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

Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2016/058

Pacific Region

Proceedings of the Pacific regional peer review on a Pilot Application of an Ecological Risk Assessment Framework to Inform Ecosystem-based Management in the Pacific North Coast Integrated Management Area

June 25-27, 2013
Nanaimo, British Columbia

Chairperson and Editor: John Holmes

Fisheries and Oceans Canada
Science Branch
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

December 2016

Canada

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.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1701-1280

Correct citation for this publication:

DFO. 2016. Proceedings of the Pacific regional peer review on a Pilot Application of an Ecological Risk Assessment Framework to Inform Ecosystem-based Management in the Pacific North Coast Integrated Management Area; June 25-27, 2013. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2016/058.

TABLE OF CONTENTS

SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on June 25-27, 2013, at the Pacific Biological Station in Nanaimo, B.C. One working paper was presented for peer review. This working paper focused on testing operational modifications of the prototype ecological risk assessment framework (ERAF) methodology previously reviewed in a May 2012 RPR Meeting, and assessing the performance of the ERAF using a limited subset of 17 significant ecosystem components (SECs), and associated activities and stressors in the Pacific North Coast Integrated Management Area (PNCIMA).

In-person and web-based participation included staff from Fisheries and Oceans Canada (DFO) Science, Oceans, Fisheries Protection, Species-at-Risk, and Fisheries and Aquatic Management Sectors; other government departments/agencies including Parks Canada, the Canadian Wildlife Service, and Transport Canada, and external participants from First Nations organizations, the Province of British Columbia, commercial and recreational fishing sectors, environmental non-governmental organizations, and universities.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to Science, Oceans and Ecosystem Management to improve an important tools that is expected to be used in development of conservation objectives for the Pacific North Coast Integrated Management Area (PNCIMA).

The Science Advisory Report and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

Compte rendu de l’examen par les pairs de la région du Pacifique sur un Projet pilote de cadre d'analyse du risque écologique visant à guider la Gestion axée sur l'écosystème dans la zone de gestion intégrée de la Côte nord du Pacifique

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions et des conclusions de la réunion régionale d'examen par les pairs de Pêches et Océans Canada (MPO) et du Secrétariat canadien de consultation scientifique (SCCS) qui s'est tenue du 25 au 27 juin 2013 à la station biologique du Pacifique de Nanaimo, en Colombie-Britannique. Un document de travail a été soumis aux fins d'examen par les pairs. Ce document de travail portait sur la mise à l'épreuve des modifications opérationnelles du prototype de la méthodologie du Cadre d’évaluation du risque écologique (CERE) examinée antérieurement en mai 2012 au cours d'une réunion régionale d'examen par les pairs. Il évaluait en outre le rendement du CERE, en se basant sur un sous-ensemble limité de 17 composantes importantes de l’écosystème (CIE), et sur les activités et agents de stress qui leur sont associés dans la zone de gestion intégrée de la côte nord du Pacifique (ZGICNP).

Étaient présents en personne et en ligne des représentants de Pêches et Océans Canada (MPO), des Secteurs des sciences, des océans, de la protection des pêches, des espèces en péril et de la gestion des pêches et de l'aquaculture et d'autres ministères et organismes gouvernementaux dont Parcs Canada, le Service canadien de la faune et Transports Canada, ainsi que des participants externes des organisations des Premières Nations, de la province de la Colombie-Britannique, des secteurs de la pêche récréative et commerciale, des organisations non gouvernementales de l'environnement et des universités.

Les conclusions et avis résultant de cet examen seront présentés au Secteur des sciences, des océans et de la gestion des écosystèmes sous forme d'un avis scientifique en vue d'améliorer un outil important qui devrait être utilisé dans l'élaboration des objectifs de conservation de la zone de gestion intégrée de la côte nord du Pacifique (ZGICNP).

L'avis scientifique et le document de recherche à l'appui seront rendus publics sur le site Web du Secrétariat canadien de consultation scientifique (SCCS).

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review Process (RPR) meeting was held on 25-27 June 2013 at the Pacific Biological Station in Nanaimo to review a pilot application of the Level 1 assessment methodology and evaluate modifications to the ecological risk assessment framework (ERAF) prototype methodology and to assess the performance of the ERAF with respect to the relative rankings of valued ecosystem components (VECs) and/or activities and stressors included in the pilot application.

The Terms of Reference (TOR) for the science review (Appendix A) were developed in response to a request for advice from Oceans and Science Sectors. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from other Federal Government departments, First Nations, the Province of British Columbia, commercial and recreational fishing sectors, environmental non-governmental organizations, and academia.

The following working paper (WP) was prepared and made available to meeting participants prior to the meeting:

> Pilot ecosystem risk assessment to assess cumulative risk to species in the Pacific North Coast Integrated Management Area (PNCIMA) by Cathryn Clarke Murray, Megan Mach, and Miriam O. (CSAP WP201 2/13-P06).

The meeting Chair, John Holmes, 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 RPR publications (Science Advisory Report, Proceedings, and Research Documents), and the definition and process around achieving consensus decisions and advice. The Chair reviewed the Agenda (Appendix B) and the Terms of Reference for the meeting, highlighting the goals and specific objectives of the meeting and then discussed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. It was confirmed with participants that all had received copies of the Terms of Reference, agenda, and working paper.

All participants were invited to join fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. Participants were reminded that everyone at the meeting had equal standing and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. The meeting room was equipped with a speaker phone and webinar on the first day to allow remote participation by the reviewers and other participants. Participants in the room were reminded to address their comments and questions so they could be heard by online participants. In total, 37 people took part in the RPR Meeting (Appendix C).

Participants were informed that Roland Cormier (DFO - internal) and Rebecca Martone (Stanford University – external) had been asked before the meeting to provide detailed written reviews of the working paper, which were forwarded to participants prior to arriving at the meeting. The reviews are intended to assist participants in shaping, but not limiting, discussion during the peer-review meeting.

The conclusions and advice resulting from this review will be provided in the form of Science Advisory Reports to Science and Oceans sectors to inform the development of the ERAF as a tool for identifying and assessing the relative risk of harm to VECs from human activities and their associated stressors in Pacific marine areas. The Science Advisory Report and supporting

Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

OCEANS CONTEXT

Joy Hillier briefly described the background context in Oceans Management, particularly the development of conservation objectives (COs), which represent an important step toward meeting DFO's commitment to a sustainable, precautionary and integrated ecosystem approach to oceans management. COs are intended to be specific, measurable, achievable, realistic and time-sensitive (SMART) and the ERAF is a tool to achieve a systematic, science-based, and defensible approach for arriving at COs for the Pacific Region. She noted that a limited subset of VECs and activities/stressors were chosen for this test and re-iterated that the results of this meeting are intended to further the development of the ERAF and that they would not be used for further management action or to inform decision-making around PNCIMA conservation objectives or priorities.

REVIEW OF WORKING PAPER

Working Paper:	Pilot ecosystem risk assessment to assess cumulative risk to species in the Pacific North Coast Integrated Management Area (PNCIMA) by Cathryn Clarke Murray, Megan Mach, and Miriam O. CSAP WP2012/13-P06.
Rapporteur:	John Holmes
Presenter(s):	Miriam O and Cathryn Clarke Murray

WORKING PAPER PRESENTATION

Miriam O and Cathryn Clarke Murray provided an overview of the context in which this working paper was developed, the goals it addresses, the methodology, and results. They highlighted areas in which the prototype methodology was modified, explained the rationale for their modifications, and requested feedback on the suitability of these changes.

The authors noted that this pilot test of the ERAF focused on the scoping phase and Level 1 risk assessment only. The authors reported that 17 species were chosen as pilot VECs from a list of potential Pacific North Coast Integrated Management Area (PNCIMA) VECs culled from the PNCIMA overview document and the ecologically and biologically significant areas (EBSA) process. These VECs were assessed against a list of activities and stressors compiled by Oceans Managers, rather than the full set of activities/stressors occurring within PNCIMA at present. Given the limitations associated with choice of VECs and activities/stressors, it was noted that evaluating the cumulative risk scoring was not possible and not attempted in this working paper.

The authors were asked to clarify the VEC selection process. They noted that the choice was challenging and that the original ERAF tried to provide guidance. However, the list of VECs used in the pilot was largely driven by EBSAs because the majority of data were assembled for the EBSAs. It was noted that the choice of VECs will drive the rankings and so VEC selection should be done carefully, especially in pilot testing.

The prototype ERAF proposes pathways of effects (POE) models to populate a VEC-Stressor matrix used to screen VECs for further risk assessment based on potential exposure and consequences. However, few peer-reviewed POE models were available for this pilot application so literature reports and expert judgement were used to define these relationships.

There was discussion about standardize POE models across the country and how to prioritize their development. National generic POEs are under development, but they need to be linked to specific VECs within a region to assess risk. The production of POEs for aquaculture was a massive undertaking owing to the peer-review requirements. The group noted that the SAR from the ERAF prototype meeting recommended the creation of a library of POEs and it was recommended that the SAR for this process contain a similar recommendation for a library of peer-reviewed POEs. Meeting participants also agreed that the VEC-stressor matrix used by the authors was an appropriate alternative approach when POEs are lacking.

The authors explained that scoring of the exposure term in the risk calculation differed relative to the prototype ERAF. Exposure was scored based on the activity/stressor and that the same score was applied to all VECs that interact with a particular stressor, rather than scoring exposure individually for each VEC-stressor interaction as proposed in the ERAF prototype. Recognizing this limitation, the authors tried spatial overlap analyses using important areas (IAs) from the EBSA process to determine if VECs and stressors overlap in PNCIMA and the results of these analyses are shown in maps in an appendix of the WP.

In contrast to exposure, the consequence score was based on VEC characteristics and so could vary among VECs, regardless of exposure. The most common attributes used for consequence scoring were population size and/or geographic range within PNCIMA. Guidance in the prototype ERAF recommends using the score of the most sensitive sub-component of consequence for scoring consequence overall. A question was asked about how the most sensitive subcomponent for consequence was chosen. The authors indicated that for the Level 1 it wasn't necessary as the choice was largely driven by data availability.

The authors found that uncertainty scores for both the exposure and consequence terms in the prototype ERAF were not carried forward through the risk calculations and concluded that this practice was at odds with the ERAF goals of transparency and explicit accounting of uncertainty. Therefore, they compared two methods for dealing with uncertainty in risk assessment scoring: the binned method proposed in the prototype ERAF, and uncertainty propagation. The uncertainty propagation method assigns an uncertainty score to each subcomponent of exposure and consequence and multiplies subcomponent scores and uncertainty to estimate a total risk score.

A question was asked about why the consequence term was cubed (i.e., consequence^3) in the risk calculation when using the uncertainty propagation method. The authors responded that the consequence term was cubed to give it equal weight to the exposure term (for which there are three subcomponents) in the risk calculation, consistent with the equal weighting recommendation from the ERAF prototype RPR meeting. There was discussion on whether balance in the exposure and consequence scores was desired and it was noted that they are already unbalanced since there were an unequal number of sub-terms in Exposure and Consequence.

The uncertainty propagation method risk scores were calculated by random sampling of a subcomponent assuming a normal distribution, with the mean defined by the variable score and the width of the distribution defined by the uncertainty score. After the mechanics of the calculation were demonstrated, it was clarified that each subcomponent score was randomly resampled 100 times and then the scores from each draw were multiplied to derive the 100 risk scores. The risk score reported in the results is the mean of the 100 scores and the 10th and 90th percentiles. There was discussion about alternative approaches for estimating risk, but in the end it was concluded that the approach used in the WP was sound. It was recommended that the authors clarify how the Monte Carlo simulation was used to calculate risk in the revised paper.

The prototype ERAF anticipated that uncertainty scores would be based primarily on the amount of information/data available concerning exposure or consequence of specific VECs. However, it was silent on how to interpret a lack of consensus in the scientific literature for either subcomponent. Thus, another modification in this pilot application was the addition of 1 unit to the uncertainty score when scientific consensus is not apparent.

It was noted that draft PNCIMA plan has four goals than balance ecological and socio-economic considerations, with a caveat that they should not be taken apart. However, the pilot test is constrained to ecological considerations only. In response, it was observed that it is not the job of Science to put all the pieces together in PNCIMA, the ERAF is a tool that contributes to the process put in place by Oceans managers. For example, VEC selection could be a broader process that identifies cultural, economic and ecological VECs and existing mitigation measures. It was suggested that it is important that socio-economic considerations be built it into the process from the start rather than adding it on at the end and that this idea should be acknowledged in the "Other Considerations" section of the SAR.

WRITTEN REVIEWS

This section provides an overview of discussion regarding the written review (Appendix E) discussed by Rebecca Martone at the meeting and documents all decisions/agreements to amend the working paper based on this discussion.

REBECCA MARTONE

The reviewer agreed that the Level 1 ERAF methodology was appropriate for large areas such as the PNCIMA. She caution that since only 17 VECs were chosen, none which were habitat or community properties, it was not possible to estimate cumulative risk. The subset of activities/stressors chosen for the pilot project lumps all land-based stressors in one bin and so would be challenging for full scale implementation in marine systems. The reviewer noted that the VEC-stressor matrix is a resource that could be used for POE development. This pilot test of the ERAF represents an advance in assessing risk due to multiple activities and stressors, but there is a need to relate the risk to impacts, capture risk tolerance of society, and to consider social and economic costs. The scoring process provides additional information on the drivers of risk not solely captured in the score itself; this includes the literature on exposure and consequences and uncertainty associated with the scoring process.

The reviewer suggested that the risk score may be affected by assessor expertise and suggested that it would be preferable to solicit a broad range of expertise related to specific VECs or activities/stressors to develop risk scores or apply techniques to get consistency across assessors (i.e., precision).

It was noted that the rankings of VECs based on relative risk may be sensitive to how the risk score is calculated, product vs. Euclidean distance. A comparison of the scores and rankings by each method would be helpful as would looking at the correlation between the two methods. If scores are highly correlated, then it probably doesn't matter which method is used. Meeting participants agreed with this suggestion and recommended that a comparison of the product and Euclidean distance risk scores be completed.

Scoring of exposure across VECs is a substantial deviation from the prototype methodology and requires discussion since it may lead to overestimation of the exposure component of risk to the VEC. There was also concern that this approach might obscure the consequence scoring. There was considerable discussion among participants on these points, focusing on terminology definitions, etc., and it was noted that Figure 6 in the WP showing the risk ranges for each VEC,

was useful approach to visualizing risk. Participants eventually agreed that scoring exposure consistently across VECs was suitable for a Level 1 assessment, but not necessarily for a Level 2 risk assessment. It was also noted that transparency in how scoring decisions were made is an important principle and it was recommended that an appendix explaining scoring decisions be included in the revised WP.

The intensity term in the exposure component of risk is intended to look at the full footprint of the activity/stressor, but in practice was scored on a single event basis rather than overall footprint. There is some difficulty with the term Intensity and what it actually means with respect to activities/stressors that were part of the pilot. See the General Discussion section for a fuller summary of this discussion.

The treatment of uncertainty by the authors was well done and addressed concerns of the reviewers of the prototype ERAF about transparency. Adding 1 to the uncertainty score when there is no scientific consensus seems to make sense. The reviewer asked meeting participants if the absence of consensus scoring was appropriate and received agreement that it was appropriate.

The reviewer noted that risk as presented in the WP, is not “real” risk because the risk scores have not been calibrated against benchmarks that represent impacts.

It was noted that a process is needed for updating the risk scores as new information becomes available. The risk scores represent a snapshot in time based on a huge amount of work. Are there simple ways to update the scoring?

The reviewer pointed out that management actions could reduce risk and that some exploration of how the risk scores change based on mitigation measures, would be informative. It is probably better to know how the change affects the system itself, but in the absence of that information, knowledge of how management actions affect the risk scores would be worthwhile.

A last comment relates to risk assessments in general and is not specific to the WP. Most risk assessments in marine systems only consider direct effects. Indirect effects through trophic interactions, e.g., predator-prey relationships, and their associated risks (or mitigation effects) are not captured by current risk assessment methodologies.

ROLAND CORMIER

The Chair read the comments of this reviewer because he was unable to attend in person or remotely via telephone.

The reviewer stated that the strength of this paper lies in the identification of high-risk stressors or activities contributing to risk so that management strategies and measures can be developed to reduce the risk.

The reviewer used the term significant ecosystem components (SEC) rather than valued ecosystem components (VECs), noting that there are guidelines for EBSA’s and ESS’s, etc., that identify SECs based on ecological criteria and that VECs are identified through the governance structure and consultations. If VEC’s were truly considered, then they would have to include social components such as esthetic values or recreational areas. The authors of the WP strongly agreed with these statements and recommended that the term significant ecosystem components (SECs) be used rather than VECs. Meeting participants agreed with this recommendation and will include it in the SAR.

Many of the reviewer’s comments focused on aligning terminology and concepts with international practice and clarifying what the ERAF can and cannot do. For example, many international risk assessments are based on the DPSIR framework (Driving forces, Pressures,

States, Impacts, and Responses), but these concepts are not explicit in the ERAF. Discussion on this point concluded that meeting participants and the authors were comfortable with the terminology as set out in the prototype ERAF.

The reviewer referred more than once to the criteria used to classify ecological consequences and how these criteria may (or may not) differ from the Departmental (DFO) risk management criteria. Since there was confusion about which criteria were the subject of comparison - SARA, Habitat, etc., - the Chair sought clarification from the reviewer via email between Days 1 and 2 of the meeting and confirmed that the corporate risk criteria that the department used for management decision-making were the appropriate criteria. These criteria consider all risks including ecological, socio-economic, operational, and strategic.

The reviewer requested further information on how the Intensity subcomponent of the exposure score was assigned. There was considerable debate about the Intensity subcomponent. This discussion is summarized in the General Discussion section.

GENERAL DISCUSSION

LEVEL 1 MODIFICATIONS

Modifications to the prototype Level 1 methodology included: (1) populating a VEC-stressor matrix based on scientific literature and expert judgment in place of approved POE models; (2) incorporating uncertainty into the risk scores as well as scoring uncertainty when there is a lack of consensus on exposure and/or consequence in the scientific literature; (3) scoring of exposure specific to an activity and stressor rather than SECs, (4) scoring the temporal subcomponent of exposure based on frequency of the event rather than duration; and (5) the interpretation of the intensity subcomponent of the exposure score. These modifications are briefly discussed below.

Lack of POE models – Discussion on the use of POEs in the ERAF noted that a requirement to use peer-review POEs would likely stall the process since few POEs are available at present. Participants agreed that delays in the absence of POEs were not satisfactory, and concluded that in the absence of POEs, the best available information should be used provided that it is explicit about caveats and uncertainty. It was noted that if no POE model was available during the scoping phase, then some low risk stressors that are insignificant individually but become significant cumulatively, might be missed. Although there were concerns that the results could change when POEs become available, meeting participants recommended that the VEC-stressor matrix approach used in the WP as an acceptable alternative provided there was sufficient justification of the cells in the matrix. It was also recommended that the WP be revised to include discussion of what would be missed if POE models are not used. A second recommendation was made to add text in Figure 1 (workflow chart of the ERAF) explaining the alternative approach when POEs are not available. Since it was noted that the VEC-stressor matrix was useful in POE development, the development of a robust mechanism to update the analysis when a POE is available was also recommended.

Incorporating uncertainty into risk scores – Participants noted that the binned method of estimating risk scores was fairly transparent since all the information was available in tables so the uncertainty associated with each term was visible, although in another table that could be separated from the risk scores. In contrast, the Monte Carlo approach to incorporating uncertainty into the risk score seems to lose this transparency, but carries the uncertainty through the risk score calculation. After much discussion on the merits of each method, meeting participants concluded that incorporating uncertainty directly into the estimated risk

score was preferable to the prototype method and recommended this approach going forward. There was further discussion about the mathematics of the calculation (see below).

Exposure scoring - Exposure scores were constant across SECs exposed to an activity/stressor. There was some discomfort among participants with this approach since it was felt that the metrics used to score exposure variables may be dependent on the SEC. Some were also struggling with the applicability of the exposure variables (temporal scale, spatial scale, intensity) to PNCIMA and other LOMAs. After much discussion, participants agreed that the approach taken in the WP of using constant exposure scores based on the stressor across all interacting SECs was acceptable and recommended making it clear in the revised WP that this was applicable only to Level 1 assessments; exposure in Level 2 and 3 assessments should be scored individually by SEC.

Intensity – The main difficulty with the exposure component of the risk score was the intensity variable. Two issues were identified: terminology and category definitions. Most participants felt that "intensity" was not the appropriate term since this variable is attempting to describe physical attributes of the stressor. Discussion focused on replacing intensity with load or loading, which is consistent with international terminology, and two attributes of load that describe the stressor: density (or how much) and persistence (how long the impact occurs). Meeting participants recommended that the WP be revised to replace the intensity variable with Load and scoring load as follows:

Score	Category	Description
1	Low	low density and low persistence
2	Moderate	high density or persistence
3	High	high density and persistence

It was noted that with the recommendation to include persistence as a sub-term of the load variable, participants were comfortable with scoring the temporal scale variable based on the frequency of an event rather than the duration of the event.

MATHEMATICS

The rationale for cubing consequence (consequence^3) in the calculation of risk scores using the uncertainty propagation method was questioned. The authors noted that this choice was driven by the desire to balance the exposure and consequence terms in the calculation since there were three variables in the exposure term, but usually only one in the consequence term. It was pointed out that the maximum possible score for exposure was 36 whereas when consequence is cubed the maximum score is much higher. Meeting participants agreed that the consequence score should be squared (consequence^2) and requested that the WP be revised to reflect this change, including recalculating all risk scores to take this recommendation into account.

A brief discussion of the product and Euclidean distance risk calculations concluded that it was desirable to have a comparison of the results in the revised WP. However, meeting participants agreed with the use of the product approach in the WP and did not request revisions to the scoring based on the outcome of this comparison.

The Monte Carlo simulation used to incorporate uncertainty into the attribute scores for exposure and consequence is based on resampling from a normal distribution. It was noted that this is not the only distributional assumption that could be used and there was concern that

the choice of a normal distribution might skew the results. A sensitivity analysis to assess the effect of distributional assumption on the risk calculation results was suggested.

It was noted that the Monte Carlo simulation was based on 100 runs from which the mean and 10^{th} and 90^{th} percentiles were calculated and reported. Since the average of tends to become closer to the expected or true value as the number of samples increases, it was recommended that at least 10,000 runs should be used to estimate risk scores and that the WP should be revised to indicate that at least 10,000 runs are needed for future applications of the ERAF.

SOCIO-ECONOMIC PERSPECTIVES

There was discussion on fitting socio-economic perspectives into the ERAF. It was noted that the ERAF is a tool for developing Science advice on risk to SECs and that this advice will be used to inform ecosystem-based management. Because the focus of the ERAF is on producing scientifically defensible results and advice, it does not deal directly with socio-economic perspectives. However, these perspectives can be indirectly brought into this process through the SEC selection process. Participants recommended adding language about socio-economic perspectives to the SAR under "Other Considerations".

It was also recommended that the term valued ecosystem components (VECs) should be replaced with significant ecosystem components (SECs) in the SAR and that the WP should be revised to reflect this change.

SPATIAL OVERLAP ANALYSIS

Spatial overlap analysis between SECs and activities/stressors was conducted to produce maps of spatially explicit cumulative risk. This analysis was considered interesting but premature at this time. More information is needed to describe the maps in the WP and a concern was raised about incorporating uncertainty into this spatial analysis. Meeting participants recommended developing guidance on data sources, biases, and incorporating uncertainty into spatial analysis results before this kind of analysis is conducted within the ERAF context. It was also recommended that the spatial overlap analysis maps in the WP be removed during the revision process as there are many concerns about their inclusion.

CONCLUSIONS

The operational modifications to the ERAF methodology reviewed at this RPR meeting are suitable for conducting a Level 1 risk assessment in PNCIMA.

Incorporating uncertainty directly into the risk calculation is the recommended approach to estimating risk for a Level 1 risk assessment, i.e., the binned method proposed in the ERAF prototype should be discarded.

A Level 1 risk assessment is a triage method/approach best suited to assessing relative risk at LOMA spatial scales (e.g., PNCIMA), where the list of potential SECs and activities/stressors is large and broad-scale data availability may be limited.

The semi-quantitative Level 2 risk assessment is best suited to local or regional scales within PNCIMA or to specific SECs of interest. The data requirements (quantity and quality) are much higher in a Level 2 assessment than for a Level 1 assessment.

Meeting participants were asked for a decision on the acceptability of the WP for publication. Participants agreed to accept the WP, subject to the revisions outlined below.

Since this working paper was a pilot test of the ERAF, a list of "lessons learned" was compiled to provide guidance for future applications. These lessons include:

1. SEC selection should be science-led and based on single species or coherent species groups;
2. POE models should be used if available, but a SEC-stressor interaction evidence matrix is an acceptable alternative;
3. Spatial input is needed to assess risk, but guidance is needed to produce appropriate results for use in the ERAF;
4. Data availability limits the applicability of a Level 2 risk assessment at the PNCIMA spatial-scale, but Level 2 risk assessments may be viable at smaller scales;
5. Gap analysis based on uncertainty will help target future research since uncertainty drove some of the rankings in the pilot test; and
6. Consensus or lack of consensus needs to be taken into consideration when scoring uncertainty.

RECOMMENDATIONS

- SEC selection is a critical issue for the ERAF. It is recommended that more specificity be used in defining stressors in order to distinguish between acute and chronic stressors, e.g., chronic oil spill versus catastrophic oil spill.
- The development of a library of activity-based POE models in collaboration with other agencies is recommended to facilitate future applications of the ERAF.
- The development of complete lists of SECs and existing activities/stressors is recommended to support the full implementation of a Level 1 risk assessment in PNCIMA. The lack of finalized lists was problematic for the pilot application of the ERAF.
- It is recommended that the term significant ecosystem components (SECs) be used rather than valued ecosystem components (VECs) because the SEC terminology is a better descriptor of the components addressed by this ERAF and it is consistent with international usage.
- It is recommended that alternative approaches to estimating cumulative risk be explored (e.g., non-additive methods).
- It is recommended that a Comments section be added to the scoring table to record information about the factors driving uncertainty, especially for Exposure and Consequence subcomponents that are data deficient or lack consensus in scientific literature as these categories are given a high uncertainty score.
- To address concerns about scoring exposure and/or consequence subcomponents when there is no information or data, it is recommended that a best guess be used for scoring and that uncertainty is scored as a 5, meaning that the score is a best guess and highly uncertain.

WORKING PAPER REVISIONS

- The framework description figure (Figure 1) should be modified with dashed lines to show that the ERAF does not have to be used hierarchically.
- Make clear for the binned risk calculation method how each score was determined if no information/data are available (high uncertainty).
- Rename the uncertainty propagation method as the uncertainty incorporation method for calculating risk.
- The risk equation in the uncertainty incorporation method should be modified so that the consequence term is squared (consequence^2) and all risk scores should be re-estimated.
- A discussion of the strengths/weaknesses of the binned and uncertainty incorporation risk estimation methods should be included in the revised WP.
- Clarify how the Monte Carlo simulation was used to calculate risk in the uncertainty incorporation method in the revised paper. The WP should be revised to indicate that at least 10,000 runs are needed for future applications.
- Emphasize that exposure scoring is constant in a Level 1 assessment and is scored specific to SECs in Level 2 assessments.
- Provide guidance on choosing the most sensitive subcomponent for scoring of the consequence term of the risk equation.
- The Intensity term of exposure should be renamed Load and the new scoring categories and descriptions developed during the RPR meeting should be used.
- A comparison of risk scores calculated using the product and Euclidean distance approaches should be provided in the revised working paper.
- Remove the spatial overlap maps from the revised working paper until guidance can be developed on data sources, biases, accounting for uncertainty, etc.
- The cumulative risk equation should be added to the WP.
- Since POEs were not used, some discussion of the pros and cons of the SEC-stressor matrix based on literature review and expert opinion, plus caveats (e.g., missing multiple low risk stressors that may not be important singly, but can be important when cumulative risk is considered) should be added to the WP.
- Appendix 4 should be changed to provide some examples and explanation of scoring to explain the scoring process. A legend should be added to the table explaining the meaning of a 1 or blank space in the table and totals should be removed.
- Provide some guidance on interpreting risk estimates and rankings of SECs in revised WP. For example, the rankings are relative because the risk scores are relative, therefore comparisons of absolute risk are not possible. At best, the analysis highlights that several SECs are ranked highly on risk, several have low rankings, and there are several in the middle. The interest should be in the drivers of this general categorization of SECs, exposure, consequence or uncertainty.
- The caveat in the first paragraph of the discussion should be in the Introduction to the WP.

SUMMARY AND CLOSING

The meeting concluded on time. The key findings, conclusions and recommendations in the Science Advisory Report were completed at the meeting and the Chair noted that he intended to circulate a draft within two weeks. The working paper was approved as a Research Document, subject to acceptance by the Chair of the consensus revisions recommended by meeting participants. The Chair thanked the participants and the presenters. He noted that the spirit of collaboration fostered during the meeting had led to constructive suggestions that will improve the Research Document and the resulting ERAF. One DFO Science Research Document will be produced as a result of this meeting.

ACKNOWLEDGEMENTS

The Chair acknowledges the assistance of Marilyn Hargreaves in organizing and running a smooth meeting and the working paper authors for a well written paper and spirited participation in responding to all questions and comments. Rebecca Martone (Stanford University) and Roland Cormier (DFO) provided constructive reviews of the working paper that formed the basis for much discussion. Meeting participants, many of whom are experienced practitioners of ecological risk assessment, are commended for engaging in a highly collaborative workshop-like dialogue with the authors and Chair that improved all of the products from this meeting.

APPENDIX A: TERMS OF REFERENCE

Pilot Application of an Ecological Risk Assessment Framework to Inform Ecosystem-based Management in the Pacific North Coast Integrated Management Area

Regional Peer Review Meeting - Pacific Region

June 25-27, 2013
Nanaimo, BC

Chairperson: John Holmes

Context

Canada's *Oceans Act* and Oceans Strategy commit Fisheries and Oceans Canada (DFO) to leading the development and implementation of a sustainable, precautionary and integrated ecosystem approach to oceans management. The development of a risk-based framework to identify and prioritize management issues for Large Ocean Management Areas (LOMAs) and Marine Protected Areas (MPAs) represents an important step toward meeting these commitments.

An Ecological Risk Assessment Framework (ERAF) was developed by a team of DFO Oceans and Science staff in Pacific Region and reviewed at a Canadian Science Advisory Secretariat-Pacific (CSAP) Regional Peer Review (RPR) meeting in May 2012 (DFO 2012). The ERAF is a framework for assessing single and cumulative risks to valued ecosystem components (VECs), and for ranking the significance of activities and stressors based on the relative risks to VECs. The aim of developing this risk-based framework is to provide managers with the process and tools to inform the development conservation objectives, management strategies, and action plans for the implementation of DFO's ecosystem-based integrated oceans management in LOMAs, such as the Pacific North Coast Integrated Management Area (PNCIMA) and Pacific Region Marine Protected Areas (MPAs).

The May 2012 RPR meeting reviewed the ERAF methodology (O et al. 2015) and recommended that a pilot project be undertaken to test the ERAF prototype and that a performance review of the ERAF be conducted through a future RPR meeting (DFO 2012). A pilot application of the ERAF, Level 1 risk assessment has been completed by DFO Science using a subset of 17 ecological VECs, and associated activities and stressors in the PNCIMA. The goals of the present RPR are to evaluate the modifications to the ERAF prototype methodology that were made as a result of the May 2012 RPR and subsequent testing of the ERAF and to assess the performance of the ERAF with respect to ranking VECs and/or activities and stressors included in the pilot application. The results of this pilot application of the ERAF are intended to further the development of the ERAF as a tool for identifying, and assessing the relative risk of harm to VECs from human activities and their associated stressors. The relative risk scores estimated in this test are not intended to be used for further management action or to inform decision-making around PNCIMA conservation objectives or priorities.

Objectives

The following working paper will provide the basis for discussion and advice respecting the objectives outlined below:

Ecological risk assessment framework to assess cumulative risk to species in the Pacific North Coast Integrated Management Area (PNCIMA). CSAP working paper by Clarke Murray, C., Mach, M.E., and O, M.

Specific objectives of this review are:

ERAF Structure and Performance

1. Evaluate whether the modifications to the ERAF prototype address gaps in structural components of the methodology that were identified in the May 2012 review, e.g., scoring metrics, cumulative risks, assumptions related to the nature of biological effects, the recovery time of ecosystem components;
2. Evaluate whether the modifications to the ERAF prototype address uncertainty in biological data inputs that were identified in the May 2012 review, e.g., lack of spatial/temporal data for some species, habitats, and communities;
3. Evaluate the transparency of the ERAF with respect to assumptions, uncertainty and risk;
4. Assess whether, and to what degree, the ERAF scoring guides and other documentation achieve repeatability based upon the knowledge and experience of the RPR participants;

PNCIMA Pilot ERAF Results

1. Provide an assessment of the performance of the Level 1 risk assessment based on the relative scoring for ecological VECs and/or activities and stressors;
2. Identify any outstanding information gaps that need to be filled to conduct a comprehensive Level 1 and/or Level 2 assessment for PNCIMA and potential approaches to address these gaps, where appropriate; and
3. Provide advice respecting next steps for an ERAF assessment of PNCIMA VECS and the applicability of moving to a Level 2 risk assessments.

Expected publications

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

Participation

- DFO Science, Fisheries Protection, Species at Risk, Fisheries Management
- DFO Risk Assessment Center of Expertise
- DFO Ecosystem Management
- Environment Canada
- Parks Canada
- First Nations
- Universities
- Environmental Non-government Organizations
- Fishing Industry
- Province of BC
- National Center for Ecological Analysis and Synthesis
- United States National Oceanic and Atmospheric Administration

Additional Information and References Cited

DFO. 2012. Risk-based assessment framework to identify priorities for ecosystem-based oceans management in the Pacific region. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/044.

Fletcher, W.J. 2005. The application of qualitative risk assessment methodology to prioritize issues for fisheries management. ICES J. Mar. Sci. 62: 1576-1587.

Halpern, B.S., K.A. Selkoe, F. Micheli, and C.V. Kappel. 2007. Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. Conservation Biology. 21: 1301-1315.

Hobday, A.J., A. Smith, H. Webb, R. Daley, S. Wayte, C. Bulman, J. Dowdney, A. Williams, M. Sporcic, J. Dambacher, M. Fuller, T. Walker. 2007. Ecological risk assessment for the effects of fishing: methodology. Report R04/1072 for the Australian Fisheries Management Authority, Canberra.

O, M., Martone, R., Hannah, L., Greig, L., Boutillier, J. and Patton, S. 2015. An Ecological Risk Assessment Framework (ERAF) for Ecosystem-based Oceans Management in the Pacific Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2014/072.vii + 59 p.

Park, L.E., L.A. Beresford, and M.R. Anderson. 2010. Characterization and analysis of risk to key ecosystem components and properties. Oceans, Habitat and Species at Risk Publication Series, Newfoundland and Labrador Region. 0003: vi + 19p.

Park, L.E., L.A. Beresford, and E. Kissler. 2011. Prioritization of key ecosystem components based on the risk of harm from human activities within the Placentia Bay/Grand Banks Large Ocean Management Area. Oceans, Habitat and Species at Risk Publication Series. Newfoundland and Labrador Region. 0004: vi + 9 p. + working notes (2422p.).

Tallis, H.T., T. Ricketts, A.D. Guerry, S.A. Wood, R. Sharp, E. Nelson, D. Ennaanay, S. Wolny, N. Olwero, K. Vigerstol, D. Pennington, G. Mendoza, J. Aukema, J. Foster, J. Forrest, D. Cameron, K. Arkema, E. Lonsdorf, C. Kennedy, G. Verutes, C.K. Kim, G. Guannel, M. Papenfus, J. Toft, M. Marsik, and J. Bernhardt. 2011. InVEST 2.2.2 User's Guide. The Natural Capital Project, Stanford.

Zhou, S., A.D.M. Smith, and M. Fuller. 2011. Quantitative ecological risk-assessment for fishing effects on diverse data-poor non-target species in a multi-sector and multi-gear fishery. Fish. Res. 112: 168-178.

APPENDIX B: AGENDA

Centre for Science Advice Pacific

Regional Peer Review Meeting (RPR)

Pilot Application of an Ecological Risk Assessment Framework to Inform Ecosystem-based Management in the Pacific North Coast Integrated Management Area

25-27 June, 2013
Nanaimo, B.C.

Chairperson: John Holmes

DAY 1- Tuesday, June 25, 2013

Time	Subject	Presenter
0930	Welcome and Introductions	John Holmes
0945	Review Agenda and Housekeeping Items	John Holmes
1000	CSAS Overview and Meeting Procedures	John Holmes
1015	Review Terms of Reference/Context for ERAF Pilot application in PNCIMA	John Holmes/Joy Hillier
1100	Presentation of Working Paper	Miriam O
1215	***Lunch Break***	
1315	Reviewer Presentation and Authors Response	Rebecca Martone
1345	Reviewer Presentation and Authors Response	Roland Cormier
1415	***Break***	
1430	Group Discussion to Identify Issues and Topics	RPR Participants
1545	Summary of Issues and Topics for further discussion	RPR Participants
1600	***Adjournment***	

DAY 2 - Wednesday, June 26, 2013

Time	Subject	Presenter
0900	Introductions & Housekeeping	John Holmes
0915	Review Day 1, Terms of Reference, and Agenda for Day 2	John Holmes

Time	Subject	Presenter
0930	• Operational Modifications to ERAF Methodology o Structural o Data-related	RPR Participants
1030	***Break***	
1045	• Transparency of assumptions, uncertainty and risk • Repeatability of process based on documentation	RPR Participants
1200	***Lunch Break***	
1300	• Performance review • Relative ranking of VECs and/or activities and stressors	RPR Participants
1430	***Break***	
1445	• Outstanding information gaps • Next steps for an ERAF assessment of PNCIMA VECs • Moving to a Level 2 risk assessments	RPR Participants
1600	***Adjournment***	

DAY 3 – Thursday, June 27, 2013

Time	Subject	Presenter
0900	Introductions & Housekeeping	John Holmes
0915	Review Days 1 & 2, Terms of Reference, & Agenda for Day 3	John Holmes
0930	Discussion & resolution of issues from Day 1 & 2	RPR Participants
1030	***Break***	
1045	Science Advisory Report (SAR) consensus: • Key findings & conclusions • Uncertainties • Recommendations for future work Recommendations for Working Paper	RPR Participants
1200	***Lunch Break***	
1300	Finalize (Draft) Science Advisory Report	RPR Participants
1430	***Adjourn meeting***	

APPENDIX C: PARTICIPANTS

Last Name	First Name	Affiliation
Ackerman	Barry	DFO Fisheries Management - Groundfish
Barrie	Vaughn	Natural Resources Canada
Bernhardt	Joey	InVEST/The Natural Capital Project
Biffard	Doug	BC Parks
Brown	Robin	DFO Science
Chamberlain	Jon	DFO Aquaculture
Clarke Murray	Cathryn	World Wildlife Fund, Vancouver
Dunham	Anya	DFO Science
Evanson	Melissa	DFO Fisheries Management--Gwaii Haanas
Giangioppi	Martine	DFO Policy, Ottawa
Hillier	Joy	DFO Oceans
Holmes	John	DFO Science-Chair
Jansen	Willi	DFO Marine Mammals
Jessen	Sabine	Canadian Parks and Wilderness Society
Jones	Greg	Environment Canada, Vancouver
Joyce	Marilyn	DFO Science
Ladwig	Aleria	DFO Fisheries Management
Leslie	Karen	DFO Oceans
Lougheed	Cecilia	DFO Science, Ottawa
Magnusson	Gisele	DFO Economics
Majewski	Sheena	DFO Science
Martone	Rebecca	Stanford Univ., Center for Ocean Solutions
McIssac	Jim	T. Buck Suzuki Foundation
Morgan	Ken	Environment Canada
O	Miriam	DFO Science
O'Hara	Patrick	Simon Fraser University
Paul	Allison	Marine Planning Partnership
Pena	Angelica	DFO Science
Reid	Bruce	DFO Fisheries Management
Saunders	Mark	DFO Science
Spencer	Jennifer	West Coast Aquatic
Stewart	Hannah	DFO Science
Templeman	Nadine	DFO Oceans
Therriault	Tom	DFO Science
Thompson	Jason	Haida Oceans Technical Team
Trudel	Marc	DFO Science
Turris	Bruce	Canadian Groundfish Res. & Cons. Society
Yamanaka	Lynne	DFO Science

APPENDIX D: SUMMARY OF THE WORKING PAPER

The challenge of managing areas with diverse human activities and effectively evaluating environmental, social and economic trade-offs requires Ecosystem-based Oceans Management. A pilot ecological risk assessment for the Pacific North Coast Integrated Management Area (PNCIMA) was conducted to test the effectiveness of an ecological risk assessment framework developed by O et al. (2015). During the scoping phase, a subset of 17 significant ecological components (SECs) was chosen to represent major functional groups in PNCIMA based on their data availability. Marine, land-based and global activities currently occurring within the area and their associated stressors were identified using an interaction matrix with accompanying evidence tables because Pathways of Effects models were under development and therefore unavailable. A subset of stressors was evaluated (76 in total) for the identified activities. Risk was evaluated using four variables: Spatial scale, Temporal scale, Load, and Consequence. Scoring was based on literature review and an uncertainty score assigned for each variable taking into consideration data availability, quality and scientific consensus. Risk scores for each stressor-SEC combination were calculated using one of two methods:

1. Binned exposure using the methods as outlined by O et al. (2015); and
2. Uncertainty incorporation using Monte Carlo simulation to directly incorporate the uncertainty scores in the risk calculation.

Cumulative risk for each SEC was calculated by summing the risk scores for each SEC. Using the uncertainty incorporation method, the SECs with the highest cumulative risk were Dungeness Crab, Salmon, Sponges, and Seagrasses. The highest ranking stressors across all SECs were trawling-related and most of the highest ranked stressors for each SEC were trawl-related. The relative ranking of risk was similar between the two risk calculation methods but the Uncertainty Incorporation showed where uncertainty was highest between exposure and consequence, and could be used to prioritize research and focus management efforts. The Qualitative Level One ecological risk assessment was found to be an effective triage tool, providing a relative ranking of SECs and stressors. However, the current pilot project is not a complete risk assessment for PNCIMA because it is based on a subset of SECs and stressors affecting PNCIMA and the resulting scores have not been vetted by experts. Therefore the results should not be used for policy or management decisions at this stage.

APPENDIX E: WRITTEN REVIEWS

REBECCA MARTONE

NB: This Reviewer is an author of the original ERAF framework that was applied in this working paper and as such I want it known that though I am trying to be as objective as possible, I am potentially introducing my bias in reviewing this document. In addition, I contributed to the development of some of the steps that were taken in this working paper, particularly the uncertainty analyses.

ERAF Structure and Performance

General Comments:

Overall, I am very impressed with the amount of work that went into the pilot application of the Scoping and Level 1 phases of the ERAF developed by O et al. (2012) to the PNICMA. Although not comprehensive as it only considers risks to 17 VECs and only evaluates a subset of activities and stressors, this pilot provides a starting point from which to evaluate whether the ERAF is able to meet the goals of

i) identifying and prioritizing anthropogenic risks to ecosystem components and

ii) to inform the development of conservation objectives and management strategies to mitigate identified risks. By providing worked examples of a Level 1 risk assessment for a suite of VECs the authors improve transparency and allow for evaluation of workability of these approaches.

As stated by the authors, a significant advance in this framework is the ability to include multiple activities and stressors in order to better understand which single stressors pose greatest risk to ecosystem components in the region of interest and the potential cumulative risk to individual ecosystem components in these systems. However, what is clear from this application is though the framework highlights threats that pose the greatest relative risk to valued ecosystem components, it is only one step in prioritizing ecological risk, and informing conservation objectives and management strategies to mitigate risks. In order to choose and prioritize actions and guide management decisions, this analysis must be incorporated into a process that considers societal preferences for different VECs, examines societal willingness to accept different levels of risk to these VECs (i.e. how much risk is too much risk), measures of how relative risk relates to “actual” risks or, more importantly, effects or impacts, and the social and economic costs of alternative actions. In his review of the working paper on the ecological risk assessment framework (O et al, CSAP Working Paper 2012/P46) Samhouri provides a few references to guide this process in the original ERAF review and I encourage DFO to turn to these if they move forward with application of this framework.

Having said that, I do believe that the risk assessment framework as applied in this working paper can give insight into how to interpret which stressors may have the greatest impact to VECs, where they may have greatest impact, and where additional information is needed to address risks from different activities and stressors. Moreover, this stressor-based approach allows for identification of potential mechanisms of impact and thus which actions may be required to address risk (if they are deemed worth addressing). Furthermore, the cumulative aspect of the approach, although currently limited to an additive model, may provide a type of baseline of current potential risks from activities and may allow consideration of how additional human activities would increase or decrease risk from these stressors, an important consideration for cumulative effects assessment. However, what is still not clear in this framework is how to systematically consider how management actions implemented in these systems would reduce risk from single or multiple activities and stressors.

There are a few key points that I would like to highlight:

1. Risk scores may be affected by the expertise of the assessors. A number of experts' opinions should be elicited in order to evaluate the consistency of scoring both of the current suite of scores developed by the authors as well as more generally for the framework. I recommend Teck et al. (2010: Ecol Applications) as an example of the types of methods that can be employed to examine the consistency among expert scores. However, I also caution that the lack of multiple experts shouldn't impede the application of this framework. For example, a next-step, middle-ground approach might be to vet the current scores using a handful of experts that can be identified for each VEC and/or stressor in a workshop-setting. This will allow the methodology and scores to be assessed for repeatability.
2. Relative risk and range of risk scores is likely sensitive to the way risk is calculated (e.g. product vs. Euclidean distance). A few additional analyses could evaluate these assumptions, as requested in the CSAS review of the framework (see comments below).
3. Interestingly, the authors chose score exposure consistently across VECs for a given stressor, because Exposure was in relation to the stressor itself, and chose to evaluate the potential overlap in between stressor-VEC as part of the Consequence score. Although I would argue that this is not what the original framework intended, I think for the Level 1 risk assessment, when evaluating a large number of VECs and a large number of stressors, this may prove useful. However, the authors should provide additional justification for why they applied the method in this manner. Furthermore, by evaluating exposure in this manner, the authors may overestimate exposure to the VEC. By evaluating consequence in this manner, the authors potentially obscure whether the consequence score for a particular VEC x stressor combination is due to the response of the VEC or its overlap with the stressor, or both. This may be something that could be evaluated separately within the Consequence score and should be discussed in the group. One possible way to address this is to apply the Level 2 Semi-Quantitative Risk Assessment by mapping VECs and activities, and scoring based on percentage overlap for spatial and temporal scale, although this methodology may also have its limitations (see uncertainty associated with spatial datasets).
4. Application of Intensity is different than the TS and SS aspects of exposure, in that this is considering the full footprint of the activity in the region considered, whereas TS and SS are considered for a single event or instance of the activity. It is unclear why the authors chose to apply the risk assessment framework in this way, and how this may affect the scoring. Using the example provided in the text, if a stressor from a single fish farm is severe at local scales but the footprint of the activity is over broad scales, would the authors score the intensity score as high? It would be helpful to have some additional explanation of this scoring approach for transparency.
5. High-ranking VECs were a mix of both high numbers of low risk stressors and a smaller number of high-risk stressors. For example, sponges and sea grasses were exposed to high numbers of low- to moderate- risk stressors, while resident killer whales were exposed to a few high-risk stressors. Cumulative risk considered by this framework highlights those species with low VEC-stressor risk relationships as at-risk species.
6. The authors' treatment of uncertainty in the paper Is changed from a single score to a score that is applied across each risk variable. I think it is more appropriate and also addresses the concerns of the reviewers in the original ERAF CSAP process. By adding a value of 1 to the uncertainty score when there is lack of consensus is also appropriate. In addition, the uncertainty propagation method can capture different opinions about uncertainty itself, if additional experts were engaged in a process.

7. Once scores of risk are determined for VECs by experts, risk scores should be evaluated in a process to determine the acceptable benchmarks for risk to each of the VECs. This process should incorporate the different metrics for combining risk, as presented by the authors (e.g. relative cumulative risk; exposure x consequence graphs; ranks based on stressor, VECs, etc.).
8. I emphasize treading cautiously in assuming that these scores represent "real" risk to VECs in PNCIMA, particularly the cumulative risk scores. Uncertainty in this analysis, though incorporated for each step, in the spatial maps the scores presented are the "average" cumulative risk scores, which do not incorporate the full range of values captured by the uncertainty analysis (i.e. quantiles). In addition, the spatial analysis doesn't necessarily consider the uncertainty associated with proposed activities in these regions nor with the spatial mapping of stressors/VECs for which so little is known or for those species that do not have spatially explicit data. One concern about processes like this is that these values become adopted as fact when in reality, caveats and nuance and uncertainty should be explained and explored in detail. For example, new data on whale migration corridors is not captured in these maps. Maps of risk should particularly be produced and used with prudence, and a process for updating VECs and stressors regularly should be adopted.
9. Like many risk assessments, these risk scores only capture direct risk to VECs. However, some risks may be due to indirect effects, such as potential interactions among species. For example, risk to a species that may be critical prey may translate into risk to the predator that relies on that prey species. The authors discuss this limitation in the paper, but I recommend that additional considerations about how to address these risks, particularly when evaluating cumulative impacts, be considered during this review process.

Specific Comments:

Scoping Phase

Selection of VECs and Stressors

As appropriate for a pilot application of the ERAF, the authors chose a subset of VECs to evaluate. I like the authors' approach of choosing a range of VECs across a suite of categories and subcategories. This allows for evaluation of the framework across different taxa with variable biological attributes and sensitivities to stressors. However, like the authors, I caution that by simply applying the framework to a subset of specific species within subgroups limits the ability of the application to be used as a final product for PNCIMA. For example, sea lions are only one type of pinniped and may have different sensitivities and exposures to stressors than other pinnipeds. Similarly, limiting the Scope of the application to a subset of stressors will also limit the evaluation of the full suite of activities and stressors. One major gap is pathways of effects from land-based activities. Still, the authors considered an expansive suite of activities and stressors in this document, and thus should be commended, especially given the lack of available pathways of effects assessments for most of the activities and stressors present in the region.

VEC-Stressor Matrix

Given the pilot-nature of this analysis, the authors limited the working group of experts to a small subset (which included the authors and this reviewer). To improve the application of this framework, a more comprehensive approach to eliciting expert opinion should be conducted.

Qualitative Variables

The authors evaluate the framework using two calculations for risk:

1. Risk = Exposure * Consequence – original calculation

2. Risk = Exposure * Consequence^3 – new calculation considered for ease of calculating uncertainty

The authors make the case that cubing the consequence score allows comparison between the direct Exposure score that is a result from multiplying the 3 aspects of Exposure (*TSij * SSij * Iij).* This allows each element of Exposure as well as the element of Consequence, to have a level of uncertainty associated with it that can be incorporated into the final risk score using bootstrapping techniques. This technique also eliminates the need to normalize the Exposure score before combining it with Consequence using either product or Euclidean distance metrics. Estimating risk using this approach, the authors have addressed some of the concerns of the reviewers of the original framework, namely that uncertainty should be considered when scoring each of the variables, as well as addressing the potential bias of either having Exposure and Consequence scores on different scales or normalizing

However, one aspect of the original framework that was not addressed was the comparison between the product method and the Euclidean distance method to assess relative risk. As stated by Samhouri in his review of the ERAF, "When exposure and consequence are very different, risk calculated using the product of E and C will be lower than if it were calculated using the Euclidean distance equation. When E and C are very similar, risk calculated using the product of E and C will be higher than if it were calculated using the Euclidean distance equation. This disparity will be particularly apparent when values of E and C are both high." I recommend that the authors use apply the scores using a Euclidean distance scoring for both the straight product scoring approach (Equation 1 above) as well as the approach with Consequence cubed (Equation 2 above) in order to show how risk varies with these types of assumptions and across different levels of the attributes (i.e. *TSij*, *SSij, Iij*, Consequence).

Results

- I like that the authors have incorporated different summaries for the scores. For example, Table 7 shows that there are different ways to rank which VECs have the highest risk, whether by cumulative risk, by # of stressors or by the mean value of risk to the VEC. This allows flexible interpretation of risk, part of the strength of this method.
- Although the authors describe the scoring process in the methods, they do not show the full table with the underlying scores for each VEC x Stressor combination. This is likely because this table was unwieldy. However, the authors do show the Exposure scoring that was used across VECs. It would be good to add the Consequence scoring as an appendix, or at least incorporating a portion of this information in a table as an example to guide the reader?
- As the authors' point out, the challenge with this method is that uncertainty is not explicitly addressed in these scores and cannot be traced, suggesting that a different approach is necessary.
- There are two tables labeled Table 8 and the second states that there are 10 and 90% quantiles incorporated in the table when they are not.
- I like Figure 6 – presenting the results in this way for each VEC would allow for a better assessment of what is driving risk for each VEC, how certain these estimates are, and where additional information could improve assessment.

Discussion

- I appreciate and agree with the authors' statement of caution in the first part of the discussion.

- On page 27, bottom of the second paragraph, the authors mention that the Consequence score is high for the two VECs but are only describing sponges. What is the other VEC?
- Spatially explicit risk to VECs using EBSAs is flawed, but I don't know that species ranges would be the recommended way to address important areas for some of these VECs. I would recommend the use of range information for sessile benthic species but the pelagic and mobile species may need better spatial data of core areas for these species.

ROLAND CORMIER

In general, I think that this document demonstrates the application of the ERAF in classifying and organizing cumulative risks in relation to human stressors.

I find the ERAF interesting as an approach for categorizing cumulative risks to inform management. However, I am not as sure as to the interpretations of Significance (referring the EBSA criteria) and VEC's. Even under CEAA, a VEC would be assigned by stakeholders involved in the EA. If I understand properly the ERAF and this paper, I would say that the approach does a risk ranking of significant ecological components.

1. Is the purpose of the working paper clearly stated? Yes, the purpose of the paper is clearly stated.
2. Are the data and methods adequate to support the conclusions? Yes.
3. Are the data and methods explained in sufficient detail to properly evaluate the conclusions? Yes.
4. If the document presents advice to decision-makers, are the recommendations provided in a useable form, and does the advice reflect the uncertainty in the data, analysis or process?
5. Can you suggest additional areas of research that are needed to improve our assessment abilities? As mentioned above, the authors may want to refer to the EBSA criteria when comparing and discussing Ecological Significance and VEC's. I would specially refer to paragraph 2 of the guidelines for both EBSA (SAR 2004/006) ESS ESCP (SAR 2006/041) and would take the time to explain the differences between the two as well as the rational for using VEC's instead of the Departmental guideline. I found that the criteria used for classifying the ecological consequences for species are interesting and I wondered how these would differ from the Departmental risk management ecological criteria or how these two set of criteria would interface.

ESS 2004/006: Identification of Ecologically and Biologically Significant Areas.

SAR 2006/041: Identification of Ecologically Significant Species and Community Properties.

1.0 Introduction

I am wondering if the author should consider the ERAF as a means of assessing cumulative pressures. Most international risk assessment framework use Pressures based on the DPSIR definitions.

Does cumulative risk from multiple activities refer or mean the risks from cumulative pressures as a result of human activities?

2.1.1 Identification of Activity/Stressor

It is noted that in order to fully assess cumulative impacts for the region, global stressors also were examined. Is the ERAF a cumulative impact assessment framework?

"For the current pilot project, a subset of activities and stressors were evaluated." Internationally, these activities and stressors would be referred to as Drivers and Pressures (DPSIR).

2.1.2 Identification of VECs

In Canada, we have guidelines for EBSA's, ESS's and ESCP's that identify significant ecosystem components based on ecological criteria. It is via the governance structure and consultations that VECs would be identified. Was this the case for the 13 VECs used in this case study? Scientist do not identify VEC's. I would read Paragraph 2 of CSAS 2004/006. If VEC's were truly considered, they would have to include social ecosystem components such as esthetic values or recreational areas.

2.2.2 Qualitative Risk Variables

How different are the Consequence criteria in Table 2 (d) from Departmental risk management criteria?

3.1 RISK ASSIGNED FROM METHOD 1: BINNED EXPOSURE

In ranking the stressors across all VECs, was the load of the "Stressor" considered such as the number of trawl strikes per square km, etc.?

3.2 RISK ASSIGNED FROM METHOD 2: UNCERTAINTY PROPAGATION

With respect to sea grasses as a VEC, I am wondering if you were aware of CSAS SAR 2011/058 and SAR 2009/018?

SAR 2011/058: "Definitions of harmful alteration, disruption or destruction (HADD) of habitat provided by eelgrass (*Zostera marina*)"

SAR 2009/018: "Does eelgrass (*Zostera marina*) meet the criteria as an ecologically significant species?"

4.1 Pilot Risk Assessment

The authors note that the results in this WP should not be considered a complete risk assessment for PNCIMA. I would suggest that this is an qualitative ecosystem risk assessment that has categorized the stressors to significant ecosystem components. It is still valuable information in terms of informing management decision-making. Frameworks are there to inform and no make the decision.

Future management actions could be specifically targeted at. The strength of this paper is that it identifies high-risk stressors or activities with a large number of high-risk stressors contributing to risk so that management strategies and measures can be developed to reduce the risk.

4.1.1 Spatially-Explicit Risk

The authors argue in the first paragraph of this section (4.1.1) that the EBSA important areas may not adequately capture spatial overlap between species and human activities because they may not fully describe the range of a species. I do not agree with this paragraph. EBSA's criteria are designed to identify the most vulnerable ecosystem component in a given area. They technically use ecological criteria to delineate subsets of components in a given Bioregion or Ecoregion. As mentioned earlier, the authors should consider Paragraph 2 of CSAS 2004/006. VEC's are based on ecological, social, economic, values.

Spatial consideration is a critical element in this risk assessment. It would have been useful to add the intensity of these activities in the assessment.

It's noted that the cumulative risk values represent spatial overlap between VEC and activities and that there is no seasonality, temporal or depth variation, although they are important components of risk to VECs. I agree. Although not a problem for the authors in this paper, the ERAF could be better aligned with Cumulative Impact Assessment practices and, yes, the data and analysis of this paper could form a very good basis for such assessment.

4.2.2 Stressors and Activities

The authors conclude that a better understanding of the pathways of effects of stressors from land-based activities to marine ecosystems would provide a starting point for meaningful dialogue and cross-jurisdiction management. Even though DFO does not have jurisdiction over these activities, it has the means of developing management strategies via integrated management agreements under the Oceans Act. I suggest the authors read ICES CRR 317, which we have recently published.

ICES Cooperative Research Report 317: "Marine and coastal ecosystem-based risk management handbook".

4.2.3 Cumulative Impacts

I suggest the following for the first sentence in this section: "The methods of estimating the cumulative risks presented here…" I think that this provides an estimate of the potential cumulative impacts using a risk categorization approach.