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## **Canadian Science Advisory Secretariat (CSAS)**

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### **Proceedings of the National Advisory Meeting for science advice on revisiting Pathways of Effects (PoE) diagrams in support of FFHPP risk assessment**

**February 23-26, 2021  
Virtual via MS Teams**

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## Foreword

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

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## SUMMARY

This Proceedings document results from the virtual Science Advisory meeting held February 23-26, 2021, titled the National Peer Review of Science Advice on revisiting Pathways of Effects (PoE) diagrams in support of FFHPP risk assessment.

Through the Canadian Science Advice Secretariat (CSAS), DFO's Fish and Fish Habitat Protection Program (FFHPP) had requested science advice on four consolidated draft Pathways of Effects (PoE) diagrams, including consideration of their redesign, validation of existing linkages, and assessment of completeness of the linkages. The four draft diagrams that were reviewed align with FFHPP's categories of Works, Undertakings, and Activities (WUAs), including: 1) Land-based WUAs, 2) Noise and Energy producing WUAs, 3) In-water WUAs, 4) WUAs affecting Flow.

Based on one working paper (Brownscombe and Smokorowski 2021), the meeting included discussions on the accuracy of the four draft consolidated PoE diagrams and the completeness of the linkages presented. Suggested changes to be made to the consolidated diagrams that were agreed to during the CSAS process were captured in the Science Advisory Report (SAR) resulting from this process (DFO, 2021) and were also detailed in the final research document (Brownscombe and Smokorowski, 2021). Meeting participants agreed that the working paper and meeting conclusions satisfied all Terms of Reference objectives.

Participants in this meeting included DFO staff from various sectors and external experts (Appendix 2).

This Proceedings Report summarizes the key information presented at the meeting, as well as the relevant meeting discussions and conclusions reached.

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## INTRODUCTION

Through the Canadian Science Advice Secretariat (CSAS), DFO's Fish and Fish Habitat Protection Program (FFHPP) had requested science advice on four consolidated draft Pathways of Effects (PoE) diagrams, including consideration of their redesign, validation of existing linkages, and assessment of completeness of the linkages.

The Program's 20 existing PoE diagrams were consolidated into four draft diagrams that align with FFHPP's categories of Works, Undertakings, and Activities (WUAs), including: 1) Land-based WUAs, 2) Noise and Energy producing WUAs, 3) In-water WUAs, 4) WUAs affecting Flow. These four revised diagrams are referred to in this document as the 'consolidated PoE diagrams.' The intent of the revised and validated PoE diagrams is to allow the FFHPP to consider impacts of project types in a consistent manner, and to better understand the impacts of a project at the local and ecosystem level. The specific objectives of this science advice process were to:

1. review and validate the pathways included in the consolidated PoE diagrams to ensure they are accurate and valid;
2. assess whether the linkages between the WUAs, pressures and endpoints on fish and fish habitat are comprehensive and complete; and,
3. determine if the process of using these consolidated PoE diagrams allows FFHPP to identify which endpoints require avoidance and/or mitigation measures to reduce and manage the risk that the proposed WUA will impair the habitat's capacity to support the life processes of fish (or result in death of fish), and to identify residual impacts to be evaluated for authorization and offset, thus ensuring that fish and fish habitats are conserved and protected.

At the start of the meeting the co-chair, Karen Smokorowski (DFO – Ontario and Prairie Region) provided an overview of the [CSAS Science National Peer Review Process](#) and the [principles and policies of CSAS](#) and described the role of all meeting participants (Appendix 2).

The peer reviewed documents resulting from this process are a Science Advisory Report (SAR) (DFO, 2021) and a research document (Brownscombe and Smokorowski, 2021) which are available on the DFO [CSAS website](#).

## OVERVIEW OF THE FFHPP PROGRAM AND THE NEED FOR SCIENCE ADVICE ON REVISITING PATHWAY OF EFFECTS DIAGRAMS

An introductory presentation by Melanie Boivin (FFHPP) provided the background information on FFHPP's needs for science advice, why and how PoE diagrams are used, and the plans for the use of the revised PoE diagrams.

PoE diagrams are the primary tool for identifying potential impacts to fish and fish habitat (including species at risk), avoidance and mitigation measures to prevent or minimize impacts, and residual impacts likely to occur once avoidance and mitigation measures are considered. The current PoE diagrams have been used by FFHPP for ~20 years however there is a need to update and to better align the pathways with the implementation of the program.

The main objectives for the PoE diagram reviews were as follows:

- to update diagrams to address gaps and inaccuracies that have been determined over the years;

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- to ensure transparency and share the tool publicly;
  - to provide nationally consistent tools for staff to communicate when discussing impacts to fish and fish habitat;
  - to ensure that DFO decisions are based on the best available science; and,
  - to standardize PoE endpoints (categorize, catalogue, and align with monitoring and reporting frameworks/processes).

Due to the high amount of overlap within the existing PoE diagrams, the request for this CSAS was for science advice to assist FFHPP with the simplification and consolidation process from the existing 20 PoE's down to four. The specific science advice request from FFHPP focused on the validation of draft consolidated PoE diagrams (including the pathways, linkages, and endpoints), to ensure that they are accurate, complete, and valid. There was a need to validate that the PoE's are a scientifically sound tool to identify and communicate potential impacts resulting from a proposed WUA, identify avoidance and mitigation measures associated with WUA pressures, and to identify residual impacts that could impair the habitat's capacity to support fish.

Following the presentation by FFHPP, questions were posed concerning changes to the *Fisheries Act (FA)* and the inclusion of the harmful alteration, disruption, and destruction of fish habitat (HADD) provision. It was clarified that the HADD provision included in the 2019 *FA* reverted to what it was prior to the 2012 *FA*.

Another item of clarification centered around the impacts of a proposed project under Species at Risk and Aquatic Invasive Species (AIS) legislation and whether the PoE diagrams being reviewed in this process would be useful for all relevant legislation. FFHPP clarified that these pathways could be used by Species at Risk Program reviews (at least to determine impacts) but are not for AIS purposes specifically.

An important point that was raised was that through this PoE diagram simplification process the endpoints were reduced to only include the main ecosystem components that FFHPP manages. However, it is important from a Science perspective to not lose sight of other endpoints that may not be managed by FFHPP but could still have significant impacts on fish and fish habitat (e.g., oxygen levels). It was flagged that this will need to be acknowledged as a consideration in the SAR for this CSAS process.

Some clarification was requested around the scope of use for these PoE diagrams, specifically if their use would be primarily in the context of risk and negative project impacts, and not to identify restoration options/positive impacts. In response, FFHPP clarified the focus was on risk and negative project impact elements, because at the moment the tools are used by assessors reviewing WUAs. It was further clarified that any incidental positive effects of projects are not eligible as offsetting under the current *FA*.

## **REVIEW TERMS OF REFERENCE INCLUDING THE OVERVIEW OF GOALS AND OBJECTIVES OF MEETING**

The chairs provided a brief presentation to review the Terms of Reference including the goals and objectives that served as the foundation for this CSAS process (Appendix 1), as well as an overview of the meeting Agenda (Appendix 3).

FFHPP requested the CSAS to conduct a peer review of the four consolidated PoE diagrams (land-based WUAs, in-water WUAs, noise and energy producing WUAs, and WUAs affecting flow). Having revised and validated PoE diagrams would allow FFHPP to consider impacts of

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WUAs in a consistent manner. The main meeting objectives for all four PoE diagrams were as follows:

1. Review and validate the pathways included in the revised PoE diagrams to ensure they are accurate and valid.
2. Assess whether the linkages between the WUAs, pressures and endpoints on fish and fish habitat are comprehensive and complete.
3. To be addressed on the last day of this CSAS meeting was to determine if the process of using these revised PoE diagrams allows FFHPP to:
  - a. identify which endpoints require avoidance and mitigation measures to reduce and manage the risk that the proposed WUA will impair the habitat's capacity to support the life processes of fish (or result in death of fish), and
  - b. to clearly identify residual impacts to be evaluated for authorization and offset, thus ensuring that fish and fish habitat are conserved and protected.

### **PRESENTATION BY THE RESEARCH DOCUMENT LEAD AUTHOR, JAKE BROWNSCOMBE (DFO) ON THE SUGGESTED CHANGES FOR EACH POE**

The lead author of the research document, Dr. Jake Brownscombe, provided an overview of each of the four PoEs, including the general structure that involves a list of the respective WUAs at the top, which then flow downward into various pressure pathways (square boxes) and endpoints (rounded boxes), which then ultimately connect to "impacts". When reviewing these PoEs, the overall consideration was to provide complete and comprehensive diagrams, while balancing a reasonable level of complexity to ensure their utility for FFHPP in their decision-making process.

If there were no suggested changes, the boxes and lines remained unchanged. Suggested changes included additional linkages, removal of linkages, addition of pressure or endpoint nodes, and changes in terminology to achieve accuracy and completeness. Additions and/or changes were identified in green. Removals were represented by red. Discussion of support for each pressure pathway were included in the text and were labelled with one of four different codes: 1. TS – theoretically sound/supported, 2. WS – well supported (no changes), 3. AS – some changes suggested, 4. LS – little support. Changes were detailed in a variety of figures in the working paper to facilitate discussion and to reach consensus on final recommended changes.

### **FORMAL REVIEWS OF THE PATHWAYS FOLLOWED BY DISCUSSIONS**

After the presentation by the research document lead author, each pathway was reviewed by a formal reviewer. The formal reviewers of the PoE diagrams were as follows: 1) Land-Based WUAs – Dr. Mike Bradford; 2) Noise and Energy Producing WUAs – Dr. Harald Yurk; 3) In-Water WUAs – Dr. Sean Naman; and 4) WUAs affecting flow – Dr. Tommi Linnansaari. The reviewer's comments generally were provided in two parts: 1) general research document methodology, and 2) specific comments regarding the individual PoE that was reviewed.

Following the formal review, each PoE diagram was discussed further by the meeting participants.

There were general questions on how the review process would unfold and how the resulting pathways would be displayed in the final product. The chair stated that the SAR will not include final clean pathways, but that all the suggestions for changes from this meeting will be included

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in both the SAR and the research document. Based on the advice provided, FFHPP will then finalize the pathways.

An external participant also asked how they and the general public could access the final cleaned up pathways. It was communicated that the final product would be posted on FFHPP's website ([Pathways of Effects \(dfo-mpo.gc.ca\)](http://dfo-mpo.gc.ca)). This website currently has links to the 20 different pathways, which will eventually be replaced by the four new pathways.

The detailed discussions as well as identification of the decisions made on each of the four consolidated PoE diagrams are summarized in Table 1 below.



## SUMMARY OF DISCUSSIONS AND PROPOSED CHANGES TO THE POE DIAGRAMS

*Table 1. Summary of the review and discussions held on each PoE diagram as originally outlined in the working paper. The rationale for the decisions that were made are outlined, including the specific changes recommended for each PoE diagram. A graphic presentation of these suggestions is included in the final research document (Brownscombe and Smokorowski, 2021). The Table below includes a reference # which corresponds to the specific change # as outlined in the Science Advisory Report produced from this CSAS process (DFO, 2021).*

Land-based PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
-	<b>For all PoEs: Consider simplifying all pathways along the lines of 'in-water' RE: nutrients and contaminants - ensure consistency</b>	<b>Agreed</b>	-	-
Link input of organic matter with change or loss of habitat structure	-	<b>Agreed - but now redundant due to Land-Based SAR Change #2</b>	'Increased input of large woody material in water ' → 'Change or loss of habitat structure and cover'	-
-	After changing to 'increased input of large organic matter'?	<b>Agreed</b>	Change wording from 'Input of organic matter in water (e.g., fallen branches, trees and woody debris)' to 'Increased input of woody material'.	1
-	Could consider putting this under 'altered vegetation' as a subset of that main pressure. Streamlines the diagram.	<b>Agreed - but now redundant due to Land-</b>	Altered vegetation' → 'Increased input of large woody material in water' → 'Change or loss of habitat structure and cover'	-

Land-based PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
		<b>Based SAR Change #2</b>		
-	Add linkage from 'increased input of large organic matter' to 'decrease in water quality'.	<b>Agreed - but now redundant due to Land-Based SAR Change #2</b>	'Increased input of large woody material in water (e.g., fallen branches, trees and woody debris)' → 'Decrease in water quality'	-
Connect 'input of organic materials' to 'increase in water temperature' directly, removing 'decrease in habitat access' as a link	Via a link through 'blockage'? (or in-water 'placement of materials' box)	<b>Agreed - but now redundant due to Land-Based SAR Change #2</b>	Increased input of large woody material in water' → 'Blockage' → 'Increase in water temperature'	-
-	Remove 'decrease in habitat access' as a connection from input of organic matter.	<b>Agreed - but now redundant due to Land-Based SAR Change #2</b>	'Increased input of large woody material in water' → 'Decrease in habitat access' (REMOVE) → 'Change or loss of fish passage'	-
-	Link to blockage before access and before the change in temperature. Linkage in the in-water POE - link to that placement of materials or structures in water	<b>Agreed - but now redundant due to</b>	'Input of large woody material in water' → blockage → see in-water pathway	-

Land-based PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	as a way to identify it as a blockage, and subsequent mechanisms of change.	<b>Land-Based SAR Change #2</b>		
-	Add link to 'smothering' from the in-water pathway - link directly from increased input of large organic matter (LOM) to 'see in water pathway'. There was further discussion that pointing specifically to where to look in the 'in water pathway' might be limiting, so a reference simply to the pathway will be made.	<b>Agreed</b>	'Input of large woody material in water' → see 'In-water diagram'	2
-	With the connection to the 'in-water' pathway, the link between 'increased input of woody material' and 'decrease in habitat access', and 'change or loss in fish passage' is not necessary since the In-water diagram more comprehensively covers those effects.	-	Remove linkage: 'Increased input of woody material' → 'Decrease in habitat access' → 'Change or loss of fish passage'	3
Change from 'increase in water temperature', to 'altered water temperature'	Most common direction is warmer - keep directionality but mention potential for increased groundwater interaction to potentially cool water as a less frequent occurrence in the res doc? Add * to the box to point this out? Note this occurs in the Flow diagram as well and there it was agreed by the review that 'altered' is better.  - Decreased groundwater in the winter results in colder temperatures so it is just as common to be in both directions, only depends on season.	<b>Agreed</b>	Change – 'Increase in water temperature' to 'Altered water temperature'	4

**Land-based PoE Diagram**

Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	- No * needed - both can happen			
Add endpoint 'decrease in wetted area' to altered groundwater flows pressure pathway	ADD - link between decrease in wetted area and increase in water temperature - less water = warmer water. NOTE: overlaps with decrease in water quantity (see 7 below). This is better captured via water quantity as the mechanism to altered temperature, not decreased wetted area.	<b>Agreed</b>	'Altered groundwater flows to surface water' → 'Decrease in baseflow' → (NEW) 'Change or loss of wetted area'	5
-	-	<b>Agreed-but already covered (#4&amp;5) so no change needed</b>	'Altered groundwater flows to surface water' → 'Decrease in baseflow' → ' Altered water temperature'	-
-	Directionality issue - change decrease in baseflow and decrease in wetted area to 'alteration' because conceivably there is a way that groundwater could be increased. NO - keep directionality because the other direction is not likely with riparian zone alteration only. Add * to flag the fact that the opposite effect (i.e., an increase in baseflow) is possible, even though less common.	<b>No change to direction for baseflow - Agreed</b>	Add * to 'Decrease in baseflow**'	6
-	Water quantity and wetted area are two different mechanisms, although wetted area has been used to imply more broad impacts in the past. Linking groundwater to quantity and	<b>Agreed</b>	'Altered groundwater flows to surface water' → 'Altered water quantity' → 'Potential direct or indirect impairment of the habitat's capacity to support one or more life	7

**Land-based PoE Diagram**

Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	wetted area. Quantity is linked directly to the 'potential indirect or direct...' to capture the greater habitat suitability aspects. These aspects will be covered in more detail in the res doc.		processes of fish (spawning, breeding, rearing, nursery, feeding, migration, thermal refuge)	
Connect decrease in baseflow to changes in food supply	-	<b>Agreed</b>	Altered groundwater flows to surface waters' → 'Decrease in baseflow' → 'Decrease in food supply'	8
Change 'decreases in nutrients/productivity' to 'Alterations in nutrients/productivity'	Changing the wording to neutral is appropriate here because there are a number of mechanisms by which nutrients and primary productivity can be altered.	<b>Agreed</b>	Change wording from 'Decrease in external nutrients/energy inputs' to 'Altered external nutrients/energy inputs'.	9
-	Removing this box is consistent with the level of detail in all diagrams.	<b>Agreed</b>	Remove the 'Decrease in nutrient concentration' box.	10
-	-	<b>Agreed</b>	Change wording from 'Decrease in primary productivity' to 'Altered primary productivity'	11
Connect 'altered vegetation' directly to 'decrease in food supply'	-	<b>Agreed</b>	'Altered vegetation' → 'Decrease in food supply'	12
Alter 'instream' to 'aquatic'	-	<b>Agreed</b>	Change wording from 'Decrease of instream organic structure' to 'Decrease of aquatic organic structure'	13

Land-based PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Add connection from 'altered vegetation' to 'bank and slope stability'	-	<b>Agreed</b>	'Altered vegetation' → 'Bank and slope instability and exposed soils'	14
Add connection from 'altered vegetation' to 'loss of undercut banks'	-	<b>Not agreed (see Land-based SAR change#15)</b>	-	-
-	Remove 'Loss of undercut banks' as a node to simplify - too specific - but in res doc when discussing this pathway the mechanism of linkage to habitat structure and cover includes undercut banks and how they are hard to replicate.	<b>Agreed to discussed changes</b>	Create a new connection: from 'Altered vegetation' to 'Change of loss of habitat structure and cover'	15
-	-	<b>Agreed (see Land-based SAR change #15)</b>	Remove 'Loss of undercut banks' as a node thus 'Alteration of slopes and banks' would now lead directly to 'Change or loss of habitat structure and cover'	16
Alter 'Fish mortality' endpoint to 'Fish mortality and sublethal effects'	-	<b>Agreed</b>	Change wording from 'Fish mortality' to 'Sublethal effects and/or mortality'	17
Connect 'sedimentation of fish habitat' to 'fish mortality'	-	<b>Agreed</b>	New connection: 'Sedimentation of fish habitat' → 'Sublethal effects and/or mortality'	18

Land-based PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Change 'decrease in water quantity' to 'altered wetted area'	Wetted area and water quantity are different - keep separate. Changing flow distribution, not necessarily mean annual flow. Impervious surfaces added to riparian areas could change flow distribution. Add link from alteration in water quantity to decrease in wetted area.	<b>Agreed to discussed changes</b>	Change wording from 'Decrease in water quantity' to 'Altered water quantity'	19
-	-	<b>Agreed</b>	New connection: 'Altered water quantity' → 'Change or loss of wetted area'.	20
-	AND add a link from alteration in water quantity to 'see flow pathway'.	<b>Agreed</b>	Altered water quantity' → 'See Flow PoE diagram'	21
Add endpoint 'Increased species invasion risk', connected to numerous pressures	On flow pathway there is 'see invasive species pathway' that doesn't yet exist. But is good to flag as potential.	<b>Agreed</b>	WUA' → ('Altered vegetation', 'Altered slopes and banks', 'Altered land drainage patterns') → See 'Aquatic Invasive Species pathway (TBD)'	22
Add endpoint 'Increased human access', connected to numerous pressures	Management measures are around altered vegetation and minimizing access as one of the mitigation measures - this is where it is captured. In smaller projects it would be hard to mitigate this occurring - where to put it is a question. Land-use issue - is this something we would report on? Endpoints included - 6 was the starting point from the DFO 2014 SAR based on the types of mitigations. Not as an endpoint - WUA → increased human access → consult with relevant management agency(ies). DFO is not the fishery manager -	<b>Agreed</b>	WUA → 'Increased human access' (NEW) → Consult with relevant management agency(ies).	23

**Land-based PoE Diagram**

Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	have to consider inclusion carefully. Integrated planning group could consider this though.			
Connect 'alteration of land drainage patterns' and/or 'alteration of slopes and banks' to 'increase in water temperature'	-	<b>Agreed</b>	'Alteration of land drainage patterns' → 'Altered water temperature'	24
-	Decided NOT to include this connection as it is not as core as alteration of and drainage patterns affecting temperature.	-	AND 'Alteration of slopes and banks' → 'Increase in water temperature'.	-
-	Oil, grease should be linked to water quality. Suspended sediment is different from sedimentation. QUESTIONS - should we change 'herbicides to pesticides' to capture the more general category?	<b>Agreed to change to pesticides</b>	Wording change from 'Introduction of oil, grease, fuel, herbicides and other deleterious substances' to 'Introduction of oil, grease, fuel, pesticides and other deleterious substances'	25
-	-	<b>Agreed</b>	'Introduction of oil, grease, fuel, pesticides and other deleterious substances' → 'Decrease in water quality'	26



Noise and Energy PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Remove connection from 'change in pressure' to 'change or loss of wetted area', thus remove 'change or loss of wetted area'	Support for this change. Context - intent was the acoustic suitability of the water. Not needed without physical shoreline alteration - covered in LB pathway.	<b>Agreed</b>	Remove 'Change or loss of wetted area'	1
Integrate 'sublethal effects' node into single 'Fish mortality and sublethal effects' endpoint	-	<b>Agreed</b>	Change endpoint to 'Sublethal effects and/or mortality'	2
Alter 'physical injury' node to 'physical injury and physiological stress'	Change to physical injury and stress to fish/mammals. In res doc consider different impact on various life stages. Decision was not to include mammals since the definition of 'fish' in the Fisheries Act includes mammals.	<b>Agreed</b>	Change node to 'Physical injury and/or stress to fish '	3
-	Link the 'change in pressure' to 'change in access to habitat' then link directly to 'potential direct or indirect...'	<b>Agreed</b>	'Denotation in or near water' → 'Instantaneous change in pressure' → (NEW) 'Altered migration patterns (avoidance behaviour) access to habitat → 'Potential direct or indirect impairment...'	4
Add node 'physical shoreline alteration' to connect 'detonation' to 'change or loss of wetted area'	Shoreline alteration covered in land-based projects do have detonations in water to change depth or remove navigation hazards. It is captured at substrate disturbance and new link to structure and cover. Physical shoreline alterations covered in land-based pathway link.	<b>No – see Review and Discussion</b>	No addition.	-

Noise and Energy PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Add 'alteration of physical cover and structure' endpoint and connect from 'physical shoreline alteration'	Covered in land-based link.	<b>No – see Review and Discussion</b>	No addition.	-
Alter 'high velocity particle release' to 'high velocity particles'	Sound wave vs. substrate being shaken which is also measured as particle velocity. What did this refer to specifically? Particle release is very important for sound transmission because it is detected by fish more than sound pressure waves. Particle refers to the actual molecule movement in the water column. If the particle is the actual substrate that is different. In this case we are discussing the movement of the physical particles that need to change and move. 'High velocity movement/shaking of material'?	<b>Agreed</b>	Change wording: change node from 'High velocity particle release' to 'High velocity water and solid particle movement'	5
-	New connection. See Nature of Alteration - Detonation in or near water leads to 5 boxes explained below.	<b>Agreed</b>	'High velocity water and solid particle movement' → 'Change or loss of habitat structure and cover' (NEW ENDPOINT)	6
Connect 'resuspension of sediment' to 'deposit of deleterious substances'	Not adding new deleterious substances but disturbing old that resides within the substrates.	<b>Agreed</b>	Detonation in or near water → Substrate disturbance → Resuspension of sediment → (NEW) Deposit of deleterious substances	7
Connect 'sedimentation of fish habitat' to 'fish mortality'	-	<b>Agreed</b>	Detonation in or near water → Substrate disturbance → Resuspension of sediment → Sedimentation of fish habitat → (NEW) 'Sublethal effects and/or mortality'	8

Noise and Energy PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Add connection from 'substrate disturbance' to 'alteration of physical cover and structure'	-	<b>Agreed</b>	'Detonation in or near water' → 'Substrate disturbance' → 'Change or loss of habitat structure and cover'	9
Add connection from 'high velocity particle release' to 'alteration of physical cover and structure'	-	<b>See discussion below</b>	Detonation in or near water' → 'High velocity particle release' → 'Physical injury or stress to fish/mammals' → 'Sublethal effects and/or mortality'	-
<p>Detonation in or near water leads to five boxes:</p> <ol style="list-style-type: none"> <li>1. Instantaneous change in pressure.</li> <li>2. High velocity water particle/energy transfer (link to physical injury to fish - sublethal effects/mortality)</li> <li>3. High velocity movement of solids (link to physical injury etc. AND to change in S&amp;C)</li> <li>4. Blast residue</li> <li>5. Substrate disturbance</li> </ol>	Movement of sound pressure wave and movement of water particles are different mechanisms. Water particle is a shock wave and sound pressure wave is moving. Particle movement transfers from molecule to molecule and has an effect on fish and invertebrates and can cause physical damage to fish larvae. Substrate disturbance over a long distance also from the pressure wave.	<b>Agreed</b>	This has been covered already on the diagram.	-
-	Change name from 'high velocity particle release' to ' high velocity water particle/energy transfer'.	<b>Agreed</b>	Covered in change 5 above.	-

Noise and Energy PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
-	Link 'high velocity water particle/energy transfer' to physical injury to fish - sublethal effects/mortality.	<b>Agreed</b>	This is already captured in the diagram with 'High velocity water and particle movement' being connected to injury	-
-	Change wording (see Noise and Energy SAR change #13-16 Review and discussion below for explanation)	-	Change from 'Sound energy pulse' to 'Impulsive sound'	10
Connect 'detonation in or near water' to 'sound energy pulse' - impulse sound, not continuous	<p>WUA needs to be tied to the impact it has, which is associated with the produced sound type and the received dose and duration:</p> <ul style="list-style-type: none"> <li>- E.g., explosions can cause both physical and auditory injury to middle and inner ear and risk is correlated with the distance of the receiver from the source</li> <li>- Explosions also can cause displacement from habitat aside from physical and chemical alteration of habitats</li> <li>- Explosions can cause startle responses that may have negative impact on group behaviours - SUGGESTED ADDITION: connect 'detonation in or near water' to 'behavioural changes' - covered via the link from sound energy pulse to behavioural change pulse effect because of initial blast and sound pulse moves on. But there is also a sound pressure wave produced at the same time - comodulated.</li> </ul>	<b>Agreed</b>	Detonation in or near water → Impulsive sound (define)	11

Noise and Energy PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
'Decreased habitat access' could be considered an endpoint	Not only linked to passage - it is the use of the habitat itself and is an endpoint. Other decisions like this have linked directly to the bottom box 'potential direct or indirect impairment'. Leave access to habitat - explain that fish passage can be an important part of this in the text, but otherwise remove 'change or loss of fish passage' since that may restrict the interpretation of the 'access to habitat' bubble.	<b>Agreed</b>	Remove 'Change or loss of fish passage': Access to habitat (keep original wording) → Directly to 'Potential direct or indirect impairment...'	12
-	Introduction of noise link to new box 'continuous sound' and link to 'sound energy pulse' but change wording to 'impulsive sound'. Remove 'release of compressed air' because it is a special case of impulsive (intermittent) sound. Need to define continuous vs impulsive sound - difference is acoustical, not temporal.	<b>Agreed</b>	'Release of acoustic energy in water (sound)' → 'Continuous sound' → 'Behavioural changes' → AND 'Release of acoustic energy in water (sound)' → 'Continuous sound' → 'Physical injury physiological stress to fish/mammals'	13-16
-	Release of acoustic energy in water' leads to 'sound pulses' and 'continuous sounds' - behavioural changes and physical injury. Change of continuous sound to cause injury is low, but the potential for pulse sound to cause injury is high. Also two boxes would be useful since the mitigation measures are different.	<b>Agreed</b>	'Release of acoustic energy in water (sound)' → 'Impulsive sound' → 'Physical injury and stress to fish/mammals' → 'Lethal/sublethal' AND 'Release of acoustic energy in water (sound)' → 'Sound pulses' → 'Behavioural changes'	13-16
Connect 'behavioral changes' to 'fish mortality and sublethal effects'	-	<b>Agreed</b>	'...behavioural changes' → 'Sublethal effects and/or mortality'	17

Noise and Energy PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Connect 'anthropogenic noise' to altered 'physical injury and stress'	To fish and mammals.	<b>Agreed</b>	Covered above with the connections from continuous or impulsive sound to physical injury and/or stress to fish.	-
Consider terminological change to achieve greater logical consistency	'Fish' as defined in FA, then mammals and inverts are included. For clarity to this endpoint change to 'sublethal physiological effects and mortality' and leave off the 'fish'.	<b>Agreed (see Noise and Energy SAR change #2 above)</b>	Endpoint wording change to 'sublethal effects and/or mortality'	-
Alter 'change in mammal communication' to 'impaired communication'	-	<b>Agreed</b>	Alter 'Change in mammal communication' to 'Impaired communication and ability to navigate'	18
-	Link from sound boxes (continuous and impulsive) to 'auditory masking' and to 'impaired communication' and both of those lead to a change in behaviour and directly to sublethal effects. Also, link from the sound boxes to change in behaviour directly.	<b>Agreed</b>	'Release of acoustic energy in water (sound)' → 'Continuous sound' → 'Acoustic masking (NEW)' → altered communication 'Impaired communication and ability to navigate (NEW)' → change in behaviour 'Behavioral changes'	19
-	-	<b>Agreed</b>	'Release of acoustic energy in water (sound)' → 'Impulsive sound' → 'Auditory masking' → 'Altered communication' → 'Change in behaviour'	20
Alter 'change in wetted area' to 'reduced habitat access'	Access to habitat is the impact here - remove change or loss of wetted area.	<b>Agreed</b>	Remove 'Change or loss of wetted area'	21

Noise and Energy PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
consider removing 'release of compressed air' as independent pressure pathway	Release of compressed air (WS):The pathway is not established through the release of the air but the associated pulse sounds with that activity. The impact and pathway is characterized by the released sound which is similar in impact pile driving	<b>Agreed</b>	Remove 'Released of Compressed Air' (covered in pulse sounds)	22
-	EM box at top link to behaviour link to access to habitat and sublethal effects	<b>Agreed</b>	New node – 'electromagnetic field production' connected to altered migration and sublethal effects  'Placement of materials/structures in water' → (NEW) Electromagnetic field production → 'Alteration of migration patterns/access to habitat' → 'Sublethal effects and/or mortality'. Also add a direct connection from (NEW) 'Electromagnetic field production' → 'Sublethal effects and/or mortality'	23
-	Note - there was no time during the meeting to thoroughly discuss a new pathway on this diagram related to electromagnetic fields. The recommended changes in the SAR related to this new pathway are therefore kept very simple and may be modified with future detailed exploration.	-	-	-

In-water PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Alter 'non-motile' to 'less mobile' species	Suggest further expanding the language to include less mobile <i>life stages</i> in addition to species. Wording to be 'trampling of less motile species and life stages'	<b>Agreed</b>	Change wording to 'Trampling of less motile species and life stages'	1
Connect 'use of machinery' to 'substrate disturbance'	Sediment disturbance is likely a widespread and pervasive impact from in-water machinery use; thus, it warrants being included as an additional connection as proposed.	<b>Agreed</b>	'Use of machinery in water' → 'Substrate disturbance'	2
Add 'reduced habitat access' as an endpoint, and connect 'use of machinery' (do we need now reduced habitat access?)	Unless there are additional mechanisms besides noise that drive behavioural avoidance, it seems like this pathway is covered in the <i>Introduction of underwater noise</i> pathway (specifically, proposed alteration # 12). Thus, for tractability suggest either leaving this off of the In-water diagrams or instead referencing the noise diagram directly. Decision: change WUA → N&E to 'use of machinery in water' → See N&E pathway	<b>Agreed to discussed changes</b>	'Use of machinery in water' → 'See Noise and Energy pathway'	3
-	-	<b>Agreed</b>	Remove connection from WUA → See 'Noise and Energy PoE diagram'	4
Connect 'deleterious substances' to 'reduced habitat access'	While there is some experimental support for behavioural avoidance of deleterious substances, I question whether adding an additional node is warranted. There is already a direct link from <i>Decrease in water quality</i> to <i>Potential direct and indirect impairment of the</i>	<b>Agreed to discussed changes</b>	No change	-



**In-water PoE Diagram**

Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	<p><i>habitat's capacity to support life processes as well as to Fish mortality (and sublethal effects if that modification is made), which could incorporate this process implicitly. There could in theory be situations where point source contaminants block access to otherwise suitable upstream habitat; however, this situation does not seem sufficiently widespread to be included as a core connection in the diagram. After discussion - might not be a 'core' enough link to include - leave off.</i></p>			
-	Loss of interstitial space → Decrease in food supply.	<b>Agreed</b>	'Loss of interstitial spaces' → 'Decrease in food supply'	5
-	Herbicides are unlikely to be introduced through commonly used machinery in water, and therefore could be removed from the pressure node.	<b>Agreed</b>	Remove the word 'herbicide' so the pathway reads: 'Use of machinery in water → 'Introduction of oil, grease, fuel, and other deleterious substances'	6
-	Decrease in water quality → Decrease in food supply.	<b>Agreed</b>	'Decrease in water quality' → 'Decrease in food supply'	7
Connect 'constriction or expansion of flow' to 'change or loss of wetted area'	This is a widely supported pathway that is well grounded in geomorphology and broadly applicable across systems.	<b>Agreed</b>	'Change in channel morphology or shoreline morphometry' → 'Constriction or expansion of flow/coastal currents' → (NEW) 'Change or loss of wetted area'	8

In-water PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Connect 'constriction or expansion of flow' to 'decrease in food supply'	While invertebrate abundance and community structure are related to hydraulic habitat conditions, which are driven by larger scale channel morphology, making clear directional predictions of food supply <i>decreasing</i> in response to channel morphology constriction is challenging. At a larger scale, habitat simplification (e.g., loss of floodplain habitat) has been shown to result in fewer energy pathways available to fish (Bellmore et al. 2013), which could be added as an empirical example if this pathway is included.	<b>No addition</b>	No change	-
-	The connection between change in channel morphology to direct or indirect impairment of fish is not always via change or loss of fish passage (currently the only linkage), so direct link to structure and cover warranted.	<b>Agreed</b>	'Change in channel morphology or shoreline morphometry' → 'Change or loss of habitat structure and cover' → 'Potential direct or indirect...'	9
Add 'stranding' as a node connecting 'removal of materials' with 'fish mortality'	These additional connections and nodes would all be well supported, and participants agreed with adding them.	<b>Agreed</b>	'Removal of materials (including organics)/structures' → 'Stranding' → 'Sublethal effects and/or mortality'	10
Connect 'removal of materials' with 'entrainment'	These additional connections and nodes would all be well supported, and participants agreed with adding them.	<b>Agreed</b>	'Removal of materials (including organics)/structures' → 'Entrainment of fish' → 'Sublethal effects and/or mortality'	11
Add 'increased species invasion risk' as an endpoint	These additional connections and nodes would all be well supported, and participants agreed with adding them - Off to the side 'see increased species invasion risk' PoE TBD.	<b>Agreed</b>	'Removal of materials (including organics)/structures' → 'see Aquatic Invasive Species pathway (TBD)'	12

**In-water PoE Diagram**

Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
-	Proposing to connect resuspension of contaminants and sediment to decrease in water quality to deposit of deleterious sub. → Contamination of fish habitat. THEN connect resuspension of sediment to sedimentation of fish habitat. Move the deposit of deleterious substances/sediment box. Connect 'introduction of oil etc. → decrease in water quality directly → deposit of deleterious substances → Contamination of fish habitat → Potential Direct and Indirect...	<b>Agreed</b>	'Resuspension of contaminants' → 'Decrease in water quality' → 'Deposit of deleterious substances' → 'Contamination of fish habitat (NEW PRESSURE NODE)' → 'Potential direct or indirect...'	13
-	-	<b>Agreed</b>	'Resuspension of sediment' → 'Decrease in water quality' → 'Deposit of deleterious substances' → 'Contamination of fish habitat' (NEW PRESSURE NODE) → 'Potential direct or indirect...'	14
-	-	<b>Agreed</b>	'Resuspension of sediment' → 'Sedimentation of fish habitat'	15
-	-	<b>Agreed</b>	'Introduction of oil, grease, fuel, and other deleterious substances' → 'Decrease in water quality (direct)' → 'Deposit of deleterious substances' → 'Contamination of fish habitat (NEW NODE)' → 'Potential direct or indirect...'	16
Alter 'fish mortality' endpoint to 'fish mortality and sublethal effects'	Altering the "fish mortality" endpoints to "fish mortality and sublethal effects" makes sense in the context of this and other pathways.	<b>Agreed - use above wording</b>	Change to 'Sublethal effects and/or mortality'	17

In-water PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	Essentially, this endpoint would incorporate all of the <i>direct</i> impacts of pressure pathways on individual fish, e.g., from sublethal effects on growth and behaviour to mortality.			
Connect 'placement of materials' to 'decrease in water quality'	Placement of materials could result in leaching of deleterious substances from the 'material' so the direct link is warranted (e.g. concrete).	<b>Agreed</b>	'Placement of materials/structures in water' → 'Decrease in water quality'	18
Add direct connection from 'placement of materials' to 'sedimentation of fish habitat'	Clarify what these additional mechanisms are. - in res document.	<b>Agreed</b>	'Placement of materials/structures in water' → 'Sedimentation of fish habitat'	19
Connect 'placement of materials' to 'stranding'	Fish stranding below hydropeaking dams would be more related to flow release practices as opposed to the addition of the dam structure per se. This pathway would therefore be more applicable to the Flows diagram and therefore have lower priority for inclusion in the In-water diagram. Instead: placement of materials in water link to flow pathway at that higher level.	<b>No to original suggested alteration. Agreed to discussed changes</b>	-	-
-	-	<b>Agreed</b>	'Placement of materials/structures in water' → 'See Flow PoE diagram'	20
-	Simplify diagram - removal of aquatic vegetation → change or loss of habitat structure and cover AND removal of aquatic vegetation → loss of substrate (already there). Removal of aquatic vegetation → decrease in	<b>Agreed</b>	'Removal of aquatic vegetation' → 'Change or loss of habitat structure and cover'	21

In-water PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	primary productivity → potential direct or indirect.			
-	-	<b>Agreed</b>	'Removal of aquatic vegetation' → 'Decrease in primary productivity' → 'Potential direct or indirect...'	22
-	In-water change 22 requires simplification of the diagram and removal of a number of nodes representing detail not consistent with the balance of the pathway diagrams.	<b>Agreed</b>	Remove nodes: 'Loss of aquatic vegetation' and 'Decrease in nutrient input' and 'Decrease in nutrient concentration'	22
-	Removal of aquatic veg -> decrease in food supply AND removal of aquatic veg → increased risk of AIS (PoE TBD).	<b>Agreed</b>	'Removal of aquatic vegetation' → 'Decrease in food supply'	23
-	-	<b>Agreed</b>	'Removal of aquatic vegetation' → 'see Aquatic invasive species pathway (TBD)'	24
Connect 'placement of materials' to 'smothering of bed/seafloor'	Agreed with moving "Smothering of bed/seafloor" as a component of the "Placement of structures/materials" pathway. Initial omission was connecting 'infilling' to smothering, but the higher level connection is warranted to cover more types of 'materials'.	<b>Agreed</b>	'Placement of materials/structures in water' → 'Smothering of bed/seafloor'	25
Connect 'sedimentation of fish habitat' to 'smothering of bed/seafloor'	[15-16]. Most examples described in Smothering of bed/seafloor pathways relate to sedimentation, warranting a connection to be added. Smothering of the bed, either through sedimentation or adding structures, also has logical and well supported impacts on aquatic	<b>No change</b>	No change	-

In-water PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	vegetation, supporting that proposed connection as well.			
Connect 'smothering of bed/seafloor' with 'loss of aquatic vegetation'	Not core enough. No connection.	No	No change	-

Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Alter 'interbasin transfer of species' to 'increased species invasion risk'	In res doc clarify that species invasions may include vertebrates, invertebrates, and/or plants - make sure that practitioners are thinking of all groups that could invade. Not necessarily AIS - could be native species that don't naturally occur in the other system and still needs to be taken into consideration. Clarify both in the res doc - even native species can be invasive when they get into a new water body. What about pathogen transfers? Clarify in res doc RE: pathogens etc. Explain interbasin in res doc.	Agreed	Change wording to 'Increased species interbasin transfer/risk of invasives' → see 'AIS pathway (TBD)'	1
Alter 'fish mortality' endpoint to 'Fish mortality and sublethal effects'	As discussed above.	Agreed	Change to 'Sublethal effects and/or mortality'	2

Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
-	Water diversions change temperature.	<b>Agreed</b>	'Water diversion' → 'Altered water temperature'	3
-	Water diversion - how well is it connected to water level/flow modification? Because they are connected across the top, need to explain that connection in the res doc. Also maybe try to emphasize the link between diversions and levels is clear in the diagram. Add direction arrow between water diversion to water level/flow.	<b>Agreed</b>	'Water diversion' → 'Water level/flow modification (change in hydraulics) including impoundments'	4
-	With the above connection then stranding and mortality are already included on the right-hand-side of the diagram - remove the boxes on the LHS.	<b>Agreed</b>	Remove: 'Water diversion' → 'Displacement stranding of fish' → 'Fish mortality' from left-hand-side because it is covered on the right (depending on the ability to cross the whole diagram for mortality)	5
Alter 'increase in water temperature' to 'altered water temperature'	Revisit discussion from above? In winter the effect of reduced baseflow is a decrease in water temperature - just as common, just different season. (reviewer comment: Yes, most definitely, because otherwise it is simply incorrect.)	<b>Agreed</b>	'Increase in water temperature' to 'Altered water temperature'	6
Connect 'decrease in baseflow' to 'change in food supply'	This connection was agreed to above.	<b>Agreed</b>	Connect 'Decrease in baseflow' to 'Altered food supply'	7

Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Connect 'increase in water temperature' to 'change in food supply'	This connection was not discussed above. Is this strong enough of a connection to warrant the arrow? Not necessarily. Add text in res doc regarding the demands of the fish (due to temperature) are changing in concert with the change in food supply that affect how those demands are met.	<b>No change</b>	No change	-
Connect 'increase in water temperature' to 'fish mortality'	Above 'increase in water temp' leads directly to potential direct or indirect' with no link to 'sublethal effects and/or mortality'.	<b>Agreed</b>	'Altered water temperature' → 'Sublethal effects and/or mortality'	8
-	In text of res doc, it was suggested to add 'and/or changes in spatial distribution' after 'mortality' - need a connection to 'alteration of migration patterns/access to habitat'? BUT look at RHS of the diagram and temp path over there (not related to groundwater though). No, original intent was to capture in the res doc only.	<b>No change</b>	-	-
-	Are the pathways after temperature really different depending on the mechanism of temp change? No. The part of the pathway after altered temperature should be consistent between both sides of the diagram and across all diagrams. Make sure to check other boxes (beyond temp) that are common among diagrams to make sure that they are consistent.	<b>Agreed</b>	-	-



Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
Connect 'sedimentation of fish habitat' to 'fish mortality'	-	<b>Agreed</b>	'Sedimentation of fish habitat' → 'Sublethal effects and/or mortality'	9
Remove or reverse connection from 'change in food supply' to 'change or loss of structure and cover'	Everything up to this point talks about the pathway from alteration of substrate composition a change in loss of habitat structure (that is correctly captured in diagram as a separate arrow). Suggestion to add the additional step (and diagram arrow) that includes the "change in food supply" have its own little bolded text pathway, and small paragraph.	<b>Agreed</b>	Remove connection between 'Change in food supply' → 'Change or loss of habitat structure and cover'.	10
-	-	<b>Agreed</b>	Change wording from 'Scouring of channel bed/bank erosion' to 'Scouring of the channel bed and bank/shoreline erosion'	11
Connect 'scouring of channel bed/bank' to 'sedimentation of fish habitat'	Suggested edit to direct link to sedimentation is supported.	<b>Agreed</b>	'Scouring of channel bed/bank/shoreline erosion' → 'Sedimentation of fish habitat'	12
-	Sediment is not always a bad thing. There needs to be sediment supply to maintain channel equilibrium and maintenance of habitat. Wording or supporting text should capture that altering flow removes sediment supply which becomes a problem - fine sediment 'starved' reaches of rivers. Disrupting the supply and removal of sediment. Changes to rate of input of sediment - decrease or increase becomes a	<b>Agree</b>	'Water level/flow modification' → (NEW) 'Altered sediment supply' → 'Change in channel morphology or shoreline morphometry'	13

Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	problem. Explain both directions of quantity in res doc and point to the literature. Not just supply, but also particulate size change.			
-	How much of an alteration from natural state is the concern? Sedimentation is different and is an issue - keep that box intact. Question of scale/intensity/how much is different? A bit beyond the PoE res doc. Diagrams represent risk - risk from both over and under supply of sediment. Need to add more about under supply - Scouring channel can link to sedimentation of fish habitat but also to fish mortality and to 'direct or indirect'?	-	'Change in channel morphology or shoreline morphometry' → 'Change or loss of habitat structure and cover'	14
Connect 'alteration of attraction flows' to 'Fish mortality and sublethal effects'	Direct link from altered flow → Mortality/sublethal is supported - removing attraction flow box.	<b>Agreed</b>	'Water level/flow modification (change in hydraulics) including impoundments' → 'Alteration of migration patterns/access to habitat' → 'Change or loss of fish passage'	15
-	-	-	Above connection requires the REMOVAL of 'Alteration of attraction flows/flow barriers node'	15
-	To be more encompassing, 'attraction' could be removed from 'alteration of attraction flows/flow barriers' and direct connection could be made from alteration of flows/flow barriers to fish mortality and sublethal effects [Flows SAR #15]. Strongly support removing to make	<b>NO Box will be removed</b>	-	-

Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	it more general. Good point - changed mind today - leave in attraction?			
-	Alteration of 'generic' flows already captured in the higher level box so this should stay with 'attraction'. Or are we being too redundant - alteration of levels/flows → Alteration of migration/access → Passage. Mention attraction in the res doc as part of this pathway.	<b>Res doc to explain attraction/motivation</b>		-
-	-	-	'Alteration of migration patterns/access to habitat' → 'Sublethal effects and/or mortality'	16
Connect 'displacement or stranding of fish' directly to 'fish mortality'	Agreed; stranding is a function of rate of change, and the activity state of fish (whether seasonal, or diel). Direct link to mortality is necessary.	<b>Agreed</b>	'Displacement or stranding of fish' → 'Sublethal effects and/or fish mortality'	17
Remove connection from 'displacement or stranding or fish' and 'change in thermal cues or temperature barriers'	Link from stranding to temp barriers etc.; support removal.	<b>Agreed</b>	Remove pressure node: 'Change in thermal cues or temperature barriers'	17
-	Water level/flow modification → Change in water temperature → Sublethal effects and/or mortality.	<b>Captured above but that was the left and it is also on the right, so make</b>	'Water level/flow modification' → 'Altered water temperature' → 'Sublethal effects and/or mortality'	18

Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
		sure it is there		
-	To be consistent with previous simplification, do we need the 'nutrient loading' and 'thermal loading' boxes?	<b>Agreed</b>	Remove node: 'Thermal loading'	19
-	One place that DO is included in the diagrams. Separate from water quality - is it needed? In the res doc that water quality necessarily includes DO and should just be part of the water quality box.	<b>Agreed</b>	Remove node 'Decrease in dissolved oxygen' and link nutrients and deleterious to quality directly	20
-	-	<b>Agreed</b>	Remove node: 'Nutrient loading'	21
-	Introduction of wastewater → Nutrient loading → Increase in nutrients → Decrease in dissolved oxygen - needs to be simplified as above.	<b>Agreed</b>	'Introduction of wastewater' → 'Increase in nutrients' → 'Decrease in water quality'	
-	Simplified pathways shown for illustration - not new changes but simply the result of the node removals above.	-	'Introduction of wastewater' → 'Deposit of deleterious substances/sediment' → 'Decrease in water quality'	
-	-	-	'Introduction of wastewater' → 'Change in water temperature'	
-	Nutrient loading → increase in nutrients → decrease in water quality. All ok (but how about case of increase of nutrients to ultraoligotrophic water? Is that a "decrease" in water quality?).	<b>No change - Agreed</b>	-	

Flow PoE Diagram				
Nature of alteration	Review and discussion	Decision	Specific new addition	Final # (SAR)
	I.e., directionality question RE: decrease in water quality - address in additional considerations. For many there is a positive or negative range of results - caveats to the most common direction in this regard.			
Add connection from 'decrease in water quality' to 'fish mortality'	Inclusion of link from water quality → fish mortality: justified.	<b>Agreed</b>	Add connection from 'Decrease in water quality' → 'Sublethal effects and/or mortality'	22
Captured now in sublethal effects? Or worth adding the behaviour link?	Water level/flow modification → behavioural changes → sublethal effects and/or mortality	<b>Captured above via link from migration/ access to habitat to sublethal</b>	No change	-
-	Introduction of wastewater also can affect water quantity - particularly in some systems with municipal STP outflows and/or storm waters.	<b>Agreed</b>	'Introduction of wastewater' → 'Water level/flow modification (change in hydraulics) including impoundments'	23
-	Levels better describes changes that happen in lentic and marine coastal environments - worth capturing at the title level. Not just lotic/flowing water erosion - box is misleading. Is it too much to have one generic PoE to represent both types of systems? Or should they be separate? things like wave attenuation and tidal currents not really captured here.	<b>Agreed</b>	Change title of PoE from just 'Flows' to 'Levels and flows'	24

**Flow PoE Diagram**

<b>Nature of alteration</b>	<b>Review and discussion</b>	<b>Decision</b>	<b>Specific new addition</b>	<b>Final # (SAR)</b>
	Caveats - consideration the development of a separate coastal PoE diagram more streamlined to dealing with coastal marine and large lake impacts.			
Referring to the sub activity 'dewatering/pumping' - Is pumping not a WUA rather than a pressure? Or, perhaps this is meant as an opposite to dewatering? If that's the case, will "flooding" or "inundating" work better?	Pumping is a WUA - remove the word 'pumping' from the dewatering box and put up into the WUA box.	<b>Agreed</b>	Change wording from 'Dewatering/pumping' to 'Dewatering' AND add 'pumping' to the list of sub-activities in the WUA box.	25

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## DISCUSSIONS ON UNCERTAINTIES, OTHER CONSIDERATIONS AND FINAL CONCLUSIONS

During the discussion, lists of sources of uncertainties and other considerations were compiled to be included as separate sections in the in the SAR. These included:

- Nature of the connections of the pathway: linear vs. non-linear
  - It was noted by the participants that the PoE diagrams, as presented, imply linear connections and equal effects with no feedback loops. They do not consider non-linear relationships that will change the resulting effects on the endpoints (i.e., productivity state response curves), which can play out throughout the whole pathway, can go through multiple paths to get to an endpoint, and will influence how strong the effect is on that endpoint.
  - Changing or adding non-linearity, weak/strong connections, and loops has the potential to enhance or subdue the impacts of these effects pathways. This does not minimize the value of the PoE diagrams, but the recommendation was made to include a statement of caution in the SAR and research document on the fact that non-linearity is not considered in PoE diagrams, which could affect outcomes, and especially unexpected cumulative effects.
- High generalization of the PoE diagrams for each WUA identified
  - The observation was made that one of the risks of simplifying the PoE diagrams to a small set of generalizable frameworks for operational gains, is that this may change how practitioners view a WUA, leading to loss of some knowledge context when interpreting WUA impacts. The revised and generalized PoE diagrams may not be applicable at all times or in all locations and there is some uncertainty related to the appropriate use of the PoE diagrams requiring the relevant background and understanding of their correct application.

The wording for objective #3 was discussed to be changed from the “full applicable suite of PoEs” to “all applicable PoE diagrams” for clarification, as well as from “ultimately identify residual impacts correctly” to “identify residual impacts” to remove the words “correctly” and “ultimately”. After the discussions addressing Objective 3 the participants concluded that the process of using these revised PoE diagrams will facilitate the application of avoidance and mitigation measures and will help identify residual impacts, if they are used in a manner that ensures all possible linkages and all applicable PoE diagrams are consulted. It was noted that this statement does not apply to marine or large system coastal processes, aquatic invasive species, and other development-specific PoE diagrams (e.g., shipping) which are not part of the four core diagrams reviewed here and for which separate PoE models will have to be developed.

The full discussion of uncertainties and other considerations are available in the SAR (DFO, 2021).

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## REFERENCES CITED

- Brownscombe, J.W., Smokorowski, K.E. 2021. [Review of Pathways of Effects \(PoE\) diagrams in support of FFHPP risk assessment](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2021/079. iv + 55p.
- DFO. 2021. [Science advice on revisiting Pathways of Effects \(PoE\) diagrams in support of FFHPP risk assessment](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2021/053.



## APPENDICES

### APPENDIX 1: TERMS OF REFERENCE

#### Science advice on revisiting Pathways of Effects (PoE) diagrams in support of FFHPP risk assessment

National Advisor Meeting – National Capital Region

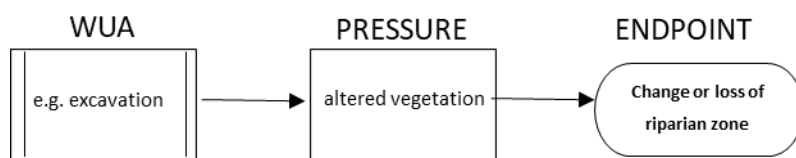
**February 23-26, 2021, 10am-12pm and 1-3pm (EST)**

**Virtual meeting**

Chairperson: Karen Smokorowski and Karin Ponader

#### Context

Fisheries and Oceans Canada (DFO)'s Fish and Fish Habitat Protection Program (FFHPP) has a regulatory regime in place to avoid, mitigate and offset the negative effects of projects on fish and fish habitat. In order to understand these negative effects, linkages need to be made between the works, undertakings and activities (WUAs), the 'pressure' by which WUAs affect the ecosystem, and the resulting 'endpoints' affecting fish and fish habitat (Figure 1).



Work, undertaking or activity (WUA)	A human action that may impose one or more pressures on fish and fish habitat.
Pressures	The mechanism by which a human activity (or WUA) changes the state of a fish habitat component and leads to an impact.
Endpoint	Measurable change to a fish habitat component caused by a WUA through one or more pressures.

*Figure 1: Example of an individual linkage within a Pathway of Effects including the work undertaking and activity (WUA), pressure, and endpoint affecting fish and fish habitat. Definitions of key terms included.*

The FFHPP relies upon existing Pathways of Effects (PoE) diagrams to support regional practitioners in identifying and communicating the effects of proposed works, undertakings, and activities on fish and fish habitat. Through changes to the modernized *Fisheries Act* in 2019, the FFHPP now has a higher regulatory standard through which proposed works, undertakings and activities will be reviewed. However, there are concerns that existing PoE diagrams cannot be applied in a consistent manner in support of the regulatory review of projects, and in the assessment of their risks to fish and fish habitat. To effectively manage fish and fish habitat, it will be necessary to have scientifically validated PoE diagrams for common WUA categories that will enable their consistent use for the assessment of effects nationally.

To facilitate the consistent assessment of projects under the *Fisheries Act*, FFHPP has reworked existing PoE diagrams and consolidated them into fewer diagrams that align with their categories of WUAs. The original 20 diagrams were simplified and consolidated into four

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categories: 1) land-based WUAs, 2) in-water WUAs, 3) WUAs affecting flow, and 4) noise and energy producing WUAs. It is thus important to ensure that the pathways and linkages to resulting endpoints on fish and fish habitat are accurate, valid, comprehensive, and complete. The restructured and validated PoE diagrams, and the standardization of their use, will help determine where a project fits in the FFHPP Risk Management Framework, and ultimately whether the project requires a non-regulatory (e.g., letter of advice), or regulatory (e.g., authorization) instrument.

DFO's FFHPP has therefore requested the Canadian Science Advice Secretariat to conduct a peer review of the revised PoE diagrams, including consideration of their redesign, validation of existing linkages, and assessment of completeness of the linkages. Revised and validated PoE diagrams will allow the FFHPP to consider impacts of project types in a consistent manner, and to understand the impacts of a project at the site and ecosystem level. This will help ensure that fish and fish habitat are conserved and protected consistently across the country.

## **Objectives**

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

1. Review and validate the pathways included in the revised PoE diagrams to ensure they are accurate and valid.
2. Assess whether the linkages between the WUAs, pressures and endpoints on fish and fish habitat are comprehensive and complete.
3. Determine if the process of using these revised PoE diagrams allows FFHPP to identify which endpoints require avoidance and mitigation measures to reduce and manage the risk that the proposed WUA will impair the habitat's capacity to support the life processes of fish (or result in death of fish), and to clearly identify residual impacts to be evaluated for authorization and offset, thus ensuring that fish and fish habitat are conserved and protected.

It is expected that this process will also have synergy with other current CSAS processes focused on freshwater habitat science advice, namely estimating impacts and offsets for death of fish and understanding cumulative effects across freshwater landscapes.

## **Expected Publications**

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

## **Expected Participation**

- Fisheries and Oceans Canada (Ecosystems and Oceans Science, Ecosystems Management, Biodiversity Management)
- Academia
- Other invited experts

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## APPENDIX 2: LIST OF MEETING PARTICIPANTS

<b>Name</b>	<b>Organization/Affiliation</b>
Boivin, Melanie	DFO FFHPP – NCR
Bradford, Mike	DFO Science – PAC
Brownscombe, Jake	DFO Science – O&P
Clarke, Keith	DFO Science – NCR, NL
Code, Kelly	DFO FFHPP – NCR
Collins, Natasha	DFO FFHPP – NL
Enders, Eva	DFO Science – O&P
Fairley, Brad	Five Smooth Stones Restoration Inc.
Grant, Paul	DFO Science – PAC
Gutowsky, Lee	Ontario Ministry of Natural Resources & Forestry
Harper, Vince	DFO FFHPP – PAC
Hedges, Kevin	DFO Science – O&P, Arctic
Hill, Jaclyn	DFO Science – QC
Koops, Marten	DFO Science – O&P
Kristmanson, James	DFO Science – NCR (CSAS representative)
Lay, Megan	DFO FFHPP Integrated Planning – NCR
Linnansaari, Tommi	University of New Brunswick
MacLean, Barbara	Turtle Island Staffing (facilitator)
Midwood, Jon	DFO Science – O&P
Naman, Sean	Simon Fraser University (post-doctoral fellow)
Ponader, Karin	DFO Science – NCR (co-chair)
Reid, Scott	Ontario Ministry of Natural Resources & Forestry
Savoie, Fernand	DFO FFHPP – NCR
Savoie, Luc	DFO FFHPP – Gulf
Scharffenberg, Kevin	DFO Science – O&P, Arctic
Schweitzer, Tara	DFO FFHPP – O&P
Smith, Colleen	DFO Science – MAR
Smokorowski, Karen	DFO Science – O&P (co-chair)
Tunney, Tyler	DFO Science – Gulf
Warner, Lucas	Five Smooth Stones Restoration Inc.
White, Hilary	DFO Science – NCR (rapporteur)
Wong, Melisa	DFO Science – MAR
Yurk, Harald	DFO Science – PAC
Voldman-Anikina, Olga	Turtle Island Staffing (facilitator)

**APPENDIX 3: MEETING AGENDA**

Fisheries and Oceans Canada  
 Canadian Science Advisory Secretariat (CSAS)  
 National Science Advisory Workshop

**Science advice on revisiting Pathways of Effects (PoE) diagrams in support of FFHPP risk assessment**

**AGENDA**

MS Teams: February 23-26, 10 a.m. - noon and 1-3 p.m. daily EST.

DAY 1		
Time	Tuesday February 23, 2021	Lead
10-10:55	<ul style="list-style-type: none"> <li>○ Introduction of participants</li> <li>○ Housekeeping notes</li> <li>○ Introduction to CSAS advisory process</li> <li>○ Overview of the FFHPP program and the need for science advice on revisiting PoE diagrams</li> <li>○ Review Terms of Reference including the overview of goals and objectives of meeting</li> </ul>	Chairs and All Facilitators Chairs Melanie Boivin (FFHPP) Chairs
	<p>Objectives to keep in mind for all PoEs:</p> <ol style="list-style-type: none"> <li><b>1. Review and validate the pathways included in the revised PoE diagrams to ensure they are accurate and valid.</b></li> <li><b>2. Assess whether the linkages between the WUAs, pressures and endpoints on fish and fish habitat are comprehensive and complete.</b></li> </ol> <p>Objective 3 to be addressed on last day:</p> <ol style="list-style-type: none"> <li><b>3. Determine if the process of using these revised PoE diagrams allows FFHPP to identify which endpoints require avoidance and mitigation measures to reduce and manage the risk that the proposed WUA will impair the habitat's capacity to support the life processes of fish (or result in death of fish), and to clearly identify residual impacts to be evaluated for authorization and offset, thus ensuring that fish and fish habitat are conserved and protected.</b></li> </ol>	

DAY 1		
Time	Tuesday February 23, 2021	Lead
10:55-11:00	5 minute health break	
11:00-11:15	○ <i>Presentation: PoE - Land Based WUA</i>	Jake Brownscombe
11:15-Noon.	○ <i>Presentation: Formal review of Land Based WUAs</i> ○ Discussion	Mike Bradford All
Noon-1p.m.	Break	
1:00 – 1:55	○ Discussion - Land Based PoE cont'd.	All
1:55- 2:00	5 minute health break	
2:00-2:15	○ <i>Presentation: In-Water WUAs</i>	Jake B.
2:15-3:00	○ <i>Presentation: Formal review In-Water WUAs</i> ○ Discussion <i>In-Water WUAs</i>	Sean Naman All

DAY 2		
Time	Wednesday February 24, 2021	Lead
10:00-10:40	○ Re-cap of day 1 ○ Review of SAR bullets captured from Day 1	Chairs All
10:40-10:45	5 minute health break	
10:45-noon	○ Discussion cont'd: <i>In-Water WUAs</i>	All
Noon-1 p.m.	Break	
1:00-1:15	○ <i>Presentation: PoE - Noise and Energy Producing WUAs</i>	Jake B.
1:15-2:05	○ <i>Presentation: Formal Review of Noise and Energy Producing WUAs</i> ○ Discussion	Harald Yurk All
2:05-2:10	5 minute health break	
2:10 - 3:00	○ Discussion: <i>Noise and Energy Producing WUAs</i>	All

DAY 3		
Time	Thursday February 25, 2021	Lead
10:00-10:30	○ Re-cap of Day 2 ○ Review of SAR bullets captured from Day 1-2	Chairs All

DAY 3		
Time	Thursday February 25, 2021	Lead
10:30-10:45	<ul style="list-style-type: none"> <li>○ <i>Presentation: PoE - WUAs affecting Flow</i></li> </ul>	Jake B.
10:45-10:50	5 minute health break	
10:50-noon	<ul style="list-style-type: none"> <li>○ <i>Presentation: Formal review WUAs Affecting Flow</i></li> <li>○ Discussion</li> </ul>	Tommi Linnansaari All
Noon-1 p.m.	Break	
1:00-2:00	<ul style="list-style-type: none"> <li>○ Discussion cont'd: <i>WUAs Affecting Flow</i></li> </ul>	All
2:00-2:05	<ul style="list-style-type: none"> <li>○ 5 minute health break</li> </ul>	
2:05-3:00	<ul style="list-style-type: none"> <li>○ Draft SAR points from Day 3</li> </ul>	All

DAY 4		
Time	Friday February 26, 2021 (if needed)	Lead
10:00-11:00	<ul style="list-style-type: none"> <li>○ Re-cap of Day 3.</li> <li>○ Review of SAR bullets captured from Days 1-3</li> </ul>	Chairs All
11:00-11:05	<ul style="list-style-type: none"> <li>○ 5 minute health break</li> </ul>	
11:05-noon	<ul style="list-style-type: none"> <li>○ Discuss Objective 3:   <b>Determine if the process of using these revised PoE diagrams allows FFHPP to identify which endpoints require avoidance and mitigation measures to reduce and manage the risk that the proposed WUA will impair the habitat's capacity to support the life processes of fish (or result in death of fish), and to clearly identify residual impacts to be evaluated for authorization and offset, thus ensuring that fish and fish habitat are conserved and protected.</b> </li> <li>○ Continue drafting Science Advisory Report</li> </ul>	All
Noon-1 p.m.	Break	
1:00-3:00	<ul style="list-style-type: none"> <li>○ Complete drafting Science Advisory Report</li> <li>○ Wrap Up/Next Steps</li> <li>○ PoE CSAS meeting ends</li> </ul>	All