Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

**National Capital Region**

**Canadian Science Advisory Secretariat**
**Science Advisory Report 2022/055**

# SCIENCE ADVICE FOR ASSESSING CUMULATIVE EFFECTS IN SUPPORT OF POLICY DEVELOPMENT AND REGULATORY DECISION-MAKING

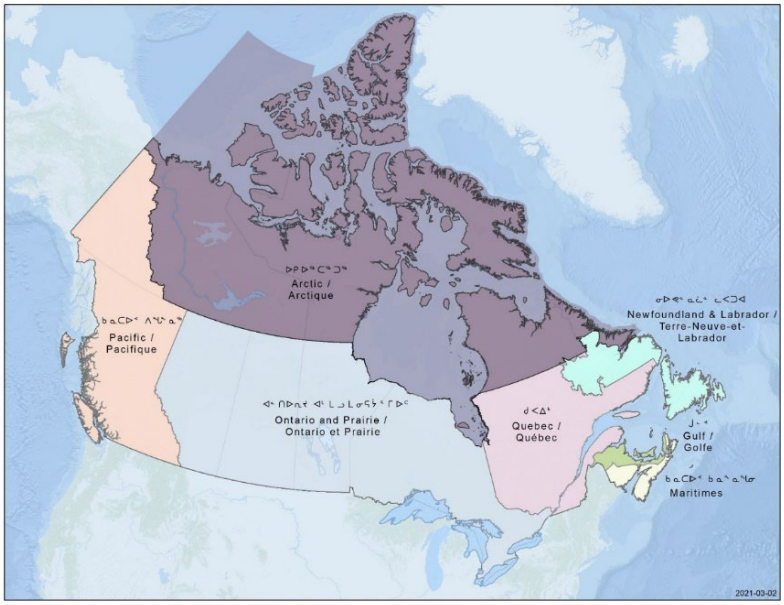


*Figure 1: Department of Fisheries and Oceans' (DFO) seven administrative regions.*

## Context:

*Through the Canadian Science Advice Secretariat (CSAS), Fisheries and Oceans Canada (DFO)'s Fish and Fish Habitat Protection Program (FFHPP) has requested that DFO Science conduct a peer review on assessing cumulative effects in support of policy development and regulatory decision-making.*

*FFHPP has been interested in science advice related to cumulative effects at various points in time. The requirement for science advice on cumulative effects became more pressing due to: (1) revisions to the Fisheries Act which include the consideration of cumulative effects under paragraph 34.1(1)(d); and (2) the recent program revitalization and creation of "Integrated Planning" within the FFHPP. Thus, science advice is necessary to support: the regulatory decisions under the revised Fisheries Act, Species at Risk Act, and Aquatic Invasive Species Regulations; ongoing policy development that will determine how cumulative effects will be considered in the FFHPP; and, a greater understanding of cumulative effects on the broader landscape scale for planning purposes.*

*While DFO Science has provided some advice on cumulative effects and related topics in the past, previous work has been largely marine-focused and advice specific to freshwater habitat has been limited. Freshwater ecosystems substantially differ from marine environments (e.g., in size, level of connectivity, and proximity to anthropogenic activities). Moreover, understanding the cumulative effects from multiple human activities is a complicated endeavor. One of the challenges is the many factors that play a role, for example: characteristics of the landscape (abiotic), characteristics of the species present (biotic), and characteristics of the human activities. This necessitates a focused review on key considerations for*

*including cumulative effects in freshwater ecosystems as it relates to departmental decision-making. This science advisory process focused on assessing and considering cumulative effects in freshwater ecosystems exclusively.*

*Two research documents were prepared by researchers in DFO's Ecosystems and Ocean Science Sector (EOSS). One of these working papers was targeted to address the broader scale context for considering cumulative effects in integrated planning and the other was targeted to address the needs within program decision-making. The two documents were intended to be closely connected and coordinated.*

***Objectives***

*The specific objectives of the working papers developed for this peer-review are listed below. These objectives are not prioritized but are listed based on representation in the two working papers.*

*Understanding cumulative effects in integrated planning:*

1. *Outline the state of knowledge on how cumulative effects are currently understood to manifest on the landscape.*
2. *Identify approaches currently used to understand and adaptively manage cumulative effects on the landscape.*

*Considering cumulative effects to support Fish and Fish Habitat Protection Program decision-making:*

3. *Evaluate the relevant elements within the current risk approach to determine if sufficient information is gathered to inform the consideration of cumulative effects.*
    a. *Identify recommendations for additional elements to be included in the current risk approach to inform the consideration of cumulative effects.*
    b. *Identify the fundamental information needed about species and habitats in the region of a project when considering cumulative effects.*
4. *Provide advice on key characteristics required to determine how habitat sensitivity can be determined in the context of cumulative effects.*

*It is expected that this process will also have synergy with other current CSAS processes focused on freshwater habitat science advice, namely revisiting Pathways of Effects and estimating impacts and offsets for death of fish.*

*This Science Advisory Report was from the March 8-12, 2021 National Peer Review on Science advice for assessing cumulative effects in support of policy development and regulatory decision-making. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.*

## SUMMARY


- Consideration of Cumulative Effects (CE) requires an ecosystem-level perspective including knowledge of ecosystem integrity (composition, structure, and function), this advice should be interpreted in this context.
- How CE considerations fit into the Fish and Fish Habitat Protection Program's (FFHPP) management cycle was reviewed with respect to two specific areas: 1) integrated planning and 2) fish and fish habitat decision-making, in addition this advisory meeting focused on freshwater ecosystems.
- IP should inform FFHPP decision-making and vice versa. This is essential to the consideration of CE by ensuring structured information flow between IP (e.g., state, thresholds, the conservation, protection, and restoration needs of systems, etc.) and changes to FFHPP decision-making depending on that state. Information from FFHPP to IP helps capture vital information on activities and cumulative effects and residual pressures.

- Integrated planning is generally considered a policy driven process to establish objectives that may include ecosystem, cultural, social, and economic components, DFO Science focus was on the ecosystem components required.
- The information requirements should be informed by the best available knowledge that includes a solid understanding of the status of fish and fish habitat in the area under consideration.
- CE considerations need assessment of past pressures (included in the status of above) as well as an assessment of the potential effects of current and foreseeable pressures on the fish and fish habitat.
- One of the main ways to consider CE in an Integrated Plan is to set objectives and targets that consider the relationships among fish, people, and the environment. These goals and targets can be policy based but should be measurable and based on the best available information.
- Objectives and targets of an IP should include agreed upon indicators with defined thresholds or ranges. Thresholds and ranges can be directly measured and could also be determined by modelling and scenario planning, or be based on Indigenous knowledge of relationships and natural conditions.
- Indicators should be specific, measurable, attainable, relevant, and time-based (SMART) as well as sensitive and responsive to anticipated management measures, in order to provide timely feedback such that management measures can be tested for effectiveness.
- CE within fish and fish habitat decision-making requires information about: (1) the proposed Work, Undertaking or Activity (WUA), (2) the species in the region, and (3) the habitats in the region.
- Specifically, there needs to be a clear determination of the ’zone of influence’ related to the WUA both from a spatial and temporal perspective. The expected pressures from the WUA needs to be understood and the current status of the habitat needs to be evaluated.
- Information on reference conditions (near pristine or prior to previous impacts) are important to document as accurately and comprehensively (e.g., broad spatial-temporal scales) as possible to predict the vulnerability of the fish and fish habitat to CE.
- Information on the species should include: presence/absence, life history characteristics/needs, general population status and sensitivity to the expected pressures for all species in the ‘zone of influence’.
- A trait based approach to consistently determine the expected presence of species in the ‘zone of influence’ was presented for data limited situations, it could also be used as a check in more data rich areas.
- Existing scientifically defensible methods (e.g., Habitat Ecosystem Assessment Tool-HEAT) and/or equivalency models can provide a means of determining the species within the ‘zone of influence’ and effects of proposed WUAs on habitat.
- Habitat information should include: the habitats present, the general habitat status and an evaluation of the habitat vulnerability (sensitivity and exposure) to the expected pressures within the ‘zone of influence’.
- Habitat sensitivity is defined based on a combination of resilience and resistance to a particular pressure and is separate from the exposure of the habitat to the pressure from a

proposed WUA. In a CE context, current habitat sensitivity is influenced by exposure to previous pressures in the watershed, as sensitivity is an intrinsic property of the ecosystem that may vary depending on the habitat status.

- Outside of management and operational uncertainties regarding the WUA and the effectiveness of the measures (SAR 2014/015), it is understood that habitat and fish distributions are dynamic and can/will change due to natural and anthropogenic forces, this is one of the reasons a broader spatial and temporal scope is required for the consideration of CE.
- The knowledge and uncertainty associated with the impacts of activities on species and habitats are complicated in considerations of CE because of interactions between pressures (additive, antagonistic, and synergistic), non-linearities, thresholds and tipping points, on top of existing challenges of accurate measurement in ecological settings.
- A standardized approach to better understand the state of fish and fish habitat within the context of natural and anthropogenic spatial-temporal variation of the ecosystem is required to inform project reviews. This approach/database would ideally track projects across Canada as one means to measure the pressure footprint within watersheds resulting from anthropogenic activities.
- There is a need for a national geospatial database with available information on species, habitats, and the CE landscape so assessors can evaluate if the information they have is correct and sufficient. While this database may not contain all the needed information, it would provide a centralized access point that could allow planners, assessors, scientists and proponents to be working from shared resources.

## INTRODUCTION

The 2019 revisions to Canada's *Fisheries Act* (FA) introduced for the first time the legislative mandate within the *Act* to consider cumulative effects (CE) in decision-making for certain habitat related decisions. Specifically, under paragraph 34.1 (1)(d) the Minster shall consider "the cumulative effects of the carrying on of the work, undertaking or activity [WUA] referred to in a recommendation or an exercise of power, in combination with other works, undertakings or activities that have been or are being carried on, on fish and fish habitat". Within Fisheries and Oceans Canada (DFO), the Fish and Fish Habitat Protection Program (FFHPP) is responsible for administering the fish and fish habitat protection provisions of the *Fisheries Act.* Groups within the FFHPP responsible for this include regulatory review groups (those responsible for project reviews), and integrated planning groups (those responsible for landscape level planning and supporting regulatory review activities). The FFHPP requested Science advice on how cumulative effects could be considered both at a regulatory review level, as well as an integrated planning level.

Participants in this meeting affirmed that integral to considering CE is recognizing that integrated planning and fish and fish habitat decision-making are intrinsically linked, and that information needs to flow between the two (Figure 2). Furthermore, using a cyclical process of integrated planning builds in flexibility to adapt to new knowledge, legislation, policies, and management objectives. Integrated planning is a multi-stakeholder driven process that relies on clear definitions of goals, targets, and indicators, but is also heavily data dependent as it necessitates evaluating the state of the ecosystem. Project-level considerations, while often reviewed in isolation, need a watershed context for CE to be adequately considered. However, as individual reviewers do not have the capacity for a full state of the system assessment when each new proposed WUA is in review, prior development of an integrated plan would create

considerable ease in project-level decision-making when considering CE. Moreover, past projects and future WUAs would benefit if a consistent approach to monitoring for compliance and effectiveness of measures taken (such as mitigation) are incorporated into project management. Information from each project, and associated monitoring, would then feed back into IP processes (Figure 2).

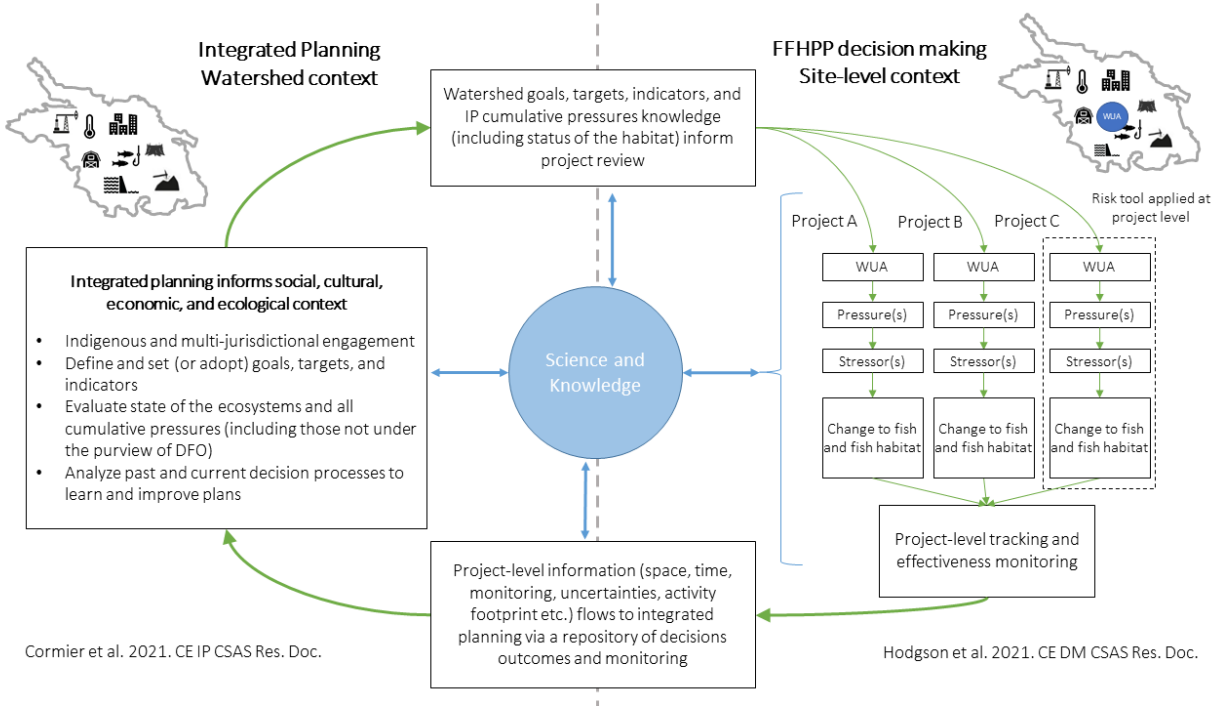


*Figure 2: Cyclical flow of information between types of activities in the Fish and Fish Habitat Protection Program (FFHPP) of Fisheries and Oceans Canada.*

## ANALYSIS

### CE and Integrated Planning

Integrated plans provide an overarching framework to operationalize an ecosystem-based management approach to cumulative effects given that it is a multi-jurisdictional process that includes Indigenous, community and stakeholder interests. The planning process is used to set ecological objectives informed by the knowledge of Indigenous peoples, other levels of government, communities and stakeholders and by scientific and technical advice. An integrated plan establishes the context for incorporating cumulative effects in DFO decision-making because of the comprehensive assessments linking past and current human activities and their pressures to ecological and biological objectives and, thus, inform regulations, policies and tools used to manage the activities and their pressures.

CE considerations also requires an understanding of the links between the spatial scales of human activities their pressures and the effects. Therefore an assessment of the area where the human activities occur (activity-footprint), the area covered by the pressures of these activities as the mechanism and intensity of the collective changes on the prevailing habitats and species (pressure-footprint), and the area of the adverse effects as a result of the stresses generated by the pressures (effects-footprint; Elliott et al., 2020b; Figure 3) is required. Environmental regulatory and non-regulatory frameworks used to regulate human/sector activities that result in

negative/harmful/undesirable impacts and disturbances within the footprint of the individual activities through conditions of regulations, authorizations, licenses, permits, codes, standards, and/or advice. In contrast, integrated planning identifies the pressures from multiple activities within the footprint of the pressures at a broader scale such as the landscape or watershed to establish management strategies, and seeks to influence actions and decisions, to eliminate or reduce the pressures and ultimately the effects within the ecological footprint of these effects (Elliott et al., 2017; Stelzenmüller et al., 2018).

Although longer term goals are typically derived from policy, immediate objectives and management targets for planning may be derived from existing resource management plans such as local fisheries and/or habitat management strategies or, may be derived through the input from Indigenous communities, stakeholders, and multi-jurisdictional authorities. For both IP and CE, the spatial boundary of a watershed is considered most conducive to set such objectives and targets for freshwater ecosystems.

Integrated planning follows a cyclical process from planning, implementing, monitoring and reviewing fulfilling an adaptive management approach (see Figure 3). The cycle is most important because of the factors that may influence a plan overtime (Box 1).

*Box 1: Factors that may influence future iterations of a plan during a review.*

- New scientific knowledge regarding habitats, species, populations (including thresholds);
- Emerging trends in ecosystems processes and components at various scales;
- New types of activities that are not addressed through current measures to address their impacts;
- Changes in legislation, policies and programs (as they affect the evaluation endpoints);
- New or more effective technologies to avoid and mitigate harm to fish and fish habitat; and
- New or more effective offsetting and restoration methods or direction.

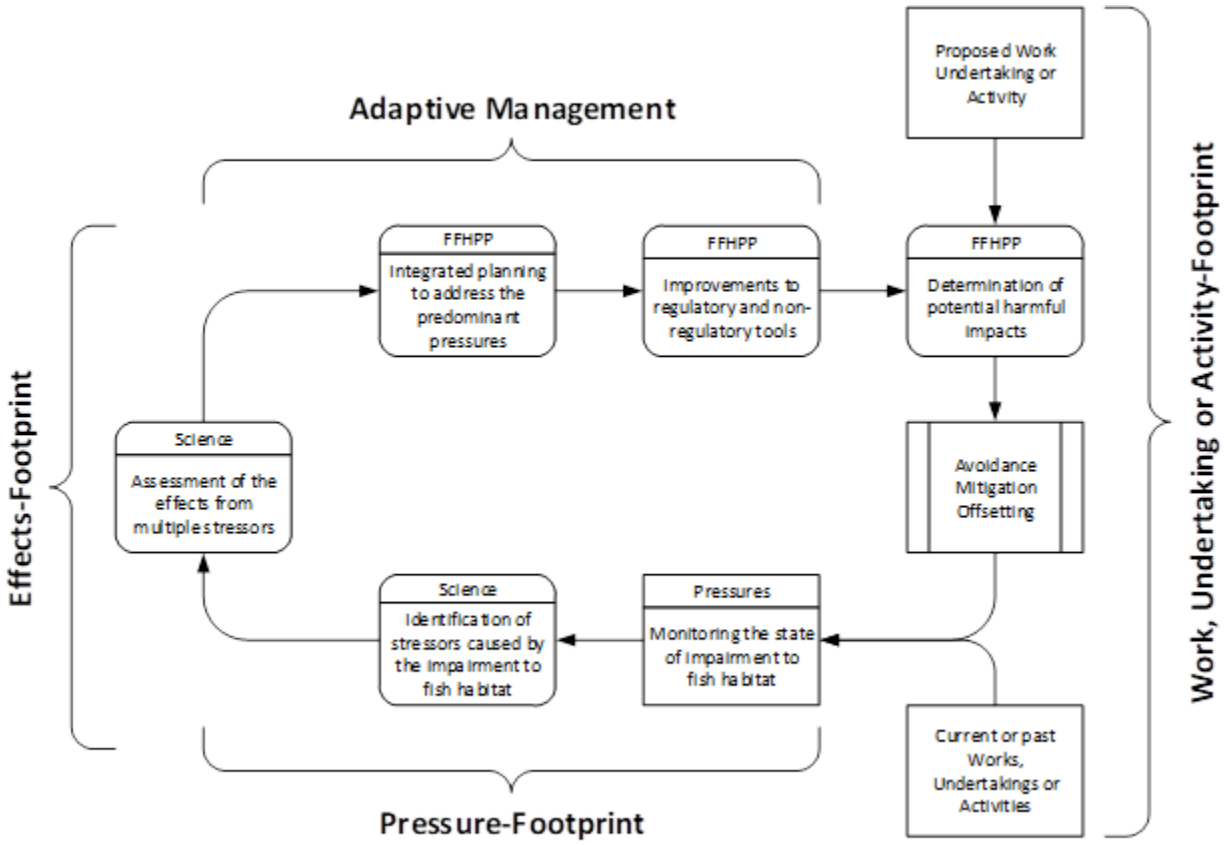


*Figure 3: A stylized integrated planning and cumulative effects assessment cycle delineating where WUA, pressure and effects footprints might be considered and by which sector. The pressures 'box' can be informed by both internal (Science and/or FFHPP) and external groups (e.g. proponents, Indigenous groups, community groups, etc.).*

## CE and Regulatory Decision-Making

In a proposal review process, there needs to be a clear determination of the project footprint (Elliott et al., 2020); what we refer to as the "zone of influence" of the WUA. The boundaries used to define the scope of influence will have a substantial impact on the information gathered on species and habitats and is a core step of all Cumulative Effects Assessment (CEA) processes (see Table A1, Hodgson et al. 2022). The scope of influence includes both the spatial extent (area of the WUA) and temporal duration of the impact (temporary or permanent) and allows assessment biologists to determine what fish and fish habitats are within the scope and therefore included in the risk based determination. Canter et al. (2012) write that the "[s]patial boundaries should minimally encompass the geographic area wherein the proposal's effects are likely to occur." However, others state that the landscape-level scale is more appropriate for a CEA (CEQ, 1997; Randall et al., 2013).

Essential to CE considerations is the need to understand the reference conditions and the current landscape of human modifications in the zone of influence. This can be thought of as the level of past disturbance. Reference conditions help provide an understanding of how impacted the region is, what activities and associated pressures are currently present, and therefore, how the system may respond to additional stress. The integration of CE into project reviews and decision-making requires fundamental information on the fish species that inhabit the area of

the WUA for all or some of their life processes. There are four categories of species information needs. First, a list of all species including native, introduced, at risk, extirpated, and aquatic invasive species. Second, characteristics of those species. This further breaks down into the life stage(s) present, the life processes undertaken (e.g., rearing or spawning), the duration of presence (e.g., timing in the year and length of stay) and functional traits (e.g., fecundity, growth rate). Third, the status of those species present is required, which can be determined using the best available knowledge. Examples include status information from field data, population models or Indigenous knowledge of species status (or trends). Finally, important for a cumulative effects context is their sensitivity to relevant pressures, meaning those associated with the WUA. Some factors to consider when evaluating sensitivity of species and communities within the area of the WUA are the tolerances and adaptive capacity of those species, their habitat specialization, and environmental triggers for their life processes.

Local and proponent supplied information should provide a robust understanding of the species present in the area of the WUA, but if this information is not available or is incomplete, a combination of broader-scale data and the species traits identified above can be used to determine which species are likely present. An example decision tree illustrates how the information may be prioritized to determine species presence or absence (Figure 4). In some cases, the habitat characteristics and traits evaluated may be dependent upon the habitat information supplied by the proponent therefore, the series of filters (e.g., substrate, vegetation) should be modified accordingly. The first filter of the tree is the tertiary watershed species list available in Habitat Ecosystem Assessment Tool (HEAT) (DFO, 2019a). Species lists for the tertiary watersheds can be thought of as regional species pools. The second filter can be aquatic ecosystem preference e.g., lake, river, wetland, which can be determined using resources such as Coker et al. (2001) and HEAT. Habitat characteristics for the area of the WUA can then be compared to the species traits to determine which species are likely to occur within the project area. Specifically, the third filter recommended for identifying species within the area of the WUA is thermal guild and several references are available that identify the guilds of different species. The final filter uses finer-scale habitat conditions such as flow regime, water chemistry, vegetation or substrate to determine species presence or absence.

Information on habitats includes the mosaic of conditions created by the interactions among the physical (e.g., substrate type), chemical (e.g., water chemistry), and biological (e.g., habitat forming plants, competition with other individuals) variables within the project area (Minns & Wichert, 2005). To understand how a habitat may change from the addition of the WUA(s) under consideration, there are three main information needs. First, the habitats (and their characteristics) need to be identified. Second, the current status of that habitat needs to be determined. This circles back to concepts discussed above regarding reference conditions, as the current status will largely be influenced by what activities and associated pressures are currently present (past and ongoing) and therefore the extent that the habitat may already be impacted. Finally, the sensitivity of that habitat to relevant pressures needs to be identified. We define habitat sensitivity as the degree and duration of damage caused by an anthropogenic factor(s) to the habitat in its current state, where these are measured through assessing the habitat’s resilience and resistance to the external factor.

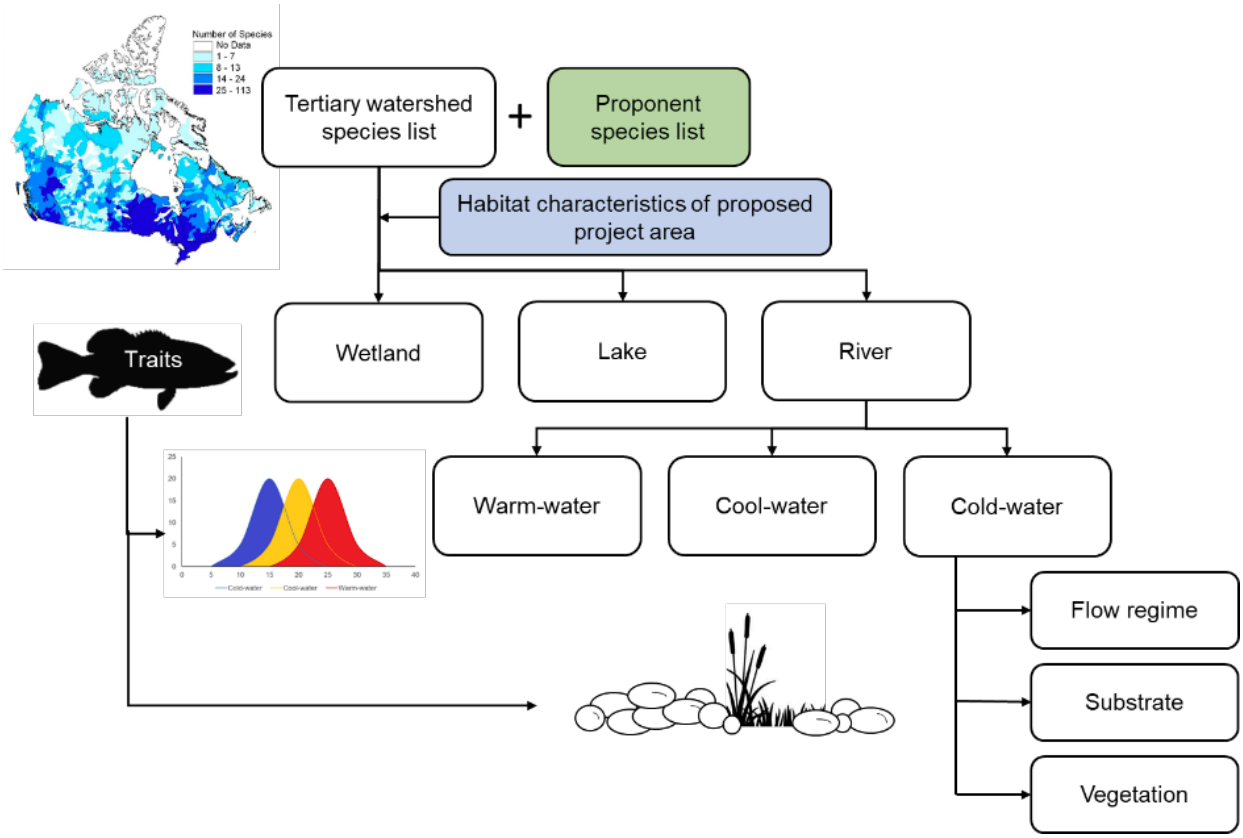


*Figure 4: Example decision tree demonstrating how trait data can be used to determine which fish species are likely to be found within the area of the WUA or different habitat types within WUA area, when proponent species lists are incomplete or require verification.*

## Sources of Uncertainty

There are several sources of uncertainty to be considered when assessing CE. CE is complicated and while the concepts are not new the application to fish and fish habitat decision-making is new. Therefore, extensive work by both science and FFHPP will be required in the future to improve our understanding and to develop new tools to allow for a better consideration with respect to fish and fish habitat decisions and planning. It should be noted that there is the potential for the continuation of the joint Science-FFHPP CE working group under the Freshwater Habitat Initiative (FHIN).

The continuing discussion on considering CE should recognize that the knowledge and uncertainty of the impacts of activities on species and habitats are complicated because of the numerous interactions between pressures (additive, antagonistic, synergistic), non-linearities, thresholds, and tipping points. Additionally, many of these processes may be expected to be altered due to climate change. For example, the expected changes in the water budget and associate flow regimes across the country and potential concurrent expected increases in temperature could potentially affect thermal habitat distributions and ice cover throughout the country. It is understood that habitat and fish distribution are dynamic and can/will change due to natural and anthropogenic forces. This is one of the reasons a broader spatial and temporal scope is required for the consideration of CE.

Canada is a large country with a vast array of aquatic ecosystems that may have regional differences that will impact the consideration of CE. There are also differences in data

availability within and amongst the different regions which will in turn influence how decisions may have to be made with incomplete data.

## CONCLUSIONS AND ADVICE

The consideration of CE within the FFHPP's integrated planning process and regulatory decision-making is still a relatively new concept and this advice provides a foundation for a more complete framework that will be required into the future. CE by its very nature requires a holistic view of both ecological and management processes. From the ecological view point, an ecosystem level perspective is required both in the planning and decision-making stage, with the requirement for these stages to inform one another to allow continuous learning and adaption. With respect to the management, the FFHPP decision-making (or risk management) approach includes other considerations beyond the ecological context, while these may impact CE considerations, they are generally not covered by this advice. Given the dynamic and ever evolving nature of CE consideration it is recommended that science and management, along with their partners, continue to work on the needs for a full CE framework for FFHPP within a formal working group setting.

The information needs for a fully formed framework for CE considerations in the FFHPP management cycle will be substantial. Many of these data streams already exist but with varying levels of precision, these differences are a key component of uncertainty in CE consideration (see above). In general, ecosystem information on the fish, the fish habitat and the status of both in the system, will be required. This will be coupled with an expectation on pressures arising from the proposed Work, Undertaking or Activity (WUA), which can be derived from the Pathway of Effects for many WUA's. All this information will need to be put into context with respect to past pressures as well as foreseeable future pressures in a spatial and temporal context that both fits the species and WUA under consideration. This advisory document outlines several methods that can be used for this analysis (e.g., using reference/benchmark conditions, trait-based analysis for data poor situation etc.) but the real need in the future will be to standardize these approaches as much as possible and to make the results of these analyses assessable to assessors and the public (e.g., national geospatial database). This standardization and tool development/adaptation would form the main objective of the joint FFHPP/Science working group.

Another key information source for CE consideration in the future will be the information generated by the integrated planning and decision-making cycle within FFHPP. Ideally these programs will continually inform each other. To provide data that can be analyzed, the planning process will need to develop objectives and targets for ecosystems under pressure from development. These objectives and targets should include agreed upon indicators that can be measured through time. By periodically evaluating the response of the selected indicators the management measures can be tested for effectiveness thus providing valuable information to the entire management cycle.

## OTHER CONSIDERATIONS

This CSAS process generally focused on freshwater ecosystems and while many of the concepts may transfer to other aquatic ecosystems (i.e., coastal and open ocean ecosystems) this would need to be verified. Undoubtably, the terminology and/or ecosystem scope may be different in the marine ecosystems, and they may require specific advice. This advisory process also focused on the FFHPP management cycle, specifically integrated planning and decision-making. The meeting used a stylized 'management' cycle (see Figure 3) and a generic risk management approach which may be altered in the future. There are also other areas where

the consideration of CE may present itself, namely under Environmental Assessments including those covered under the *Impact Assessment Act*, and/or those dealt with through prescribed works or class authorizations. The concepts discussed in this advisory process may apply in these cases but was not a focus of the meeting.

There has been a great deal of previous science advice over the past decade that can be used to inform the fish and fish habitat status and the expected pressures (i.e., pathways of effects) from a WUA over the past decade, especially in freshwater ecosystems. There has also been advice on indicators, monitoring protocols and overall productivity elements for freshwater ecosystems. Much of this advice still holds true and can support the consideration of CE. Considering and integrating existing advice with the methods and considerations provided by this advisory process will provide a better framework for CE considerations.

## LIST OF MEETING PARTICIPANTS

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## SOURCES OF INFORMATION

This Science Advisory Report is from the March 8-12, 2021 National Peer Review on Science advice for assessing cumulative effects in support of policy development and regulatory decision making. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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Glossary of terms provided in Hodgson et al., 2022.

## THIS REPORT IS AVAILABLE FROM THE:

Centre for Science Advice (CSA)
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ISSN 1919-5087
ISBN 978-0-660-46375-9 N° cat. Fs70-6/2022-055E-PDF


Correct Citation for this Publication:

DFO. 2022. Science advice for assessing cumulative effects in support of policy development and regulatory decision-making. DFO Can. Sci. Advis. Sec. Sci. Avis. Rep. 2022/055.

*Aussi disponible en français :*

*MPO. 2022. Avis scientifique pour l'évaluation des effets cumulatifs à l'appui de l'élaboration des politiques et de la prise de décisions réglementaire. Secr. can. des avis sci. du MPO. Avis sci. 2022/055.*