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Proceedings of the National Peer Review of the Science Advice for Pathways of Effects for Marine Shipping

November 19 – 21, 2019
Sidney, British Columbia

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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

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) National Peer Review of Science Advice for Pathways of Effects for Marine Shipping held from November 19 – 21, 2019 at the Institute of Ocean Sciences in Sidney, British Columbia.

Pathways of Effects (PoE) conceptual models for activities associated with commercial marine shipping in Canada, consisting of a visual representation of the structure of the model, supported by evidence describing each pathway (linkage) based on available scientific literature and expert opinion, were presented for peer review. These PoE models were developed to be broad enough to be applicable in a range of marine environments and locations, and to build upon, and supersede, those developed in a previous process (DFO 2015). Each model describes links from a sub-activity to associated stressors to broad-scale effects on the environment, and the provided tables of evidence describe the supporting evidence for effects to examples of generic biological and ecological endpoints. Through these models and supporting evidence, DFO Science has provided a systematic review of the potential effects of shipping-associated activities on marine biological and ecological endpoints, in response to a request by Transport Canada (TC).

PoE models are useful scoping tools for a variety of types of environmental assessment, such as ecological risk assessment, environmental impact assessment, and cumulative effects assessment, as they describe the potential stressors and effects that could be included in such assessments. They do not include an evaluation of the magnitude of impact of these activities on specific endpoints; this would occur in a subsequent assessment step and is not the goal of the current work.

In-person and web-based participation included representatives from DFO Science Sector and external participants from TC, First Nations organizations, port authorities, and provincial jurisdictions. Joclyn Paulic (DFO Science Sector) and Maya Paul (North Coast-Skeena First Nations Stewardship Society, Marine Plan Partnership for the North Pacific Coast, and Environmental Stewardship Initiative North Coast Cumulative Effects Program) presented formal reviews of the Working Paper during the meeting.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR), providing advice to TC to support the development of a Cumulative Effects of Marine Shipping Framework under the Oceans Protection Plan. The SAR and supporting Research Document will be made publicly available on the CSAS website.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), National Peer Review (NPR) meeting was held from November 19 to 21, 2019 at the Institute of Ocean Science in Sidney, British Columbia. Pathways of Effects (PoE) conceptual models for activities associated with commercial marine shipping in Canada, consisting of a visual representation of the structure of the model, supported by evidence describing each pathway (linkage) based on available scientific literature and expert opinion, were presented for peer review.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from Transport Canada (TC) to develop a suite of PoE conceptual models for marine shipping in Canada. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from First Nations organizations, port authorities, provincial jurisdictions, TC, and DFO.

The following Working Paper was prepared and made available to meeting participants prior to the meeting (Working Paper abstract provided in Appendix B):

Pathways of Effects Conceptual Models for Marine Commercial Shipping in Canada by Lucie Hannah, Kate Thornborough, Cathryn Murray, Jocelyn Nelson, Andrea Locke, James Mortimor, and Jack Lawson.

The Chair of the meeting, Jeffrey Lemieux (DFO Science Sector), welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various NPR publications (Science Advisory Report (SAR), Proceedings Report (PRO) and Research Document), and the definition and process around achieving consensus decisions and advice. The Chair reviewed the Agenda (Appendix C) and the TOR for the meeting, highlighting the objectives.

In total, twenty-seven people participated in the NPR (Appendix D). Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the Working Paper being discussed. The Chair also reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review.

Participants were informed that Joclyn Paulic (DFO Science Sector) and Maya Paul (North Coast-Skeena First Nations Stewardship Society, Marine Plan Partnership for the North Pacific Coast, and Environmental Stewardship Initiative North Coast Cumulative Effects Program) had been asked to provide detailed, formal reviews of the Working Paper to assist everyone attending the NPR meeting. Both reviewers had provided comments to the authors in advance of the meeting and would be presenting their formal reviews to participants during the meeting. Natasha Salter (DFO Science Sector) was identified as the Rapporteur for the meeting.

The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by those online.

The conclusions and advice resulting from this review will be provided in the form of a SAR to TC to support the development of a Cumulative Effects of Marine Shipping Framework under the Oceans Protection Plan. This work will also have relevance to management and risk

assessment within DFO. The SAR and supporting Research Document will be made publicly available on the CSAS website.

CSAS OVERVIEW, MEETING PROCEDURES AND TERMS OF REFERENCE REVIEW

Presenter: Jeffrey Lemieux (Chair), Fisheries and Oceans Canada

The Chair, Jeffrey Lemieux, provided an overview of the role of CSAS in coordinating scientific peer review and advice for DFO and explained that the scientific NPR process must follow the Government of Canada's Scientific Advice for Government Effectiveness principles. He described the three documents that would be published following the meeting: a Research Document synthesizing existing knowledge on the topic, which has been validated and assessed through this rigorous peer review of the Working Paper; a SAR summarizing advice and recommendations generated by participants; and a PRO documenting discussions during the meeting. He explained the role of meeting participants as reviewers, with equal standing, who had been invited to contribute their relevant expertise and to develop consensus on defensible advice and recommendations based strictly on scientific information and Traditional Ecological Knowledge. The chair stated the ground rules for the meeting and reviewed the TOR (Appendix A). In particular, he highlighted the objectives, reminding participants that the TOR sets the scope of the Research Document. In response to questions from participants, the following clarifications were provided:

- During the meeting, the entire Working Paper is subject to the peer review process.
- Revisions to the Working Paper based on consensus will be incorporated into the published Research Document.
- Areas of uncertainty will be identified in the SAR.
- The SAR and Research Document will be published within several weeks and several months, respectively.
- The final documents will be circulated to all participants.
- The PoE models were developed to build upon, and supersede, those developed in a previous process (DFO 2015).

REVIEW

Working Paper:	Pathways of Effects Conceptual Models for Marine Commercial Shipping in Canada
Rapporteur:	Natasha Salter, Fisheries and Oceans Canada
Presenter:	Lucie Hannah, Fisheries and Oceans Canada
Reviewer 1:	Joclyn Paulic, Fisheries and Oceans Canada
Reviewer 2:	Maya Paul, North Coast-Skeena First Nations Stewardship Society; Marine Plan Partnership for the North Pacific Coast; Environmental Stewardship Initiative North Coast Cumulative Effects Program

The presentation of the Working Paper was split into five sections. An overview of the Working Paper was provided, followed by presentations of each of the PoE conceptual models that were developed for activities associated with commercial marine shipping in Canada. After each section the formal reviewers were giving the opportunity to present their reviews related to the section and then the discussion was opened up to the rest of the meeting participants.

PRESENTATION OF WORKING PAPER - OVERVIEW

The presenter, Lucie Hannah, provided an overview of the Working Paper (Working Paper abstract provided in Appendix B), explaining that, in response to a request from TC, PoE conceptual models were developed to provide a systematic review of the pathways by which activities directly associated with commercial shipping in Canada can affect the marine environment. These PoE models for activities related to marine shipping build upon, and supersede, those developed in a previous process (DFO 2015).

These PoE models are intended to support TC's Cumulative Effects of Marine Shipping Initiative as a component of the scoping phase of a Cumulative Effects of Marine Shipping Framework that is under development. These PoE models were described as also having value for other types of frameworks and assessments. Hannah clarified that activities associated with recreational, pleasure craft, military, and fishing vessels were beyond the scope of this work, as were land-based or water-based activities in support of marine shipping, such as port infrastructure, transshipping, dredging, and oil and gas exploration.

While there are important regional differences, these PoE models are meant to be broad enough to be relevant in different marine environments and locations across Canada and represent the current knowledge of the linkages between commercial shipping-related activities, associated stressors, and effects on ecosystem endpoints. A visual representation of each conceptual model is supported by text describing each pathway (linkage) and tables of evidence, based on available scientific literature and expert opinion. Hannah clarified that theoretical linkages based on expert opinion were retained even if no scientific evidence could be found to support them. PoE models were developed for seven sub-activities associated with commercial marine shipping in Canada: 1) anchoring and mooring, 2) vessel at rest, 3) grounding and sinking, 4) movement underway, 5) discharge (debris), 6) discharge (oil), and 7) discharge (other). The PoE models contain fifteen stressors (e.g., substrate disturbance, vessel strikes, etc.) related to three broad-scale effects (change in fitness, mortality, and change in habitat) on ten generic endpoints (e.g., marine mammals, physical habitat, etc.). Hannah pointed out the difference between effects and impacts, explaining that effects include any measurable changes, whereas impacts refer to effects that have reached the level of being deleterious. She also emphasized that the generic endpoints are for illustration and guidance purposes only and that specific endpoints would be chosen by end-users during the assessment phase.

After the presentation, through discussion with the authors, participants sought clarification or raised concerns with regards to the following:

- **Generic Endpoints**: While the Working Paper indicated that the generic endpoints were included to serve as examples and not meant to be comprehensive or used without tailoring them to the specific context, the concern was raised that end-users may consider them as a definitive list of Valued Ecosystem Components, for example, during environmental assessments. The decision was made to include a statement within the SAR cautioning against the use of the generic endpoints as an exhaustive list.
- **Changes in Fitness**: The change in fitness effect raised concerns because it is a broad effect that is difficult for managers to address through mitigation measures. To improve the usability of the Research Document, it would be helpful for end-users to be able to refer to specific examples. The decision was made to provide a clear definition of fitness and an explanation of what constitutes a change in fitness as well as a list of examples in an appendix of the Research Document.

- **Shifting Baselines:** A discussion of shifting baselines raised the concern that a point from which an effect is measured needs to be specified when applying the PoE models during an assessment. The decision was made to provide a discussion in the Research Document and a recommendation in the SAR that a baseline that takes into account the local context needs to be specified during the assessment phase.
- **Archaeological Resources:** The concern was raised as to whether the effects of marine commercial shipping-related activities on archaeological resources could be incorporated into the PoE models. As the PoE models were scoped to address only ecological considerations, participants agreed that the Research Document should clarify that archaeological resources are beyond the scope of this work and include guidelines on how PoE models could be applied to other valued components.
- **PoE Models for Scoping Phase of Assessments:** Through the discussion of the topics raised above, the consensus was that the SAR should highlight for end-users that the PoE models in the Working Paper are high level and need to be tailored to the specific context during the assessment phase.

PRESENTATION OF REVIEWS

Joclyn Paulic

Joclyn Paulic provided comments to the authors during a call ahead of the meeting, including editorial comments to decrease inconsistencies within the document and a list of additional references. During the meeting she presented her formal review to the participants. Paulic, who works for DFO Science Sector in the Central & Arctic Region, thanked the authors for inviting her, noting the importance of including representatives from outside Pacific Region in the process. She praised the Working Paper for its well-defined scope and its applicability across different environments and locations, emphasizing that because all potential linkages, even those without known impacts, were included, the PoE conceptual models would be easy to apply in different contexts. Paulic's feedback focused on additions to the Research Document that would improve its applicability in the context of the Canadian Arctic:

- Describe the extent to which shipping in the Canadian Arctic has already increased rather than is predicted to increase, and include a clearer map of the shipping routes and planned ports/harbours.
- Discuss how the PoE models will need to be updated as the commercial shipping industry changes.
- Use months or a range of months, rather than seasons, to facilitate comparability among regions.
- Discuss how effects of shipping-related activities may differ in more pristine environments compared to more degraded environments (e.g., the effects of anchoring in a pristine environment compared to a frequently used area) and how these effects compare to natural processes (e.g., ice scouring).
- Ensure that whale entrapment and other possible disturbances to organisms due to shifts in nearshore or landfast ice caused by ice breaking during the shoulder seasons are captured in the PoE models.
- Indicate whether the PoE models consider Aquatic Invasive Species (AIS) as exclusively those that have already established or also those that may establish in the future. For

example, in the Arctic many AIS have not yet established, but the risk is increasing with increasing vessel traffic in the region.

- Ensure that the description of sea ice as a physical habitat encompasses organisms that live on, within, and below the sea ice.

Further, Paulic noted that the following should be clarified or modified in the Research Document:

- Define the use of the term ‘voyage’ that is, whether it refers to a one-way trip or a return trip.
- Emphasize that, during the assessment phase, a baseline from which to evaluate impacts will need to be defined.
- Ensure that pathogens are consistently defined as a stressor.
- Ensure that the description of substrate as a physical habitat encompasses epifauna and infauna.
- Reconsider the current partitioning of the discharge sub-activities into three PoE models to address, for example, how the magnitude of the discharge may impact the linkages.This was revisited, and a decision as to how to address the discharge sub-activities occurred later in the meeting.
- Ensure that the possible effect of ballast water, which is included in the discharge (other) PoE model, on the physical and chemical water properties of small or isolated water bodies is accounted for.

After the reviewer presentation there was agreement to amend the working paper to address Paulic’s feedback. Further, authors specifically addressed a few of Paulic’s comments. The term ‘AIS’ would be replaced with ‘species introductions’ to clarify that this stressor referred to the process by which species are introduced through commercial shipping-related activities rather than the final state. The use of seasons may still be considered most appropriate for these high level PoE models but could be adjusted during a regional-scale assessment.

Maya Paul

Maya Paul, who co-manages the integrated Marine Plan Partnership and Environmental Stewardship Initiative Cumulative Effects Program on the North Coast of British Columbia, provided comments in a review document ahead of the meeting. During the meeting she presented her formal review to the participants. Paul thanked the authors for inviting her, noting that she appreciated being able to share her perspective, which comes from working with First Nations communities along the coast and from developing frameworks that integrate social and ecological components in a holistic manner.

She praised the Working Paper for its upfront explanation of what is within and out of scope but suggested that the limitations be made clearer in the title of the document; otherwise, readers might expect a comprehensive PoE analysis rather than one focused on ecological considerations. The title should also specify that the developed PoE models are activity-based. During the final phase of the discussion of the Working Paper, participants engaged in a discussion regarding the title of the document. While the title of the SAR cannot be changed as it links back to the original request by TC and the published TOR that was developed by a committee, participants agreed that the title of the Research Document would be changed. The authors would come up with a title that described the PoE models as activity-based and identified that the scope was limited to ecological considerations. Further, under other considerations in the SAR, the consensus was that it should be clarified that these PoE models

link exclusively to ecological endpoints, although the PoE models could also be tailored to address social and economic endpoints.

Paul also pointed out that since many important activities indirectly associated with marine shipping were out of scope of these PoE models (e.g., port infrastructure, dredging etc.), it would be useful to mention if the intention was to fill these gaps through future work or to provide guidelines as to how these might be factored in during the assessment phase.

Paul raised the concern that the PoE model for discharge (other) lumped together discharges like air emissions and wastewater that do not affect the ecosystem through the same mechanisms. This difference might make it difficult to tease apart the PoE model when tailoring it to one of these activities. This was revisited, and a decision as to how to address the discharge sub-activities occurred later in the meeting.

Paul suggested that a more thorough discussion of how stressors may alter water chemistry, resulting in possible changes in habitat, be included in the Research Document as the current emphasis was on physical changes. Paul also cautioned that, in the case where no evidence is currently available, it should not be concluded that there is no effect of the activity. As such, this should be highlighted in the Research Document and these potential linkages, for which no evidence currently exists, should be represented in the PoE models. This was revisited, and a decision as to how to address these potential linkages occurred later in the meeting. She also mentioned that, for clarity, in the tables dealing with stressors, when the effect of a stressor has been accounted for elsewhere then that portion of the table should be blocked out to aid the novice end-user. Paul indicated that she would provide additional references related to noise disturbance as a stressor, commenting that evidence of direct effects exists. Finally, Paul recommended that an indication of the relative weighting of effects would be useful during the assessment phase.

After the reviewer presentations, there was agreement to amend the working paper to address most of Paul's feedback, and authors specifically addressed a few of Paul's comments. Authors noted that any exercise to assign relative weighting of risks is not part of a scoping phase, and is rather part of an assessment phase, and so is beyond the scope of the current work. Authors agreed that a discussion of data gaps in terms of available evidence to support PoE linkages would be included in the Research Document.

GENERAL DISCUSSION

After the presentation of the overview of the Working Paper and associated presentations by the formal reviewers, participants engaged in discussion of the following:

- **Ice Breaking**: Participants discussed how the effects of ice breaking may be different in the Atlantic compared to the Arctic; for example, ice breaking in the Arctic affects caribou migration as animals can become stranded on ice flows. In the Working Paper, ice breaking is captured within the disturbance (wake, turbulence, water/ice displacement) stressor, but given its importance it could be discussed more thoroughly within the body of the Research Document.
- **Types of Pathways of Effects (PoE) Models**: There was agreement that the Research Document should make reference to the different types of PoE models and their different applications and provide an explanation of why activity-based PoE models were chosen.
- **Regional Differences in Marine Shipping**: The section of the Working Paper that discusses regional differences in marine commercial shipping across Canada does not include the most up to date information. Given that any proposed additions or changes

would not be substantive, the decision was made that those participants with knowledge in this area could provide editorial comments directly to the authors.

- **Social, Cultural and Economic Effects**: While social, cultural, and economic effects are beyond the scope of this work, there was consensus that the Research Document should explain work that is being conducted in parallel by TC to address these effects.
- **Regional Ecosystem Descriptions:** The authors had attempted to include a description of the ecosystems in each of the regions (Arctic, Atlantic and Pacific), but it had become repetitive. As participants thought this would be useful, the consensus was that a short section that focused on describing the main differences between regions would be an informative addition to the Research Document.

PRESENTATION OF WORKING PAPER - ANCHORING AND MOORING, AND VESSEL AT REST PATHWAYS OF EFFECTS MODELS

Hannah presented the anchoring and mooring PoE model, which considers the act of deploying and retrieving anchors, or attaching to a mooring system during commercial vessel operation, including movement of the anchoring and mooring system while deployed. She described the six stressors (substrate disturbance (sediment resuspension), substrate disturbance (crushing), foreign object/obstacle, noise disturbance, entrapment/entanglement/smothering, and AIS) associated with this sub-activity and how they relate (through thirteen linkages) to three effects (change in fitness, mortality, and change in habitat) that then link (through twenty-seven linkages) to eight endpoints. Most studies on the effects of anchoring and mooring pertain to recreational vessels, making it difficult to apply as evidence in the context of commercial shipping. It was also difficult to incorporate the extent to which effects could be different depending on whether anchoring and mooring were occurring in established areas compared to more pristine areas.

She also presented the vessel at rest PoE model, which considers the effects of commercial vessels that are anchored or attached to a mooring buoy system and excludes the effects from the anchor and mooring systems themselves. She described the four stressors (foreign object/obstacle, light disturbance, noise disturbance, and AIS) associated with this sub-activity and how they relate (through seven linkages) to three effects (change in fitness, mortality, and change in habitat) that then link (through sixteen linkages) to nine endpoints.

PRESENTATION OF REVIEWS

Joclyn Paulic

Paulic explained that, in the Arctic, commercial vessels will ram into the ice and drift along with it as a means of ‘anchoring’. There was agreement that this practice, of which the authors were previously unaware, would be described in the Research Document. Paulic considered whether this practice falls under the anchoring and mooring PoE model or under the movement underway PoE model. If this practice is analogous to anchoring, light disturbance would need to be included as a stressor in the anchoring and mooring PoE model; for example, polar bears can be attracted to a vessel that is drifting with the ice. This was revisited, and a decision as to which PoE model this practice belongs occurred later in the meeting.

Maya Paul

Paul initiated a discussion of how biogenic habitats have been addressed as endpoints; for example, asking where corals and sponges, which can be destroyed by anchoring and mooring, are included. It was agreed that effects on habitat-forming species would be considered within

both the physical habitat (substrate) generic endpoint and the relevant organism-level generic endpoint. Text in the body of the Research Document would also explain how biogenic habitats are treated within the PoE models.

GENERAL DISCUSSION

After the presentation of the anchoring and mooring, and the vessel at rest PoE models, participants engaged in discussion of the following:

- **Evidence of Effects of Stressors on Generic Endpoints:** In the Working Paper a table displaying linkages to generic endpoints accompanies each PoE model. It was agreed that all potential linkages based on expert opinion should be shown even if no evidence is available in the appendices to support the linkage. The rationale was that since the review of the evidence was not comprehensive, for example, Indigenous Knowledge was not included, all potential linkages should be retained. It was also agreed that the table captions should be updated to reflect that all potential linkages are shown whether or not supported by information in the appendices and point readers to the evidence in the appendices. Participants were also invited by the authors to provide additional references for any evidence that was missing from the appendices; for example, specific evidence that AIS introduced through anchoring and mooring can smother invertebrates causing mortality was not yet available in the appendices. This additional evidence would also contribute to updating these endpoint tables.
- **Indigenous Knowledge and Local Knowledge as Evidence:** The consensus was that text should be added to the Research Document acknowledging that Indigenous Knowledge and Local Knowledge were not used as evidence, and a recommendation that they be used as sources of information in subsequent assessments should be included in the SAR.
- **Vessel Not Underway:** It was proposed that ‘vessel at rest’ should be replaced with ‘vessel not underway’ to align with TC nomenclature. However, the definition of the term ‘vessel not underway’ incorporates other sub-activities, such as grounding, which are separated out in the PoE models, so the original term was retained.
- **Vessel Positioning:** Sediment can be kicked up as a vessel positions itself to get on a mooring or on anchor. A participant mentioned that this is not explicitly considered in the anchoring and mooring PoE model; therefore, there was agreement that, although the stressor sediment disturbance (sediment resuspension) was included in the PoE model, a description of positioning would be provided in the text.
- **Combining AIS and Pathogens:** Since AIS and pathogens operate through similar pathways, it was agreed that these should be combined in all of the PoE models.
- **Degree of Impact between Anchoring and Mooring:** The difference between the relative effect of anchoring compared to mooring was brought up, with mooring described as a lower impact activity because the structure is permanent, causing a single disturbance event when it is installed, followed by much smaller disturbances during its use. It was agreed that a description of this difference would be included in the text of the Research Document, although this addition would not affect the PoE model since both anchoring and mooring link to the same pathways. The point was also raised that mooring is not common for commercial vessels and that different types of moorings are used for recreational and commercial vessels. Clarifying these differences in the text was also recommended.

PRESENTATION OF WORKING PAPER - GROUNDING AND SINKING PATHWAYS OF EFFECTS MODEL

Hannah presented the grounding and sinking PoE model, which considers a commercial vessel impacting the seabed or underwater objects (grounding) and a commercial vessel reaching the seabed to become a shipwreck (sinking). She described the five stressors (substrate disturbance (sediment resuspension), substrate disturbance (crushing), foreign object/obstacle, noise disturbance, and AIS) associated with this sub-activity and how they relate (through eight linkages) to three effects (change in fitness, mortality, and change in habitat) that then link (through seventeen linkages) to six endpoints.

PRESENTATION OF REVIEWS

Joclyn Paulic

Paulic explained that one would expect that intentionally grounding a vessel to anchor it, for example against the ice, which is a common practice in the Arctic, would have the same effects on ecosystem endpoints as anchoring and mooring. However, in the Working Paper the effects on ecosystem endpoints from the grounding and sinking PoE model do not completely match those from the anchoring and mooring PoE model. It was agreed that, while the PoE models would remain separate, they would be reviewed to ensure that the linkages to endpoints matched. Further, Paulic considered whether the practice of intentionally grounding a vessel to anchor it in the Arctic could be included in the grounding and sinking PoE rather than the anchoring and mooring PoE. This was revisited, and a decision as to which PoE model this practice belongs occurred later in the meeting.

Maya Paul

Paul explained that the linkage between AIS and mortality of ecosystem endpoints should be included across all the PoE models. It was agreed that Paul would provide specific references that would be included in the Research Document and the corresponding linkages would be updated.

GENERAL DISCUSSION

After the presentation of the grounding and sinking PoE model, participants engaged in discussion of the following:

- **Vessel Recovery:** While vessel recovery is beyond the scope of this work, there was consensus that the Research Document should explicitly mention that, under the Nairobi International Convention on the Removal of Wrecks, as legislated through Bill C-64: The Wrecked, Abandoned and Hazardous Vessel Act, a vessel of 300 gross tonnage or greater will be required to maintain insurance or other security to cover the potential cost of recovering a wreck. As such, the Research Document should also clarify that any consideration of whether the vessel will be recovered could be included in the subsequent assessment phase.

PRESENTATION OF WORKING PAPER – MOVEMENT UNDERWAY PATHWAYS OF EFFECTS MODEL

Hannah presented the movement underway PoE model, which considers a commercial vessel under power and travelling through the water as it transits from one port of call to another. She described the seven stressors (substrate disturbance (sediment resuspension), substrate

disturbance (crushing), light disturbance, noise disturbance, vessel strikes, disturbance (wake, turbulence, water/ice displacement), and AIS) associated with this sub-activity and how they relate (through sixteen linkages) to three effects (change in fitness, mortality, and change in habitat) that then link (through forty linkages) to ten endpoints.

Presentation Of Reviews

Joclyn Paulic

Paulic commended the authors for the quality of the appendices, including the generic evidence provided with respect to ice breaking for the movement underway PoE model. However, she proposed that a more thorough discussion of ice breaking be included in the text of the Research Document. This discussion should highlight possible differences between ice breaking and navigating in icy waters; for example, effects of ice breaking may not occur in the immediate vicinity of the vessel. She also commented that the effect of ice breaking on pupping should be explicitly discussed.

Paulic raised the concern that the limited evidence of vessel strikes in the Arctic is complicated by the fact that, while vessel strikes are likely fewer because of the lower number of ships, a wounded animal is also less likely to be observed. Paulic also noted that marine mammals and birds aggregate as they migrate through an area (e.g., Lancaster Sound); if this migration corridor corresponds to a shipping route, it may become a chokepoint.

Maya Paul

As the ports in the Pacific Region are located in estuaries, Paul commented that this should be mentioned in the Research Document. She indicated that this is particularly important because at certain times of year, such as during eulachon and salmon runs, marine birds aggregate in these areas.

Paul also commented that there is stronger evidence than presented in the Working Paper that noise disturbance from vessels underway affect the fitness of fish and mammals and that she would provide these additional references.

GENERAL DISCUSSION

After the presentation of the movement underway PoE model, participants engaged in discussion of the following:

- **Shoreline Erosion:** Participants raised concerns about whether shoreline erosion caused by the wake from vessels underway was captured in the movement underway PoE model. The authors explained that erosion of the terrestrial shoreline was out of scope, as it would lead to an indirect effect on the marine ecosystem. However, erosion of the intertidal was in scope and captured under the substrate disturbance (sediment resuspension) stressor. The consensus was that this should be explicitly explained in the Research Document and that the link between vessel-generated wake and substrate disturbance should be elaborated upon in the text. Also, in some cases, the appendices referred to erosion of terrestrial shorelines, and since this is out of scope, it was agreed that this would be removed.
- **Egg Mortality of Marine Birds:** Since some marine birds nest low on the shoreline in protected areas, vessel-generated waves can swamp nests, affecting reproductive fitness. Participants agreed that this should be captured in the movement underway PoE model and supporting evidence.

- **Vessel Speed:** Vessel speed can affect the likelihood of a vessel strike and the fatality of the strike. It was agreed that this would be discussed in the Research Document.
- **Climate Change:** The effects of climate change are out of scope because, except for the direct effect of black carbon on ice, they are indirect. Participants agreed that the SAR should advise that considerations regarding shifting baselines under climate change should be part of the assessment phase. Further, the consensus was that a discussion of the confounding and cumulative effects of climate change on the effects (change in fitness, mortality and change in habitat) included in the PoE models should also be included in the Research Document.
- **Hydrodynamics:** While this would not affect the linkages in the movement underway PoE, participants agreed that the hydrodynamic pressure effects from vessels underway, especially in shallow waters, should be added to the supporting evidence in the appendices of the Research Document. Also, the role of bubbles generated by large vessels in disorienting fish and dolphins would be added to the appendices.
- **Ice Breaking:** Under the Collision Regulations of the Canada Shipping Act (2001), a vessel underway is defined as a vessel that is not at anchor, made fast to the shore, or aground. Consequently, a vessel that has rammed into the ice, maintaining a fixed location relative to the ice, is considered a vessel underway because it is made fast to ice rather than to shore or with an anchor. Conveniently, the current movement underway PoE model includes the relevant stressors resulting from this practice. It was agreed that a description of this practice would be included in the Research Document.
- **AIS:** It was agreed that AIS should be linked to mortality of marine invertebrates in the movement underway PoE model as well as in the other PoE models.
- **Light and Noise Disturbance:** The description of noise disturbance as a stressor goes into much greater detail than that of light disturbance. Participants agreed that both descriptions should be more generalized.

PRESENTATION OF WORKING PAPER - DISCHARGE PATHWAYS OF EFFECTS MODELS

Hannah presented the PoE models for the three discharge sub-activities (discharge (debris), discharge (oil), and discharge (other)). She explained that these PoE models were originally a single model, but it was split up into three individual PoE models with no overlapping stressors for ease of presentation and to reduce complexity.

Hannah first presented the discharge (debris) PoE model, which considers the release of solid materials from commercial vessels either accidentally or operationally. She described the five stressors (substrate disturbance (sediment resuspension), substrate disturbance (crushing), foreign object/obstacle, entrapment/entanglement/smothering, and prey imitation) associated with this sub-activity and how they relate (through eleven linkages) to three effects (change in fitness, mortality, and change in habitat) that then link (through thirty linkages) to nine endpoints. The existing evidence was considered broadly, as it was difficult to separate effects of ship-sourced debris from other debris.

Hannah next presented the discharge (oil) PoE model, which considers oil discharged from vessels as a result of significant oil spills as well as through operational discharges, which are smaller scale though still significant, such as bilge releases. She described oil as a stressor and how it relates (through three linkages) to three effects (change in fitness, mortality, and change in habitat) that then link (through fifteen linkages) to nine endpoints. It is difficult to assess the effect from oil in studies of real spills where other factors are involved (e.g., cleanup and

dispersal), although lab-based studies can be valuable. Operational releases of oils are almost always part of a mixture including many other substances, which makes it difficult to find evidence of the effects from the oil component alone.

Hannah also presented the discharge (other) PoE model, which considers discharges other than debris and oils, including sewage, ballast water, air emissions, and contaminants. She described five stressors (biological materials, pathogens, AIS, air emissions, and contaminants) associated with this sub-activity and how they relate (through eleven linkages) to three effects (change in fitness, mortality, and change in habitat) that then link (through thirty-two linkages) to nine endpoints. There are knowledge gaps related to the understanding of the behavior of contaminants in seawater, the impacts of microplastics on the fitness of marine organisms, and the long-term effects of vessel air emissions.

PRESENTATION OF REVIEWS

Joclyn Paulic

Paulic commented that, during the subsequent assessment phase, a PoE model where several types of discharges are considered together, as in the discharge (other) PoE, is not meaningful, especially since discharges, in many instances, have cumulative effects. As such, the SAR should highlight that these PoE models are a flexible tool that can be adapted to the specific contextby end-users. Paulic also suggested that text be included to indicate whether the PoE model is conceptualizing the release of each type of discharge independently or cumulatively. She indicated that the scale of the spill considered by the discharge (oil) PoE model should also be clarified in the Research Document since it may affect the linkages. This concern was further discussed by participants (see below). References should also be made as to how the linkages in the discharge PoE models might change with new technologies or under new regulations. Finally, she suggested that the nomenclature used to refer to the three PoE models for discharge be more thoroughly defined.

Maya Paul

Paul considered whether the PoE model should be the same for an oil spill whether it is catastrophic or small, which was further discussed by participants (see below). She commented that the discharge (other) PoE model should be teased apart into multiple PoE models because, for example, including air emissions in this PoE model masks this important pathway, which was also further discussed by participants (see below)

GENERAL DISCUSSION

After the presentation of the three PoE models for the sub-activities (discharge (debris), discharge (oil), and discharge (other)), participants engaged in discussion of the following:

- **Catastrophic Versus Chronic Oil Spills:** The authors explained that the discharge (oil) PoE model is meant to be applicable to both large, catastrophic, and small, chronic spills, with the generic evidence provided in the appendices dealing with the effect of oil itself and the specific evidence dealing with large, catastrophic spills. It was agreed that, since the magnitude of effects are not within the scope of this process, both types of spill would continue to be included in the same PoE model. However, the consensus was that guidance should be provided in the SAR indicating that during the assessment phase more specific application of the discharge (oil) PoE model could be carried out, including an evaluation of the magnitude of effects.

- **Air Emissions in Discharge (Other) PoE Model:** Participants discussed how including air emissions in the discharge (other) PoE model seemed to mask its importance. However, authors noted that, except for the effect of black carbon on sea ice, most of the effects of air emissions from marine commercial shipping are indirect and related to climate change. The consensus was that the Research Document should explicitly describe that the indirect effects of air emissions are beyond the scope of this work, and key references regarding indirect effects should be provided. Further, indirect effects of air emissions would be discussed in the other considerations section of the SAR. Participants also agreed that the local effects of air emissions on marine mammals and birds, for example from NOx and SOx, should be included in the text of the Research Document and the supporting evidence provided in the appendices.
- **Accidental Discharges Versus Operational Discharges:** Participants discussed the merit of splitting the discharge PoE models into two models, rather than three, based on whether vessel discharges are operational or accidental. This division would be useful for developing management levers that could be used to address the stressors resulting from vessel discharges. However, some discharges are both operational and accidental. For example, operational concentrations of oil are allowed to be discharged in bilge water, but oil can also be spilled accidentally. Moreover, in most cases, the stressors in the PoE models would overlap regardless of whether they were split into operational and accidental discharge PoE models, and management levers would only be considered at the subsequent assessment phase.
- **Oil as a Contaminant under the Discharge (Other) PoE Model:** A discussion was held regarding whether oil could be considered as a contaminant, meaning that the separate discharge (oil) PoE model could be combined with the discharge (other) PoE model. The oil and contaminants stressors have the same pathways except for the effect of oil on sea ice, which could support combining the models. However, many contaminants do not interact with water in the same way as oil, which is immiscible in water and, therefore, is significantly different mechanistically. Also, a large oil spill has immediate and long-term effects on the ecosystem. Moreover, oil is ubiquitous in commercial shipping because of its use in the propulsion of vessels and its presence as a good being transported. These facts may warrant having a separate PoE model for oil. The separate discharge (oil) PoE model may also be useful for the client, TC, especially when considering that much of the detail would be lost if oil was subsumed under contaminants and that oil spills are typically of great concern among the current community of practice. During the assessment phase, it may also be useful to have oil in a separate PoE model because it can have such an overwhelming effect on ecosystem endpoints, which could mask the effects of these other stressors. To address this choice, text could be added to emphasize that much more evidence exists with regards to the effects of oil on generic endpoints compared to other contaminants. Moreover, managing for an oil spill is different than managing for discharges of other contaminants. That said, if oil was lumped with other contaminants in the PoE models, it could be separated out by end-users at the assessment phase.

  A participant mentioned that, under the Canada Shipping Act (2001), oil is characterized as petroleum products, which have a huge spectrum of chemical composition and include naturally occurring and refined products. This definition should be included in the Research Document, which would clarify that oils like canola are not addressed in this PoE analysis. It was agreed that ‘oil’ would be referred to as ‘petroleum products’ and that contaminants would be referred to as ‘other contaminants’ in the Research Document, including in the PoE models.

- **Workshopping Discharge PoE Models:** Along the same lines, the discussion continued around whether the three discharge PoE models should be combined into a single PoE model or separated in an alternative manner. Suggestions ranged from splitting the discharge PoE model by whether the discharge was a solid or liquid to whether it was a physical, chemical, or biological stressor. It was concluded that splitting the discharge as to whether it was a physical, chemical, or biological stressor was not possible because some stressors have multiple types of effects on the ecosystem.

  In turn, it was suggested that contaminants should be placed in a separate PoE model. During a subsequent cumulative effects assessment, the most critical impacts, which would likely result from a catastrophic spill of oil or another contaminant, are often the focus, so it could be useful to have these in a separate PoE model.

  All three discharge PoE models could be combined into a single comprehensive PoE model, which would place equal weighting on each pathway and avoid emphasizing any one pathway. During the assessment phase, specific stressors of concern to a community could be teased out. This also aligns with the author's original intention, which was to have discharge as a single sub-activity, but it was then split up for ease of presentation and to reduce complexity. Participants agreed that a single combined discharge PoE model would be presented as an overview, followed by two separate discharge PoE models, discharge (debris) and discharge (other), representing artificial constructs that are included for ease of use. Within the discharge (other) PoE model, oil would be represented by the stressor 'petroleum products' and contaminants by the stressor 'other contaminants'.

  Additionally, the consensus was that the Research Document should explain up front that the PoE models are useful for the scoping phase of an assessment and that it is incumbent on the user to tailor the stressors and endpoints of concern to the specific context.

CONCLUSIONS

Through this NPR process, the Working Paper was unanimously accepted with revisions. The consensus was that the objectives of the TOR had been fully achieved. PoE models allow the end-user to clearly articulate and define the system of interest in a structured way utilising graphical display with corresponding scientific evidence (Canada 2012). The suite of PoE models developed for marine shipping in this work identify known PoE components and pathway linkages that describe how the stressors associated with sub-activities can result in broad-scale effects to generic endpoints. The presence of each PoE component was supported by scientific evidence and/or expert opinion with areas of uncertainty and knowledge gaps identified, including areas of future research. PoE models are the first step in the scoping phase of an assessment and are primarily used to ensure that all activities and stressors have been identified and described, and that all effect pathways are captured. Once assessment-specific endpoints (which may consist of single or multiple valued components) are identified, the user can identify the types of stressors and effects that may be applicable to that specific endpoint. The creation of PoE models has been recommended as a first step in risk assessment (O et al. 2015) and are used explicitly in cumulative effects assessments (Murray et al. 2019). Caution is advised when applying these shipping PoE models during an assessment since indirect effects and cumulative effects (interactions) were not included. The agreed upon revisions will substantially improve the Research Document and the value of the PoE models as scoping tools in subsequent assessments.

RECOMMENDATIONS & ADVICE

The following recommendations and advice were developed to guide end-users in applying these marine shipping-related PoE models and supporting evidence during the scoping phase of assessments:

- The conditions, such as the baseline(s) against which change is measured, have not been defined in the PoE models but should be clearly specified and defined during an assessment phase.
- Cumulative effects from multiple stressors, stressor interactions, and indirect effects (such as those associated with climate change) were not included in this work; however, these undoubtedly occur and are important considerations when using PoE models in an assessment, or when implementing an ecosystem-approach to management.
- Stressors and their broad-scale effects are the focus of this advice, rather than the endpoint examples provided, which are not comprehensive and were chosen to illustrate how stressors may interact with features of the marine environment, and caution is advised when interpreting the outlined endpoints. In an assessment, users choose from many candidate endpoints, which can be specific to the region or area of interest. The goal in developing these endpoints was that they adequately describe the effects of a stressor while remaining generic enough to be applicable across Canadian regions.
- The PoE models developed could be used in a variety of processes and assessments, including environmental impact assessment, cumulative effects assessment, risk assessment, and in a number of management contexts (e.g., Species at Risk, Marine Spatial Planning, and Ecosystem-Based Management).
- This work describes potential pathways of effects of marine shipping and synthesises evidence for effects based on current levels of understanding and regulations. As additional evidence is obtained over time, understanding of the effects and impacts will change, along with the environmental (e.g., climate), technological, and social (e.g., management measures, legislation, and regulations) factors that influence them. The shipping PoE models should be considered “evergreen” and should be reviewed and updated when our understanding of these factors changes.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the invaluable contributions of our meeting chair Jeffrey Lemieux, our two formal reviewers, Joclyn Paulic and Maya Paul, our rapporteur, Natasha Salter, as well as each of the meeting participants. The authors thank these people who spent significant time reviewing the working paper, participating in the NPR process, and/or working with the authors to produce a robust final product. Though unable to attend the meeting, the authors acknowledge and thank the contributions of Michael Kim and David Kyle in providing information and review relating to the anchoring and mooring PoE model. The authors also gratefully acknowledge the invaluable assistance with audio-visual equipment and setup and other meeting support provided by Ann Mariscak.

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APPENDIX A: TERMS OF REFERENCE

SCIENCE ADVICE FOR PATHWAYS OF EFFECTS FOR MARINE SHIPPING

National Peer Review - National Capital Region

November 19 - 21, 2019
Sidney, British Columbia

Chair: Jeffrey Lemieux

Context

Pathways of Effects (PoE) conceptual models describe the pathways (linkages) between human activities, associated stressors, and effects on the environment, and are developed to be broad enough to be applicable in a range of environments and locations. PoE models are useful scoping tools for environmental assessments, such as ecological risk assessment, environmental impact assessment and cumulative effects assessments, as they describe the potential stressors and effects that could be included in such assessments.

DFO Science was requested to provide science advice to develop a suite of Pathways of Effects models for marine shipping. PoE development will involve identification and review of specific Activities associated with commercial shipping in Canadian marine waters (e.g., anchoring, grounding, discharge, etc.) and the resulting Stressors on the marine ecosystem (including but not limited to contaminants, noise, strikes, substrate disturbance, and introduction of invasive species). The Effects of shipping stressors will be identified and described at a high level. The PoE models developed will be supported by scientific justifications for the components (i.e., Activities, Stressors, Effects) and linkages (i.e., Activity→Stressor and Stressor →Effect) identified and described, resulting in a comprehensive suite of PoE models that represent the Activities and Stressors and generic Effects of marine shipping (within the scope outlined).

The scope of the PoE models excludes activities that are not directly caused by commercial ships. Therefore, land-based or water-based activities in support of shipping, such as dredging, infrastructure construction, port operations, and fishing-related impacts will not be considered. The scope of the PoE models also excludes vessel types that are not engaged in commercial shipping (recreational, pleasure craft, military, research and fishing vessels). Furthermore, the description of the Effects of shipping Stressors will be limited to high level Effects (e.g., change in fitness, mortality, etc.) because ecologically measureable endpoints (or indicators) are ecosystem-specific and require development for each geographic unit or species to be analysed in any given shipping impact assessment.

The PoE models are intended to support Transport Canada’s Ocean Protection Plan Initiative to develop a Cumulative Effects of Marine Shipping Framework. This work will also have relevance to management and risk assessment within DFO.

Objectives

The working paper will present a suite of PoE conceptual models for marine shipping in Canadian marine waters. Each PoE model will represent an identified Activity, and will outline the relevant components and pathway linkages for the Activity, supported with scientific justifications.

This national peer review process will validate and assess the components and linkages outlined in the shipping PoE models using the following objectives:

1. Identify known components (i.e., Activities, Stressors, Effects) and pathway linkages (i.e., Activity→Stressor and Stressor →Effect);
2. Review the description of the state of knowledge (scientific justifications) with respect to each component and linkage; and
3. Identify areas of uncertainty and knowledge gaps with respect to the linkages, including areas of future research.

Expected Publications

- Science Advisory Report
- Proceedings Report
- Research Document

Expected Participation

- Fisheries and Oceans Canada
- Transport Canada
- Other Government Departments
- Academia
- Aboriginal Organizations
- Industry
- Non-governmental Organizations
- Other invited experts

APPENDIX B: WORKING PAPER ABSTRACT

Vessels involved in commercial marine shipping in Canada engage in the movement of goods or people by sea on the Arctic, Atlantic and Pacific oceans. To explore the ways that the activities associated with commercial shipping can impact the marine environment, a suite of Pathways of Effects (PoE) conceptual models were developed. PoE conceptual models represent the current knowledge of the linkages between human activities, associated stressors, and effects on ecosystem endpoints. A visual representation of each conceptual model is supported by text describing each pathway linkage supported by available scientific literature. PoE models are useful tools for scoping phases of environmental assessments, such as ecological risk assessment, environmental impact assessment and cumulative effects assessments as they help to clearly outline activities and stressors, clarify links between human activities and potential impacts on ecosystem endpoints and provide a science-based foundation for decision-making.

The objective of these models and supporting evidence, is to provide a systematic review of the effects of shipping-associated activities on marine ecosystems. The activities associated with recreational, pleasure craft, military, and fishing vessels were not included. Land-based or water-based activities in support of marine shipping (such as port infrastructure, transshipping, dredging and oil and gas exploration) were also not included. PoE models have been developed for seven activities associated with commercial marine shipping in Canada: 1) anchoring and mooring, 2) vessel at rest, 3) grounding and sinking, 4) movement underway, 5) discharge (debris), 6) discharge (oil), and 7) discharge (other). The PoEs were developed to be broad enough to be applicable in a range of environments and locations, and detail the potential stressors and effects that could be included in an assessment. The PoE activity models contain fifteen stressors (e.g., substrate disturbance, vessel strikes, etc.) and are related to three effects (change in fitness, mortality, and change in habitat) on ten generic endpoints (e.g., marine mammals, physical habitat, etc.). An evaluation of the relative or absolute impact of these activities on specific endpoints would occur in a subsequent assessment step, such as risk assessment, and is not the goal of the current work.

APPENDIX C: AGENDA

Canadian Science Advisory Secretariat

Centre for Science Advice (National), Regional Peer Review Meeting (RPR)

Pathways of Effects Conceptual Models for Marine Commercial Shipping in Canada

Sidney, BC
Chair: Jeffrey Lemieux

DAY 1 – Tuesday, November 19th

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chair
0915	Review Terms of Reference	Chair
0930	Presentation of Working Paper – Overview	Authors
1030	***Break***	
1045	Opportunity for Formal Reviewers	Chair + Reviewers & Authors
1145	Presentation of Working Paper – Anchoring & Mooring and Vessel at Rest Pathways of Effects (PoE) Models	Authors
1200	***Lunch Break***	
1300	Identification of Key Issues for Group Discussion	RPR Participants
1330	Presentation of Working Paper – Grounding & Sinking PoE Model	Authors
1345	Identification of Key Issues for Group Discussion	RPR Participants
1445	***Break***	
1500	Presentation of Working Paper – Movement Underway PoE model	Authors
1515	Identification of Key Issues for Group Discussion	RPR Participants
1630	Adjourn for the Day	

DAY 2 – Wednesday, November 20th

Time	Subject	Presenter
0900	Review Agenda & Housekeeping Review Status of Day 1 (*As Necessary)*	Chair
0915	Presentation of Working Paper – Discharge PoE models (Discharge (debris), Discharge (oil), and Discharge (other)).	Authors
0945	Identification of Key Issues for Group Discussion	RPR Participants
1030	***Break***	
1045	Further discussion of key issues	RPR Participants
12:00	***Lunch Break***	
1300	Discussion & Resolution of Results & Conclusions	RPR Participants
1445	***Break***	
1500	Develop Consensus on Paper Acceptability & Agreed-upon Revisions (TOR objectives)	RPR Participants
1630	Adjourn for the Day	

DAY 3 - Thursday, November 21st

Time	Subject	Presenter
0900	Review Agenda & Housekeeping Review Status of Day 2 (*As Necessary*)	Chair
0915	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • Summary bullets • Sources of Uncertainty • Results & Conclusions • Figures/Tables Additional advice to Management (as warranted)	RPR Participants
1030	***Break***	
1045	*Science Advisory Report (SAR) cont'd*	RPR Participants
1200	***Lunch Break***	
1300	Next Steps – Chair to review • SAR review/approval process and timelines • Research Document & Proceedings timelines Other follow-up or commitments (*as necessary)*	RPR Participants
1400	***Break***	
1415	Other Business arising from the review	Chair & Participants
1430	***Adjourn meeting***	

APPENDIX D: LIST OF PARTICIPANTS

Last Name	First Name	Affiliation
Burton	Sara	Transport Canada
Clarke	Keith	Fisheries and Oceans Canada, Science, Newfoundland and Labrador Region
Doucette	Paula	Transport Canada
Galbraith	Lindsay	Council of the Haida Nation
Hannah	Lucie	Fisheries and Oceans Canada, Science, Pacific Region
Herbert	James	Gitxaala Nation
Herborg	Matthias	Fisheries and Oceans Canada, Science, Pacific Region
Houston	Kim	Fisheries and Oceans Canada, Science, Pacific Region
Klaver	March	Fisheries and Oceans Canada, Science, Pacific Region
Lawson	Jack	Fisheries and Oceans Canada, Science, Newfoundland and Labrador Region
Lemieux	Jeffrey	Fisheries and Oceans Canada, Science, Pacific Region
Locke	Andrea	Fisheries and Oceans Canada, Science, Pacific Region
Mortimor	James	Fisheries and Oceans Canada, Science, Pacific Region
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Nelson	Jocelyn	Fisheries and Oceans Canada, Science, Pacific Region
O	Miriam	Fisheries and Oceans Canada, Science, Pacific Region
Paslawski	Darcy	Vancouver Fraser Port Authority
Reid	Dan	Transport Canada
Salter	Natasha	Fisheries and Oceans Canada, Science, Pacific Region
Scherr	Jason	Prince Rupert Port Authority
Taft	Spencer	Tsleil-Waututh Nation
Templeman	Nadine	Fisheries and Oceans Canada, Science, National Capital Region; remote attendee
Trounce	Krista	Vancouver Fraser Port Authority
Vagle	Svein	Fisheries and Oceans Canada, Science, Pacific Region

Formal reviewers who provided comments for the CSAS National Science Peer Review of the Science Advice for Pathways of Effects for Marine Shipping

Last Name	First Name	Affiliation
Paul	Maya	North Coast-Skeena First Nations Stewardship Society; Marine Plan Partnership for the North Pacific Coast; Environmental Stewardship Initiative North Coast Cumulative Effects Program
Paulic	Joclyn	Fisheries and Oceans Canada, Science, Central and Arctic Region; remote attendee