both past and in the future as a result of the data arising from this standardized monitoring approach.
- Consideration should be given to the ecological costs of monitoring (i.e., lethal or sub-lethal effects), particularly for sensitive populations or systems (e.g., species-at-risk or of concern, Arctic systems), or constructed ecosystems with populations and communities still in the establishment phase.
- Consideration needs to be given to monitoring invasive species, and when relevant, to monitoring fish suitability for consumption, during the development of this standardized monitoring system.
- It should be noted that even if two projects are conducted in the exact same manner, that the outcome may be different, and this should be considered in the success/failure assessment.
- Indigenous and other non-government groups are conducting ecological monitoring and could inform the development of standardized monitoring protocols so that future data sets may be comparable and broadly usable. A collaborative approach could enhance the ability to set and meet the objectives of monitoring and inform future effectiveness and/or trend analysis.
- DFO has a duty to consult when contemplating decisions that may adversely impact potential or established Aboriginal or Treaty rights. This includes Authorizations requiring the implementation of standardized monitoring requirements issued under the *Fisheries Act* and *Species at Risk Act*. Indigenous communities will be consulted on a project-by-project basis, which would include review of standardized monitoring required for each project.

3.7. Sources of Uncertainty

- In any monitoring program, it is important to have a comparator to the project site, whether it be a reference condition, before (pre-modification) sampling, control site(s) sampling, or regional benchmark. These different comparators are often collectively referred to as the 'baseline' or target against which the project may be deemed a success or failure. 'Shifting baselines' is a term used to describe when changes occur in the comparator due to broader influences such as a changing climate or other human pressures that result in the 'unimpacted' site shifting what is considered 'normal' for an area. A continually degrading comparator represents a lower reference bar, possibly resulting in a false declaration of success (or vice versa), because success is judged relative to the comparator. Changing or inappropriate baselines can therefore impart uncertainty in judging the effectiveness of the aquatic habitat works.
- Single (unreplicated) comparators can also impart uncertainty because it is unclear whether differences are caused by unmeasured differences between locations (a single control site) or changing conditions over time (a single "before" sample; Hurlbert 1984).
- There is uncertainty in long- and short-term variability in habitats. For example, not all systems will necessarily follow the same trajectory to a projected state, even if they started from a similar, newly constructed state. In addition, some endpoints are more inherently variable, and could be driven by external factors that need to be considered (e.g., weather and climate).

- There will be time lags for any new construction to establish ecologically, both in terms of the time between the HADD and the habitat construction, and the fact that new aquatic habitat takes time to reach dynamic equilibrium.
- Establishing equivalency to determine the offset requirements requires modelling or making assumptions, and there is always uncertainty in projecting future or desired biological states. This is called structural or process uncertainty; to reduce this uncertainty, proximal and generic predictions are better than distal and specific. For example, habitat (proximal) predictions are more certain than productivity (distal), and guild or life stage responses are often more certain than species-specific responses.
- Uncertainty should be considered when setting bounds around scoring and success criteria – the greater the uncertainty, the more flexibility may be required for meeting criteria ranges.
- In some instances, there will be a requirement to replace stream habitat for lake habitat, and these two types of systems often support different species or life-stages and have different rates of fish productivity. Using any type of modelling for equivalency requires ongoing validation, and the data collected via monitoring could be used for this purpose.
- Broadscale monitoring data could be used for multiple purposes such as future metanalysis or informing variance and baseline target expectations for other regional or ongoing monitoring programs.
- Uncertainty can be reduced by establishing regional and habitat-based benchmarks, and appropriate timelines for measuring progress (i.e., some projects will take longer to equilibrate, and some will be in more dynamic environments that require resilience to persist).
- Limitations of sampling precision and thus the ability to detect differences exist and can be a particular challenge for some metrics (e.g., fish population dynamics). Uncertainty inherent in measuring ecological systems, such as errors in measurement (precision and accuracy) or natural variability of indicators being measured, needs to be considered throughout the processes. These sources of uncertainty can be mitigated with sufficient sample size, which also allows for uncertainty to be estimated but also needs context and achievability. This should be considered when developing sample size recommendations for standardized monitoring protocols, for both the number of true independent samples and subreplicates.
- Uncertainty exists due to the partial observability of systems in time and space (i.e., complete temporal and spatial coverage of a system is not possible), resulting in sampling bias that is unequal among systems. The selection of gear or technique also influences the spatial and temporal coverage, and therefore can influence this bias. Standardizing techniques, using multiple gears, sufficient timing and spatial coverage can reduce this uncertainty.
- Confounding factors can cause additional uncertainty in terms of linking the effect to the management action or to something else that may be happening that affects the endpoint (e.g., environmental or climatic variation or a major catastrophic event).
- Uncertainty exists in the implementation of management actions (i.e., partial controllability). Structural and process uncertainty, specifically, uncertainty in implementation, construction, avoidance and mitigation etc., relating to the uncertainty we have in control measures. Controllability is linked to the difficulty of the project type (e.g., wetland versus shoal) and size (e.g., shoal versus large dam).

- There can be an inability to sample in certain situations (e.g., when ice is involved or other hazardous conditions), which can lead to higher uncertainty in expected and actual responses during those times and in those places. Remote techniques (e.g., telemetry, photogrammetry, remote sensing, loggers) should be explored but all methods have pros and cons and different precision, etc. Promoting some redundancy, validation, and multiple techniques helps reduce uncertainty in space and time.
- Uncertainty exists regarding the expertise of those implementing a robust monitoring plan and in their ability to do so correctly. This can be mitigated by ensuring training, professional certification, expertise, and experience.
- Methodologies for important core metrics should be standardized but updated with new advancements/recommendations to allow for consistency across projects and over time, and harmonization with broadscale monitoring techniques and approaches.

Conclusions

Overall, the consensus from reviewers was that the three contracted documents, which contained proposed standardized monitoring protocols for lake construction, channel construction, and aquatic habitat works, provided a good foundation for achieving DFO FFHPP Ontario and Prairie region’s ultimate objective, which is to produce standardized monitoring protocols for use at all offsetting, habitat banking, enhancement, or restoration projects required or supported by DFO. All three contracted documents were much more prescriptive than past DFO and other monitoring science advice, and this level of detail is required to operationalize a scientifically-sound, standardized monitoring program. Achieving this ultimate objective could transform the way data are both collected and used in Canada, allowing for greater opportunities for learning from the multitude of resource management decisions made each year that affect Canada’s aquatic resources.

However, this peer-review identified a large number of issues and concerns such as: a) lack of clarity regarding the scope and application of the protocols, b) lack of consistency among protocols and with past science monitoring advice, c) lack of prescriptive advice related to study design or appropriate comparators, d) lack of clarity on recommended tiered sampling, how tiers are defined quantitatively, and what is included in each tier, e) lack of clarity in terms of setting targets and disagreement with proposed scoring and success criteria, and f) lack of prescriptive sampling specifics that would ultimately lead to a lack of standardization. There were also many concerns raised regarding the sampling specifics that were recommended in the documents, namely the narrow focus of sampling for some project types, lack of incorporation of modern sampling techniques, and lack of adequately prescribed spatial and temporal coverage to achieve standardization. Based on these findings, it is recommended that a more stepwise and iterative approach be taken to complete the standardized monitoring protocols.

The following steps are recommended as one potential iterative approach that could be taken and should be subject of future CSAS scientific peer-review:

1. Develop one overarching, higher-level framework document to guide the standard development of specific monitoring protocols. This higher-level framework, based on the recommendations of this Science Response Report, would guide monitoring conducted or required by the Department going forward, and help ensure that consistent decisions were made regarding:

a. the level or tier of monitoring to be undertaken depending on project type, with examples;

b. establishing sound study design options and recommendations;

c. selection of appropriate comparator(s);

d. the process by which indicators are selected and how they are to be measured (e.g., process, tools, units).

e. establishing scientific targets appropriate to system type, region, and data type;

f. provide guidance for stratifying effort by system type and size (e.g., sample size, and how to select sampling locations or distribute them spatially and across habitat features (e.g., pelagic versus littoral habitats)); and,

g. the use of vetted custom-designed software application(s) (such as Survey123) for data collection, long-term storage, and management.

h. Provide guidance on how those applying the protocols should be trained and how data quality should be reviewed.

   As part of the production of the overall framework, it is recommended that templates be developed (e.g., common headings and outlines) for the standard development of the specific, tiered, monitoring protocols that comprise the next step of this iterative process.

2. Using the higher-level framework and the templates developed in the previous step, develop individual monitoring protocols covering the specific prescriptions for monitoring different projects for conformity, function, or effectiveness to their intended purpose. These could be effectively developed through ecosystem component (e.g., water/sediment quality, physical habitat, lower trophic levels, and fish) specific expert working groups. The specific protocols should outline core monitoring components for each level of monitoring by system type, region, and project type, identify ancillary data likely to benefit analyses, and any specialized data requirements for unique situations. Working groups should consider provincial protocols and any other relevant protocols (e.g., those developed for monitoring Species at Risk), or other well-established global protocols. To this end, all specific, technical sampling concerns and recommendations identified from the review of the original three contracted protocols from this Science Response process have been retained to be considered by relevant working groups as appropriate.

3. The final recommended step in establishing a standardized monitoring framework and protocol is the development of a system to score outcomes and establish criteria to determine the level of success of a project, including unintended results. While all three original, contracted protocols included potential methods for scoring and success criteria, many concerns were raised by reviewers in this Science Response process. Given that this final, but important, step in understanding the outcome of Departmental decisions was not part of the original objectives for this Science Response process, all comments related to these sections of the reports were captured, complied, and retained but were not considered in this Science Response Report, but should be considered in future work as appropriate. Since developing success criteria depends on targets (e.g., deviation from fixed value, outside of bound range, etc.), target setting guidance should be developed in tandem with developing scoring and success criteria.

To support the development of steps listed above, it is also recommended that the following be considered:

1. A thorough review of the software application be conducted (by software, statistical and database design experts), including:
   a. Consideration of license issues and ability for widespread use by the Department and a range of proponents;
   b. Assessing its ease of use and set-up for data capture;
   c. Investing in database design and structure to allow for data extraction and data security;
   d. Data management is a large and costly undertaking and needs to be carefully considered;
   e. Server capacity needs to be considered in the case of ‘big data’ for ‘future proofing’ (eDNA, telemetry, remote sensing, loggers etc.). Consider using lessons-learned from existing systems (e.g., Ocean Tracking Network [OTN], Great Lakes Acoustic Telemetry Observation System [GLATOS]);
   f. The creation of a generic data format (not specific to Survey123) that could be uploaded to DFO for analysis and interpretation using our chosen software (data universality) would be useful. An interface to store the data is critical for this option;
   g. Data uploading framework, accessibility and appropriate meta-data must be kept at the forefront;
   h. Consideration of practical field data upload options; and,
   i. Clarifying QA/QC steps required prior to data use, including the incorporation of post-field data collection and capture.

   There was widespread agreement that using a software application with the abilities of Survey123 was critical for the ultimate secure, long-time storage and maximal use of the data produced by monitoring programs. Moving beyond examining monitoring data project-by-project, future meta-analyses combining data from multiple common aquatic habitat works would significantly advance the understanding of the impacts of decisions on aquatic ecosystems.
2. Given that there are outstanding terminology issues that were not discussed during this process, it is recommended that DFO continue its efforts to standardize terminology definitions to standardize use across its processes. Ultimately a formal, published lexicon of terms, that is periodically updated, can be used by the Department. Establishing clear meaning and consistency in terminology would improve clarity in Departmental activities across sectors.

Addressing the recommendations above could achieve all the objectives of this process and go beyond to a final goal of establishing success or failure criteria for projects monitored using these protocols; and ultimately learning from the hundreds of projects that alter aquatic habitat annually. This achievement would transform how data are collected and used by DFO, would iteratively contribute to more effective decision-making, provide a scientifically defensible assessment of habitat gained and lost per year that can be reported to Canadians, and ultimately benefit the advancement of habitat alteration and conversions and restoration science in aquatic ecosystems in Canada.

Contributors

- Susan Doka (Chair), DFO Science, Ontario and Prairie Region
- Karen Smokorowski (Science Lead), DFO Science, Ontario and Prairie Region
- Warren Currie, DFO Science, Ontario and Prairie Region
- Paul Blanchfield, DFO Science, Ontario and Prairie Region
- Haitham Ghamry, DFO Science, Ontario and Prairie Region
- Rob Bajno, DFO Science, Ontario and Prairie Region
- Tyler Tunney, DFO Science, Gulf Region
- Gabriel Goguen, DFO Science, Gulf Region
- Douglas Braun, DFO Science, Pacific Region
- Keith Clarke, DFO Science, Newfoundland Region
- Court Berryman, DFO Fish and Fish Habitat Protection Program (FFHPP), Ontario and Prairie Region (O&P Region)
- Brent Valere, DFO FFHPP, O&P Region
- Brandi Mogge, DFO FFHPP, O&P Region
- Richard Kavanagh, DFO FFHPP, O&P Region
- Kevin Esseltine, DFO FFHPP, Pacific Region
- Shawn Seguin, DFO FFHPP, Pacific Region
- Kelly Code, DFO FFHPP, National Capital Region
- Leanda Delaney, DFO FFHPP, Maritimes Region
- Ryan Pugh, DFO FFHPP, Newfoundland Region
- Eva Enders, Institut national de la recherche scientifique, Université of Québec
- Allen Curry, University of New Brunswick
- Jenny Petrynko, Manitoba Métis Federation
- Jack Imhof, Trout Unlimited Canada
- Nick Lapointe, Canadian Wildlife Federation
- Cameron Stevens, Golder Associates
- Darryl Chudobiak, Canadian Natural Resources Limited

Approved by

Lynn Bouvier, Great Lakes Laboratory for Fisheries and Aquatic Science, Division Manger

Tricia Mitchell, Ontario and Prairie Region, Regional Director of Science

December 16, 2023

Sources of Information

Arnqvist, G., and Wooster, D. 1995. Meta-analysis: synthesizing research findings in ecology and evolution. Trends in Ecol. and Evol. 10(6): 236–240.

Bradford, M.J., Randall, R.G., Smokorowski, K.S., Keatley, B.E., and Clarke, K.D. 2014. A framework for assessing fisheries productivity for the Fisheries Protection Program. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/067. v + 25 p.

Bradford, M.J., Smokorowski, K.E., Clarke, K.D., Keatley, B.E., and Wong, M.C. 2016. Equivalency metrics for the determination of offset requirements for the Fisheries Protection Program. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/046. vi+32 p.

Bradford, M.J., Macdonald, J.S., and Levings, C.D. 2017. Monitoring fish habitat compensation in the Pacific region: lessons from the past 30 years. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/033. vi + 26 p.

Braun, D.C., Smokorowski, K.E., Bradford, M.J., and Glover, L. 2019. A review of functional monitoring methods to assess mitigation, restoration, and offsetting activities in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2019/057. vii + 75 p.

Cambridge University Press and Assessment. 2023. Cambridge Dictionary. Cambridge University Press, Cambridge, UK. (accessed 14 June 2023).

Cooke, S.J., and Hinch, S.G. 2013. Improving the reliability of fishway attraction and passage efficiency estimates to inform fishway engineering, science, and practice. Ecol. Eng. 58: 123–132.

DFO. 1986. Policy for the Management of Fish Habitat. Department of Fisheries and Oceans. Fisheries and Oceans Canada, Ottawa Ontario. iii + 28 p.

DFO. 2012. Assessing the Effectiveness of Fish Habitat Compensation Activities in Canada: Monitoring Design and Metrics. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/060.

DFO. 2019a. Science advice on operational guidance on functional monitoring: Surrogate metrics of fish productivity to assess the effectiveness of mitigation and offsetting measures. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/042.

DFO 2019b. Policy for Applying Measures to Offset Adverse Effects on Fish and Fish Habitat Under the *Fisheries Act*. Fisheries and Oceans Canada, Ottawa, ON. 23 p.

DFO. 2020. Science Advice on the Effectiveness of Spawning Habitat Creation for Substrate Spawning Temperate Fish. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/013.

DFO. 2022. Science Advice to the Fish and Fish Habitat Protection Program on Estimating Impacts and Offsets for Death of Fish. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2022/052.

DFO. 2023. Applicant's Guide Supporting the "Authorizations Concerning Fish and Fish Habitat Protection Regulations". Fisheries and Oceans Canada, Ottawa, ON. (accessed 17 January 2023).

Government of Canada. 2023. Fisheries Act (R.S.C., 1985, c. F-14). Government of Canada, Ottawa, ON. 111 p. Act current to 2023-07-25.

Harrison F. 2011. Getting started with meta-analysis. Methods Ecol. Evol. 2: 1–10.

Hatfield Consultants and Ecofish Research. 2018. Refinement of Fish Habitat Pre-Disturbance Models. Final Technical Report – Phase 2. Prepared for: Canada's Oil Sands Innovation Alliance (COSIA), Fisheries Sustainable Habitat (FiSH) Committee. May 15, 2018.

Krall, M., Clark, C., Roni, P., and Ross, K. 2019. Lessons learned from long-term effectiveness monitoring of instream habitat projects. N. Am. J. Fish. Manag. 39: 1395–1411.

Lewis, F.J.A., Harwood, A.J., Zyla, C., Ganshorn, K.D., and Hatfield, T. 2013. Long term Aquatic Monitoring Protocols for New and Upgraded Hydroelectric Projects. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/166. ix + 88

Lindenmayer, D.B., and Likens, G.E. 2010. The science and application of ecological monitoring. Biol. Conserv. 143: 1317–1328.

McLain, R.J., and Lee, R.G. 1996. Adaptive management: promises and pitfalls. Environ. Manage. 20(4): 437–448.

Midwood, J.D., Blair, S.G., Boston, C.M., Brown, E., Croft-White, M.V., Francella, V., Gardner Costa, J., Liznick, K., Portiss, R., Smith-Cartwright, L., and van der Lee, A. 2022. First assessment of the fish populations beneficial use impairment in the Toronto and Region Area of Concern. Can. Tech. Rep. Fish. Aquat. Sci. 3503: xvii + 283 p.

Minns, C.K., Moore, J.E., Stoneman, M., and Cudmore-Vokey, B. 2001. Defensible Methods for Assessing Fish Habitat: Lacustrine habitats in the Great Lakes Basin – Conceptual basis and approach using a habitat suitability matrix (HSM) method. Can. Tech. Rep. Fish. Aquat. Sci. 2559: viii + 70 p.

Pearson, M.P., Quigley, J.T., Harper, D.J., and Galbraith, R.V. 2005. Monitoring and assessment of fish habitat compensation and stewardship projects: Study design, methodology and example case studies. Can. Manuscr. Rep. Fish. Aquat. Sci. 2729:xv + 124 p.

Quigley, J.T., and Harper, D.J. 2006. Compliance with Canada's *Fisheries Act*: A field audit of habitat compensation projects. Environ. Manage. 37: 336–350.

Randall, R.G. 2003. Fish productivity and habitat productive capacity: definitions, indices, units of field measurement, and a need for standardized terminology. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/061. ii + 14 p.

Randall, R.G., Bradford, M.J., Clarke, K.D., and Rice, J.C. 2013. A science-based interpretation of ongoing productivity of commercial, recreational or Aboriginal fisheries. DFO. Can. Sci. Advis. Sec. Res. Doc. 2012/112 iv + 26 p.

Radinger, J., Britton, J.R., Carlson, S.M., Magurran, A.E., Alcaraz-Hernández, J.D., Almodóvar, A., Benejam, L., Fernández-Delgado, C., Nicola, G.G., Oliva-Paterna, F.J., Torralva, M., and García-Berthou, E. 2019. Effective monitoring of freshwater fish. Fish and Fisheries. 20: 729–747.

Ricker, W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull. Fish. Res. Board Can. 191: 382 p.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, Colorado. 350 p.

Ruppert, J.L., Hogg, J., and Poesch, M.S. 2018. Community assembly and the sustainability of habitat offsetting targets in the first compensation lake in the oil sands region in Alberta, Canada. Biol. Conserv. 219: 138–146.

SER (Society for Ecological Restoration International Science and Policy Working Group). 2004. The SER International Primer on Ecological Restoration. Society for Ecological Restoration International, Tucson, AZ. 16 p.

Smokorowski, K.E., Bradford, M.J., Clarke, K.D., Clément, M., Gregory, R.S., Randall, R.G. 2015. Assessing the effectiveness of habitat offset activities in Canada: Monitoring design and metrics. Can. Tech. Rep. Fish. Aquat. Sci. 3132: vi + 48 p.

Stoddard, J.L., Larsen, D.P., Hawkins, C.P., Johnson, R.K., and Norris, R.H. 2006. Setting expectations for the ecological condition of streams: The concept of reference condition. Ecol. Appl. 16(4): 1267–1276.

Sutula, M.A., Stein, E.D., Collins, J.N., Fetscher, A.E., and Clark, R. 2006. A practical guide for the development of a wetland assessment method: the California experience. J. Am. Water Resour. Assoc. 42: 157–175.

Underwood, A.J. 1991. Beyond BACI: Experimental designs for detecting human environmental impacts on temporal variations in natural populations. Aust. J. Mar. Freshw. Res. 42(5): 569–587.

Underwood, A. J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecol. Appl. 4(1): 3–15.

USFWS (U.S. Fish and Wildlife Service). 1980. Habitat Evaluation Procedures. Ecological Services Manual 102. U.S. Fish and Wildlife Service, Division of Ecological Services, Washington, D.C. 130 p.

USFWS. 1981. Standards for the development of habitat suitability index models for use in the Habitat Evaluation Procedures. Ecological Services Manual 103. U.S. Fish and Wildlife Service, Division of Ecological Services, Washington, D.C. 170 p.

Walters, C.J., and Hilborn, R. 1978. Ecological optimization and adaptive management. Annu. Rev. Ecol. Syst. 9: 157–188.

Williams, B. K. 2011. Adaptive management of natural resources—framework and issues. J. Environ. Manag. 92(5): 1346–1353.

Appendix

Appendix 1. Glossary of terms commonly used by DFO.

Term	Description	Reference
Adaptive Management	The application of experimentation to the design and implementation of natural-resource and environmental management policies and practices	Halbert 1993 *as cited in* McLain and Lee 1996
BA	Before-After - A commonly used monitoring design that compares data collected before and after a putative environmental disturbance or human-induced change.	Underwood 1991
BACI	Before-After-Control-Impact - A commonly used monitoring design where the control and impact sites are sampled before and after a human-induced change is planned that may cause environmental damage.	Underwood 1991
CI	Control-Impact - A commonly used monitoring design that compares data between control and impact sites.	Underwood 1991
Compliance	The act of obeying a law or rule, especially one that controls a particular industry or type of work.	Cambridge University Press and Assessment 2023
Compliance Monitoring Objective	To determine if the requirements of the prohibitions of the legislation and the regulations are met.	This document (Figure 1)
Conformity	The process of a product being made as it was designed, without mistakes or faults.	Cambridge University Press and Assessment 2023
Conformity Monitoring Objective	To determine if advice provided or conditions of instruments are implemented and functioning as intended.	This document (Figure 1)
Effectiveness Monitoring	A science-based activity, requiring a standardized, transferable design. The metrics or indicators must measure fish production or fish-based surrogates of fish production. (NOTE: the original definition included the term 'productive capacity', which is no longer used by the Department)	Modified from DFO 2012
Effectiveness Monitoring Objective	Determine if measures either recommended or imposed on the proponent, met their performance goals to protect and/or offset impacts to fish and fish habitat as anticipated.	This document (Figure 1)
Enhancement	The process of improving the quality, amount, or strength of something.	Cambridge University Press and Assessment 2023

Term	Description	Reference
Equivalency	In the context of offsets, “equivalency” refers to the process to determine the amount and nature of offsets required to achieve a fair exchange between project impacts and gains associated with offset measures.	Bradford et al. 2016
Equivalency metric	The unit of loss or gain that is used to determine how much offsetting is needed to counterbalance unavoidable losses	Bradford et al. 2016
Fish Habitat	Spawning grounds and other areas, including nursery, rearing, food supply, and migration areas, on which fish depend directly or indirectly in order to carry out their life processes.	Government of Canada 2023
Fish Production	The total elaboration of new body substance in a stock in a unit of time, irrespective of whether or not it survives to the end of that time.	Ricker 1975
Fish Productivity	A survival parameter specific to a population of fish (e.g., maximum growth rate of a population at low density). Productivity may also be characterized by other population traits such as growth, fecundity and age-at-maturity.	Randall 2003
Fisheries Productivity	Fishery productivity is the potential sustained yield of all fish populations and their habitats that are part of or support relevant fisheries.	Fish and Fish Habitat Protection Policy Statement 2019
Functional Monitoring	A science-based, scaled-down version of effectiveness monitoring that relies on surrogate metrics to assess whether management measures provide expected conditions suitable for fish to carry out their life processes.	DFO 2012
Habitat Evaluation Procedure (HEP)	The Habitat Evaluation Procedure (HEP) is a method which can be used to document the quality and quantity of available habitat for selected wildlife species, and can be used in environmental impact assessments to document and budget habitat losses and gains.	USFWS 1980
Habitat Suitability Index (HSI)	A numerical index that represents the capacity of a given habitat to support a selected fish or wildlife species. HSI values range from 0 to 1 and the value(s) can be multiplied by the area of available habitat to obtain habitat units (e.g., Weighted Useable Area [WUA]).	USFWS 1981
Indicator	Some quantity that describes, and is hypothesized to be related to, changes in fish productivity. Indicators may be comprised of one or more quantitative metrics, or may be qualitative in nature (cf. “change in Large Woody Debris (LWD)”, “loss of structure”).	Bradford et al. 2014

Term	Description	Reference
Fisheries Act Authorizations	Guidance for a project proponent from FFHPP outlining how to avoid or mitigate for impacts where possible and requirements for restoration and offsetting where impacts are unavoidable and cannot be mitigated.	DFO 2023
Management Monitoring Objectives	Monitoring objectives of the Fish and Fish Habitat Protection Program related to project monitoring are: 1) to ensure conformity with advice, construction/design standards (including 'functioning as intended') and compliance with the Fisheries Act and Species at Risk Act (compliance monitoring program); and 2) to evaluate the effectiveness of management measures aimed at reducing the impacts of projects on fish and fish habitat (functional and effectiveness monitoring programs).	Modified from Braun et al. 2019
Measurements	Measurements are taken in the field and describe the current state of the ecosystem or its biota. Examples include fish abundance or discharge.	Bradford et al. 2014
Meta-analyses	A specific set of statistical quantitative methods that are designed to compare and synthesize the results of multiple studies.	Arnqvist and Wooster 1995
Metric	The specific representation or quantification of an indicator. Metrics are used to evaluate change or the relationship between the altered site and control(s) or relevant comparator(s). A metric can be derived from before-after field measurements (e.g., change in fish abundance), or can be estimated from baseline measurements and a predicted or modelled effect.	Bradford et al. 2014
Mitigation measures	Measures to mitigate are actions taken to reduce the spatial scale, duration, or intensity of adverse effects to fish and fish habitat that cannot be avoided. The best available measures to mitigate should be implemented by proponents while carrying out any work, undertaking or activity.	DFO 2019b
Offsetting Measures	Measures to offset are actions taken to counterbalance the residual effects on fish and fish habitat at a given location, with measurable benefits for fish and fish habitat. These measures may take place where the residual effects will occur or elsewhere.	DFO 2019b
Productive Capacity of Fish Habitat	The **maximum natural capability** of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend (Note: The DFO Fish and Fish Habitat Protection Program no longer uses the term productive capacity).	DFO 1986
Quantitative	Collecting both physical and biological measures, metrics and indicators through varying degrees of measurement.	Smokorowski et al. 2015

Term	Description	Reference
Rapid Assessment	An assessment protocol that can be conducted in a short amount of time (e.g., < 1 day for 2 people to collect the data, manage the data, analyze the data, and complete reporting).	Sutula et al. 2006
Reference Condition Approach (RCA)	An approach that compares a test site to a set of conditions defined by multiple reference sites that represent some desirable state (e.g., undisturbed, pristine or not-impaired).	Stoddard et al. 2006
Restoration	The act or process of returning something to its earlier good condition or position.	Cambridge University Press and Assessment 2023
Ecological Restoration	The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.	SER 2004
Standardized Monitoring	Monitoring programs that use consistent data collection, analysis, and reporting protocols.	Braun et al 2019.
System Type	Lake, river, stream, estuary, marine, coastal, wetland or other major category of waterbody.	Modified from Braun et al. 2019.

This Report is Available from the:

Center for Science Advice (CSA)
Ontario and Prairie Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, MB
R3T 2N6

E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address:www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769
ISBN 978-0-660-70061-8   Cat. No. Fs70-7/2024-006E-PDF

Correct Citation for this Publication:

DFO. 2024. Science Review of Standardized Monitoring and Success Criteria Reports for Lake Construction, Channel Construction, and Aquatic Habitat Works. DFO Can. Sci. Advis. Sec. Sci. Resp. 2024/006.

Aussi disponible en français :

MPO. 2024. Examen scientifique de rapports normalisés sur la surveillance et les critères de réussite pour la création de lacs, la construction de chenaux et les travaux sur l'habitat aquatique. Secr. can. des avis sci. du MPO. Rép. des Sci. 2024/006.