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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 presentations and discussions of the national science advisory meeting held on March 1-3, 2016 at the Hotel Indigo Ottawa, Ontario. The conclusions and advice resulting from this meeting will be provided in the form of a Science Advisory Report that will be made publicly available on the CSAS website. Meeting participants included experts from various sectors and regions of Fisheries and Oceans Canada, as well as external participants from Environment and Climate Change Canada, Transport Canada, National Oceanic and Atmospheric Administration (NOAA) and the Vancouver Aquarium. One working paper was distributed prior to the meeting. The purpose of this meeting was to assess whether the proposed framework identified scientifically defensible vulnerabilities in aquatic ecosystems to ship-source oil spills. Additionally, the scope of the framework was reviewed for national consistency and applicability.

SOMMAIRE

Le présent compte rendu résume les présentations et les discussions pertinentes de la réunion de consultation scientifique nationale qui s'est tenue du 1er au 3 mars 2016 à l'hôtel Indigo, Ottawa (Ontario). Les conclusions et avis découlant de cette réunion seront présentés sous la forme d'un avis scientifique qui sera rendu public sur le site Web du Secrétariat canadien de consultation scientifique (SCCS). Les participants à la réunion comprenaient des spécialistes de différents secteurs et régions de Pêches et Océans Canada ainsi que des participants externes, provenant d'Environnement et Changement climatique Canada, de Transports Canada, de la National Oceanic and Atmospheric Administration (NOAA) et de l'Aquarium de Vancouver. Un document de travail a été distribué avant la réunion. L'objectif de cette réunion était d'évaluer si le cadre proposé permet de déterminer les vulnérabilités, justifiables sur le plan scientifique, des écosystèmes aquatiques aux déversements d'hydrocarbures provenant de navires. De plus, la portée du cadre a été examinée à des fins de cohérence et d'applicabilité à l'échelle nationale.

INTRODUCTION

Gilles Olivier (chair) opened the meeting by welcoming the participants, providing a brief overview of the Canadian Science Advisory Secretariat (CSAS) peer-review process, and requesting that everyone consider, throughout the course of the meeting, the objectives set out in the Terms of Reference (Appendix 1) and how the advice could be developed in relation to these. The Terms of Reference indicate that the purpose of this meeting was to assess whether the proposed framework identified scientifically defensible vulnerabilities in aquatic ecosystems to ship-source oil spills. Additionally, the scope of the framework was reviewed for national consistency and applicability. Each participant was introduced as there was representation from a variety of divisions of Fisheries and Oceans Canada (DFO), as well as Environment and Climate Change Canada (ECCC), Transport Canada, National Oceanic and Atmospheric Administration (NOAA) and the Vancouver Aquarium (Appendix 2). The Chair reviewed the agenda (Appendix 3), discussed deadlines for the expected publications, and verbally determined that there was consensus for the Terms of Reference.

A FRAMEWORK TO ASSESS VULNERABILITY OF BIOLOGICAL COMPONENTS TO SHIP-SOURCE OIL SPILLS IN THE MARINE ENVIRONMENT

PRESENTATION – CONTEXT SCOPE AND OBJECTIVES

Presenter: Miriam O, DFO National / Environment & Biodiversity

Synopsis of Presentation

An overview was presented that indicated DFO's role in the event of an oil spill. It was explained that DFO provides information to support oil spill pre-planning (area response plan development) and response. A framework was developed as a way to triage information that fed into a risk assessment or other management strategies. This framework was developed to be flexible and high level for use in all regions. The framework provided a rapid technique to identify which biological components were most affected by ship-source oil spills. Other classifications that assess the sensitivity of shoreline types to oil already exist, and terrestrial environments do not fall under DFO's purview.

This framework considered the following elements:

- Biological components below the mean high water level.
- Various oil types that impact all depths of a marine environment.
- Algae and coral treated as species instead of habitats.
- Vulnerability defined as the degree to which a system is susceptible to and unable to cope with injury, damage or harm.

This framework did not incorporate the following elements:

- Indirect or secondary effects of oil.
- Mitigation measures.
- Ecologically and Biologically Significant Areas (EBSAs) instead were indirectly incorporated through the assessment of rare species or aggregations.

Discussion

A participant clarified that, although the meeting was being conducted by Science and therefore focussed on the ecological issues alone, DFO also provides data on socio-economic and

cultural issues. Further to this, the authors noted that human elements and effects on biological components were removed from the framework. This allowed fish, for example, to be assessed as organisms as opposed to as a resource exploited by humans.

Although the framework was developed in relation to ship-source oil spills, it was indicated that adjustments could be made in the future to consider other stressors. These alternative scenarios were included in the text at the end of the working paper.

A participant noted that the framework outputs could feed into the World Class Tanker Safety System. Similarly, the authors added that the framework products could be fed into a risk assessment but a risk assessment would require additional data from other sources.

The authors indicated that both critical habitat and EBSAs were indirectly incorporated into the framework through the assessment of rare and unique species or aggregations. Additionally, not all SARA-listed species were considered vulnerable in the framework but many were.

Collectively participants agreed that salt marsh systems and ponds would be important environments to consider in this framework in other regions. The framework was developed in the Pacific region but could be adjusted to incorporate these other ecosystems.

A suggestion was made to incorporate sea birds into the framework even though they are considered ECCC's jurisdiction. It was agreed that in the event of an oil spill DFO and ECCC would work together to provide information to support response planning. ECCC could be consulted after the CSAS advice was developed to discuss how terrestrial species would be incorporated into the framework.

PRESENTATION – FRAMEWORK OVERVIEW & GROUPING BIOLOGICAL COMPONENTS

Presenter: Kate Thornborough, DFO Pacific / Ocean Sciences Division

Synopsis of Presentation

An overview of the framework was presented in 3 stages:

1. Biological components were grouped using a top down approach. All biological components below the mean high water level were included.
2. The groupings were evaluated against criteria to assess vulnerability. The criteria were divided into 3 categories: Exposure, Sensitivity, and Recovery. The criteria were applied to the species groupings sequentially to reduce the number of groupings at each step. For example, a user would not need to evaluate the Sensitivity of a group if there was no Exposure to oil. Groups identified to have no risk of Exposure, no Sensitivity to oil, or high potential for Recovery were filtered out.
3. The list of vulnerable species were presented using a geospatial approach. After the application of criteria the remaining groupings were populated with a list of regionally specific species. A table was developed to identify each group's most important habitats, such as marine mammal nursery sites.

Further details for stage 1 were presented. Sub-groups for 5 higher-level groups (Marine Mammal, Marine Reptile, Fish, Marine Invertebrates, and Marine Plants) were developed to represent all possible biological components under DFO's mandate. Members of a sub-group were similarly vulnerable to oil. Each sub-group was developed using in-house expertise and literature searches.

The grouping exercise increased the rapidity of the assessment by ensuring that each species did not need to be evaluated individually. It was necessary to develop the sub-group divisions accurately because all species from a single sub-group were filtered out simultaneously.

In addition to assessing vulnerability to oil, the framework also feeds into a gap analysis. Throughout the course of the framework, strategies are described for flagging and identifying data gaps.

Discussion

A participant recommended that as a national framework, all the terms used to divide the sub-groups needed to be well defined for consistency in regional application.

The authors clarified that when scoring the sub-groups against the criteria, a preliminary list of regional species was kept in mind. This framework was intended to rapidly identify vulnerable species. For example, the third stage of the framework populated the remaining sub-groups with an exhaustive list of regionally specific species. This allowed for a faster assessment than having to segregate a regional list of species into sub-groups first.

Participants were reminded that species within a sub-group needed to be as vulnerable as all other species in the same sub-group. For example, all the species of a sub-group evaluated separately against the criteria should result in the same vulnerability score.

The authors suggested that users did not have to further divide sub-groups if the larger sub-groups were sufficient for their region. However, larger, more inclusive sub-groups would not be as focussed as smaller sub-groups and would result in a long list of vulnerable species.

A discussion was conducted on whether the framework evaluated chronic or acute exposure to oil. It was agreed that a ship-sourced oil spill was a single event that would result in acute exposure. Chronic exposure would result in the event of a pipeline leak, for example. The participants collectively agreed that the framework would focus on acute exposure to oil. Acute exposure would have a large impact on species that aggregate together compared to those that were spread out across a habitat.

Marine Mammals Discussion:

A participant inquired about including Polar Bears in the Marine Mammal sub-groups. The authors responded that although Polar Bears were marine mammals they fell under ECCC's purview. The sub-groups only addressed species that lived below the mean high water level.

Marine Mammals were divided into further sub-groups based on "narrow" versus "wide-ranging" behaviours. The authors noted that distance parameters were not established for these divisions for regional flexibility. In the Pacific region, species were considered wide ranging if they travelled outside the region. Several suggestions were made to replace the terms for this division because "narrow ranging" was intended to identify species that crowded together resulting in the greater exposure of a population at once. Suggestions included:

- resident and non-resident (seasonal occurrence),
- resident and migrant,
- resident and transient,
- social and not-social, and
- aggregated and spread out.

After some discussion the agreed upon decision was to replace this division with "discreet" or "dispersed" populations.

Marine Fish Discussion:

The sub-groups for Marine Fish were discussed at length. The authors noted that the sub-groups were selected through a consultation with a DFO fish expert. The “coastal” and “offshore” divisions were intended to account for the diversity found in intertidal communities. Furthermore intertidal environment were heavily exposed to oil in the past. Unfortunately, this division was not effective for regions on the east coast. A suggestion was made to base the divisions strictly on biological differences as opposed to habitat preferences. The term “benthic” was used to replace “offshore”.

Participants collectively agreed that the anadromous division should be replaced with “Diadromous”. The definition of diadromous captured both anadromous (species that lived in the ocean but spawned in freshwater) and catadromous (species that lived in freshwater but spawned in salt water) fish.

Marine Invertebrates Discussion:

The sub-groups for Marine Invertebrates were discussed at length. The “sessile”, “low mobility”, and “high mobility” divisions required clearer definitions. It was argued that jelly fish should not be included in the “high mobility” category as they travel by drifting on water currents.

Marine Plants Discussion:

It was agreed that although *Spartina sp*. inhabits salt water marshes, it should be added as a third sub-group under Benthic, Vascular plants because it occurs below the mean high water level.

The participants collectively agreed that the sub-group title of Marine Plants should be changed to “Marine Plants/Algae”.

PRESENTATION – VULNERABILITY CRITERIA

Presenter: Kate Thornborough, DFO Pacific / Ocean Sciences Division

Synopsis of Presentation

This presentation discussed the second stage of the framework. The sub-groups were evaluated against criteria to assess vulnerability. Research conducted by NOAA on the Exxon Valdez oil spill in Alaska was used to develop the criteria in this framework. The criteria were divided into 3 categories of assessment: Exposure, Sensitivity and Recovery. Sub-groups determined to be less vulnerable to oil, based on the criteria, were filtered out systematically.

Exposure criteria identified sub-groups with species that exhibited:

1. Concentration (aggregation) and/or site fidelity. These species had a greater potential for exposure to oil if the spill occurred close by.
2. Sessile life stages or low mobility (e.g., corals or echinoderms). Without the ability to move away from an oil spill these species were at risk of being exposed.
3. Surface interaction. These species had a greater risk of being exposed to oil slicks characteristic of ship-sourced spills.

Sensitivity criteria identified sub-groups with species that exhibited:

1. Loss of insulation as a result of exposure to oil, such as sea otters.

2. Reduction of feeding as a result of exposure to oil (e.g., baleen becomes clogged). This criterion included the loss of the ability to photosynthesize as a result of the smothering effects of oil.
3. Impairment due to toxicity as a result of exposure to oil. These species experienced severe or irreversible effects from direct contact with oil. Secondary or indirect pathways of oil exposure were not considered in this framework.

Recovery criteria identified sub-groups with species that exhibited:

1. Low population levels, such that the population would have difficulty recovering from the impacts of an oil spill. For example, both SARA and COSEWIC listed species would be considered to fulfill this criterion.
2. Low reproductive capacity, such that the population would have difficulty recovering from the impacts of an oil spill. For example, K strategists have fewer offspring and high reproductive investment.
3. Endemic or isolated populations, such that species with global distributions would have a higher potential for recovery.
4. Inability to metabolise, excrete, or remove hydrocarbons. Some species have mixed function oxidase (MFO) capabilities to metabolise oil. Alternatively, species with high lipid content would have a greater potential to retain oil and suffer toxic effects.
5. Close association with sediments, such that individuals would be exposed to oil products absorbed into the sediment for longer.

Discussion

Exposure Criteria Discussion:

A participant suggested that “aggregation” be clearly defined in the text so regions could apply the term consistently.

A participant suggested that, although oil would impact many aggregated individuals at one time, the population as a whole may be unaffected. The authors agreed to remove references to “effects on the population” from the aggregation criterion. Additionally, in consideration of gyres or ice edge environments that are constantly moving, the terms “transient habitats” were added to this criterion.

A lengthy discussion was conducted on the mobility of organisms. There were no definitive studies indicating that organisms with high mobility will actively avoid oil spills, purposely move toward them, or move without regard to them. However, through observation it was noted that killer whales, some sea birds, and baby sea turtles have actively moved towards oil spills. Alternatively, highly mobile organisms can be hazed away from oil, but this was considered a mitigation measure. In the end, it was agreed that the sessile/low mobility criteria would remain as it was initially written but text would be added to the working paper to discuss studies that documented species’ attracted to oil.

Participants collectively agreed that the term “sea surface”, in the surface interacting criterion, needed to be clearly defined. Organisms floating 5-10m below the surface (e.g., eggs or larvae) could still be affected by oil naturally mixing with the water. A greater amount of mixing could occur if the source of an oil leak on a ship was below the surface. Furthermore, oil spills in the Bay of Fundy have been recorded to drift under water for a distance before surfacing. The authors agreed to include a proper definition based on the literature and change the terminology to “near surface” to be more inclusive.

It was noted that the progression of oil, from a ship-source spill, into the environment began with a surface slick and fumes, then mixed with water and was absorbed by sediment. A suggestion was made to repeatedly use the framework to reassess the vulnerability of species as time elapsed since different species would be affected at different stages of an oil spill.

Participants agreed that an additional criterion should be added that addressed species exposed to oil as a result of their association with sediment or the benthic environment. A discussion ensued during the introduction of the Recovery criterion for “close association with sediments”. Additionally, in areas where freshwater rivers met nearshore habitats, sediment was suspended and mixed with oil which increased the potential for exposure in pelagic organisms. The new criterion was titled “Sediment Interacting” and identified sub-groups with species that closely associated with sediments that could retain oil. It was argued that the term “sediment” would continue to be used because oil could not be absorbed by rock or similar substrates. Sediment could absorb oil and continue to expose new individuals to the effects of oil over a long period of time.

Sensitivity Criteria Discussion:

A participant suggested that the smothering effects of oil on photosynthetic organisms should be included in the Sensitivity criteria under “reduction of feeding”. The authors agreed that photosynthesis should be addressed by this criterion.

The authors indicated that they considered adding a criterion that addressed the impacts of oil to breathing structures but determined that it would not filter out any sub-groups. This criterion had not helped to reduce the list of species to the most vulnerable. Participants agreed that this rationalization should be added to the working paper so users would be aware that effects on breathing were accounted for.

A lengthy discussion was conducted on the impairment due to toxicity criterion. It was explained that reproductive success was not considered in this criterion, which lead to an inquiry about whether effects on offspring were considered. The authors clarified that effects on offspring were considered secondary effects and therefore were not addressed by the framework. Text was added to the working paper to clarify that the framework addressed immediate and direct effects only. Secondary effects were difficult to evaluate and were not sufficiently documented in the literature. Even though this criterion did not directly address the effects on the next generation, the flexibility to select the most vulnerable life stage allowed the user to address effects on larvae or juveniles.

Recovery Criteria Discussion:

A participant pointed out that the population status criterion addressed neither declining populations, discreet constrained populations, nor populations in isolated zones. The authors agreed to add “declining populations” to the description.

It was explained that species with greatly reduced populations were scientifically assessed by a conservation status committee such as the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Participants suggested that several conservation status lists should be consulted since some committees only identify species with socio-economic impacts.

An inquiry was made as to whether the density of a species, within a habitat, was considered under the reproductive capacity criterion. As an example, abalone has a high reproductive capacity but will be unsuccessful if other abalone do not live in close proximity. The authors agreed that this scenario was captured under the criterion. Additionally, the reproductive capacity of a species was evaluated regardless of its reproductive season.

A lengthy discussion was conducted on the geographic range criterion. It was intended to address unique habitats, where an oil spill could impact a large proportion of a population at once. A species with a vast range would be less affected by an oil spill because individuals could occupy other clean and healthy habitats. A point was made that habitat alone was not a consideration for this criterion because any habitat sufficiently distant from the spill would remain unaffected and therefore the only species filtered in would be sessile or have low mobility. Additionally, the connectivity of populations increased a species' potential for recovery after exposure. It was suggested that the intent of this criterion could be captured more accurately by using the terms "endemic species or isolated populations". This wording would identify species with healthy population levels that, for one reason or another, were restricted to a particular area. It was pointed out that species with limited distributions that were not endemic still had the potential for recovery in other areas or countries.

A participant noted that the new wording on "endemic species or isolated populations" would filter out sea otters, vulnerable due to site fidelity, and killer whales, vulnerable due to aggregation behaviour. It was clarified that both of these species would have been addressed by other criteria.

Participants discussed the criterion for the inability to metabolize, excrete, or otherwise remove hydrocarbons. It was noted that many studies have been conducted on the metabolism of hydrocarbons (e.g., MFO capabilities). Unfortunately, many species with this ability produce an intermediate metabolite from which they suffer long-term toxic effects. The authors agreed that this criterion addressed effects from oil exposure accumulated over time as opposed to acute effects and should be removed from the framework. Text was added, to the working paper, that described research conducted on the metabolism and excretion of hydrocarbons.

The authors explained that the criterion for the close association with sediments was intended to address acute effects only. Therefore the effects on progeny would not be evaluated by this criterion, however, the flexibility to assess the most vulnerable life stage of a species allowed the user to address effects on larvae and juveniles.

Further Discussion on Species Groupings:

A discussion was conducted about including Arctic or ice edge associated species. It was determined that adjustments were needed before the sub-groups could represent Arctic and freshwater species. The authors agreed to add this explanation to the working paper. Additionally, it was noted that insufficient information exists to fully evaluate Arctic and ice edge species and associated environments. The authors added a section in the working paper that addressed the gaps and data limitations and explicitly stated that the framework was "developed based on current knowledge". As further studies are conducted, species groupings in this framework could be revisited.

The authors clarified that the columns in the right side of the sub-groups table identified examples of species. This column was not meant to represent a complete list of possible species. A note to this effect was added to the working paper for clarity.

Marine Fish:

A participant recommended adding "coastal" to the first set of divisions of fish sub-groups. After some discussion the authors changed the first set of divisions to better capture the diversity of species across various habitats; Estuarine, Intertidal, Onshelf, Offshelf, and Diadromous. Both the "Onshelf" and "Offshelf" categories were further broken down by Demersal/semi-demersal, Small pelagics/forage fish, and Large pelagics. Demersal and Semi-demersal were combined because Semi-demersal was an ineffective category for regions on the east coast.

Marine Invertebrates:

It was suggested that a category be added to separate intertidal organisms from demersal. Many intertidal organisms have the ability to close themselves off completely from their environment (e.g., blue mussels) which could prevent their exposure to oil. Many demersal organisms (e.g., giant scallops) do not have this ability and are vulnerable to exposure in the event of an oil spill. The authors agreed to add a division that segregated intertidal organisms from demersal.

PRESENTATION – SCORING AND FILTERING

Presenters: Candice St. Germain, DFO Pacific / Ocean Sciences Division

Synopsis of Presentation

Further detail on the second stage of the framework was presented. The criteria were divided into 3 categories: Exposure, Sensitivity and Recovery and applied to the species groupings sequentially. Each criterion had equal weighting and the sub-groups were assessed using the most vulnerable life stage of an associated species. Sub-groups were assigned a score based on the number of criteria in a single category they fulfilled. A user would evaluate the sub-groups against the exposure criteria first to eliminate groups before evaluating sensitivity. Groups determined to be less vulnerable were filtered out.

A threshold was introduced, at the discretion of the user, to help refine the number of vulnerable sub-groups. For example, if 75% of the sub-groups received a score of 1 or higher, then a threshold could be set to filter out all sub-groups that received a 0. Several options were provided in the working paper to account for the preferences or time and resource limitations of the user. Options included implementing a more complex scoring rubric, or identifying one criterion as essential.

Uncertainty was flagged whenever insufficient data or literature was available to conclusively determine whether a sub-group met a criterion. The sub-group continued to be included in the list of vulnerable species but was flagged for the gap analysis. The data and knowledge gap analysis provided direction and focus for future research.

The authors were developing a database of over 800 papers on oil spill information. Each paper was searchable by species, oil type, and other elements. The database was intended to help standardize the application of the framework across regions.

Discussion

A participant suggested that using the most prevalent life stage of a species at the time of the spill would be more effective for the framework. The authors had recommended using the most vulnerable life stage.

A lengthy discussion was conducted on the scoring system. There was concern about comparing species' scores across regions that supported different levels of risk management. Some species live all across Canada and their vulnerability to oil should remain the same, however if the framework was conducted by different regions, depending on the location of the spills, these species may receive different scores. The framework was designed to be relative within a region and scores and species lists were not meant to be compared nationally. Additionally, the final score was intended to help provide a ranked list of species to narrow down the number of species on which to focus mitigation efforts.

The authors added that the database of publications they were compiling on oil spill material included grey literature. Additionally, a centralized location for regional use was to be discussed at a later date.

PRESENTATION – TRIAL APPLICATION (PACIFIC EXAMPLE)

Presenters: Candice St. Germain, DFO Pacific / Ocean Sciences Division

Synopsis of Presentation

A trial application of the framework, using species from the Pacific region, was presented.

First, a list of all the sub-groups were given a score based on the number of Exposure criteria they fulfilled. A threshold of 1 was applied so that sub-groups that did not fulfill a single Exposure criterion, like some marine fish, were removed from the table. The majority of sub-groups of marine plants fulfilled all three Exposure criteria.

Second, this process was repeated with the Sensitivity criteria applied to the remaining sub-groups. A threshold of 2 was used so that sub-groups that did not fulfill more than 1 Sensitivity criteria were removed from the table (e.g., toothed cetaceans, sea turtles, and canopy forming kelp).

Third, this process was repeated with the Recovery criteria applied to the remaining sub-groups. A threshold of 1 was used so that sub-groups that fulfilled at least 1 of the Recovery criterion remained in the table (e.g., Baleen whales and fur-bearing pinnipeds).

Whenever insufficient data or literature was available to conclusively determine whether a sub-group met a criterion, they were assigned a score of “1*”. This ensured that these sub-groups were not filtered out without proper justification and were flagged for the gap analysis. Users could distinguish between sub-groups removed from the assessment as a result of not meeting any criteria and those without enough data.

Discussion

The authors clarified that the trial application was conducted with the adult life stages of species. The example became too complex when other life stages were incorporated. The most vulnerable life stage will be used in the full trial.

An inquiry was made about using a model or algorithm to score the criteria. The authors conducted the scoring manually in their trial but developed an excel spreadsheet to connect sub-groups across the criteria categories. The spreadsheet allowed individual changes to be reflected throughout the framework at once.

All oil types were considered in the trial application.

The criteria provided justification for the score that sub-groups received as well as communication points to explain the vulnerability of a species. The authors commented that a separate CSAS meeting would be conducted with species experts to validate the trial application. The species experts would determine whether important species were filtered out. Species that are mandated or legislated as important were already under consideration by oceans managers. These considerations were not directly assessed through this framework, however, it’s anticipated that many mandated or legislated ‘important’ species will likely be screened into the assessment since they meet many of the recovery criteria.

The authors clarified that the product of the framework was intended to help inform other processes and was not appropriate as a final recommendation on its own. A participant

suggested that once the short list of vulnerable species was produced, further useful criteria could be applied based on client interests and needs. The framework provided a quick way to identify a list of species of highest concern in the event of an oil spill. Vulnerable species could be further ranked on their cultural or socio-economic importance.

A lengthy discussion was conducted on the thresholds applied to the framework. Participants agreed that a score shouldn't be used for the first 2 categories of criteria (Exposure and Sensitivity) because it could not be definitively concluded that a sub-group that fulfilled 2 exposure criteria, for example, was more exposed than those that fulfilled 1 exposure criterion. It was agreed that the list of sub-groups should be refined based on the Exposure criteria first because they were the easiest to score. Finally it was agreed that the process needed to be as inclusive as possible and use the following steps:

- Sub-groups that met at least 1 Exposure criteria were screened through and were assessed against the Sensitivity criteria. The remaining Exposure criteria were scored to provide additional information.
- Sub-groups that met at least 1 Sensitivity criteria were screened through and were assessed against the Recovery criteria. The remaining Sensitivity criteria were scored to provide additional information.
- This produced a list of sub-groups that met at least one Exposure and one Sensitivity criteria that was then ranked according to the number of Recovery criteria they fulfilled.
- The final product was a table of sub-groups ranked most vulnerable to least.

PRESENTATION – GEOSPATIAL REPRESENTATION OF SUB-GROUPS

Presenter: Kate Thornborough, DFO Pacific / Ocean Sciences Division

Synopsis of Presentation

The third stage of the framework was presented. The final table of sub-groups were ranked most vulnerable to least and was populated with a list of regionally specific species. Species databases and literature were used to develop the regional list. Sub-groups that did not have a known species in the region were flagged for the gap analysis.

It was determined that this information would be most useful to managers if it was spatially represented. A table was developed that identified important habitats for each sub-group for management consideration (e.g., nursery sites for marine mammals). A map represented areas that included species aggregations or habitats important for juvenile development. If such information was missing then the entire species distribution would be mapped and flagged for the gap analysis. Accompanying data tables were constructed to provide supporting information and justification on the vulnerability of each species.

Discussion

A participant noted that the whole distribution of a species was too broad for use by managers. The geospatial mapping activity was a very complex and time consuming process but helped the user easily identify data gaps. The accompanying data tables provided a good representation of useful information for each species from a management perspective. It was suggested that in the event of an oil spill the framework be divided into 2 CSAS meetings:

1. Development of the list of vulnerable sub-groups,
2. Mapping the list of vulnerable species.

A solution was proposed to use the table of important habitats to guide data providers. Data providers could develop an information package on the habitats of vulnerable species for mitigation discussions. Habitats with insufficient information could be flagged for the gap analysis. It was agreed that the framework did not need to limit or identify the method in which the species' data was presented (e.g., geospatially). It was deemed that the list of vulnerable species, accompanying data tables, and table of important habitats for each sub-group were sufficient.

The authors noted that the table of important species' habitats was not a complete list and only provided examples. A participant requested that feeding areas for baleen whales be included in the table.

A participant suggested that contact information for scientists that can interpret the data may be more valuable to response coordinators than the data itself.

PRESENTATION – CHALLENGES, LIMITATIONS, AND FUTURE WORK

Presenter: Miriam O, DFO National / Environment & Biodiversity

Synopsis of Presentation

The gap analysis portion of the framework was presented. Knowledge gaps (e.g., missing information or conflicting information) or data gaps would both be included in the analysis. The analysis was used to identify areas where future research could benefit the field. Areas flagged for the gap analysis included:

- Sub-groups that did not have a known species in the region.
- Species for which insufficient information existed to conclusively fulfill or fail a criterion.
- Important habitats of vulnerable species for which insufficient information existed.

Knowledge gaps were addressed through either literature searches, short term research projects or full scale research projects. Some data gaps were overcome through the development of data sharing agreements.

The authors indicated that the framework was limited in assessing the indirect or secondary effects of oil on species (e.g., accumulation of oil through the food web). The framework would be improved through regional use, such as in the development of an Area Response Plan. Freshwater and Arctic species were not considered in the development of this framework but needed to be incorporated for other regions.

The framework was developed with regional flexibility in mind, thus clear records needed to be kept during implementation for repeatability purposes.

Discussion

The authors indicated that they would conduct a full application of the framework including the knowledge gap analysis.

A participant noted that Arctic transport would continue to increase in the future. It was agreed that the framework would require sub-group adjustment for Arctic implementation before long.

Participants agreed that the framework was applicable for freshwater environments as well as marine. The sub-groups would require adjustments to appropriately divide freshwater species.

It was suggested that the framework could alternatively be used in the event of chemical spills into marine environments or by other departments, such as ECCC.

APPENDICES

APPENDIX 1: LIST OF MEETING PARTICIPANTS

Name	Affiliation
Gilles Olivier	DFO National Capital Region
Miriam O	DFO National Capital Region / Environment & Biodiversity Science
Jerome Marty	DFO National Capital Region / Environment & Biodiversity Science
Boumy Sayavong	DFO National Capital Region / Environment & Biodiversity Science
Darren Williams	DFO National Capital Region / Oceans Policy and Planning
Nadine Templeman	DFO National Capital Region / Environment & Biodiversity Science
Fred Page	DFO Maritimes / Coastal Ecosystem Science Division
Sean Corrigan	DFO Maritimes / Coastal Ecosystem Science Division
Amélie Rondeau	DFO Gulf / Aquatic Resources Division
Michel Gilbert	DFO Quebec / Pelagic and Ecosystem Science Branch
Christine Desjardins	DFO Quebec / Fisheries Protection Division, Regulatory Reviews
Larry Trigatti	DFO Central & Arctic / Canadian Coast Guard - Environmental Response
Bev Ross	DFO Central & Arctic / National Contaminants Advisory Group
Kate Thornborough	DFO Pacific / Ocean Sciences Division
Candice St. Germain	DFO Pacific / Ocean Sciences Division
Sarah Patton	DFO Pacific / Ocean Sciences Division
Joanne Lessard	DFO Pacific / Marine Ecosystems and Aquaculture Division (MEAD)
Michael Wallace	Transport Canada - Marine Safety & Security
Georges Long	Environment and Climate Change Canada – Environmental Emergencies
Stephane Leblanc	Environment and Climate Change Canada - Environmental Emergencies
Dominique Poulin	Environment and Climate Change Canada - Environmental Emergencies
Steve Lehmann	National Oceanic and Atmospheric Administration (NOAA)
Peter Ross	Vancouver Aquarium
Kim Houston	DFO Pacific / Ocean Sciences Division
Lauren Ellis	DFO National Capital Region / Canadian Science Advisory Secretariat

APPENDIX 2: MEETING TERMS OF REFERENCE

A framework for assessing vulnerability of aquatic ecosystems to ship-source oil spills

National Advisory Process

March 1-3, 2016
Ottawa, Ontario

Chairperson: Gilles Olivier

Context

The Department of Fisheries and Oceans Canada (DFO) is committed to ensuring sustainable aquatic ecosystems. The development of a framework for assessing vulnerability of aquatic ecosystems to ship-source oil spills represents an important step toward meeting this commitment, and supports the Organizational Priority identified in the Report on Plans and Priorities by "Commencing the collection and analysis of science and marine ecosystems information and data as key supporting elements of the world class tanker system initiatives". More specifically, the proposed framework may be used to identify the potential impacts of ship-source oil spills on aquatic ecosystems, as well as provide advice on the ability of ecosystems to recover from such impacts.

A structured approach to identify ecological components most affected by a ship-source oil spill has been developed utilising a suite of criteria to assess vulnerability. This approach divides criteria into three categories: exposure, sensitivity, and recovery, each encompassing a number of criteria which are envisaged to be consistent and broad enough to be usable in multiple aquatic environments. In support of this, the framework has been developed and refined with input from biologists from three DFO regions who are currently contributing to the development of ship-source oil spill area response plans (i.e. Pacific, Quebec & Maritimes). If successful, it is anticipated that this approach will be useful for identification of ecological components most affected by ship-sourced oil spills in any aquatic environment.

Objectives

The following working paper will be reviewed to provide the basis for discussion and advice:

A framework for assessing vulnerability of aquatic ecosystems to ship-source oil spills. Working Paper by *Thornborough, K. Hannah, C. St. Germaine, and M. O*

The overarching objective of this National Advisory Process is to assess whether the proposed framework identifies scientifically defensible vulnerabilities in aquatic ecosystems to ship-source oil spills.

Specific objectives of this Advisory Process are to:

1. Determine if the proposed species groupings for assessing vulnerability to ship-source oil spills are appropriate;
2. Determine if the criteria used to identify species groupings most affected by ship-source oil spills are complete and appropriate;
3. Determine if the proposed criteria are appropriate (for identifying species groupings most affected by ship-source oil spills) for multiple aquatic environments;
4. Provide recommendations on best approaches and methods to address knowledge and data gaps in the application of the criteria (i.e. uncertainty with scoring of criteria); and,

5. Provide recommendations on potential uses of this framework for assessment of ecological vulnerability to environmental stressors, and specifically for ship-source oil spill preparedness and response.

Strategy and Working Paper

There will be a two-staged review for this framework. The first stage would entail the review of the framework and its National consistency and applicability (Stage 1 – March 1-3, 2016). The second stage will entail a review of the regional applications of this framework, any necessary modifications and lessons learned (Stage 2 – date to be determined).

Expected publications

- CSAS Science Advisory Report (1)
- CSAS Research Document (1)
- CSAS Proceedings

Expected Participation

- DFO Science (National and regional) DFO Oceans (National)
- Canadian Coast Guard (National)
- Environment Canada (National)
- Transport Canada (National)
- National Oceanic and Atmospheric Administration (NOAA)
- Vancouver Aquarium

APPENDIX 3: MEETING AGENDA

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

A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment

Venue: Indigo Ottawa Downtown City Centre (Indigo Room, Lower Lobby)
123 Metcalfe Street, Ottawa, Ontario, K1P 5L9, Canada, 1-613-231-6555
March 1-3, 2016

Chairperson: Dr. Gilles Olivier

Note: All times tentative and subject to change depending on progress of discussions.

DAY 1 - Tuesday, March 1, 2016

Time	Topic
9:00am–10:00am	• Welcome and Context (15 minutes) • Introduction of participants (5 minutes) • ***Presentation***: Overview of DFO CSAS advisory process • *Presenter*: Gilles Olivier (15 minutes presentation, 15 minutes questions) • Review Terms of Reference (5 minutes) **Time: ~60 minutes**
10:00am-10:15am	**Presentation:** A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment– Context, Scope and Objectives Presenter: Miriam O **Time: ~15 minutes**
10:15am-10:30am	Discussion, questions and answers on Context/Background: All **Time: ~15 minutes**
10:30am–10:45am	Break
10:45am-11:05am	**Presentation:** (WP) A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment– *Framework Overview & Grouping Biological Components* Presenter: Kate Thornborough and Lucie Hannah **Time: ~20 minutes**

Time	Topic
11:05am-12:00pm	Reviewer comments and group discussion on Framework Overview & Grouping Biological Components: All **Time: ~55 minutes**
12:00pm–1:00pm	Lunch Break (lunch not provided)
1:00pm–1:20pm	**Presentation:** (WP) A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment– *Vulnerability Criteria* Presenter: Kate Thornborough **Time: ~20 minutes**
1:20pm–3:00pm	Reviewer comments and group discussion on vulnerability Criteria: All **Time: ~100 minutes**
3:00pm–3:20pm	Break
3:20pm–3:35pm	**Presentation:** (WP) A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment– *Scoring and Filtering* Presenter: Kate Thornborough and Candice St. Germain **Time: ~15 minutes**
3:35pm-**5:00pm**	Reviewer comments and group discussion on Scoring and Filtering: All **Time: ~85 minutes**

DAY 2 – Wednesday March 2, 2016

Time	Topic
9:00am–9:45am	*If necessary:* Discussion, questions and answers (continued from yesterday): All **Time: ~45 minutes**
9:45am-10:15am	Review of day 1 key points and outstanding discussion Discussion, questions and answers: All **Time: ~30 minutes**

Time	Topic
10:15am-10:30am	Presentation: (WP) A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment– *Trial Application (Pacific example)* Presenter: Kate Thornborough and Candice St. Germain **Time: ~15 minutes**
10:30am–10:45am	Break
10:45am-12:00pm	Reviewer comments and group discussion on Trial Application (Pacific example): All **Time: ~75 minutes**
12:00pm–1:00pm	Lunch Break (lunch not provided)
1:00pm–1:15pm	Presentation: (WP) A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment– *Geospatial Representation of Sub-groups* Presenter: Kate Thornborough **Time: ~15 minutes**
1:15pm-2:15pm	Reviewer comments and group discussion on Geospatial Representation of Sub-groups: All **Time: ~60 minutes**
2:30pm–2:45pm	Presentation: (WP) A Framework to Assess Vulnerability of Biological Components to Ship-source Oil Spills in the Marine Environment– *Challenges, Limitations, and Future Work* Presenter: Kate Thornborough **Time: ~15 minutes**
2:45pm–3:00pm	Break
2:50pm–5:00pm	Discussion, questions and answers on Challenges, Limitations, and Future Work: All **Time: ~120 minutes**

DAY 3 - Thursday March 3, 2016

Time	Topic
9:00am–9:30am	*If necessary:* Discussion, questions and answers (continued from yesterday): All **Time: ~30 minutes**
9:30am-10:00am	Review of day 2 key points and outstanding discussion Discussion, questions and answers: All **Time: ~30 minutes**
10:00am–12:00pm	• Re-cap of days 1 and 2 • Review of Terms of Reference to ensure all questions answered • Drafting of Science Advisory Report (SAR) **Time: ~120 minutes**
12:00pm–1:30pm	Lunch Break (lunch not provided)
1:30pm–3:00pm	• Finalize drafting of SAR • Review and endorse summary bullets of SAR • Next steps to finalize Research Documents **Time: ~90 minutes**
3:00pm (approx.)	Conclusion (time approximate)