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Pacific Region

Proceedings of the Pacific regional peer review of the Review of Conservation Targets and Network Design Options for the Northern Shelf Bioregion Marine Protected Area (MPA) Network

May 23-25, 2017
Vancouver, British Columbia

Chairpersons: Miriam O and Russ Jones
Editor: Erika Anderson

Fisheries and Oceans Canada
Science Branch
3190 Hammond Bay Road
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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.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting of May 23-25, 2017 at the Pinnacle Hotel Harbourfront in Vancouver, British Columbia. The working paper focused on design strategies for the Northern Shelf Bioregion Marine Protected Area Network development.

The working paper reviewed scientific literature on ecological best practices for Marine Protected Area network development. Methods were recommended to identify coarse and fine filter ecological conservation targets for species and areas recommended previously as ecological conservation priorities for MPA network planning in the Northern Shelf Bioregion. A flow chart was presented for evaluation of spatial data for inclusion in Marxan analysis. MPA size, spacing, and replication recommendations were presented. MPA protection levels were discussed, along with performance scaling factors for MPAs, to estimate their ability to meet ecological conservation targets under different protection levels.

In-person and web-based participation included Fisheries and Oceans Canada (DFO) Science, Oceans, and Fisheries and Aquatic Management Sectors staff; and external participants from Indigenous Peoples, commercial and recreational fishing sectors, environmental non-governmental organizations, academia, Province of BC, and Gwaii Haanas Parks Canada.

There were several improvements arising from discussions, including the inclusion of more context and terminology in the Science Advisory Report. The ecological conservation targets will be calculated with both quartiles and thirds, then sensitivity analyses run in Marxan. The variance of the expert reviewers was addressed, and in select cases such as marine mammals, re-evaluation recommended. While the scientific literature provides rationale for the use of a 10% minimum threshold for coarse-filter ecological conservation priority features, it was recommended that sensitivity analyses be undertaken to assess how this baseline will influence the design scenarios. Sessile and highly mobile species were removed from the calculation of MPA size. The initial 30% no-take MPA level of protection was changed to a 20-50% no-take recommendation. In addition, the uncertainties and next steps were discussed, resulting in a detailed list for sensitivity analysis and future research.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report providing advice to DFO and the Marine Protected Area Technical Team (MPATT) to inform the development of the Marine Protected Area Network in the Northern Shelf Bioregion.

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

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held on May 23-25, 2017 at the Pinnacle Hotel Harbourfront in Vancouver, British Columbia.

The Terms of Reference (TOR) for the science review (APPENDIX A) were developed in response to a request for advice from DFO Oceans. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from Indigenous Peoples, commercial and recreational fishing sectors, environmental non-governmental organizations, academia, the Province of BC, and Gwaii Haanas Parks Canada.

The following working paper was prepared and made available to meeting participants prior to the meeting (working paper abstract provided in APPENDIX B):

> Design Strategies for the Northern Shelf Bioregional Marine Protected Area Network by Rebecca Martone, Carrie Robb, Katie SP Gale, Alejandro Frid, Chris McDougall, and Emily Rubidge. CSAS Working Paper 2015OCN05B.

The meeting Chairs, Miriam O and Russ Jones, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chairs discussed the role of participants, the purpose of the various RPR publications (Science Advisory Report, Proceedings and Research Document), and the definition and process around achieving consensus decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the Terms of Reference, working papers, and draft SARs.

The Chairs reviewed the Agenda (APPENDIX C) and the Terms of Reference (APPENDIX A) for the meeting, highlighting the objectives and identifying the Rapporteur. The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation. The room was equipped with microphones to allow remote participation by web-based attendees, and in-person attendees were reminded to address comments and questions so they could be heard by those online.

Members were reminded that everyone at the meeting had equal standing as participants and they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 59 people participated in the Regional Peer Review (APPENDIX D). Erika Anderson was identified as the Rapporteur for the meeting.

Participants were informed that Mark Carr (University of California), Isabelle Côté (Simon Fraser University) and Ryan Stanley (DFO Science Maritimes) had been asked before the meeting to provide detailed written reviews for the Design Strategies for the Northern Shelf Bioregional Marine Protected Area Network working paper to assist everyone attending the peer-review meeting. Participants were provided with copies of the written reviews (APPENDIX E).

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report to DFO Oceans to inform the Marine Protected Area network planning process in the Northern Shelf Bioregion. The Science Advisory Report and supporting Research Document will be made publicly available on the Canadian Science Advisory Secretariat (CSAS) website.

PRESENTATION OF NETWORK PLANNING PROCESS

Presenter: Hilary Ibey

Organization: DFO Oceans and Marine Protected Area Technical Team (MPATT) co-chair

An overview presentation was given on the Marine Protected Area (MPA) Network planning in the Northern Shelf Bioregion (NSB) and the goals and objectives of the network planning process. The planning process is based on international best practices and considers lessons learned from other planning processes. The goals are based on the Canada-BC Marine Protected Area Network Strategy. Design strategies were described within the larger process (Figure 1). Design strategies will describe how the conservation priorities will be spatially incorporated into the network and include area-based targets. Targets were defined as quantitative estimates of how much of a feature should be included in the NSB MPA network, as well as key variables such as size, spacing and replication. These targets will be used to create design scenarios using Marxan as a spatial optimization tool using an iterative process that includes engagement. This engagement will include local people, stakeholders, advisory committees and bilateral meetings. It will also align with the Pacific North Coast Integrated Management Area (PNCIMA) initiative signed in February 2017. The NSB MPA goals are nested within the PNCIMA ecosystem based management framework goals.

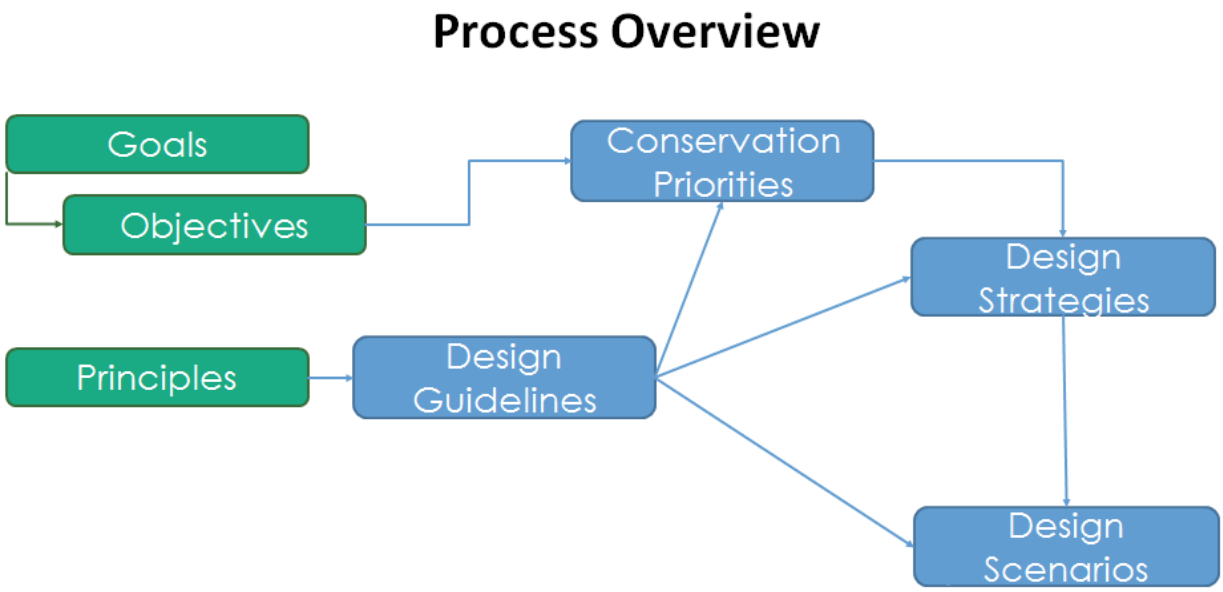

Figure 1. Process Overview for the MPA Network Planning in the Northern Shelf Bioregion taken from PowerPoint presentation.

The chairs requested that Hilary Ibey return on day three of the Regional Peer Review meeting to address question relating to the process and present an overview on the process. Figure 1 was displayed again to show how this design strategy working paper recommends tools to develop design scenarios within Marxan.

REVIEW

Working Paper: Design Strategies for the Northern Shelf Bioregional Marine Protected Area Network by Rebecca Martone, Carrie Robb, Katie SP Gale, Alejandro Frid, Chris McDougall, and Emily Rubidge. 2015OCN05B.

Presenters: Rebecca Martone, Carrie Robb, Katie Gale

PRESENTATION OF WORKING PAPER

The authors presented their working paper in several sections over the three days including: an overview, settings targets for conservation priorities, MPA replication size and spacing, and MPA Levels of Protection.

OVERVIEW AND CONSERVATION PRIORITIES

Martone thanked participants for attending and gave a short presentation on the working paper. An overview of where design strategies fit into the NSB MPA network process was presented (Figure 2). Targets, later renamed ecological conservation targets, were developed for input into Marxan. Design guidelines were incorporated as design strategies, if they could be spatially incorporated into the process. Additional design guidelines will be included post-hoc during the scenario evaluation phase.

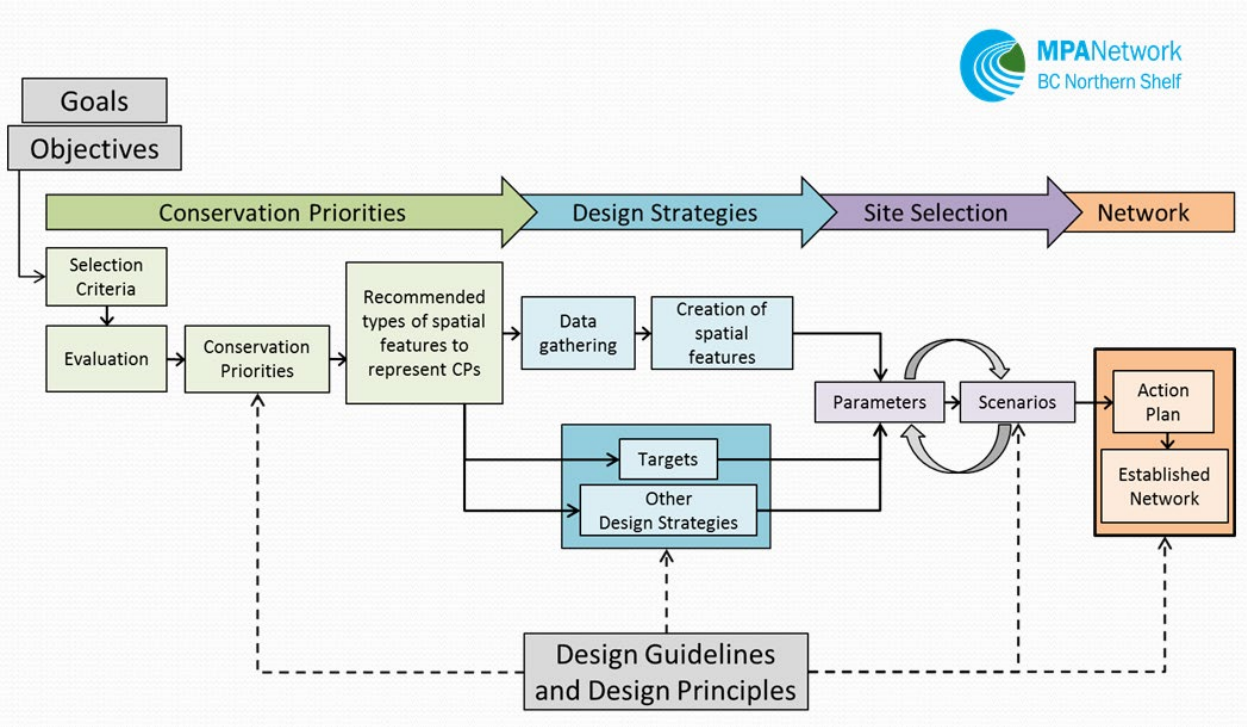

Figure 2. Conceptual diagram showing how design strategies fit within the NSB MPA planning process developed by MPATT in the Pacific Region. Reproduced from the PowerPoint presentation and Figure 2 of the working paper.

Gale described how conservation priorities were determined for species using systematic evaluation of criteria based on conservation concern, ecological role and expert knowledge. Marine birds were also assessed using conservation concern and expert review; however, the Environment and Climate Change Canada Priority Species list, replaced ecological role,

following a recommendation from the November 2016 CSAS process. Area-based ecological conservation priorities, include features or habitats known to fulfil MPA network objectives, and are supported by information in the literature. They included areas of climate resilience, degraded areas, and features associated with ecological and biologically significant areas (EBSAs). The framework strengths and limitations were itemized. The strengths were that the framework is systematic, transparent, repeatable and adaptive. The framework is limited as the scores only reflect existing knowledge.

Martone described the levels of protection that allow multiple uses within the MPA network and an effectiveness score for a MPA and the ecological objectives within those levels of protection. Effectiveness was later renamed scaling factor after discussion. The working paper proposed size and spacing recommendations, with some post-hoc suggestions for shape. The uncertainties in ecosystem base management were addressed. A flow chart was proposed to evaluate which data to include in the Marxan analysis. Marxan is a decision support software tool that will output multiple scenarios that optimize the ecological conservation targets. High conservation values will be indicated with heat maps. Sensitivity analysis will be done to see how different target ranges influence the results. Finally, the design scenarios will need to have data gaps addressed, be ground truthed and have consultation. Human activities and concerns will be incorporated during the consultation process.

MPA SIZE AND SPACING

Although this was listed in the agenda, it was only briefly covered within the overview presentation. MPA size and shape was covered more extensively within the later presentation on replication, size, spacing and shape.

SETTING TARGETS FOR CONSERVATION PRIORITIES

Robb briefly reviewed other processes that have used targets for Marxan for conservation in British Columbia: British Columbia Conservation Analysis (BCMCA), Marine Plan Partnership (MaPP) and research in Gwaii Haanas (unpublished work). Ecological conservation targets may be coarse or fine filter features and recommend a range for protection. Coarse filter features are based on areas of habitats (i.e. ecosections, coastal classes), whereas fine filter features include both small scale habitats (i.e. breeding colonies, submarine canyons), as well as individual species (Figure 3).

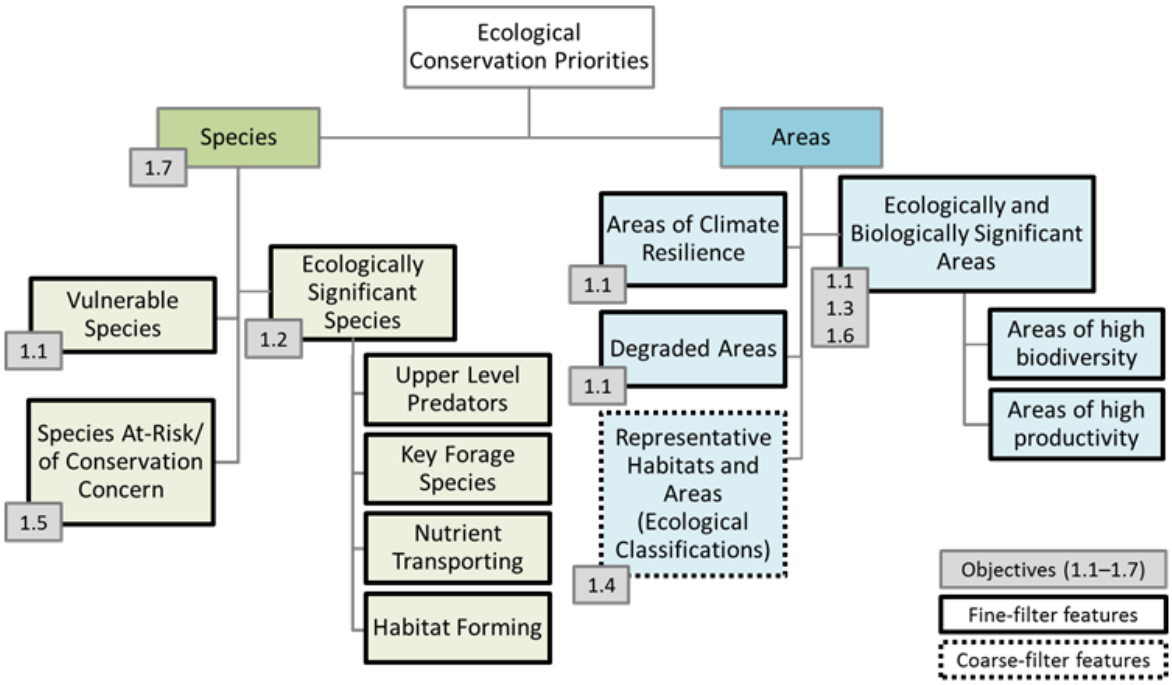

Figure 3. Ecological conservation priority framework (Gale et al. 2018 in prep). Numbers in grey boxes refer to network objectives and indicate the objectives met by identification of each conservation priority. Reproduced from Figure 4 of the working paper.

The framework, to develop target ranges for conservation priorities, was described (Figure 4). Examples such humpback whales, lingcod, ancient murrelet breeding colonies, and underwater banks were used to illustrate how the scores are calculated. The scores were calculated using the square root of the sum of squares following recommended best practices for Marxan. Species target ranges were based on quartiles, although this was later adjusted to both thirds and quartiles. Three species target ranges were assigned as low = 10%, moderate = 20%, or high = 30%. Coarse-filter targets were suggested based on six spatial data sets based on benthic, pelagic and coastal realms. The target ranges of low = 10%, moderate = 20%, or high = 30% were assigned based on the size of the area. All areas lower than 10% were raised to 10% as a minimum base. This 10% baseline became a subject of discussion and a sensitivity analysis with and without the baseline of 10% was eventually agreed upon.

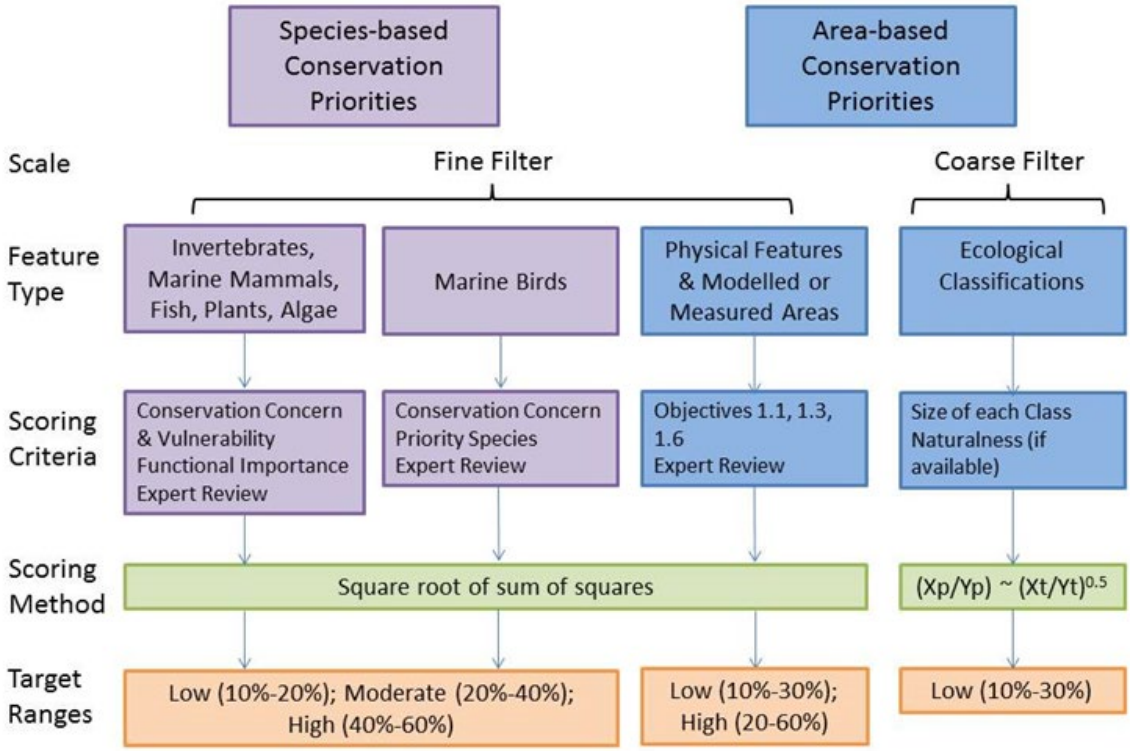

Figure 4. Framework for developing target ranges for coarse- and fine-filter ecological conservation priorities in the NSB. Reproduced from Figure 8 of the working paper.

Challenges regarding the expert review process were outlined. In the case of disagreement between reviewers, the average was used. Degraded areas may be excluded, using a naturalness qualifier in the coarse-filter targets. A decision tree, later renamed a flow chart, was presented to help identify appropriate data for Marxan and data gaps (Figure 5).

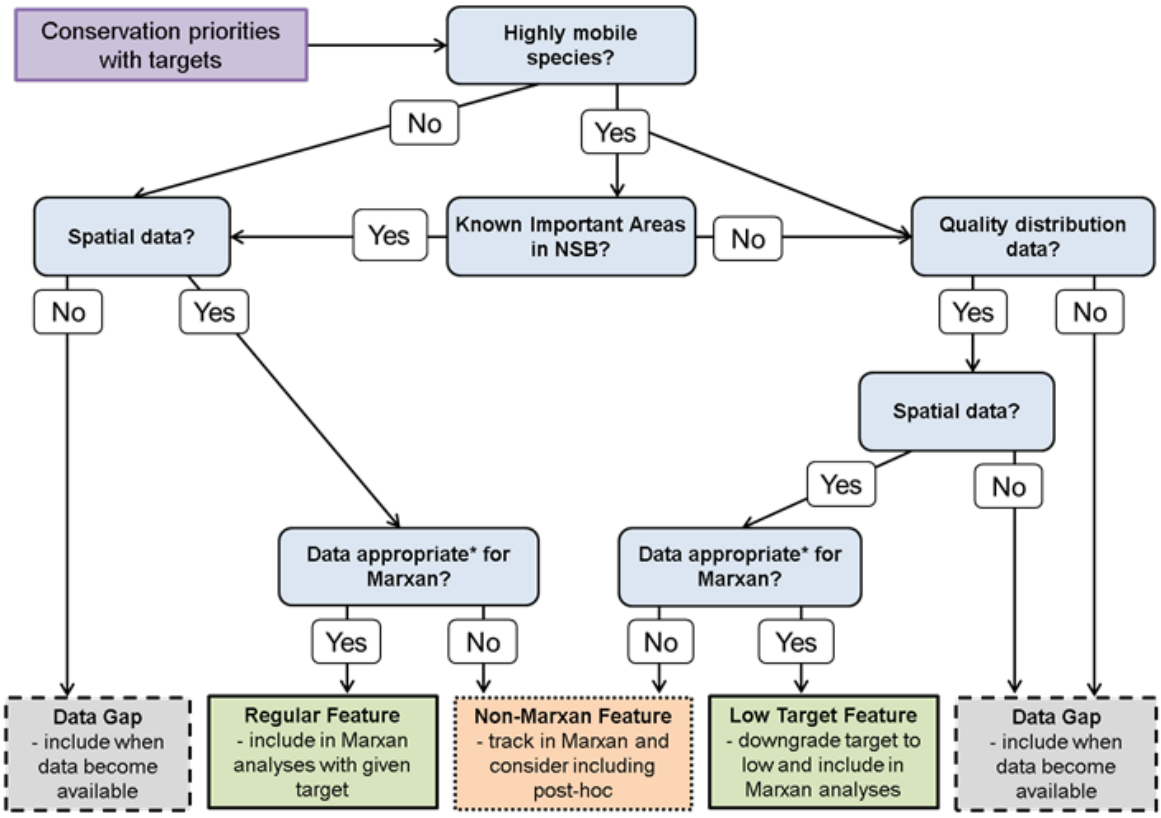

*Figure 5. Flow chart to guide the identification of conservation priorities appropriate for inclusion in design scenarios. * Data should be high quality, at an appropriate scale, and comprehensive for the NSB. Preference will be given to data that have been ground-truthed. Reproduced from Figure 9 of the working paper.*

REPLICATION, SIZE, SPACING AND SHAPE

Martone explained how replication provides insurance in case of uncertainty and abiotic changes. Replication should vary at multiple scales and patch sizes with three replicates preferred as a minimum. A method to stratify the replicates by ecoregions was proposed, although it is hard to evaluate without data. Common spatial features will have less replication than rare spatial features.

The calculation of the recommended MPA size was based on adult home ranges. Species were separated by nearshore and shelf/slope species to reduce variability. MPA spacing recommendations were based on pelagic larval durations to ensure genetic or population connectivity. There was some discussion on how isolation may also be beneficial within an MPA network. Upon recommendation of the reviewers, sessile and highly mobile species were removed from the data sets. This was justified since intermediate ranging species benefit most from the MPA network. On day 3, the authors presented recalculated minimum MPA size values of 50-140 km^2 in the nearshore and 60-154 km^2 in the offshore and proposed simplifying the recommendations to 50-150 km^2 overall. MPA spacing of 40-200 km^2 was recommended.

The authors recommended that size, spacing, and replication be integrated into Marxan iteratively. Shape may have to be included post hoc.

MPA LEVEL OF PROTECTION

Martone presented how management restrictions could range from no-take to sustainable use within the MPA network. MPA effectiveness will depend on the levels and types of protection in the individual MPAs relative to their conservation priorities. The authors proposed a risk-based approach where individual conservation priorities would be weighted with an effectiveness score according to a decision framework (Figure 6). This terminology was later changed to MPA performance scaling factor.

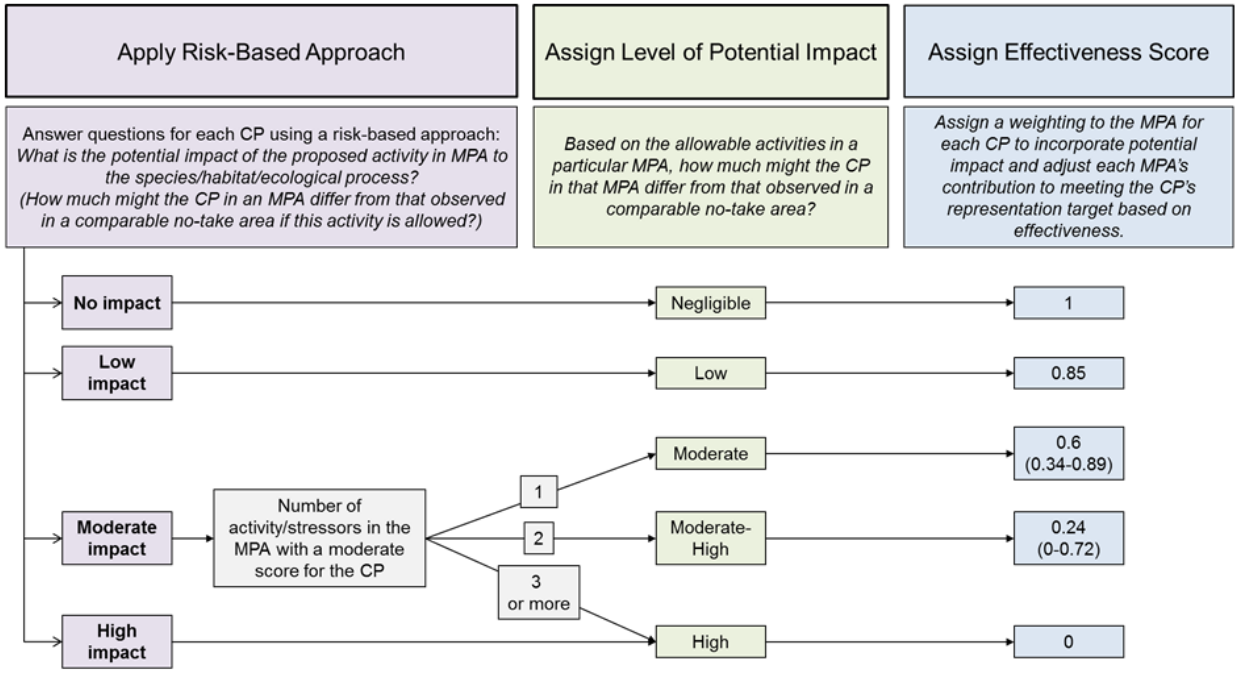

Figure 6. Decision framework for incorporating risk-based approaches to assign levels of potential impact to ecological conservation priorities (CPs) from allowable activities in each MPA and effectiveness scores (Ban et al. 2014) used to adjusting the calculation of the contribution of each MPA to the conservation priority targets based on the assigned level of potential impact. Reproduced from Figure 15 of the working paper.

Bootstrapping was initially proposed to calculate means and confidence intervals due to high uncertainty. This was later simplified to means, as it gave similar results. Fisheries were the only activities evaluated. Other activities could be included within the framework, although industrial activities are generally inconsistent with the objectives of an IUCN 6 protection level. The authors proposed that thresholds for activities should be discussed further. If the ecological conservation targets become too low with the scaling factor, an MPA size could be increased or the allowable activities could be reevaluated.

Initially, a "no-take" or IUCN Level 1a protection within at least 30% of the MPA network was proposed. After debate both for more or less protection, the authors agreed to rephrase to "scientific literature recommends that 20-50% should be protected" within the MPA network and these ranges should be tested post hoc.

PRESENTATION OF WRITTEN REVIEWS

The reviewers, Mark Carr and Ryan Stanley, were asked to present their reviews addressing three topics: Setting targets for conservation priorities, MPA Replication, Size, and Spacing, and

MPA Levels of Protection. In addition, reviewers actively participated in the general discussions. Miriam O presented the written comments on behalf of Isabelle Côté. Reviewer comments have been grouped by topic. For complete details, please refer to the written reviews provided by the reviewers in APPENDIX E.

ECOLOGICAL CONSERVATION TARGETS

Reviewers appreciated the objectivity of the ecological conservation target scoring method, although it was suggested that the tool would benefit from fine tuning and concrete examples. Additional definitions and reference numbers added to calculations should be added for clarity. The flow chart should be modified to remove the diagonal between “Highly mobile species “yes” and “Quality distribution data?” (Figure 5).

The calculation of coarse filter features and the use of the relative proportion of habitats should be more explicitly defined both in the text and Tables 9 to 13 of the working paper. There was a suggestion that all area-based coarse-filter targets be adjusted upwards, instead of having a baseline of 10%. After discussion, the authors later agreed to include the unadjusted minimum values, with the suggestion to include a minimum 10% into Marxan. Reviewers mentioned the amazing resolution of potential ecosystems, but the shore zone classifications is potentially too detailed. It was requested the species area curves not be used to support the minimum area-based targets.

Reviewers requested more clarity in the calculation of fine filter feature targets. An explanation was requested why ecological (predator, forage species, nutrient transporter, structural species) role is not additive in section 4.3.1 of the working paper. There was recognition that SARA and COSEWIC introduce a bias (i.e. invertebrates) and this should be addressed in the uncertainties section. Section 4.3.2 focused on bird species as conservation priorities, but the real issue should be habitat protection. The authors responded that habitat vulnerability is addressed with the inclusion of critical habitats as area-based targets. A reviewer commented on the difference in data resolution between the Maritime and Pacific regions. Participants agreed that Pacific region data resolution may be better (ground fish trawls, nearshore dive surveys, CHS multi-beam data), but more offshore benthic data is still needed. Reviewers requested that the limitations of the effectiveness of MPAs for transient species be addressed in the text.

Reviewers recognized that expert reviews are difficult to incorporate objectively, particularly when there is variability. The absence of academics and limitation of expert reviewers to government scientists was noted.

REPLICATION, SIZE, AND SPACING

Reviewers liked how rare features have more replicates than common features; however, the use of subregions was questioned because they may represent political, not ecological boundaries. Reviewers suggested either using an environmental gradient, or supporting the use of subregions by relating it back to the environment. Reviewers wondered if weighting by patch size, instead of categorizing data by quartiles would improve replication calculations. Reviewers cautioned the authors regarding the term “adaptive management” and emphasized that replication is necessary for MPA connectivity and evaluation. One reviewer requested that the independence of replicates be justified within the Science Advisory report.

Reviewers requested that highly mobile species and sessile species be removed from the MPA size and spacing calculations. The authors presented modified minimum MPA size ranges of 50-140 km^2 in the nearshore and 60-154 km^2 in the offshore and MPA spacing of 40-200 km^2. There was a question about separating shelf and slope data similar to the East coast. The

authors agreed that it could be done to reduce variability in the future, but there is not enough data yet (only 11 shelf-slope species).

A reviewer noted that extremely small MPAs, used for corals, may not be appropriate in BC and they would only be effective if there was a high level of protection in the entire MPA. The addition of text about critical habitats and movement of adults into MPAs for mobile species was requested. The treatment of sperm whales in section 9.1.4 of the working paper was mentioned specifically, as this highly mobile species may not be well served by MPAs, and the expert review was modified.

Reviewers requested that the authors define the term actual dispersal (genetic or measured) since dispersal includes arrival, as well as survival. Estimates of larval dispersal distance have high uncertainty. East coast scallops were given as an example of how habitat suitability and larval dispersal are interrelated and future particulate dispersal distances research is recommended. As some larval dispersal estimates were from non-native species, it was requested that the local species be differentiated from the other species by color in figures.

Reviewers agreed that ecosystem MPA connectivity and shape were important to include; however, section 8.2 may be too broad to be operational. Reviewers agreed that both connectivity and isolation are important consideration within the MPA network. The shape of MPAs from onshore to offshore is supported by rockfish moving from shallower to deeper waters (design guideline).

LEVELS OF PROTECTION

The risk-based framework is a novel approach. It was requested that the authors clarify how the risk-based framework fits into the bigger process. It was suggested that the authors consider California data for impacts of different fishing gear. Bootstrapping should be justified better or replaced by means/medians. The effectiveness of 30% no-take protection within the MPA network was questioned. There was an error in interpretation that the authors agreed to fix, regarding the recommended protection being 30% of ecosystem, from Jessen et al. 2011, Fernandes et al 2005, and O'Leary et al. 2016. In addition, linear additive impact of disturbance was not addressed in the working paper.

Please see APPENDIX E for complete details from the reviewers.

GENERAL DISCUSSION

PROCESS

Participants expressed concerns that the supporting documents were not provided early enough for this meeting. The draft Research Document from the 2016 November meeting was not available.

It was noted that multi-objective decision-making creates tension between ecological and management trade-offs. Concerns were raised that science was supporting policies and not being used to form policies. The process may be rushed for political reasons and the timelines tight so data gaps may impact the outcomes. More information was requested on how social and economic concerns will be incorporated after ecological design scenarios are produced.

There were discussions on the exact role of the Science Advisory Committee and how the social sciences will be integrated into the process. If the Science Advisory Committee will be asked to review MPA network, but not involved in development, how will social and economic concerns be incorporated? There was a recommendation that DFO fishery scientists be encouraged to participate in both the CSAS reviews and Science Advisory Committee.

A participant questioned how the terms of reference for the working paper were written. The CSAP office agreed to provide a copy of the 2015 request for science advice.

CONTEXT

There were concerns that ecological conservation targets are intended for MPA network development and not management targets. There was a repeated concern over how these ecological conservation targets from the working document will be used in future.

Existing designated areas and other effective measures should be incorporated into MPA network analysis. Since participants felt that other effective area-based conservation measures may not be spatially defined or permanent, there was discussions on how those areas could be incorporated into the MPA network by reclassification or other methods. As the MPA design phase goes forward, consideration of other measures in the MPA network design should be addressed.

Participants wanted to know how data sources and gaps would be identified as well as how the data will influence MPA network design. There was a suggestion that a spatial map of human impact be added as a layer to the Marxan analysis.

A discussion regarding how climate change fits into this design was requested. Although there was not time for a full discussion, the authors mentioned that a section on bioclimatic methods was removed from the report due to length. These bioclimatic methods dealt with predicting when species will be with climate change using assemblage based models.

Concerns were raised regarding the southern boundary and whether it included Bute Inlet or not. The figures were inconsistent in the working paper and presentations due to recent changes in boundaries.

CONSERVATIVE PRIORITIES

The Northern Shelf Bioregion regional peer review meeting in November 2016 defined conservation priorities. It was recognized that the use of COSEWIC and SARA lists introduced bias. For example, many invertebrates are not listed because they have not been assessed. There was some concern that SARA and COSEWIC are not peer-reviewed. The method is good for transparency, nevertheless, species not evaluated by SARA and COSEWIC score lower.

The use of quartiles to categorize conservation priorities was discussed. The authors showed how using thirds changed the ranking of conservation priorities. It was decided that both quartiles and thirds should be applied to see how the outcomes of scoring impacts outputs from Marxan.

Birds were discussed separately, because the conservation priority method is different compared to other species and habitat vulnerability for birds must be addressed. Habitat vulnerability was addressed later in area-based filters and levels of protection.

ECOLOGICAL CONSERVATION TARGETS

This section was controversial due to the potential use of the ecological targets for management decisions. Whether target is an acceptable term was debated and there were various types of targets discussed and different way to articulate them. Other suggestions to rename targets included “interim targets”, proportional weighting”, “input parameters”, “Marxan targets”, or “representation goals”. Others supported the use of the term target for consistency across Canada, as well as best practices within Marxan software. There was agreement that target ranges should not to be used as management recommendations for final MPA network design,

but as ecological starting points for the design scenarios. There was a suggestion that there needs to be a reasonable and clear expectation for targets (i.e. rebuilding stocks, habitat restoration). The authors agreed to use “ecological conservation targets” and add a glossary with definitions to the science advisory response.

The concept of trade-offs in both ecological (between species), socio-economic and cultural values were discussed. Marxan was presented as a good tool to optimize trade-off scenarios while minimizing impact and space covered. Without concrete examples, there was concern that these targets will result in recommending that the entire Northern Shelf Bioregion be protected. Sensitivity analyses were requested to look at how changes in ecological conservation targets would impact the design of the network.

Targets should not be the only consideration in the NSB MPA network development. It was requested that consultation on these targets be clearly communicated to the public.

The decision tree (Figure 5), to guide the identification of conservation priorities appropriate for inclusion in Marxan was renamed to “flow chart”. It was requested that “adequate” spatial data by defined for this flow chart. It was also requested that the authors define “meaningful” and “more threatened” within the conservation priorities sections.

COARSE FILTER TARGETS

The increase of the baseline to 10% for the coarse filter targets was discussed. Authors defended the use of 10% as a minimum amount of protection supported by ecological literature and guidance from Scotia shelf work. There were concerns that the base target was raised to 10% artificially for Marxan process and was not useful ecologically. It was recommended that the base target of 10% should be justified and sensitivity analysis comparing 10% to unaltered ranges be done.

Clarification of the calculation of coarse filter targets was requested. All areas were ranked relative to total habitats. There was a request that of the relative availability of habitat data be added to Tables 9 to 13 of the working document. The process to scale back large areas in Marxan analysis was questioned. The assumptions should be clearly stated. Whether all classifications were necessary to the analysis was questioned, in particular, shoreline classification may be collapsed.

The authors asked for input on how to incorporate naturalness into design strategies. A combination of both natural and restored areas are likely needed to include vulnerable species since vulnerable species often live in disturbed areas, but there is also value in preserving pristine areas. This resulted in questioning how naturalness could be used for prioritizing. Naturalness could be incorporate post-hoc or fisheries layers could be included in Marxan. It was suggested that degraded areas should only be included if the stressors can be reduced by the MPA. Furthermore, low conservation status is not always linked to habitat reduction or degradation so an MPA would not improve those situations. Future work should identify areas of change and look at how species assemblages change over time.

FINE FILTERS TARGETS

There was concern that current protected areas without fisheries data will be inadvertently omitted from the Marxan analysis (i.e. Broken Group Islands in Barkley Sound). The authors suggested that this would need to be addressed post hoc, after running the Marxan analysis. It highlighted importance of ground truthing the design scenarios and the role of the Science Advisory Committee in the MPA network development.

The ranking of keystone species was questioned. The authors maintained that keystone species were ranked as high due to their ecological roles. This was not done additively to avoid bias in the conservation priorities.

Participants were uncomfortable with level of ecological conservation targets for deep water corals as medium, compared to sponges as high. The authors mentioned that the deep water corals will be included as important areas (i.e. canyons).

EXPERT REVIEW

The level of expert review, particularly for marine mammals and fishes, was questioned. The difference in ranking of deep water corals (medium) and sponges (high) was debated. There were discussions on the preferred method to address variance in expert reviews, comparing average and consensus. Should species with a disagreement have further reviews, discussions between reviewers, average or highest value chosen? The authors used the average in the working paper.

Some participants wanted more expert reviews, whereas other cited “reviewer burnout” and recommended waiting for the design scenarios before further involvement of expert reviewers. The next opportunity for experts to be included in the process was questioned. Sensitivity analysis was suggested as an alternative to additional expert review to see if the differences change the Marxan output.

The omission of academic expert reviewers was noted. And one participant wondered if the level of expert review in the working paper captured the breadth of knowledge on these conservation priorities. There was a request to improve the clarity of the expert review tables and include expert review as a source of uncertainty within the Science Advisory Report.

REPLICATION, SIZE, AND SPACING

Using patch size to calculate replicates is a novel approach. There was extensive discussion on the specific calculations and uncertainties. The authors demonstrated how weighting by patch size in birds changed the calculation. Participants questioned the use of subregions based on political boundaries and would prefer ecological boundaries or environmental gradients. Fjords were mentioned specifically as not fitting well within the nearshore classifications.

The use of replication was emphasized both for protection and to access the performance of the MPA network. As replication will be needed within all levels of protection, there were concerns over the amount of protection and “double counting”.

Different modifications to estimate larval dispersal distance were considered including truncating, running in log-log, removing zeros, or using Shanks regression. The authors agreed to remove sessile and highly mobile species from analysis and presented how this changed the recommended MPA sizes. Participants agreed that this change simplified the design strategies. Although there were concerns that large offshore areas were removed after these changes and large offshore areas are important for other reasons.

Connectivity between MPAs was proposed as beneficial. However, it was pointed out that isolation may be useful in certain situations, such as disease outbreak. It was suggested that connectivity presents an opportunity to communicate how MPA networks can benefit fisheries.

How replication, size and spacing will be included in Marxan should be clarified and future work mentioned. In order to reduce variability, shelf and slope species and/or hard and soft substrate species may be separated if there is adequate data. Connectivity could incorporate particle dispersion modelling for the BC coast. In addition, fisheries data using tow video, dive surveys, and species lists for different bottom types could be incorporated.

LEVELS OF PROTECTION

The suggestion of 30% as “no-take” within the MPA network was controversial as participants disagreed on the amount and justification of the value. The authors agreed to change the wording to “scientific literature recommends that 20-50% should be protected” within the MPA network and these ranges be tested post hoc.

It was requested that the term “effectiveness score” be changed to MPA performance scaling factor. The authors emphasized that these scaling factors allow for human activities within the MPA network. Scaling factors are based on data from outside BC and the method should be evaluated as local data becomes available. If bycatch is used to test scaling factors, there was concern that bird bycatch would not be accurate due to underreporting.

There was a question whether the scaling factors are outside scope of Terms of Reference. The chairs confirmed that it fits within the scope of the document.

Participants inquired whether human activities, such as mining, would be considered in the levels of protection and how multiple activities would impact MPA scaling factors. Interactions between species are not currently accounted for in the risk-based framework, but could be incorporated into future work.

The use of bootstrapping was questioned in calculating the risk-based framework. The use of the high and low values, followed by sensitivity analysis was proposed. After discussions, the authors agreed to use mean or median to simplify the calculation.

The authors agreed to reword the halibut example (pg. 55 of working document), following a request.

MARXAN ANALYSIS

There was concern about quality of data input into Marxan. The need to validate the design scenarios both by scientists and consultation was emphasized. The iterative nature of the process is necessary to ensure the accuracy of the process.

There was some discussion on how a simplified matrix will be required within Marxan as a preliminary step. The combinations of individual conservation priorities and level of protection combinations may be too complex initially, even with Marxan with zones.

UNCERTAINTIES

The sources of uncertainty within the working document were identified. The use of SARA and COSEWIC introduces bias into the conservation priorities, in particular for invertebrates. Breeding grounds are unknown for many species, so the inclusion of these habitats may not be inclusive. Expert review introduces variance and becomes apparent when there is disagreement between expert rankings. There are limitations of ecological conservation target uses. Species with full habitat protection may still decline depending on the reason for the initial decline. There is minimal local information on larval behavior and ocean conditions used to estimate larval dispersal distance for spacing calculations. Patch size and scaling factors are both novel approaches that need to be assessed with experimental data. There is uncertainty associated with the data including fisheries stocks, distribution, feeding, and ecology. This data gap is even more apparent for non-commercial fish and invertebrates.

CONCLUSIONS

- The working paper and regional peer review process provided design strategies for development of an ecological MPA network and quantified ecological conservation targets. Other key variables included MPA size, shape, spacing, and protection levels.
- The working paper was accepted with revisions and contingent on the Science Advisory Report recommendations being reviewed by the participants via email.

ECOLOGICAL CONSERVATION PRIORITIES

- Spatial targets were determined for coarse-filter ecological classification features based on feature sizes and an approach was developed for fine-filter area-based and species-based conservation priorities based on conservation concern, vulnerability, ecological role, and expert review.
- Application of this approach to fine-filter area-based conservation priorities resulted in 55% in the low and 45% in the high target ranges. The approach was also applied to species-based conservation priorities and ranges determined using quartiles or thirds to distribute the scores.
- Ecological conservation targets for each of the ecological conservation priorities were identified and reviewed by experts.
- A framework was developed to select which ecological conservation priorities are appropriate for use in site selection analyses, based on available data and quality.

REPLICATION

- An approach was proposed to determine the number of replicate areas needed to meet representation of ecological conservation priorities based on patch size or rarity, stratified at the scale of ecosections and subregions in the Northern Shelf Bioregion.

MPA SIZE AND SPACING

- MPA size and spacing were based on home ranges and estimated larval dispersal distance of species conservation priorities identified in the literature.
- MPA size was calculated to be 50-140 km^2 in the nearshore and 60-154 km^2 in the shelf/slope. This is a minimum size and does not preclude large MPAs and could be simplified to 50-150 km^2.
- MPA network spacing of 40-200 km distance was calculated as a guideline for spacing.

MPA PROTECTION LEVELS

- A risk-based framework was proposed to assess the performance of each MPA in meeting the ecological conservation priority targets by accounting for potential impacts of allowable human activities on the conservation priorities found within them, by using scaling factors derived from a global meta-analysis of MPAs published in the scientific literature.

RECOMMENDATIONS & ADVICE

- It is recommended that these guidelines are incorporated into the broader MPA network design process – and that the process for development of design scenarios (including data

review and interpretation, input, development of Marxan outputs and iterations) are clearly outlined by MPATT.

- It is recommended that the Science Advisory Report and related documents include glossary of terms and acronyms and uses a table or call out box to explain the types of targets and their uses (key terms to define would include conservation priority, feature, Marxan).
- It is recommended that ecological conservation target ranges be used to develop initial site selection analyses to identify potential areas that meet the ecological network objectives and be 'starting points'/'base case' for possible MPA network configurations in the Northern Shelf Bioregion.
- It is recommended that the two suites of ecological conservation target classes, based on quartiles and thirds, be tested in the design scenarios.
- Where data are lacking or areas of known importance are not reflected in existing data sets, expert review/input should be used to validate or ground truth outputs.
- While the scientific literature provides rationale for the use of a 10% minimum threshold, it is recommended that sensitivity analyses be undertaken to assess how setting a low-end baseline of 10% for coarse-filter ecological conservation priority features will influence the outcomes of the ecological network objectives in the initial ecologically-based design scenarios.
- Based upon recommendations from the scientific literature that 20-50% of ocean space be designated as no-take within a planning area to meet ecological network objectives (e.g., protecting biodiversity), it was recommended that, minimally, a proportion falling within this range of the MPA network be found in no-take or limited-take MPAs.
- It is recommended that various proportions of the network in no-take MPAs be evaluated in design scenarios phase of the MPA network planning process. (e.g., 20%, 30%, 40%, etc.).
- Recognizing that there is existing spatial protection within the Northern Shelf Bioregion, it is recommended that initial design scenarios incorporate and account for existing protected and conserved areas, and assess them for their contribution to ecological conservation priority targets.
- The assessment of the proposed framework should be fully evaluated during the design scenarios phase.
- It is recommended that multiple scenarios be undertaken to assess:
    - target ranges, especially when there is conflicting expert opinion before another level of expert review is necessary
    - Coarse filter versus fine filter targets – first run habitats, then species, then combination of two
    - Nearshore/offshore
    - Naturalness
- New relevant spatial data should be incorporated as it become available.

ACKNOWLEDGEMENTS

Mark Carr (University of California), Ryan Stanley (DFO Science Maritimes Region), and Isabelle Côté (Simon Fraser University) provided reviews and their feedback is appreciated. Thank you to all the participants for their valuable and constructive discussions.

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APPENDIX A: TERMS OF REFERENCE

REVIEW OF CONSERVATION TARGETS AND NETWORK DESIGN OPTIONS FOR THE NORTHERN SHELF BIOREGION MARINE PROTECTED AREA (MPA) NETWORK

Regional Peer Review Process – Pacific Region

May 23-25, 2017
Vancouver, British Columbia

Chairpersons: Miriam O and Russ Jones

Context

Canada has committed to establishing a well-connected system of Marine Protected Areas (MPAs) to protect at least 10% of coastal and marine areas by 2020[1]. Through Canada's *Oceans Act* and its 2004 memorandum of understanding with the Province of British Columbia regarding implementation of Canada's Oceans Strategy, Fisheries and Oceans Canada (DFO) is working with other federal and provincial departments to collaborate on understanding and protecting the marine environment on the Pacific Coast. The federal government also signed the 2008 *Memorandum of Understanding on Pacific North Coast Integrated Management Plan (PNCIMA) Collaborative Oceans Governance* and the 2012 *Letter of Intent to Collaborate on Marine Planning and other Fisheries Related Issues in the Pacific North Coast* with both Coastal First Nations and the North Coast Skeena First Nations Stewardship Society as well as Nanwakolas Council in an amendment to the former Letter of Intent. In addition, the Province of BC and First Nations in British Columbia (BC) have developed marine use plans for areas within the Northern Shelf Bioregion (NSB) to be considered for candidate MPAs. Building on previous collaboration and commitments, Canada, the Province of BC, and First Nations have formed the Marine Protected Areas Technical Team (MPATT) to coordinate the technical aspects of MPA network design, planning and implementation in the NSB.

The development of Canada's MPA network is guided by the 2011 National Framework for Canada's Network of MPAs (Government of Canada 2011). Additionally, DFO Science has provided general guidance on

1. the design of MPA networks (DFO 2010),
2. achieving representativity in these networks (DFO 2013),
3. formulating ecological conservation objectives for individual MPAs (DFO 2008, 2013) and
4. identifying conservation priorities for large ocean management areas (DFO 2007, 2012, Murray et al 2016).

In the Pacific region, the Canada – British Columbia Marine Protected Area Network Strategy (2014) ("the Strategy") serves as a basis for guiding the design, development, and implementation of MPA networks for Canada's Pacific waters. The Strategy outlines six conservation, social, cultural, and economic goals to be achieved by the development of a network of MPAs. Goal 1 of the Strategy is of primary importance and specifies the ecological objectives that guide protection and maintenance of marine biodiversity, ecological representation and special natural features. As one key step in addressing Goal 1 of the Strategy, a Canadian Science Advisory Secretariat (CSAS) peer review was held in November,

[1] 2020 Biodiversity Goals and Targets for Canada

2016, to identify ecological conservation priorities for the Northern Shelf Bioregion (NSB) MPA network. However, MPA network ecological design strategies have not yet been developed for the Northern Shelf Bioregion.

Ecological design strategies for the NSB MPA network include the following elements:

- targets for ecological conservation priorities identified for the NSB
- size
- spacing
- connectivity
- replication
- protection levels

Targets for the ecological conservation priorities identified for the NSB are the focal design strategy, and are assigned to each ecological conservation priority. The other elements identified above will interact with the assigned targets, and be incorporated into the overall network design.

All of the elements functioning together make up the design strategies, and support key decisions needed to integrate and analyze available and relevant spatial data in a systematic conservation planning process for MPA network design in NSB. Ecological design strategies for the MPA network in the NSB will describe how the ecological conservation priorities will be spatially incorporated into the network design, and influence where MPAs will be located and how they will be managed, to achieve network goals and objectives. For example, design strategies for ecological conservation priorities provide recommendations on the proportion of a species range or habitat area that should be protected in the MPA network to achieve the ecological objectives described in the Strategy.

Guidance on ecological design strategies is available in the literature based on MPA network design processes from within BC and other jurisdictions (e.g., California Dept. of Fish and Game 2008, Gaines et al 2010, Jessen et al 2011, Ban et al 2013, Burt et al 2014, Lieberknecht et al 2016). DFO Ecosystem Management Branch requested that Science Branch develop ecological design strategies for the NSB MPA network planning process, including area-based targets for the ecological conservation priorities of the NSB identified during the November 2016 CSAS peer review, as well as operational recommendations that inform site selection analyses; including MPA size, spacing, replication, connectivity and protection levels of the MPA network. Note that socio-economic and cultural design strategies are outside the scope of this work. The assessment and advice arising from this Canadian Science Advisory Secretariat Regional Peer Review will be used to inform MPATT's development of a network of MPAs in the NSB.

Objectives

The following working paper will be reviewed and provide the basis for discussion and advice on the specific objectives outlined below.

Martone, R., C. Robb, K. Gale, et al. (TBD) Ecological design strategies for a network of MPAs in the Northern Shelf Bioregion. CSAP Working Paper 2015OCN05B

The specific objectives of this review are to:

1. Assess the approach for identifying targets for MPA network ecological Conservation Priorities in the NSB.

2. Review whether the targets for ecological Conservation Priorities for the MPA network in the NSB are appropriate to support the ecological objectives of the MPA network.
3. Evaluate the criteria and methods that guide how targets should be applied in site selection analysis.
4. Determine if recommendations for other design strategies (including size, spacing, replication, connectivity, and protection levels) are appropriate to support the ecological objectives of the MPA network.
5. Provide advice regarding the suggested approaches for applying other design strategies during the site selection analysis and target application process.
6. Identify and discuss uncertainties and gaps in methods and results.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- Canada-British Columbia-First Nations Marine Protected Area Technical Team (MPATT)
- Fisheries and Oceans Canada (DFO) (Ecosystems and Oceans Science, Ecosystems and Fisheries Management, Science)
- Parks Canada Agency
- Environment and Climate Change Canada
- Transport Canada
- Natural Resources Canada
- Province of British Columbia
- First Nations
- Academia
- Industry representatives
- Environmental non-government organizations

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APPENDIX B: ABSTRACT OF WORKING PAPER

Canada has committed to establishing a well-connected system of Marine Protected Areas (MPAs) that protect at least 10% of coastal and marine areas by 2020. To advance that goal in the Pacific region, the Government of Canada, Government of British Columbia (BC), and 17 member First Nations are collaborating on marine planning in the Northern Shelf Bioregion (NSB). A set of goals, objectives, principles, and design guidelines informed the development of conservation priorities, which are the ecological and cultural features to be prioritized for protection within the MPA network, and design strategies, which describe how to spatially incorporate conservation priorities into the network. This paper focuses exclusively on Goal 1 of the Canada-BC MPA Network Strategy (2014), which specifies the protection and maintenance of marine biodiversity, ecological representation and special natural features. We developed ecological design strategies for the MPA network in the NSB. These include area-based targets specifying how much of each conservation priority (or feature) an MPA network aims to protect and approaches for determining the size, shape, and protection levels of MPAs, and the connectivity, representation, and replication of ecological conservation priorities. Specifically we (1) set the context for developing ecological design strategies for the MPA network in the NSB by reviewing the components of MPA network planning processes in BC, best practices from these and other planning processes, and guidance from the scientific literature; (2) developed methodology for setting coarse-filter and fine-filter conservation targets and a decision tree to determine which ecological conservation priorities and associated targets are appropriate for inclusion in site-selection analyses in the next phase of planning; (3) provided recommendations on design strategies for size, spacing, and replication by adapting best practices and guidance from the literature to the NSB; and (4) developed an iterative approach for adjusting targets in site-selection analyses based on protection levels that are linked to MPA effectiveness research. Together with the conservation priorities, the design strategies will inform site selection analyses conducted during the design scenarios phase of MPA network planning to identify priority areas for conservation and options for possible MPA network configurations in the NSB.

APPENDIX C: MEETING AGENDA

Canadian Science Advisory Secretariat

Regional Peer Review Meeting(RPR)

Design Strategies for the Northern Shelf Bioregional Marine Protected Area Network

May 23-25, 2017

Vancouver, British Columbia

Chairs: Russ Jones and Miriam O

DAY 1 - Tuesday, May 23

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping CSAS Overview and Procedures	Chairs
1000	Review Terms of Reference	Chairs
1015	*Presentation* of Context: Network Planning Process • *MPATT* • *Goals and objectives* • *Conservation priorities & design strategies* • *Scope of working paper* • *How will this advice be used in the process?* • *Where else do people get involved in MPA network planning?*	Oceans Manager: Hilary Ibey
1030	***Break***	
1045	*Presentation* of Working Paper: Overview • *Questions of clarification*	Authors: Rebecca Martone and Katie Gale
1115	*Presentation* of Working Paper: *Setting targets for Conservation Priorities (CPs)*	Authors: Carrie Robb
1200	***Lunch Break (not provided)***	
1300	Reviewer comments: *Setting targets for (CPs)*	Reviewers & Authors
1400	Identification of key issues and discussion related to *Setting targets for coarse filter (CPs)*	RPR Participants
1445	***Break***	

Time	Subject	Presenter
1500	Identification of key issues and discussion related to *Setting targets for fine filter CPs*	RPR Participants
1615	Check in on progress and confirmation of topics for discussion on Day 2	Chairs
1630	***End of Day 1***	

DAY 2 - Wednesday, May 24

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping Re-cap of Day 1	Chairs
0930	*Presentation* of Working Paper: *MPA Size, Spacing, and Replication* • *Questions of clarification*	Authors: Rebecca Martone
1000	*Reviewer comments: MPA Size, Spacing, and Replication*	Reviewers & Authors
1030	***Break***	
1045	Identification of key issues and discussion related to: *MPA Size, Spacing, and Replication*	RPR Participants
1200	*Lunch Break (not provided)*	
1330	*Presentation* of Working Paper: *MPA Level of Protection* • *Questions of clarification*	Authors: Rebecca Martone
1400	Reviewer comments: *MPA Level of Protection*	Reviewers & Authors
1430	***Break***	
1445	Identification of key issues and discussion related to: *MPA Level of Protection*	RPR Participants
1600	Check in on progress and confirmation of topics for discussion on Day 3	Chairs
1630	***End of Day 2***	

DAY 3 - Thursday, May 25

Time	Subject	Presenter
0900	Introductions Review Agenda & Housekeeping Re-cap of Days 1 and 2	Chairs
0930	Continue outstanding discussion from previous days (if needed)	Chairs
1030	***Break***	
1130	Review Terms of Reference • *Have all objectives been addressed?* • *Is working paper accepted?*	Chairs + RPR Participants
1200	***Lunch Break (not provided)***	
1330	*Science Advisory Report (SAR)* Develop consensus on the following for inclusion: • *Sources of Uncertainty* • *Results & Conclusions* • *Additional advice to Management (as warranted)*	Chairs + RPR Participants
1430	***Break***	
1445	*Science Advisory Report (SAR)* (cont'd)	RPR Participants
1545	Next Steps – Chairs to review • *SAR review/approval process and timelines* • *Research Document & Proceedings timelines* • *Other follow-up or commitments (as necessary)*	Chairs
1600	***Adjourn Meeting***	

APPENDIX D: PARTICIPANTS

Last Name	First Name	Affiliation
Acheson	Chris	Canadian Sablefish Association
Alidina	Hussein	World Wildlife Fund
Anderson	Erika	DFO Science
Ban	Natalie	University of Victoria
Barron	Alexandra	Canadian Parks and Wilderness Society (CPAWS)
Beattie	Alasdair	DFO Oceans
Benson	Ashleen	Landmark Fisheries
Blight	Louise	Province of BC
Bocking	Bob	Nisga'a Lisims Gov't
Boutillier	Jim	DFO Science, Emeritus
Burt	Jennifer	Simon Fraser University (SFU)
Carr	Mark	University of California - Santa Cruz
Chaves	Lais	Haida Oceans Technical Team
Christensen	Lisa	DFO Centre for Science Advice Pacific (CSAP)
Depey	Francois	North Coast Skeena First Nations Stewardship Society
Edwards	Dan	Commercial Fishing Caucus (CFC)
Eros	Carole	DFO Oceans
Frid	Alejandro	Central Coast Indigenous Resource Alliance (CCIRA)
Gale	Katie	DFO Science
Gullage	Lauren	DFO Science
Heaslip	Susan	DFO Science
Ibey	Hilary	DFO Oceans
James	Michelle	BC Seafood Alliance
Jones	Russ	Council of Haida Nation
Kristianson	Gerry	Sport Fishing Advisory Board (SFAB)
Ladwig	Aleria	DFO Fisheries Management
Lee	Lynn	Gwaii Haanas Parks Canada
Lessard	Joanne	DFO Science
Lewis	Margot	Hakai Institute
MacDougall	Lesley	DFO Centre for Science Advice Pacific (CSAP)
Mar	Amy	DFO Oceans
Martone	Rebecca	DFO Science
McCarthy	Julie Beth	DFO Oceans
McDougall	Chris	Haida Oceans Technical Team
McIsaac	Jim	Commercial Fishing Caucus (CFC)
Mitchell	Jessica	DFO Oceans
Morgan	Ken	Environment Climate Change Canada - Canadian Wildlife Service
O	Miriam	DFO Science
Oldford	Grieg	DFO Oceans

Last Name	First Name	Affiliation
Pretty	Christina	DFO Science
Robb	Carrie	DFO Science
Rubidge	Emily	DFO Science
Rusel	Christa	A-Tlegay Fisheries Society/Nanwakolas
Schroeder	Bethany	DFO Science
Scriven	Danielle	DFO Fisheries Management
Setterington	Lisa	DFO Science
Sporer	Chris	Pacific Halibut Management Association
Stanley	Ryan	DFO Science
Tadey	Rob	DFO Fisheries Management
Tingey	Rick	The Nature Conservancy
Tucker	Krista	DFO Science
Turris	Bruce	Canadian Groundfish Research and Conservation Society
Warren	Margaret	DFO Science
Watson	Maryann	West Coast Environmental Law
Wells	Nadine	DFO Science
White	Penny	North Coast Skeena First Nations Stewardship Society
Wilson	Laurie	ECCC - Canadian Wildlife Service

APPENDIX D: WORKING PAPER REVIEWS

MARK CARR, UNIVERSITY OF CALIFORNIA

Overarching Comments

The purpose of my comments are two-fold. First is to evaluate the design principles, guidelines, and strategies proposed in this report and, secondly, provide comments and suggestions that might enhance a revision of the draft report. Overall, this is one the most comprehensive and well developed set of design strategies that have been developed for any planning process of a marine protected area (MPA) network to date. It builds on a thorough review of the literature on the design of MPA networks, both from the peer-reviewed literature and governmental reports. Based on that foundation of existing international knowledge and experience, it extends that body of work with some novel concepts and approaches, and tailors the design strategies and guidelines for species and ecosystems of the Northern Shelf Bioregion (NSB). In doing so, it provides extremely valuable guidance for a planning process for a MPA network in the NSB. Below are my thoughts and recommendations as they pertain to the various elements of the report.

The overall structure of the report was well-developed, including the supporting material provided in the Appendices. One shortcoming I had with the structure was a lack of examples that clearly illustrated the application of the design strategies. This was particularly the case for the section that described the proposed methods for setting conservation targets for ecological conservation priorities. Actual examples that provide comparison of the range of outcomes of this method would give the reader a better feel for the consequences of the proposed methods. I realize the body of the report is already quite long, so perhaps those could be in appendices or text boxes. Appendix 6 provides a summary of the values generated by these methods, but not how they were generated by the quantitative and qualitative analyses.

Comments by Sections

The “Context” section provided a nice overview of Canada’s federal MPA strategy and the NBS planning effort, including other NBS-related reports and working groups. Figure 2 was extremely useful for illustrating the overall design of the process and the relationship of the various proposed design elements in the process.

The proposed design principles reflect those from the literature that are considered of most fundamental importance to the effectiveness of MPA networks as conservation tools. Thus, they are very appropriate and I have no comments about these.

Section 3.1: The authors state that “Although cultural conservation priorities and economic and social activities will also inform the design of the network, target-setting for ecological conservation priorities is independent of them.” This isn’t entirely true because many cultural and socio-economic conservation priorities are ecologically based (e.g., protection or sustainability of culturally significant species). It might be good to qualify this statement as such.

Section 3.2.1: The authors state: “The project team subsequently used a heuristic approach to create a standardized set of target ranges.” Check if I’m wrong, but I believe this is the first time “target ranges” are introduced to the reader, and the term is not defined. Apparently this refers to the percent of habitat or population to be set aside in MPA. This term needs to be justified and explained here… it is in large part for application of Marxan, and also conceptually based on values generated in the literature and previous MPA planning processes.

Section 4: The authors state: “In the context of Marxan analyses, the term “feature” refers to the spatial representation of a CP that will be targeted for inclusion in an MPA network (Ardron et al. 2010).” I know that CP refers to conservation priority, but has this acronym been defined?

Section 4.1: The authors state: “The framework included criteria for identifying species-based and area-based conservation priorities, based on global best practices and the ecological objectives associated with Goal 1 of the Canada – BC MPA Network Strategy (2014) (Table 6, Figure 4). It might be good to add something to the effect that in doing so, it included “ecosystem-based conservation priorities” or indicate here that these were included with area-based conservation priorities. A key goal should be ecosystem-based conservation, rather than area per se.

Section 4.1: The authors state: “Species-based ecological conservation priorities included species considered vulnerable, of conservation concern, or ecologically significant (upper-level predators, key forage species, nutrient-transporting species, and habitat-forming species).” Did it not also include species of cultural or socio-economic significance?

Section 4.1, Table 6: I assume this report is required to stick with the Objectives previously defined, but it would have been good to call out important “primary producers” in the functional groups identified in Objective 1.2. I realize that most of these are also important habitat formers (kelp, seagrasses), but noting that they fuel entire foodwebs is important… perhaps in that sense they fall under the “forage species” category?

Section 4.2: The authors state: “Coarse-filter features are included in site selection analyses to ensure that natural areas characteristic of the study area are represented in MPA network configurations.” Give the reader an example of a course-filter feature in the text right here (e.g., shallow rocky reef, sea grass bed), because this fine and course filter terminology is foreign to readers. Note that you did this when introducing fine-filter CPs.

Section 4.2: $(Xp/Yp) \sim (Xt/Yt)^{0.5}$ Give this equation a reference number (as in a publication) and refer to the equation number when referring to targets and target ranges for habitats.

Also, regarding this equation that attempts to ensure that representation of habitats in the network is proportionate to their relative availabilities, it compares two different habitats but you have lots of habitats across the region. What habitats constitute X and Y when you’re comparing the relative abundance among multiple habitats?

Section 4.2: The authors state: “This methodology generates a range of targets…” Not to get to anal, but the term “methodology” refers to the study of methods. You are not using it in this context here (or elsewhere). The appropriate term is “method”.

Section 4.2: The authors state: “To ensure the representation of target classes throughout the NSB, the habitat classes within each classification system also should be targeted separately within each of the subregions within the NSB, once those boundaries have been finalized.” Seems it is necessary to provide a brief rationale for the distribution among subregions - “because these features vary in species composition and genetic composition and contribute to meeting species and representation goals.”

Section 4.3: More anal editing… the term “fish” should be “fishes” because you are referring to multiple species.

Section 4.3: The authors state: “For example, highly mobile species may be difficult to protect in static MPAs, unless the species aggregates in predictable geographic locations or utilizes particular habitat types at key lifecycle stages or times of year. In such cases, the priority feature for which to set targets is the representative spatial feature (i.e., habitats or geographic locations), such as seasonal breeding, feeding, and resting areas for birds, seal haul-outs, or

key staging areas along a migration route of a migratory species (Ardron et al. 2010).” But of critical importance here is protecting those habitats that support these ecological functions for the target species, not the species itself! It only bears on the species if that species experiences a disproportionate mortality relative to other areas (e.g., fishing is focused on areas of aggregation, increasing the CPUE at that specific location). All of these mobile species can be killed outside the MPA, such that the value of protecting the species in these areas is limited unless mortality is exceptional at these areas.

Section 4.3.1, “Ecological Role” section: The authors state “We assessed the values for each ecological role independently and not additively to ensure that species of importance in any ecological role were considered equally (BCMCA and PacMara 2010).” I simply don’t agree with that guideline. Why would you not give a species that fulfills multiple ecological roles a greater value than a species that fulfills only one of these roles?? For example, Figure 5 indicates predator OR Forage Species OR Nutrient Transporter OR Structural Species, but *Macrocystis* is one of the most important coastal marine species with respect to all of the above with the exception of Predator. Why would you not value *Macrocystis* greater than a species like the seastar, *Pisaster giganteus*, which fulfills only the Predator role??

Section 4.3.1, “Ecological Role” section: For this, and all other CP calculations (including area-based), I would like to see the potential range of values lowest to highest, that can be generated by this equation. I would also like to see an example of a species and habitat that was given a very low and very high value.

Section 4.3.1, “Ecological Role” section: Am I right that the only table that gives examples of these scores for species is Table 30, which is restricted to birds? I want to see examples of target scoring for fishes, algae and invertebrates to see the relative quantitative values generated by this equation for example species that vary in their characterization.

Section 4.3.2, Conservation Concern and Vulnerability section: Does this take into account vulnerability of supporting habitats for these bird species?

Section 4.3.3, “Area-based Conservation Priorities”: See all of my comments raised for the “Ecological Role” calculations that I think apply to this section as well.

Section 4.3.4: “Expert Review” section: I’m curious why all of the experts appear to be government scientist to the exclusion of academics (Appendix 5)? Are there no taxon experts in academia?

Section 4.3.5: “Calculation” section: give this equation a reference number that can be referenced in the text.

Section 4.3.6: Table 7: I don’t understand the value of this table (i.e., the target ranges presented) if I don’t know whether these are species or habitats. The figure legend needs to clarify what the targets (CPs) are for these target ranges.

Section 5, Figure 9: What does the diagonal between “Highly mobile species “yes”” and “Quality distribution data?” represent? How do you go there without knowing whether there is known important areas in NSB?

Section 6: The authors state “Following advice from work in the Scotian Shelf (King et al. 2016 in prep), these targets were adjusted so that the lowest assigned target was 10% for all classes within all of the target ranges.” I do not understand why all of these classes have the same lower range of 10%, nor do I understand the rationale for overlapping target ranges (Tables 9 and 10)?

Section 6: The authors state “The low end of this target range concurs with the 10% CBD target (CBD 2008) as well as species-area curves that were created during the creation of the MPA

network in California and showed that protecting 10–30% of the area protected 75–90% of the biodiversity in representative habitats (CDFG 2008).” (Note that they repeat this comment at the bottom of page 35.) These percentages must have been generated by the authors? The species-area relationships were generated to determine the minimum **absolute** (not proportionate) area to constitute a replicate of a given ecosystem/habitat within a single MPA. There was no percent area used to calculate the minimum area to constitute a habitat (ecosystem) replicate in the MLPA process. This is disconcerting because values generated in the MLPA process were not to be applied in this way.

Section 6, Tables 9-14: The table legends need to describe what the values are in these tables (they’re not ranges) and how they were generated. I’m also very interested in know how very similar habitats get very different scores. For example, “Rock Platform with sand Beach, narrow < 30m”, “Rock Platform with Sand and Gravel Beach, narrow < 30m” and Rock Platform with Gravel Beach, narrow < 30m” received scores of 24, 10 and 10, respectively. Similarly, Rock Platform, narrow < 30m and Rock Platform, wide > 30m received scores of 14 and 10, respectively. Why?

Section 7.1, Table 15: Boy… it sure seems that the range of target scores for medium quantiles would range from 3.75 to 4.75 (not 4.12) based on the frequency distribution in Figure 10.

Section 8.1.1: The authors state “Ecosections occur at the scale of 100s–1000s of km and are based on abiotic pelagic oceanographic processes (Figure 12) (Rubidge et al. 2016).”

I don’t see ecosection defined elsewhere in the report? If not, this concept of an ecosection needs a more explicit definition… perhaps something like “Continuous areas of distinct oceanographic condition defined by water temperature, salinity, productivity…. Examples include…”.

Section 8.1.1: The authors state “The MaPP subregions, primarily based on political boundaries (Marine Plan Partnership Initiative 2016), can be used to ensure replication across north-south and east-west gradients that are not captured by the ecosections.” This seems dicey to use politically based areas to capture the distribution of replicates across the NBS. Why not ignore the subregions and just ensure that all ecosections are represented, where possible (i.e. where they occur), throughout the entire NBS? I don’t think the subregions are a useful approach to achieve representation of each ecosection throughout the NBS.

Section 8.1.2: The authors state “In addition to considerations of scale, the design guidelines recommend that rarer features and smaller patches should have more replicates” This makes very good sense.

Section 8.1.2: The authors state “a set of patch size classes should be determined and a minimum replicate range assigned, based on recommendations in the scientific literature (Table 17).” For clarification and per their following sentences, make explicit that patch size, and therefore patch size classes, will vary among habitat classes. For example, patch sizes of shallow rock will be smaller than patch sizes of shallow or deep soft bottom and the size classes will have to vary accordingly. Based on Table 17, I am not convinced this was the case. It appears that the sites that had areas in the upper 75% of available patch sizes received the same number of replicates regardless of the absolute size of the habitats?

Section 8.2: The authors state “MPATT design guidelines provide a starting point for addressing MPA size and spacing in the network, suggesting that MPAs size should (a) vary widely (minimum sizes between 5->600 km^2) based on specific conservation objectives; and, (b) should be larger offshore than nearshore (Appendix 2).” I agree that this falls far short of reasonable size and spacing guidance.

Section 8.2: The authors state “Preferably, an understanding of species-specific movements, dispersal patterns, and population parameters provide the basis for size-related recommendations (Kinlan and Gaines 2003, Shanks et al. 2003, Shanks 2009, Gaines et al. 2010, Pelc et al. 2010, Grüss et al. 2011).” I would cite Saarman et al here!

Section 8.2.1: The authors state “While there is no ideal size applicable to all MPAs, it is suggested that MPAs size should be at least as large as the average larval dispersal distance and encompass the adult or juvenile home range or neighbourhood sizes of the species targeted for protection…” I think these are wrong on both criteria. Larval dispersal distance has little to do with MPA size (assumes scorched earth and single MPAs must be self-replenishing for even rather long-distance dispersers). Rather, dispersal distances determine spacing between MPAs. Similarly, MPA size needs to be much larger than an individual’s home range to scale up to protecting a local population. While home range is a critical determinant of the size of a single MPA, the actual size of the MPA needs to be substantially larger than an individual’s home range. Indeed, below the authors state that MPAs should be at least twice as large as the hmie range of the species.

Section 8.2.1: The authors state “Results from the synthesis reveal that …” One problem with this summary paragraph is that it does not distinguish the much smaller home range of hard bottom-associated species relative to soft bottom species.

Section 8.2.1: The authors state “Given their short distance movements, species with home ranges less than 1 km likely will benefit from smaller MPAs. For many species in the nearshore, MPAs of at least 6.3 km^2 (based on a diameter of 2 km) to 12.6 km^2 (based on a diameter of 4 km) should be sufficient to protect adults within their boundaries,…” I am not disagreeing with this statement, but like the California MLPA, it is unclear how these MPA areas were generated based on the home range distances. This is because you are trying to scale up from individual home ranges to protecting some local population size for multiple species. It appears that the actual size is three-fold the area of species home ranges. I think this simply needs to be made more explicit, indicating that the MLPA used the same logic or approach.

Section 8.2.1: The authors state “Based on the median and mean home ranges for many of the nearshore species, we recommend that MPA sizes between 12.6 km^2 and 200 km^2 (based on a diameter of 63.6 km) be considered in the nearshore (Table 18).” This makes sense and it corresponds with the rationale of spacing guidelines… species whose adults and larvae don’t move or disperse much, respectively, don’t count when it comes to size and spacing. Nor do the species whose adults and larvae that have very large home ranges and larval dispersal. It is the many species that have intermediate distances (the median) that should dictate these design criteria. These are the species whose distances are most sensitive to size and spacing guidelines. It is the many species whose adults have 10-50 km home ranges that will be protected in MPAs that range from 12.6-200 km^2.

Section 8.2.1: The authors state “For highly mobile species (50–1000 km, >1000 km movement classes), MPAs should target critical life stages or aggregations if they are spatially distinct, as the spatial scale of MPAs required to cover their distributions are likely prohibitively large (Hooker et al. 2011).” Cite Saarman et al for this same rationale.

Section 8.2.2: The authors state “Species were grouped based on the spatial area in which they generally release their larvae/spores: intertidal (area between high and low tides), nearshore-subtidal (0–60 m depth), nearshore to shelf/slope (spawn across a broad spatial and/or depth range), or shelf/slope (larvae released offshore or at deeper depths (>60 m).” The rationale for this approach is sound and needs to be explained with examples… larvae of a given PLD released in fjords are very unlikely to disperse any distance close to larvae with the same PLD

released on the expose coast (e.g., shelf). Thus, dispersal potential, as defined in the literature needs to be modified by these regions of exposure to currents.

Section 8.2.2: The authors state “Given the ranges of estimated larval dispersal distance, we recommend that spacing should aim to be between 20–100 km in the nearshore, and 50–250 km in the shelf-slope (Table 19).” These upper distances and ranges seem too large for effective replenishment and guidance among adjacent MPAs and populations between them. This comment is based on the rationale argued in my earlier comments, that long-distance movers and dispersers, should not be considered in these distance calculations.

Section 8.3.1: To be more comprehensive, it would be good to mention the rather different alternative approach applied in the MLPA process (see Saarman et al.).

Section 8.3.3: The authors state “Based on this literature and work done elsewhere (Airamé et al. 2003, Fernandes et al. 2005, Jessen et al. 2011), we recommend that 30% of the MPA network should be in no-take (IUCN Level Ia) or at least limited-take (IUCN Level Ib, II, III) reserves.” This seems pretty arbitrary and the extent of overall protection depends on the overall area proposed to be placed in MPAs rather than a separate approach to determine the absolute extent of no-take regardless of the rest of the MPAs. These target percentages seem to reflect the Marxan approach.

Section 9: The authors state “We recommended a range of MPA sizes between 12.6–200 km^2 in the nearshore and 62.8–314 km^2, up to 673–2048 km^2 in the offshore.” and “We recommended MPA network spacing of 20-100 km distance in the nearshore and 50–250 km distance in the offshore.” Again, these are such huge ranges that it is not clear how useful they will be without greater explanation for the sources of this variation.

Section 9.1.2: The authors state “…it is important to avoid targeting degraded areas where functions have been severely disrupted by human activities (King et al. 2016 in prep). Therefore, we recommend incorporating a spatial assessment of naturalness within the NSB before determining the areas to target within the chosen classification systems.” Yes, this assessment is important, but realize that de-emphasizing areas exposed to human activities (e.g., fishing) will limit both the extent to which an MPA will enhance/restore a perturbed area/species, and an evaluation of the magnitude to which MPAs can restore areas/species, depending on whether the habitat itself has been degraded. I would favor the second approach identified below that includes both more pristine as well as perturbed areas (but restricted to areas where the species, rather than the environment has been perturbed).

Section 9.1.4: The authors nicely articulate and describe how they address the problems that invariably arise with expert review. Their solution is reasonable given the conflict between the competing values of multiple independent inputs of advice (avoiding group think) and shared collaborative interactions converging on a more robust consensus. The small taxon-specific approach seems in conjunction with independent update appropriate as long as the advisors were able to also provide broader context to avoid biased ranking of particular taxa (“our taxon is so special”).

Section 9.1.4: The authors state “For example, experts recommended both high and medium targets for coldwater coral conservation priorities, and a medium target was assigned (Appendix 6).” This result should be explained here.

Section 9.1.4: The authors state “A medium target was suggested for sperm whales, for example, but because of their high functional importance and conservation concern, the target remained high (Appendix 6).” This would be a good example of the distinction between a conservation priority versus the value of an MPA as a conservation tool and how this influences target scores. Sperm whales are undeniably of great ecological and vulnerability significance,

but no MPA in BC is likely to be a useful conservation. How do these influence the ultimate score?

Section 9.1.4: The authors state “Because the scores for the ecological criteria have been assessed previously (Gale et al. 2017 in prep), we did not alter those values when experts voiced disagreement with the original scores (e.g., Northern Lampfish, Appendix 6).” Why? Explain.

Section 9.1.4: The authors state “Where discrepancies existed in the resulting targets, we have documented the expert recommendations and the final target ranges assigned to the conservation priority (Appendix 6).” Excellent!!!!

Section 9.1.5: The authors state “We assigned three target ranges to a diverse suite of species…” This paragraph highlights the difficulty of trying to build a conservation tool that attempts to simultaneously address single species and ecosystems and when the species vary markedly in traits that bear on the design of that conservation tool. This is why “rules of thumb” that are broad in their application appear most appropriate when so many species for which little data exist are targets of conservation (i.e. “biodiversity” and “ecosystem structure and functions”).

Section 9.2.1: The authors state “Our recommendations are consistent with the literature…” As in California’s MLPA , it should be pointed out that replicates also strongly influence the statistical power to evaluate the consequences of establishing MPAs and their adaptive management (i.e. decisions to alter design criteria).

I believe that one shortcoming of the replication section is not clarifying that replication of ecosystems can be met for multiple ecosystems when multiple ecosystems are included within a single MPA. This is how the importance of having multiple ecosystems within an MPA for reasons of protecting and leveraging ecosystem connectivity also make for more efficient replication of the separate ecosystems across the network.

Section 9.2.2: The authors state “However, we recommend a wider range of MPA minimum sizes in the nearshore (12.6–200 km^2), and in the shelf-slope region (minimum of 62.8–314 km^2, and up to 673–2048 km^2)…” As mentioned above, I’m concerned about such wide ranges unless some resolution is provided that clarifies how this range is applied to specific ecosystems and the species they support.

Section 9.2.2: The authors state “The MPA network with a range of MPA sizes should benefit species with intermediate and larger movement patterns if individuals spend part of their life history in MPAs that limit harmful activities.” Not sure I understand this point… rather, the collection of particular ecosystems and their species should dictate the size of an MPA.

Section 9.2.2: The authors state “Given that targets for more mobile species will be set on features where individuals aggregate–such as key habitats or areas important to breeding, feeding, or nursery areas– the MPA network should benefit these species even if MPA size is smaller than the species’ home ranges.” But consider connectivity and protect a sufficient number of that population in non-breeding or nursery habitats adjacent to these specific locations or protecting these habitats will be ineffective. These critically important areas should be the seed of larger areas that include multiple ecosystems to ensure the process of connectivity for target species and ecosystems targeted for conservation.

Section 9.2.2: The authors state “In addition to encompassing adult movements, the effectiveness of MPAs relies on successful recruitment of individuals into the protected area boundaries (Botsford et al. 2001, Botsford et al. 2003, Botsford et al. 2009, Shanks 2009).” In addition, the magnitude and spatial extent to which larvae produced by protected populations

within MPAs replenish populations outside MPAs is determined by the size (and spacing) of MPAs.

Section 9.2.2: The authors state “However, there is a lot of uncertainty in the method we used to estimate dispersal distance (Shanks 2009), and the coastline of B.C. is influenced by different oceanographic currents than California,…” The complexity of current patterns (eddies, tidal flux) within the complex nearshore waters of BC should also limit the dispersal distances of those species with long-distance dispersal too. Thus, the proposed size range is likely conservative for conservation goals across the spectrum of larval durations of nearshore BC species. However, this is less so for offshore species along the open coast. This reinforces the “rule of thumb” of larger MPAs in offshore than nearshore waters.

Section 9.2.2: The authors state “MPAs should be spaced far enough apart to allow for recruitment and spillover of larvae to areas adjacent to MPAs, but close enough together…” It should be recognized that this design criterion (spacing MPAs by the distance of intermediate dispersers) also increases the extent of coastline (including fished populations) replenished by larvae produced within MPAs (see the Connectivity report written by the US MPA Federal Advisory Committee, which is also in press in Aquatic Conservation).

Section 9.2.2: The authors state “Our recommended approach for integrating potential impacts from human activities with conservation targets should ensure that sizes will vary with protection level when applied in the MPA network design strategies phase.” This is an intriguing concept that was not considered explicitly in California’s MLPA design process.

Section 9.2.3: The authors state “Although similar to the IUCN levels of protection approach, this method allows for ecosystem-specific assessment of impacts.” And specific to a proposed allowable activity within the MPA.

Section 9.2.3, Table 21 legend: “… between activities and populations or assemblages of speciesError! Bookmark not defined..” Why not refer to a community and ecosystem?

Section 9.2.3, Table 21: “Negative interaction can occur and may cause substantial impacts to local population abundance and persistence due to extensive habitat damage, loss of food resources, and/or other factors.” This doesn’t seem to involve ecosystem-wide ramifications of diminishing a species’ ecological function. It seems far too narrowly focused on the target species. How is loss of a keystone species ranked relative to a less influential species?

Section 9.2.3, Table 21: “Major Positive Effect: Positive interaction can occur and may create substantial benefits to populations through creation of new habitat, long term increases in population size, and/or other factors that increase the range of a species or community.” Similar to above, what about positive effects for one or more species, which are either more positive to other species or perhaps detrimental to the community/ecosystem as a whole? Too focused on the target species.

Section 9.2.3: The authors state “Moreover, the recent application of this approach does not reflect how much the conservation priority in an MPA might differ from that observed in a comparable no-take area if the activity were allowed. For example, in assessing risk to Pacific Halibut from long-line fisheries, the interaction was scored as negligible based on fisheries sustainability reports. However, in the context of MPAs, allowing halibut long-line fishing with the boundaries of an MPA would likely have a major negative impact on halibut biomass within that MPA compared to a no-take area. To address this shortcoming, the scores would need to be reviewed and revised with this context in mind.” Exactly! Excellent point and example!

Section 9.3.3: The authors state “Because climate change is occurring faster than many species can adapt, protecting areas that are experiencing less extreme climactic change may promote

species' persistence or recovery…" Yes, but it has also been suggested that protecting areas where species currently experience extreme conditions may contribute to the persistence of local populations (and genotypes) that are adapted to future environmental conditions. These populations may contribute to colonization of areas that existing populations will not be able to tolerate or adapt to.

RYAN STANLEY, FISHERIES AND OCEANS CANADA

Overview

Thank you for the opportunity to participate in the review process of the Northern Shelf Bioregional MPA draft design strategies. Overall I found that the strategies are well conceived and the methodology is very well-articulated. My comments are organized below according to the thematic structure of the working paper. This working paper was very well written, and I have little to offer in terms of editorial changes. I will, however, provide the version of the working document with track changes so the authors can consider some small suggestions and edits.

I have generally provided contextual suggestions to the proposed design process, and I primarily focus on the strengths and weaknesses of the approach towards the network conservation priorities and general design objectives for the network. I expect that interaction with species experts and stakeholders during the presentation review process will help to highlight further what will work, or might not work, for each conservation priority.

Designing a network 'panacea' is a difficult process, especially with the abbreviated timelines facing all who contributed to this design strategies synthesis. My suggestions should be viewed as a method to punctuate and articulate how the general concepts of MPA design can tractably be integrated into a plan. Moreover, much of my input will frame limitations of incorporating biological parameters (e.g. dispersal, connectivity) into design.

This working paper is clearly a synthesis of a tremendous amount of work, consultation, and consideration. The authors should be commended for charting a clear path towards a robust and defensible MPA network.

General Comments

There are some terms (jargon) used in the document which don't appear to have a definition. In some cases, terms are introduced in sections before their definition. I believe that a glossary should be included for important terminology. Some of these terms are ecologically loaded, so a definition will add clarity to the document. Examples include but are not limited to:

- Climate resilience
- Ecological linkage
- Dispersal
- Ecosystem
- Connectivity (demographic, genetic, community, ecosystem) – also could reference the specific (sub) sections in section 9.3.

Introduction

This section provides a detailed background of federal MPA objectives couched within regional and international processes. The authors might consider adding more detail when describing

the goals and objectives of the BC MPA Network strategy. Goals 1 and 2 clearly form the basis for the design and future evaluation process; however, there would be merit in highlighting all of the goals outlined by the strategy since these will provide an important backdrop for the design. These could be integrated into Table 1. Note all that the footnote (6) hyperlink does not bring up the information alluded to in text.

Figure 2 provides a nice visual for how information is channeled into a decision. One thing that strikes me about this figure, and the introduction in general, is that there is no reference to trade-offs with existing use (e.g. current fisheries footprint). There are references peppered throughout the paper to trade-offs (e.g. "*not isolated from, the social, economic, and cultural network design principles" & "Although cultural conservation priorities and economic and social activities will also inform the design of the network, target-setting for ecological conservation priorities is independent of them*"), but their role in the design process is not fully described. Though not the intent of the process, it should be noted whether this information will or will not be incorporated into the final design phase (e.g. through the Parameters – Scenarios step). I think it would be useful to have some small paragraph or acknowledgment in the text about how existing ocean use will be (eventually) married to this ecologically driven design process. I do acknowledge that this step is not part of the intent of the working paper, however I believe it is needed to set the context of how the product from the proposed strategy will be fully implemented (balance of cost and benefit). This information is important when assessing CP targets, as boundary adjustments associated with cost-benefit analysis will likely reduce or limit the percentage of area recommended for protection. With this in mind, it is important to set targets which will provide the 'room' for negotiation with socio-economic and political considerations.

Section 2.1

- Great overview of representation (scales) and replication. It is interesting the how the concept of connectivity and replication are rarely considered in parallel. Could two 'connected' features/areas really be replicates? This is partially addressed with the scale of replication consideration (e.g. ecosections), but is connectivity a prerequisite for replication? This is clearly getting into the weeds so to speak, but bares further discussion, especially if the replication focus is for a species specific feature. Dependency could be counterproductive to the intent of a replicate (loss of one draws down another) and at the same time might be needed (loss of one is mitigated by another).

Section 2.3

- The definition of what distinguishes each type of connectivity is important. For example, in what context might a practitioner use demographic connectivity vs. genetic connectivity? Overall what do the authors mean by *connectivity*?
- "Outside of MPAs, the spillover effect can supplement fisheries harvest by providing exports of target species from MPAs into adjacent areas" – Yes this is most certainly the case. However, this basic analogy with fisheries makes an important assumption, that the management action (spatial closure) offset some activity that was there. Moreover, to actually be able to 'see' an effect, this offset would have to protect a large enough fraction of a stock or population so that the signal will be greater than the natural variability (noise). These promises are often made but are difficult to quantify, especially in northern, temperate systems.
- "There are few examples of connectivity being explicitly incorporated into MPA design. Representation (Section 2.1.1), replication (Section 2.1.2) … ," – Here is where the

consideration of whether replicates should be connected comes into play. Is replication a form of connectivity? To me, replication is not a measure of connectivity, but some insurance that multiple habitats are represented. This could fit in with connectivity (e.g. step stone if replicates are focussed along a coast). If replication and connectivity are to be integrated, then I suggest that Section 2.1.2 should make some reference regarding this justification and how that design principle relates to connectivity objectives.

- Defining spatial patterns in productivity (sources and sinks) is an important topic. Mainly here the interest is in whether an area is likely productive and whether that productivity leads to realized (dispersal + survival) connectivity. Demographic connectivity, to me, represents the transport of individuals who move between habitats and occupy resources but do not necessarily reproduce again (genetic connectivity). Source-sink information is important for MPA design and in some ways is the most tractable avenue for incorporating connectivity, vis-à-vis productivity, into network design, as it provides a defined spatial feature to set targets for.

Section 2.4

- "… and provide resilience for future … " – for future what?
- *"… , to areas that allow the sustainable use of natural resources …"* – So if this is the case, does that mean that fisheries management, as it is currently implemented, is unsustainable? I don't disagree with the comment, but it might be worth highlighting how this is additional (e.g. in addition to existing measures which have the same sustainability objectives) insurance against risk of unsustainable activity, both currently and into the future. In this case, the MPA is protecting a composite of ecological attributes (habitat and communities) as opposed to just the focal species, thus reducing uncertainty about management effectiveness.

Section 2.5

- Define 'ecologically linked'
- Table 2 – Good review of MPA design. It is worth noting, however, that the majority of the noted studies are from warmer systems. This is a problem with MPA research in general is that the playbook of design is rooted in these warmer systems. The replicability of many of these observations to temperate systems is questionable.
- Table 3 – The recommendation is more about representativity than shape. Certainly MPAs which are positioned to cross multiple broad-scale habitat zones and depth ranges (e.g. nearshore-offshore) are desirable and do for some species accomplish some connectivity assumptions, provided that species remain in the boundaries throughout ontogeny.
- Page 12- The variability in dispersal and uncertainty when estimating connectivity limit the application of rules thumb. Though noted later in the paper, I think their use should always be noted with a qualifier as to why they are suitable or what uncertainty is associated with their use.
- Page 12 (Spacing) Habitat is an important consideration here. Dispersal is a distribution of potential connections, which will vary year to year, species to species, and even month to month. Rarely are set or fixed values suitable to describe the complexity of dispersal for one and especially among multiple species. The habitat between two areas is an important consideration for connectivity. For example, we have found evidence that scallop populations which are geographically spread out but are linked by highly suitable habitat are

in fact more genetically similar than populations which are very close but are separated by inhospitable habitat. This comment is to highlight uncertainly, but not to detract from the application of spacing ranges. I think it would be useful in the tables to add a column which describes where these rules were derived (e.g. tropical, sub-tropical, temperate, arctic). This is important because beyond simple differences in oceanography among regions, pelagic larval duration and thus dispersal distance will likely increase, on average, with latitude.

Section 3.1

- I certainly agree that heuristic approaches should be favoured in the absence of quantitative data. This section (3.1.2) provides a nice overview and justification of this background. However, as previously mentioned, I strongly suggest noting the limitations of applying rules of thumb from lower latitudes to the NSB.
- *"Other evidence-based approaches for setting targets are more quantitative and more scientifically defensible, but can also be data-intensive and may produce results with a high level of uncertainty"* – Is this uncertainty higher than would be expected of heuristic approaches? I am guessing probably not if the data is available to conduct these types of analyses.
- *"Although scientifically sound, quantitative methods are usually difficult to apply when conservation planning focuses on multiple conservation features"* – But this is really true of any design feature (e.g. size, spacing, etc.)? To me, some of these approaches (e.g. minimum viable population size) are the first cut at actually incorporating resiliency into MPA design. Though areas with high biodiversity might be more 'resilient' to change, biodiversity does not directly inform resiliency. In particular, resiliency of a conservation priority species would benefit from this type of information.

Section 3.2

- This is a useful overview of similar local processes.
- Subsection 3.2.3 – Note for our region, connectivity was brought into the process using broad scale layers reflecting the dominant, multispecies, north-south genetic break present in our region. This was a first cut at incorporating connectivity into design and highlights a potential application of genetics in constraining the view of connectivity in design. Because our region is characterized by a cryptic biogeographic break, heuristic approaches would have likely lead to misplaced assumptions of connectivity. This really highlights how genetics can be incorporated and how the definition of connectivity (demographic vs. genetic) is important when evaluating network design. Without baseline information, the application of this approach to the NSB is unlikely, but it might be useful add this application for context.
- *"Targets were set at 30% based on empirical evidence that targets of 30% result in the retention of 70-85% of a species within its range (Dobson 1966)"* (Section 3.2.4). – I am not sure what his means. This work was done using a very broad overview and I assume it means that covering 30% of an area would cover about 70-85% of the biota. However, again this is a big assumption in the area and probably has some underlying assumptions that species are evenly distributed.

Section 4

- What is, and how does one measure, 'climate resilience'?

- I believe the methods outlined, and those reviewed in Section 3, capture the detail necessary to understand the process and considerations for setting CPs.
- Section 4.3.1 – This is a well thought out and integrated system. This is easy to follow and does a good job, I believe, at incorporating and balancing information into a transparent scoring system.
- Ecological role – This is a nice piece of information. However, it is a bit ambiguous how the scoring (e.g. 1, 1* or 2) was assigned. This information might be in Gale et al. but it should be briefly outlined here.
- *"Therefore, it is not appropriate to consider each criterion independently in a scoring matrix. Further, each variable has inherent drawbacks that are offset by the other"* – I am not sure I follow the logic here. Why is it not appropriate and what are the variables? This should be revised for clarity.
- I like the approach for setting Fine-Filter Target ranges (4.3.6). However I found myself having to read this section a few times to be sure I followed the guide. To be sure the reader can fully understand the integration of data, it would be useful to have an example of the calculation.

Section 5

- "We define highly mobile species as those in movement classes 50–1000 km and >1000 km" – Clarify whether this is exclusively adult/non-passive movement.
- Figure 9 is a really useful schematic to understand the decision process.
- Tracking the 'non-marxan' features is a really nice way to understand how these features are incidentally covered in planning scenarios. This is well described and I like the approach.

Section 6

- It is hard to interpret / comment on the data layers as presented (Table 8). It would be useful include maps of the input layers in an appendix, or to append relevant existing reports that review the input data.
- *"Following the Lieberknecht et al. (2010) approach, we assigned the coarse-filter features to a range of targets by assigning the smallest habitat class within each classification to a top starting target of 10%, 20%, or 30% to calculate the relative … "* – I think more information is needed here to see how the relative scoring was done. A paraphrased description of this method would be useful.
- The bottom 10% target for course-filter targets is certainly defensible. I am unsure what the 'species-area curves' from the Californian Network contribute to this justification, however. The relationship between coverage and space will vary considerably area to area depending on the distribution of the species. This comment follows for the same analogy in Section 7.2. The best solution here might be to add a qualifier the first time this comparison is used to justify with the NSB would be comparable to this system. Without this information the relationship between the application and this study is left wanting.

Section 7

- Species-Based Conservation Priorities (7.1) – Is there any flexibility in this approach to adjust targets for specific species conservation priorities (e.g. Stellar sea lion rookeries)

beyond the 60% limit? Similarly for species which have a low priority (e.g. Northern Smoothtongue or species not listed in Appendix 6) or those species which might not obviously benefit from MPA protection (e.g. a species which is broadly distributed, has a 'healthy' abundance and is relatively un-impacted by fishing) , can lower core or target of 0 (with post-hoc analysis) be assigned? It is important that the spatial targets set out here reflect the next stage in the process when boundaries are adjusted to reflect existing use.

Section 8.1

- Figure 12 is really useful to see how the ecosections and sub-regions align in the NSB. Are the 'gradients' referred to in text based on geography only? It seems that any physical gradient (e.g. temp or substrate) should be captured by the ecosections. In the Maritimes region we have a very steep environmental gradient (temperature) which defines population structure. Just to be clear, the authors should define what gradient they are referring to here.
- Is it only pelagic abiotic information which delineates the ecosections?
- This section might be a good place to reiterate how connectivity and replication can interplay. Should replicates be interconnected? Connectivity can lead to recovery but it can also lead to depletion (e.g. breakdown of source-sink relationships). Observing this in situ is probably unlikely, however, it would still be useful for this document to present the discussion and design considerations for replication and connectivity.
- How would you replicate a patch (8.1.2)? I think what you mean here is those features which are characterized by multiple small patches. What happens in a scenario where there is a distribution of patch sizes? Would the smaller patch size be selected, and replicated, more than a larger patch with the same summed area?

Section 8.2

- Rules of thumb are ok to use provided they are 1) vetted where possible for relationship to the study region (e.g. focus not biased towards tropic and sub-tropic systems) and 2) applied with consideration for how the NSB differs from the areas where the rules were developed.
- The optimal target for size is a bit disjointed where it was listed as *'… at least the average larval dispersal distance …'* and *' … be at least twice as large as the home range of the species …'*. Whereas both pieces of information fit design objectives, it would appear that adult home range is more tractable for individual MPA size. This should be made clear in the text.
- Can the shelf and slope species be separated in this analysis? Slope habitat in some ways might be as different from shelf habitat as nearshore is. Median vs mean comparison suggests that there is a very broad distribution of ranges. It would be useful to see if the shelf-slope delineation constrains this variance. Likely shelf species will have larger home range than those species on the slope associated with more constrained habitat features.
- It would be useful to develop a plan for fine-scale delineation of MPAs after Marxan selection (e.g. centre MPAs on specific features particularly when protecting correspondingly small features).
- PLD is not a spatial parameter, and thus is only really useful as a relative comparison point. PLD certainly doesn't provide information on the realized movement.

- The model provided by Shanks et al. (2009) shows considerably variability in the relationship between PLD and dispersal distance as does the relationship in Figure 18. If the two values with 'realized dispersal' greater than 300 km were removed, the analysis would show little to no relationship between PLD and dispersal distance. For example, at PLDs between 2200-2400 there is as much evidence that dispersal would be really far (<450 km) and really short (>40 km).
- How were values translated from the table 40 to Figure 18? Particularly, how were ranges plotted (e.g. *Chaetodon vagabundaus* 29-48 days and 100-500m)? Given the importance of this analysis, it would be better to see the relationship between PLD and dispersal distance be elaborated on. For example, this could take the form of a mixed model accounting different groups, origins, or dispersing stages. It would also be useful to see how species from the NSB region stack up against this relationship (e.g. studies from the region or in the temperate northeast Pacific). At minimum this part of the analysis should acknowledge the limitations of this approach. Where limitations aren't noted the output might be given more confidence than it can provide.
- As this process develops it would be useful to take advantage of existing particle tracking and circulation models (e.g. FVCOM and ROMS) to generate a more localized prediction of dispersal distance. This is, of course, not a trivial task especially with the abbreviated MCT deadlines. However, I do believe that this would be a useful exercise even if it were used as a post-hoc evaluation of the MPA design. That said, more direct measures of connectivity (e.g. tagging or genetics) should always be favoured where available.
- For Figure 18 (Appendix 10) what is 'realized dispersal distance'. PLD certainly isn't realized dispersal and by definition realized would likely better fit genetic connectivity where the disperser moves between areas, occupies resources, and reproduces.
- Figure 14 is difficult to read and should be made a 2 column figure.
- Where do size and spacing guidelines fit into the design process? Is this a post-hoc process or will this be integrated more systematically into the Marxan parameterization?

Section 8.3

- What are 'effectiveness estimates'?
- How would/could this methodology be applied to MPAs with multiple activities? (e.g. portion of the MPA is no-take).
- I think it is important to note that this section is really a post-hoc evaluation procedure. I cannot see how it can fit into the design phase (Marxan parameters).
- How is the 'level' of impact going to be known at the design scenarios phase? I presume this process is meant to be post-hoc validation procedure. If major changes (additions) are needed, how will the network plan be adjusted? This highlights the danger of setting the minimum thresholds of targets at low levels.
- *"For conservation priorities in these MPAs, the original target values would be down-weighted by a value chosen using a bootstrapping approach from a distribution with a mean of 0.24 and 95% CI of 0–0.72 (i.e., IUCN Category VI effectiveness score range - Ban et al. 2014)"* – Don't you mean that the original target values would actually be increased to compensate? Down weighting, to me, would come when you multiply one minus effectiveness score by the coverage to see what is missing. It isn't clear how the bootstrapping will be applied. What is the rational for bootstrapping instead of taking the

mean or median of the distribution of down weighting values? To me randomly sample with replacement would be more intuitive of what, I think, the approach is outlining.

Section 9.1.2

- A point to consider when conceptualizing naturalness in MPA network planning. If 'natural' areas are preferentially selected (e.g. those areas which are more or less devoid of any human activity), what does the MPA network achieve besides formalizing human footprint and offsetting risk? This is not to say that this is an undesirable outcome, but if the objective is that MPAs will contribute output (as eluded in Goal 2), than it is important that MPAs affect change. I think it is important to capture the areas which have some activity, or else MPA network designs risk not doing much beyond offsetting future risk, which is difficult to measure. This is something similar to 'response ratios' where those areas where the conservation measure does displace something, then we should expect a relatively bigger and measureable effect.

Section 9.1.3

- There might also be a seeding effect, where high targets on discrete events (patches) might drive the selection of areas over multiple runs. The potential influence of seeding should be monitored and where present, the associated fine-scale features could be added afterward lowering the target or setting it to 0 all together and adding it back in afterwards.

Section 9.1.4

- This was a rigorous and well thought out process. There is no panacea for design, so the objectivity of this approach is well placed.

Section 9.1.5

- Few studies are available to establish 'appropriate target ranges' because measuring the appropriateness (results vs objectives) will take a considerable amount of time!
- In reality, a PVA analysis doesn't lend itself to the selection process other than some applicability when considering size vs replication for spatial targets. Any PVA endeavour should focus on species of concern or species that are particularly prone to decline associated with fishing activity (e.g. SAR species that might be captured as bycatch or might lose habitat due to fishing activity). This exercise would be a question of self-dependency and resiliency of a population under protection by a spatial conservation measure.

Section 9.2.2

- *"Our results suggest that species that are sessile or exhibit limited movements should benefit from MPAs …"* – this assumes of course that the management action evokes change from the 'status quo'. If an MPA was placed in an area with little historical fishing activity, or where a particular species was not influenced directly by fishing, than expected benefit should be tempered.
- I think it will be important in the future to test the similarity between the NSB system and those systems where MPA related work is most often derived (e.g. California). Is 1km or even 2 km a reasonable larval dispersal scale for a nearshore temperate species? Though PLDs are estimated locally, the tie to dispersal distance is difficult, as noted by the authors. All reference about 'rules of thumb' developed in very different systems, both in terms of oceanography and PLD, should always be taken with a grain of salt. PLD vs dispersal

distance is an extremely simplistic predictive model which ignores many other factors which might have as big of an influence on dispersal as the larval duration itself (e.g. behaviour). The results from the noted particle tracking studies near BC will provide really important contextual data to validate the PLD – dispersal distance predictions.

- So at what step in the design process would shape changes come into play? Theoretically those shapes which minimize the perimeter should be favoured. This consideration could be used as an index for relative scoring, however I agree with the authors that considerations fr enforcement and to maintain cohesive habitat structure is critical.

Section 9.2.3

- I still think the 'bootstrapping procedures' need more description and qualification.

Section 9.3.1

- The definitions of connectivity in this section are good. It might be worthwhile referencing these sections earlier in the report when they are first introduced.
- The restoration of any connectivity depends on the existing landscape. It is important to always remember that outside of MPAs there is existing management which is supposed to maintain population demographic processes (e.g. fisheries management for egg production and recruitment). Much of the discourse surrounding MPA benefits (which there are undeniably many) focus with some underlying construct that MPAs operate autonomously to other sustainable management tools. So it is important to keep this in mind when constraining how MPAs are linked to connectivity.
- Genetic connectivity is also influenced by habitat, particularly where genetic structure is robust and selection is occurring. For example, larvae might be exchanged but the realized 'connectivity' to the settlement location depends on their survival. In areas where selection is taking place, the connectivity might be limited by post-settlement survival and genetic structure. Even if dispersal could connect two areas it does not mean they are actually 'connected' in a population demographic sense. This is of course an extreme scenario where dispersal is occurring across a selective gradient. However, even in the absence of a string gradient, subtle differences in the survival associated with genetic structure can influence connectivity across a landscape.
- Unfortunately, most planning exercises focus on representativity which is not in the same units as connectivity.
- How does a map of habitat aggregation lead to ecosystem connectivity? Do the authors mean mapping the habitat required for connectivity among ontogenetic habitats (e.g. larval settlers – juveniles – adults) or linkages between carbon sources (e.g. kelp and eel grass beds) and sinks? One partial way of getting at this is developing MPAs which cut across multiple habitat types (e.g. nearshore – shelf) instead of focussing MPAs to specific, likely habitat delineated, features.

Section 9.3.2

- Should MPAs target areas which have no stressors, so to provide additional protection to those systems, or should MPAs target degraded systems so they have a better chance to recover by alleviating some stress (e.g. fishing)? Not sure there is a perfect answer, but it is something to consider in the document.

- Where possible the link between species and populations (genetic structure) and habitat should be made. Species distribution models coupled with climate projections can help to provide a spatial picture of where the influence of climate change is most likely to be pronounced and where species distributions might shift.

Final comments

Marxan is a useful tool for integrating a diversity of intersecting data layers and priorities. However, the output should serve as a guide. It was very promising to see from this report that the authors have listed numerous data driven considerations and post-hoc evaluations which can be used to craft this starting point.

It was also promising that this paper reviewed, in detail, many a wide variety of ecological concepts which jointly influence MPA effectiveness. I think it was important that the conservation priorities are informed by a wealth of ecological data and considerations as they will provide the baseline for the next steps. It would be useful to provide some guidance on how the interactions of conservation priorities will be evaluated (e.g. summed solution among different parameterizations) and how the chosen ecological scenario will be contrasted and integrated with the cultural, social, and economic considerations. How will the ecological priorities that are defined and targeted here be prioritized and balanced in the final plan? The amount the optimal ecological picture will change depending on this step.

Thanks again for the opportunity to review this paper and participate in the review process. I thoroughly enjoyed reading this tremendous work and am pleased about the pathway the Pacific region is taking towards MPA network planning.

Please don’t hesitate to contact me if you have any questions.

ISABELLE CÔTÉ, SIMON FRASER UNIVERISTY

Page 8 (bottom)

'*Recent developments in oceanographic modeling, genetics, and spatial modeling provide an opportunity to include connectivity explicitly in MPA design, where larval sources that are important for maintaining populations can be identified and incorporated as features in the network.'*

While this is true, there is rarely enough information on any of these aspects to produce a model that can accurately predict spatial patterns of dispersal or recruitment.

Page 9 (near bottom)

'Several reports detailing science-based MPA guidelines specifically recommend that a proportion of the MPA network should be zoned as no-take reserves '

1. Add O'Leary et al. 2016 for a more recent study that supports the notion that 30-35% of the ocean should be protected.

O'Leary, Bethan C.; Winther-Janson, Marit; Bainbridge, John M.; et al. 2016. Effective Coverage Targets for Ocean Protection. CONSERVATION LETTERS 9, SI398- SI 404

2. The interpretation of some of these studies is incorrect. These targets for strict protection often do not apply to the MPA network but to **the whole ocean or the whole ecosystem**. This is the case for Jessen et al. ('At least 30% of each bioregion should be within no-take reserves', page 11) , Fernandes et al 2005 (which applies to the whole Great Barrier Reef) and for O'Leary et al. ('protecting several tens-of-percent *of the sea* is required to meet goals', page 1). On the whole, I feel that this paragraph downplays the importance of strict protection.

This misinterpretation re-occurs on page 47 ('we recommend that 30% of the MPA network should be in no-take (IUCN Level Ia) or at least limited-take (IUCN Level Ib, II, III) reserves'). The end result is that if Canada reaches its target of 10% of sea under protection by 2020, only 3% of our marine waters will be under strict (no-take) protection. I seriously question how effective this will be to protect our marine biodiversity.

Page 10 (last line)

It's important to note here that these extremely small MPAs might be effective in coral reef habitats (which is what Fernandes et al. 2012 pertains to) since that size can encompass an entire reef. It is less clear that this is a scale suitable for most of the habitats on our Pacific coast.

Page 11 (near bottom)

…each potential MPA network configuration should be assessed for adequacy based on whether they can sustain viable target populations…

What is 'they' in this sentence? A network or each MPA within it?

Page 22

This paragraph should acknowledge more explicitly the source of information regarding conservation status of species. There is a well-known bias against the listing of marine fishes on SARA, especially for species that are commercially important (e.g., Schultz et al. 2013). At least

for fish, COSEWIC recommendations are a more accurate assessment of status than actual listing.

Schultz, Jessica A.; Darling, Emily S.; Cote, Isabelle M. 2013 What is an endangered species worth? Threshold costs for protecting imperilled fishes in Canada. MARINE POLICY 42, 125-132

Page 26 (top)

There are no academics listed in Appendix 5 as experts consulted.

Table 13

Shorezone coastal classes. I am flabbergasted by this classification! I'm not sure whether this is the place to debate whether these classes are meaningfully different in terms of the species assemblages they harbour. As an experienced diver, I would say that many are not.

Pages 40/41

It's not clear to me how the 'correlation' (which is actually a regression) shown in Figure 18 was arrived at. The sample size and stats are different than Shanks 2009, who found a weak, linear relationship between PLD and dispersal distance in log-log space. I'm also concerned about the uncertainty around the estimates of dispersal distance derived from this relationship because there is so much noise, especially for long PLDs. It should be made clear in Figure 14 which estimates of dispersal distance were measured empirically and which were derived from the Shanks relationship. It should also be possible to derive errors from that relationship for each estimated distance.

Section 8.3.1

It is not clear how interactions between stressors, which do not necessarily generate linear, additive impacts, are going to be dealt with in this framework. For example, the decision that 'If there are no moderate impacts, but there are one or more activities with a low impact on the conservation priority, the conservation priority is assigned a low level of potential impact for the MPA' (page 45), does not leave scope for these multiple low-impact activities to have a synergistic combined impact.

General points

There is great emphasis on connectivity, which is obviously important for designing networks, but some more isolated locations can contribute to representation of locally adapted populations and potential sources of adaptation for the future. Isolation (by deep water or sand) is also a key characteristic that contribute to the success of individual MPAs (i.e., the 'I' in NEOLI, Edgar et al. 2014, Nature).

You should consider a paper currently in review by D'Aloia et al. that shows the effect of using the movement characteristics of individual species characteristics vs multi-species averages to identify connectivity hubs when designing MPA networks. The framework is implemented using a set of hypothetical species that represent regional trait diversity in coastal BC. If this is of interest, I can ask the senior author to email you a copy of the MS.