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Proceedings of the Pacific regional peer review on Biogeographic Classification Framework to Inform Bioregional Marine Protected Area Network Design in Pacific Region

February 12-14, 2013
Nanaimo, British Columbia

Chairperson and editor: John Holmes

Fisheries and Oceans Canada
Science Branch
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Foreword

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

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting February 12-14, 2013, at the Pacific Biological Station in Nanaimo, British Columbia. One working paper, focusing on the components of a framework to describe marine species and habitat diversity for Pacific Region, that will contribute to marine protected area (MPA) planning at regional scales and to coastal zone management and planning activities at local scales in DFO Pacific Region was presented for peer review.

In-person and web-based participation included staff from DFO Science, Fisheries Management, and Oceans Sectors, and external participants from Parks Canada, the Province of British Columbia, First Nations organizations, environmental non-governmental organizations, and universities.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report with advice to Oceans and Ecosystem Management to inform the process of identifying ecologically coherent bioregional networks of marine protected areas (MPAs) in Pacific Region and to facilitate collaborative MPA network development and implementation in an international context in the northeastern Pacific Ocean.

The Science Advisory Report and supporting Research Document will be made publicly available on the CSAS Science Advisory Schedule.

Compte rendu de la réunion régionale d’examen par des pairs du Pacifique portant sur le Cadre pour la classification biogéographique qui servira de base à la conception d'un réseau biorégional de zones de protection marine dans la région du Pacifique

SOMMAIRE

Le présent compte rendu résume les discussions pertinentes et les principales conclusions de la réunion d'examen régional par des pairs du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada (MPO), qui a eu lieu du 12 au 14 février 2013 à la Station biologique du Pacifique de Nanaimo, en Colombie-Britannique. Un document de travail portant sur les composantes d'un cadre permettant de décrire la diversité des espèces marines et des habitats dans la région du Pacifique et qui contribuera à la planification des zones de protection marines (ZPM) à l'échelle régionale et à la gestion et à la planification des zones côtières à l'échelle locale dans la Région du Pacifique a été présenté en vue d'un examen par les pairs.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, on compte notamment le personnel du Secteur des sciences, du Secteur de la Gestion des pêches et du Secteur des Océans du MPO ainsi que des participants externes de Parcs Canada, de la province de la Colombie-Britannique, des organisations des Premières Nations, des organisations non gouvernementales de l'environnement et des universités.

Les conclusions et les avis découlant de cet examen seront fournis sous forme d'un avis scientifique à la Gestion des océans et des écosystèmes afin de guider le processus d'identification de réseaux biorégionaux de zones de protection marine cohérents sur le plan écologique dans la Région du Pacifique et de faciliter la collaboration dans le cadre de leur création et de leur mise en place dans le contexte international qui s'applique au nord-est de l'océan Pacifique.

L'avis scientifique et le document de recherche à l'appui seront rendus publics dans le calendrier des avis scientifiques du SCCS.

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS), Regional Peer Review (RPR) meeting was held February 12-14, 2013, at the Pacific Biological Station in Nanaimo, British Columbia, to review the components of a framework to describe marine species and habitat diversity for Pacific Region that will contribute to marine protected area (MPA) planning at regional scales and to coastal zone management and planning activities at local scales in DFO Pacific Region.

The Terms of Reference (TOR) for the review (Appendix A) were developed in response to a request for science advice from DFO Oceans Sector. Notifications of the science review and conditions for participation were sent to representatives with relevant expertise from within DFO, Environment Canada, Parks Canada, First Nations, the Province of British Columbia, environmental non-governmental organizations, and academia.

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

A framework for the application of ecological models, Delphic systems and habitat classification systems for describing what species and habitat diversity occurs where in the Pacific Canada marine environment by C. Robinson, J. Boutillier, D. Biffard, E. J. Gregr, J. Finney, T. Therriault, V. Barrie, M. Foreman, A. Pena, D. Masson, K. Bodtker, K. Head, J. Spencer, J. Bernhardt, J. Smith, C. Short. CSAP Working Paper, 2012/P45.

The meeting Chair, John Holmes, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications (Science Advisory Report, Proceedings and Research Document), and the definition and process around achieving consensus decisions and advice. All participants, whether attending in person or via webinar, were invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. The Chair confirmed that all participants had received copies of the Terms of Reference, working paper, working paper reviews, and a draft of the SAR prior to the meeting.

The goal of this RPR is to ensure that the proposed framework for marine ecological classification and modelling is suitable for the identification of fine scale biogeographic units in the Pacific marine waters of Canada at appropriate scales to meet varying management and policy needs in Pacific Region.

The Chair reviewed the Agenda (Appendix B) and the Terms of Reference for the meeting, highlighting the objectives and identifying the Rapporteurs for the review. 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 that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 34 people participated in the RPR (Appendix C). Jason Dunham and Cathryn Clarke Murray were the Rapporteurs for the meeting.

Participants were informed that Michelle Greenlaw (DFO - internal) and Mary Yoklavich (NOAA - external) were asked to provide detailed written reviews of the working paper to assist in shaping, but not limiting, discussion during the peer-review meeting. Michelle Greenlaw was present at the meeting and presented her reviews in person. Mary Yoklavich was unable to attend in person or via webinar and her review was read by the Chair, John Holmes. The

presenters of the working paper (Jim Boutillier and Cliff Robinson) were provided with copies of the reviews in advance of the meeting in order to prepare responses to the issues raised by the reviewers. Participants were also provided with copies of the written reviews in advance of the meeting.

The conclusions and advice resulting from this review will be provided in the form of a Science Advisory Report (SAR) to Ecosystems Management Branch of Oceans Sector, to inform marine spatial planning and marine protected area (MPA) planning in Pacific Canada marine waters. The Science Advisory Report and supporting Research Document will be made publicly available on the CSAS Science Advisory Schedule.

MARINE PROTECTED AREA NETWORK CONTEXT

Karen Leslie provided a brief overview of the Marine Protected Area (MPA) management context in DFO Pacific Region that led to the request for Science advice. Existing MPAs within Pacific marine waters have been designated using an ad hoc approach. A systematic approach to the development and designation of MPAs, which includes a framework to tease apart habitats, will be beneficial for MPA network planning and should contribute to enhanced long-term conservation and protection benefits for these areas through improved coordination of policies, work, and projects of other federal and provincial government agencies and ministries, First Nations, and stakeholder groups (i.e., fisheries, recreation, tourism, industry, conservation organizations, transportation, energy) in the region.

REVIEW OF WORKING PAPER

Working Paper: A framework for the application of ecological classification and modeling systems used to describe marine biodiversity in Pacific Canada bioregions. Cliff Robinson, Jim Boutillier, Doug Biffard, Jessica Finney, Ed Gregr, Mike Foreman, Vaughn Barrie, Karin Bodtker, Jo Smith, Joey Bernhardt, Jennifer Spencer, and Tom Therriault. CSAP Working Paper, 2012/P45.

Rapporteurs: Jason Dunham and Cathryn Clarke Murray

Presenter(s): Cliff Robinson and Jim Boutillier

PRESENTATION OF THE WORKING PAPER

Jim Boutillier provided an overview of the context in which this working paper developed and the goals it attempts to address and Cliff Robinson provided an overview of the methodology and findings in the working paper.

The authors noted immediately that they changed the title on the working paper from the title submitted above to "*Discussion and guidance on elements required for describing what species and habitat diversity occurs where in Pacific Canada marine environments*" because it better reflects the contents of the working paper.

The authors also noted that the Terms of Reference for this RPR meeting and the content delivered in the working paper were misaligned. They sought to reframe the working paper to bring it into better alignment with the TOR by focusing on the key elements of a framework to describe species and habitat diversity at ecologically meaningful sub-bioregion scale biogeographic units in Pacific Canada. The working paper also reviews strengths and weaknesses of the key elements, progress in Pacific Canada, and existing guidance to minimize or mitigate known issues. The RPR Chair asked the group if this revised focus in the working paper (and title) was acceptable and all participants agreed to proceed on this basis. The abstract of the working paper submitted for review is in Appendix D.

With the exception of single species assessments of commercially-valued species and SARA-listed species with defined critical habitats, there are few if any reference points that managers in DFO Pacific Region can use to evaluate the significance of human activities on the distribution of species and habitat diversity. This working paper and this meeting are attempts to provide further guidance on establishing reference points concerning the size and distribution of species and habitat diversity that could inform the policies, work, and projects of other federal and provincial agencies and ministries, First Nations, and stakeholder groups in Pacific Canada. It is expected that these reference points would be utilized within an ecological risk assessment framework (DFO 2012) to inform DFO Pacific region managers of the single or cumulative risks to diversity arising from human activities.

The authors described four key elements in a biogeographic classification framework for Pacific Canada (see Fig. 22 in the working paper):

1. management objectives, which bound the spatial area and determine spatial scale of the resulting biogeographic unit;
2. biotic and abiotic data in both the pelagic and benthic realms, including the identification of data availability and spatial resolution of data, which will inform the choice of tools that can be used, and identification of gaps;
3. tools (species distribution models (SDM), abiotic distribution models (ADM), Delphic (expert) systems) to analyze and summarize biotic and abiotic data; and
4. Ecological classification system through which elements 1-3 are synthesized, leading to maps of biodiversity.

The original intention of the working paper was to develop a framework for biogeographic classification to describe Pacific Canada marine biodiversity, but the authors realized that it was not possible to achieve this goal. A framework connects the key elements shown above in a logical and standardized sequence of steps from objectives through data review and analysis to the end product and provides guidance for completing each step and actions to take if certain conditions arise. The working paper is not prescriptive, as might be expected of a framework. The authors felt that it was too premature to propose a specific framework given progress to date in Pacific region and so focused on understanding the key elements of a framework. Data types and information available are problematic and had to be summarized for all to understand. Case studies were examined.

A literature review and assessment of 20 case studies to understand the strengths and weaknesses of different approaches and data needs in Pacific marine waters revealed that: 1) species and habitat diversity mapping in Pacific region tends to consist of one-off, single-species based projects using relatively disjointed data sets; 2) no single habitat classification system has been used in the benthic or pelagic realms; 3) several species distribution models have been used in Pacific Region, but there is no clear guidance on ‘best’ practices or structured application of these models; 4) relatively little research has been directed at describing pelagic realm diversity, and 5) there are large gaps in multi-beam acoustic data, particularly interpreted bottom backscatter data, which are limiting current descriptions of benthic diversity.

As a first step to make progress toward developing a framework, the authors recommended choosing an ecological classification system using the following criteria:

1. a system that is designed within ecosystems in mind;
2. a system that is presently used; and
3. a system that provides information at the spatial extent and resolution to meet management objectives.

Based on the criteria listed above, a biotically focused hierarchical ecosystem-level classification system developed by Last et al. (2010) in Australia was endorsed in the working paper as a model for BC marine waters after suitable modification and pilot-testing. Concerns raised by the meeting participants included: the Australian framework is based primarily on physical criteria rather than biota, it is unknown whether this approach has been used for MPA planning in Australia, and we may not be able to populate particular levels in the framework. Further, since BC shares the Pacific Ocean with other countries that have already developed frameworks, the question of standardization among frameworks was raised.

Lessons can be learned from existing classification systems, especially:

1. BC's terrestrial classification system, which was initially designed for the forestry industry, but is used by many groups. It took several decades to develop.
2. CMECS (Coastal and Marine Ecological Classification Standard), which was developed by NatureServe and NOAA in the US to provide a standard language for describing and comparing marine ecosystems. Pros and cons to CMECS were acknowledged; a pro is the classification scheme extends from the high water mark to depth. A con is that the system has not been widely adopted within the US. In general the overall structure of CMECS is useful and could be modified for the BC framework.

WRITTEN REVIEWS

MICHELLE GREENLAW

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

There was discussion (and disagreement) on how much the working paper authors should draw from existing DFO national papers, including one paper on representivity, although this paper does advocate classifying benthic and pelagic realms separately.

The reviewer showed a useful slide depicting ecological units at different scales that are used for marine planning on Canada's east coast. This scheme provides a general guide and recognition of different scales. Meeting participants were interested in this scheme and how it matches or differs from the scheme recommended by the working paper authors. Both schemes have a benthic focus and both were considered useful models for Pacific region to consider.

Often physical data are used to predict biota because biological data are lacking. However, rarely has the relationship between physical and biological data been ground-truthed. The working paper recognizes that the lack of ground-truthing is an important gap. Nevertheless, it is assumed that physical data, even in the absence of biological data, are useful in a classification scheme, regardless of whether or not ground-truthing is available. In reality, this issue will likely continue. In the Maritimes region there has been no ground-truthing for MPA planning layers.

It was noted that some discussion concerning the trade-offs among approaches to fill in data gaps, e.g., abiotic versus species distribution models, would be helpful in the revised Research Document.

The 3-5 year (i.e., short) time-line to develop a network of MPAs in BC was acknowledged. With data available today, the hierarchy will be filled from the top down, and then in the future as more data are available at finer scales, the hierarchy will be filled from the bottom up, and only then will we be able to assess the adequacy of the framework. Currently planning will have to be done at the level data exist, possibly at the regional instead of habitat level.

The group discussed whether the working paper should apply only to MPA network development or to a much wider range of resource management issues. The authors believe the working paper is applicable and useful for many management purposes and this should be reflected in the TOR. The working paper should acknowledge the initial expected focus and how it has changed because of the broader needs that were identified.

MARY YOKLAVICH

This section provides an overview of discussion regarding the written review provided by Mary Yoklavich prior to the meeting (Appendix F) and documents all decisions/agreements to amend the working paper based on this discussion.

The authors might want to consider additional tools such as:

1. Integrated Ecosystem Assessments (IEAs) - used in the US and considered in Canada in Gwaii Haanas; and
2. How Essential Fish Habitat (EFH) for salmon and groundfish are determined.

The framework being developed should be somewhat consistent with that being used in the US, although consistency in the US is also an issue. It is likely that the BC framework will not include human impact data which other frameworks do consider.

Spatially explicit ecosystem models such as Atlantis and Ecospace were briefly discussed.

The benthic and pelagic realms are separated in the proposed framework in the working paper. However, these realms are connected in the real world so perhaps the framework should consider the interaction between the two.

DISCUSSION

Discussion was organized around the four key elements of a biogeographical classification framework identified by the authors of the working paper and agreed to by meeting participants.

MANAGEMENT OBJECTIVES

Resource managers are seeking a tool for MPA network design that provides guidance in identifying areas for protection that are representative, rare, and connected. Such a tool is also needed for implementing ecosystem-based management. Managers need to know where different habitats are, the underlying ecosystem components, and the nature and extent of impacts and associated Reference Points. Managers need a framework that addresses many different objectives and can produce maps and inventories of biodiversity.

Resource management issues range from coast-wide MPA planning to site-specific exercises such as evaluating log dumping impacts so spatial scale is a critically important variable. Under the ecosystem approach to management managers need to know species distributions and habitats at various scales. What are the various spatial scales of decision-making? Scale must be defined by ecological relevance and not data availability. What are the scales of information available now? Currently data do not exist at all scales and likely never will. Managers must decide what level of error they are willing to accept because there will always be data gaps (i.e., lack of data and ground-truthing). The group recognized that the revised Research Document does not need to focus on specific management objectives, but the various scales need to be resolved, and data availability at the those scales needs to be identified.

The working paper requires several additional tables: one table to show high level objectives of the framework elements, another table with more specific information that outlines types of

management objectives, the various scales associated with different objectives, and existing data at each particular scale.

CLASSIFICATION SYSTEM

The hierarchical framework developed by Last et al. (2010) (and perhaps Michelle Greenlaw's slide of ecosystem scales) is central to the working paper. There was discussion about how well the Australian framework applies to the Pacific coast and to what extent it has been evaluated. In comparison, CMECS has different terminology, operates at finer scales, and has abiotic drivers at the top, biotic drivers at the bottom.

Consensus is required on the number of Levels, terminology for the Units, and Spatial Resolution and Extent (number of kilometres) for the proposed BC framework.

The next step will be to align data collection methods with the Levels.

The working paper will need to state why the Last et al. (2010) and east coast frameworks were ultimately chosen as templates. Terminology chosen for the Units will also have to be explained, and how they relate to terminology in existing frameworks. An appendix could be inserted in the working paper showing other common models with related terminology. The authors can draw on existing review papers to accomplish this task.

Spatially explicit frameworks do not capture temporal scales, but the BC framework will need to incorporate some temporal data such as fish migrations and seasonal use areas. A framework that is more biotic than abiotic-based will inherently have levels that change over time and scale.

Levels and Units

Defining Provinces in BC waters will be problematic due to a lack of data using a biogeographic species distribution approach. The group decided to keep the Province unit. BC probably has one province.

The ecoregion terminology is not consistent with the Last et al. (2010) classification system. Several participants disagreed with how Bioregions have been defined, while others believed they are acceptable, except the Offshore zone. The group agreed the Ecoregion is the correct scale for BC and a combination of the east coast framework and Last et al. (2010) will work well.

There was some discussion about the sub-divisions of Regional unit on the east coast and its utility in a BC framework. Some direction about this could be sought from PNCIMA work and the subunits that were considered.

The primary and secondary biotopes (in the Last et al. (2010) framework) were considered to be important; they are used on the east coast, although habitat is more often defined by physical attributes instead of species.

The working paper should have a table that starts with Level 1 as Province, and also include Species, Populations, and Genes. Benthic and Pelagic descriptors should be included as two separate columns. Scale will be similar for benthic and pelagic descriptions, although the pelagic divisions will not likely extend as far down the table as benthic.

Recommendations

1. The spatially explicit ecosystem model called Atlantis should not be used.
2. Acoustic bottom mapping (both bathymetry and bottom classification) of the shallow (white) zone should continue; it is an important data gap (as documented in the working paper). Both deep and shallow zones are important for different reasons.

3. The working paper introduction should provide some context about the present status of Pacific region in the “developing a framework” process.
4. Standardize terminology in classification at least in BC, and probably nationally.

PACIFIC MARINE ECOLOGICAL CLASSIFICATION SYSTEM PROTOTYPE

Meeting participants agreed on the need to amalgamate the Australian system, which has a biogeographic perspective (Last et al. 2010), and a scheme developed in Maritimes region with a benthic focus (Greenlaw et al. 2013) into a prototype Pacific marine ecological classification system (PMECS) during the RPR meeting. PMECS attempts to capture the scale-dependence and hierarchical organization of biota in both the pelagic and benthic realms. Meeting participants agreed on nine levels with standardized terminology, and information on spatial scale and data resolution. Some text was discussed on benthic and pelagic realm descriptions at each level, but the meeting left it to the authors to develop these descriptions more fully in the revised working paper. There is a clear break in the hierarchy below Level 9, which consists of species, populations, and genes in the Last et al. (2010) system. These levels are not hierarchical in that they cannot be nested within the higher ecological levels shown here and meeting participants agreed that further work on these levels is needed but was not necessary at this time.

Level 0	Realm
Level 1	Province
Level 2	Bioregion
Level 3	Ecosection
Level 4	Bathome
Level 5	Geozone
Level 6	Primary biotope
Level 7	Secondary biotope
Level 8	Biological facies
Level 9	Micro-communities

Clear definitions of each level of classification are required, including what makes each level distinct. All of the columns of the table are required to define each level (description, spatial extent, and data resolution). The spatial extent and the spatial resolution decrease moving from lower to higher levels in the hierarchy. The Australian classification scheme (Last et al. 2010) utilizes a hierarchy of spatial habitat units as well as hierarchy of ecological units (ecosystem>communities>species) in parallel.

The level 0 designation could be called Realm and linked to the ecoregions of the world (Spalding et al. 2007). The subregion level from other schemes was called Ecosections, after the BC Provincial classification. The Ecosections classification should use descriptors from the BC Marine Ecological Classification System (see Zacharias et al. 1998) based on three criteria: physiographic, oceanographic, and biological. An example of an Ecosection is Hecate Strait, within the Northern Shelf Bioregion. There are oceanographic conditions occurring at different scales (bioregion>ecosection). Not all levels will be useful for all areas. The Ecosection level of classification does not have to apply to each Bioregion, as some Bioregions are smaller than others, e.g., the Strait of Georgia Bioregion may not have any Ecosections.

The next level, Bathome, brings in a third dimension, depth. Following Bathome, the group agreed on Geozones, followed by biotopes. Ecounits from the BCMEC (Zacharias et al. 1998)

are a good starting point for the biophysical properties required to classify biotopes. But this level also requires biotic information. There must be a clear definition of the biological properties used for primary versus secondary biotopes. Both primary and secondary biotope levels were used by Last et al. (2010). Primary biotopes would be soft, hard, etc., while secondary biotopes could be soft>mud, sand, ooze, etc.

The classification works nicely as a benthic classification (similar to CMECS), but it gets more complicated when pelagic components are added and even more so with the interaction between benthic and pelagic. The benthic-pelagic classification starts to become non-hierarchical at some point.

The group felt that the classification scheme should have separate descriptions for benthic and pelagic environments. An example of a pelagic biotope is seabird foraging areas (in some cases large scale, predictable areas) driven by oceanographic processes/bottom type, etc. A benthic biotope could be considered continuous while the pelagic may be discrete. Surface primary productivity is one continuous variable that could be useful for delimiting pelagic biotopes. The classification could utilize separate spatial scales and extents for pelagic and benthic, as long as they decrease moving down the hierarchy.

The next levels, Biological facies and Micro-communities, may not make sense for Pacific region as they are based originally on the fundamental units for the Great Barrier Reef, the coral reef. It is common in classification schemes to go from biophysical to biological characteristics and there is a fundamental break between micro-communities (ecosystem) and species. Species>populations>genes almost break down in the hierarchical scheme, they become descriptors and not necessarily hierarchical. The classification scheme should explicitly acknowledge the transitions and break points, perhaps as a footnote. The biological facies term is not commonly used and is difficult to understand. There was discussion about changing to a more intuitive term, but no obvious candidates were proposed and so meeting participants decided to continue with biological facies, at least in the prototype PMECS.

It was noted that the spatial scale of micro-communities is 10s of meters and that spatial resolution is less than $1m^2$. It was emphasized that care should be taken not to get into taxonomic classifications, e.g., metapopulations, breeding populations, etc. The Last et al. (2010) system for spatial management normally stops at biological facies and rarely goes below to species. In a practical sense it is a management question as to the level at which management will occur. The lower levels after micro-communities may not be useful for MPA-level planning but in some cases single species (Species-at-Risk Act - SARA) or population level management are needed. The levels after Micro-communities should not have spatial scale or extent values because scale and resolution are not useful at these levels and vary between habitats and species.

Participants felt that from a planning perspective, the needs are very simple and captured by the PMECS prototype classification scheme table, as long as the tool is common between areas and planning needs. The group proposed using the PMECs prototype hierarchical structure as a straw man to examine how the data fits into the scheme. Although the classification schemes that work have a field data requirement, the scheme should act as a blueprint rather than its structure being driven by the spatial scale of available data. The classification scheme will not work well for large migratory species and perhaps another column could be added to highlight that migratory species span the classification scheme. The heart of a classification scheme combines smaller classification schemes and should include relevant published schemes where available (Provincial Ecosections, BCMECs as an input to the Biotope levels).

Two revisions to the working paper were noted;

1. the spatial extent for Ecosections is likely 100s-1000s, not 100s as written in the draft table. Spatial extent could also be presented as a measure of area (km2); and

2. the classification captures intertidal areas to the deepest depths. The table should be modified to include the full range of habitats from the BCMECs classification.

Data Sources

There are four types of data available that could be used in a biogeographic classification system, including water properties, bathymetric, geological, and biological. Research data collected for a single purpose can be used for other purposes, for example, CHS data can be refined to get at bottom types. Within DFO, hundreds of dive surveys, scientific surveys and data collected for fisheries quota management can be used for other purposes, such as biogeographic classification. In addition, consultants conduct ecological assessments (usually just a report) but there is no system in place to upload, interpret and conduct quality control checks on the data supporting these assessments.

Standardization is required for research methods, data collection, and protocols for use in secondary purposes, quality assurance, data management, and distribution. A good example is the freshwater fish survey permits issued by the Province of BC which stipulate that permit holders must adhere to published standards and they must enter the raw data directly into a centralized data warehouse. The group identified a number of data source issues: 1) standards for data collection (available, agreed and enforced), 2) data storage, 3) data access, 4) data products. For example, it may not be useful to access raw data, but a "product" such as a GIS layer, query, or masked data could be provided to maintain confidentiality, 5) communication (data gaps, etc.), 6) data integration (a part of data storage and access). In the current system, shellfish data, groundfish data, bathymetry, etc. are all stored separately. DFO has a data management policy, however compliance with the policy is often lacking. Another issue within DFO is the lack of a dedicated GIS unit.

A consensus was developed among participants to capture the data issues in the SAR recommendations and bring them to the attention of managers.

A matrix showing the PMECS levels and where the four data types fit or are informative from a users' perspective, was partially developed during the meeting. Meeting participants agreed that this classification-data matrix should be added as a revision to the working paper and that examples within the working paper should be used to populate the table. Reorganize how the data is presented in the frame of the proposed classification system, tie to data, methods and management objectives back to the hierarchy. The SAR could also make a recommendation to test and populate the table more thoroughly, in an adaptive manner. There is a break in the scheme where biological data comes in (at the biotope level).

In the working paper, the authors fell short of recommending the Last et al. (2010) classification scheme. Meeting participants modified this scheme to meet perceived Pacific region needs during the meeting and suggested that: 1) the revised classification should be in the working paper, noting that it started from Last et al. (2010) and was adapted by the group; and 2) the classification/data matrix should be included with the data examples/model types and outputs already in the working paper.

Models/Tools

There are some examples in the Pacific region of the use of species distribution models (SDM). SDMs map species distributions at lower levels and are used in the absence of observational data. One of a number of recommendations in the working paper was an evaluation of the different SDMs to determine their utility within a biogeographic classification framework in Pacific Region. Validation is a problem for these types of classification schemes and the SDMs could be used as part of the validation exercise. The SAR should recommend that standards be

developed for the use of models such as SDMs. Guidance could be provided on how to choose models/tools and examples, rather than specifically which model to choose.

Meeting participants highlighted two paths forward regarding models:

1. Identify standards or criteria for deciding which models/tools to use; and/or
2. A pilot study to test models (using a pilot set of data) and develop standards based on the knowledge gained.

A generic recommendation will be added to the working paper regarding standards for the use of models.

Uncertainty

There should be a recommendation for standards in addressing uncertainty. The appetite for explicit identification of uncertainty depends on the user. Some uncertainty is a result of lack of knowledge and some is due to data uncertainty and it is important to distinguish the source of uncertainty. Track uncertainty and the sources of uncertainty, within the context of the framework. The degree and type of uncertainty may vary at each level of the hierarchy. There are simple methods to assign a measure of confidence/uncertainty for each dataset (qualitative) and in turn there are more complex ways to test models (bootstrapping, simulations, etc.). It could be a requirement that models based on the ecological classification system report their uncertainty. Meeting participants agreed that the recommendation for the working paper should be that sources and measures of uncertainty be captured and documented at each stage and at each of the classification levels.

Scalability and Adaptability

The issue of scalability has been addressed in the classification scheme and the identification of spatial scale/resolution at each level. Scalability should be specifically addressed in the SAR.

The classification scheme should be adaptable, able to incorporate new information. However, guidance is needed on how and when to incorporate new information such as new models and updated model outputs into the system. The adaptability of the scheme should be noted in the SAR.

Temporal Change

There was recognition that ecological classification schemes do not capture temporal change very well, .e.g., climate change. Modifiers for temporal change can be applied at each of the levels, but this is a crude approach. Some sort of process to track temporal changes and update the framework is needed and should be a recommendation in the SAR.

CONCLUSIONS AND RECOMMENDATIONS

Meeting participants agreed that the working paper, subject to revision, was acceptable for publication as a CSAS Research Document. The meeting participants and authors developed consensus on the following list of revisions to the working paper as well as conclusions, recommendations, and key advice arising from this review and discussion of the development of the Science Advisory Report. The group discussed which items were to be reflected in the Science Advisory Report, by working though bullets for the SAR drafted by the Chair and working paper authors.

WORKING PAPER REVISIONS

1. The title of the working paper should be changed to “Key elements in the development of a hierarchical marine ecological classification system to support ecosystem approaches to management in Pacific Canada”
2. Two ecological classification systems were amalgamated into a prototype Pacific marine ecological classification system (PMECS) during the Regional Peer Review meeting. There is a need to standardize and clarify terminology, probably using existing DFO terminology for the different levels. The working paper authors were asked to complete the development of PMECS, including terminology, spatial extent and data resolution at each level, and provide detailed descriptions of the benthic and pelagic realms at each level in the revised working paper. It was noted that PMECS should be able to scale up to broader levels (e.g., North Pacific) and scale down to species, populations, and genes. O’Boyle (2010) summarizes the terminology of biogeographic classification systems and should be included in the revised working paper.
3. The working paper should be re-organized around the prototype PMECS classification system developed during the RPR meeting. Discussion of the other key elements in a framework - management objectives, data, and tools - should occur within the context of the PMECS classification system.
4. The revised working paper should include the classification-data matrix table partially developed at the RPR as it provides a useful way to discuss data sources, issues and gaps in Pacific marine waters.
5. The revised working paper should provide management applications examples to illustrate the point that management objectives (level at which decisions are made) informs spatial scale and resolution of data needs, applicable tools, etc. for developing biodiversity information.
6. Application of any of the reviewed tools (SDMs, ADMs, Delphic models, etc.) will generate questions about which tools should/could be used in addressing a wide variety of management objectives. Guidance on trade-offs between different model types, i.e., when to use abiotic model vs. SDM vs. Delphic process would be useful.

RECOMMENDATIONS FOR THE SCIENCE ADVISORY REPORT

1. Pilot testing of PMECS;
2. Pilot study to examine utility of different SDMs applied to same data sets over a range of areas;
3. begin addressing data issues identified in the working paper;
4. Develop standardized methods and protocols to support both the data collection and application requirements of SDMs, ADMs, Delphic processes, etc., for their use in Pacific Region. A review of existing abiotic and biological datasets within the Region combined with existing literature could identify key variables required to apply these tools; and
5. Data standards and data management issues will need to be further resolved moving forward with these tool applications. Requires agreement among all players for smooth functioning system. Took about 40 years in terrestrial world to get appropriate ECS in place.
6. It is recognized that ecological classification systems capture enduring features well, but do not capture temporal change very well. A process is need to track change and to update

the PMECS as new information becomes available, e.g., guidance on accepting output for new/different models

It is recommended that both the SAR and Research Document acknowledge the initial expectation for paper as shown in the TOR and the pathway it subsequently took, i.e., discussion and guidance on key elements in a framework.

SUMMARY AND CLOSING

The meeting concluded on time. The majority of the Science Advisory Report was completed and the Chair noted that he intended to circulate a draft within two weeks of the meeting. The working paper was approved as a Research Document, subject to acceptance by the Chair of revisions for which consensus was developed by meeting participants. The Chair thanked the participants and the presenters. He noted that the spirit of collaboration fostered during the meeting had led to constructive suggestions that will improve the Research Document and resulting biogeographic classification framework.

The key findings and conclusions of this meeting were captured in the associated Science Advisory Report. One DFO Science Research Document will be produced as a result of this meeting.

ACKNOWLEDGEMENTS

The Chair acknowledges the assistance of Marilyn Hargreaves and Nic Dedeluk in organizing and running a smooth meeting. The Chair thanks the working paper authors for a well written paper and spirited participation in responding to all questions and comments. He also thanks Mary Greenlaw (DFO) and Mary Yoklavich (NOAA) for their detailed and constructive reviews of the working paper, which stimulated highly constructive discussion and recommendations. Meeting participants, many of whom are experienced practitioners of biogeographic classification are commended for engaging in a highly collaborative dialogue with the authors and Chair that improved all of the products from this meeting. Finally, the Chair and working paper authors are grateful to Jason Dunham and Cathryn Clarke Murray for their skill as rapporteurs in capturing the relevant discussion, agreements and recommendations.

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Zacharias, M.A., Howes, Don E., Harper, J. R., and Wainwright, Peter. 1998. The British Columbia Marine Ecosystem Classification: Rationale, Development, and Verification. Coastal Management 26:105-124.

APPENDIX A: TERMS OF REFERENCE

Biogeographic Classification Framework to Inform Bioregional Marine Protected Area Network Design in Pacific Region

Regional Peer Review – Pacific Region

February 12 – 14, 2013
Nanaimo, BC

Chairperson: John Holmes

Context

In June 2009 CSAS hosted a Science Advisory Process on the Review of Biogeographic Classification Systems which identified 12 major biogeographic units for Canada's three oceans (four in the Pacific, five in the Arctic, and three in the Atlantic) (DFO, 2009). The review concluded that each of the major biogeographic units represents a "maximum scale" that can be disaggregated/subdivided further into smaller units that are ecologically meaningful. It was noted that there is no single prescription for determining the level of disaggregation for finer scale units as the choice will be guided by the management or policy use being made of the biogeographic classification system. Based on these conclusions, it was agreed that discussion and guidance on the disaggregation/subdivision of the major biogeographic units should occur in each DFO Region through their formal review process.

Science advice and guidance on biogeographic classification is critical to the development of bioregional networks of MPAs in the Pacific Region at appropriate biogeographic scales. Canada has agreed to utilize the scientific criteria for identifying ecologically or biologically significant marine areas and the scientific guidance for selecting areas to establish a representative network of MPAs articulated by the United Nations Convention on Biological Diversity (CBD) in Decision IX/20 (CBD, 2008). For Canada to meet this commitment, the appropriate units of biogeographic regions need to be identified regionally.

The goal of this meeting is to review a proposed framework of marine ecological classification and modelling for the Pacific coast of Canada to guide the identification of fine scale biogeographic units that capture habitat and biotic diversity at appropriate scales to meet varying management or policy needs in Pacific Region. The meeting will not review products of the framework, as the focus is on the process used to derive scientifically defensible fine scale biogeographic units. The resulting scientific guidance and advice will fulfill DFO's commitment to develop regionally-based guidance on multi-scale biogeographic classification and it will meet international commitments to support broader MPA network development. The framework and associated guidance will be used by DFO Pacific region to continue the process of identifying ecologically coherent bioregional networks of MPAs in collaboration with federal and provincial partners, First Nations, and stakeholders and to facilitate collaborative MPA network development and implementation in an international context in the northeastern Pacific Ocean.

Objectives

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

A framework for the application of ecological classification and modeling systems used to describe marine biodiversity in Pacific Canada bioregions. Cliff Robinson, Jim Boutillier, Doug Biffard, Jessica Finney, Ed Gregr, Mike Foreman, Vaughn Barrie, Karin Bodtker, Jo Smith, Joey Bernhardt, Jennifer Spencer, and Tom Therriault. CSAP Working Paper, 2012/P45.

The objectives of this Regional Peer Review meeting (RPR) are to:

1. Ensure that all marine biogeographic classification systems/approaches relevant to British Columbia marine environments were reviewed using appropriate criteria;
2. Assess the capacity of the framework to capture habitat and biotic diversity of BC marine environments based on ecological criteria including, but not limited to, representivity, connectivity, replication, and adequacy/viability;
3. Ensure that uncertainty, bias, and data gaps are appropriately captured and addressed in the proposed framework;
4. Assess the scalability of the proposed framework for application at different spatial scales, depending on management and policy needs;
5. Assess the adaptability of the proposed framework to the integration of additional data or information as they become available;
6. Recommend additional criteria or approaches for capturing habitat and species diversity that are appropriate for BC marine areas; and
7. Make recommendations on whether the proposed framework serves the intended function of guiding the development of finer-scale biogeographic units in fulfillment of DFO's commitment to develop regionally-based guidance on multi-scale biogeographic classification for MPA network development in Pacific Region and international commitments to support broader MPA network development in the Pacific Ocean.

Expected publications

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

Participation

- DFO Science. Oceans, Habitat, Species at Risk
- DFO Fisheries Management
- DFO Ecosystem Management
- Environment Canada
- Parks Canada
- Province of British Columbia
- First Nations
- Marine Use Planning Initiatives (e.g. municipalities/West Coast Aquatic partnership)
- Environmental Non-governmental Organizations
- Universities
- United States National Oceanic and Atmospheric Administration

Additional Information and References Cited

Convention on Biological Biodiversity (CBD). 2008. Annex III: Scientific Guidance for Selecting Areas to Establish a Representative Network of Marine Protected Areas, including in Open-Ocean Waters and Deep-Sea Habitats. COP 9 Decision IX/20. Marine and Coastal Biodiversity.

DFO. 2009. Development of a Framework and Principles for the Biogeographic Classification of Canadian Marine Areas. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2009/056.

APPENDIX B: AGENDA

REGIONAL PEER REVIEW MEETING (RPR)

Centre for Science Advice Pacific

Biogeographic Classification Framework to Inform Bioregional Marine Protected Area Network Design in Pacific Region

February 12-14, 2013
Nanaimo, BC

Chairperson: John Holmes

Day 1 Tuesday 12 Feb, 2013

Time	Subject	Presenter
09:30	Welcome and Introductions	John Holmes
09:45	Review Agenda and Housekeeping Items	John Holmes
10:00	CSAS Overview and Meeting Procedures	John Holmes
10:15	Review Terms of Reference/ Context	Karen Leslie
10:30	Presentation of the Working Paper	Cliff Robinson/Jim Boutillier
11:30	Reviewer Presentation and Authors Response	Michelle Greenlaw
12:15	***Lunch Break***	
13:15	Reviewer Presentation and Authors Response	Mary Yoklavich
13:45	Framework Components – Management objectives & spatial requirements	RPR Participants
14:30	***Break***	
14:45	Classification Schemes	RPR Participants
16:30	***Adjournment***	

Day 2 Wednesday 13 Feb, 2013

Time	Subject	Presenter
09:00	Introductions & Housekeeping	John Holmes
09:15	Review Day 1, TOR, & Agenda for Day 2	John Holmes
09:30	Classification Table – Terminology, scale and resolution, pelagic and benthic descriptors	RPR Participants
10:15	***Break***	
10:30	Data (bias, gaps) • Bathymetric, Geological, Oceanographic, Biological	RPR Participants
12:15	***Lunch Break***	
13:15	Tools – Mapping, Modeling, Expert Approaches	RPR Participants
14:30	***Break***	
14:45	Adaptability – integration of new data/information	RPR Participants
15:15	Moving Forward • Pacific Region applications • Pilot studies • User input and recommendations	RPR Participants
16:30	***Adjournment***	

Day 3 Thursday 14 Feb, 2013

Time	Subject	Presenter
09:00	Introductions & Housekeeping	John Holmes
09:15	Review Days 1 & 2, TOR, & Agenda for Day 3	John Holmes
09:30	Discussion & resolution of issues from Days 1 & 2	RPR Participants
10:15	***Break***	
10:30	Science Advisory Report (SAR): Develop consensus on • Key findings & conclusions • Uncertainties • Application to Pacific MPA network design • Recommendations for future work • Recommendations for Working Paper revisions	RPR Participants
12:00	***Lunch Break***	
13:00	Finalize (Draft) Science Advisory Report	RPR Participants
14:30	***Adjournment***	

APPENDIX C: ATTENDEES

Name	Affiliation
Biffard, Doug	BC Parks, Victoria
Bodtker, Karin	Living Oceans Society, Vancouver
Boldt, Jennifer	DFO Science, Marine Ecosystems and Aquaculture Division
Boutillier, Jim	DFO Science, Marine Ecosystems and Aquaculture Division
Brown, Robin	DFO Science, Ocean Science Division
Chamberlain, Jon	DFO FAM--Aquaculture
Chandler, Peter	DFO Science, Ocean Science Division
Clarke Murray, Cathryn	World Wildlife Fund, Vancouver
Curtis, Janelle	DFO Science, Marine Ecosystems and Aquaculture Division
Diggon, Steve	Coastal First Nations
Dunham, Jason	DFO Science, Marine Ecosystems and Aquaculture Division
Gauthier, Stephane	DFO Science, Marine Ecosystems and Aquaculture Division
Greenlaw, Michelle	DFO Science, Coastal Ecosystem Science, Maritimes
Greigr, Ed	UBC--Scitech Environmental Consulting, Vancouver
Hargreaves, Marilyn	DFO Science, Canadian Science Advisory Secretariat-Pacific
Holmes, John	DFO Science, Marine Ecosystems and Aquaculture Division
Hunter, Karen	DFO Science, Salmon and Freshwater Ecosystems
Jackson, Dave	DFO Science, Canadian Hydrographic Service
Jessen, Sabine	Canadian Parks and Wilderness Society, Vancouver
Leslie, Karen	DFO Ecosystem Management Branch, Oceans
Lougheed, Cecilia	DFO Science, Environment and Biodiversity, Ottawa
MacConnachie, Sean	DFO Science, Marine Ecosystems and Aquaculture Division
Mitchell, Jessica	DFO, Oceans Policy and Planning, Ottawa
O, Miriam	DFO Science, Ocean Science Division
Perry, Ian	DFO Science, Marine Ecosystems and Aquaculture Division
Reid, Bruce	DFO Ecosystem Management Branch
Robinson, Cliff	Oceanus Ecological Services, Nanaimo, BC
Short, Charlie	BC Forests, Lands and Natural Resources, Victoria
Simpson, Jennifer	DFO Ecosystem Management Branch, Oceans
Smith, Jo	Marine Planning Partnership, Smithers, BC
Stadel, Angela	Environment Canada, Regional Analysis and Relationships
Therriault, Tom	DFO Science, Marine Ecosystems and Aquaculture Division
Thompson, Jason	Haida Nation
Workman, Greg	DFO Science, Marine Ecosystems and Aquaculture Division
Yoklavich, Mary	NOAA

APPENDIX D: ABSTRACT OF WORKING PAPER

The focus of this working paper was to discuss the development of a sub bioregion-scale assessment framework for marine species and habitat diversity in Pacific Canada and is intended to contribute to both MPA planning at regional scales and to coastal zone management and planning activities at local scales. The ultimate goal of the framework is to provide resource managers with a plan for a collaborative, coordinated, pragmatic and science-based approach for generating inventories and maps of marine species and habitat diversity at appropriate spatial scales and resolutions. The science-based framework considered the following key elements:

1) species and habitat diversity within pelagic and benthic realms,
2) management objectives and spatial requirements,
3) application of a suite of tools to analyze and summarize biotic and abiotic data, and
4) identification of important data sources and gaps.

Twenty case studies were assessed with a questionnaire and literature review to better understand the types of models, expert systems, and classification systems used presently to describe species and habitat diversity in the pelagic and benthic realms of Pacific region, and to understand data requirements and gaps. The assessment revealed that:

1) species and habitat diversity mapping in Pacific region tends to consist of one-off, single-species based projects using relatively disjunct data sets.
2) No single habitat classification system has been used in the benthic or pelagic realms,
3) a few different species distribution models have been used in Pacific Region, but there is no clear guidance on 'best' practices or structured application of these models,
4) relatively little research has been directed at pelagic realm diversity, and
5) large gaps in multi-beam acoustic data, particularly interpreted bottom backscatter, are limiting current descriptions of benthic realm diversity.

Based on these findings, it was recommended that an assessment of species distribution models is warranted using a pilot study approach, that standards for data collection, storage and sharing are required, and finally that an Australian-based ecosystem-level classification system with a biotic focus should be adopted, modified and pilot-tested in Pacific region. The recommended framework and way-forward is the end-result of many discussions with more than 20 experienced practitioners in Pacific region, and ultimately will only succeed through further collaborative interactions between biodiversity researchers and resource managers, and through adaptive modification of elements within the framework.

APPENDIX E: WRITTEN REVIEWS

Reviewer #1: Michelle Greenlaw, Fisheries and Oceans Canada, Ecosystem Science, St. Andrews Biological Station, Maritimes Region

Working Paper: Robinson, C., J. Boutillier, Doug Biffard, Jessica Finney, Ed Gregr, Mike Foreman, Vaughn Barrie, Karin Bodtker, Jo Smith, Joey Bernhardt, Jennifer Spencer, and Tom Therriault. A framework for the application of ecological classification and modeling systems used to describe marine biodiversity in Pacific Canada bioregions. CSAP Working Paper, 2012/P45.

This document describes a framework to establish appropriate biogeographic and physiographic data to identify fine scale biogeographic units for many (DFO) management decisions in the Pacific Region. I appreciate this effort, and have begun to think of how we similarly might begin consolidating our work in the Maritimes Region. It is a difficult task considering the variety of biogeographic and geophysical data required to establish biogeographic units appropriate for the different management purposes under DFO purview. The broad management needs will also require the incorporation of a broad variety of methods that incorporate these data for different purposes, considering the limited amounts of time and data that are available. That being said, I realize you would like to fit your discussion into a readable amount of text. I have consolidated some of my thoughts below as I read through the report. I have also made editorial comments and suggestions within the document using track changes. If you have any questions, feel free to contact me.

As a note, there is some discrepancy between what the TOR and the title, and then what document actually describes. I had a bit of difficulty suggesting changes without clarification on what should be accomplished from this document.

The document is more of a description of the different types of methods available, and an inventory of international and Pacific-based approaches. The document doesn't do a lot to compare and contrast the methods, or guide which should be used for specific management decisions. If I were to title the current document I would call it "An inventory of methods and tools for describing species and habitat diversity in the Canadian Pacific" rather than "A framework for the application of……". There are a couple recommendations at the end for moving forward, but I would hardly call that a framework.

The TOR states that the goal is to review the framework…..to guide the identification of fine scale biogeographic units that capture habitat and biotic diversity. This suggests that the document will make suggestions on which methods to use to guide this identification depending on the management context.

The title "A framework for the application…..", suggests that the framework will talk about how to apply these methods, so again how to choose between and apply these methods for describing fine scale biogeographic units or species and habitat diversity.

Overall the document has the required elements necessary to create a framework of the nature described in the title and the TOR. To achieve such a framework, there are many sections of the document that should be bolstered. In many cases I found the framework does not provide enough clarity and detail for management to make a proper decision on which tool and scale would be the appropriate for their management decision, as the decisions and scales will vary. I would encourage suggestions of how you would choose one method over the other, in the context of the popular management decisions they will inform. A discussion of short term goals vs. long term goals would also be appropriate.

Many of my comments in the document are centered around keeping the document in concordance with DFO national guidance and international advice and with proper DFO terminology.

Some of the elements I mention below, you've included in the document and just need more clarity, once you have clarified the discrepancy between the objectives in the TOR and the title of the document.

Specific Comments

Consolidate the title (or clarify the title):

- "A framework for the creation and application of biogeographic and physiographic data in the Canadian Pacific marine environment (bioregions)"
    - Encompasses all the types
    - Spatially based
- "A framework for the application of ecological modeling data and classification systems in the bioregions of the Canadian Pacific"

Management will also have to decide which ecosystem functions or processes need to be mapped, predicted or inferred to inform the selection of scale and method. Mapping of boundaries at one level in the hierarchy requires information at the next level down in the hierarchy. i.e. boundaries between geomorphic units are based at least in part on information about substrate type and sedimentary process.

A difficult question is what biological, geological and oceanographic information are relevant to map, predict or infer, based on which functions and processes are important to map within the particular area of interest. This is not captured in the "identify data requirements section". If there is data to map these functions and processes they should be used directly, otherwise those variables that best describe their distribution patterns should be used (either from regional knowledge or from international advice)…surrogates.

There is no distinction between methods that have fuzzy or crisp boundaries, or map distributions instead of classifications, even though these terms are implied in the section titles? Mapping expected biological diversity and distribution gradients, vs. mapping recognizable biologically distinctive units, that are expected, or predicted to have different biological species diversity and distribution patterns.

The term "habitat" in the context of habitat mapping does not have a fixed definition and can be used to describe a range of attributes from the same extent at different spatial and temporal scales. Brown defines the term habitat mapping to mean "the use of spatially continuous environmental data sets to represent and predict biological patterns". The definition you're working with should be included in the document, along with some other definitions. Also, remember to keep your definitions DFO specific, or at least reference where they come from. (i.e., the definition of biodiversity in the context of this document).

The issue of scale for the identification and mapping of habitats is dependent upon their being viewed as nested within a hierarchy of spatial and temporal scales. The ecosystem-based approach to planning uses habitats and other natural regions as planning units, but natural regions need to be identified on a range of hierarchically nested scales to design habitat mapping programs as well as for planning for management needs. You do mention this at some point, but scale should be discussed explicitly somewhere in the document, not just under the discussion of one method as it is now. Include an ecological hierarchy for management to choose an appropriate scale, fine scale features vs. regional scale delineations. The production of habitat maps or ecological classifications for management uses within DFO will require a variety of scales, which may not be captured under the term 'habitat' mapping as they are not all

going to be at the habitat scale. Specifically, MPA planning may begin at a regional scale. You have one on page 70 that should be brought up front and discussed explicitly, including recommendations of which one to use for your region.

Biodiversity was a particularly touchy term in this document. Many times, you will not be mapping biodiversity at all, but inferring it or predicting it. Your definition of the data your creating and methods used to create them should reflect this.

Bioregions are NOT biodiversity, they are biogeographic units, defined based on their geologic history and endemic species, and divided based on their ecology into the intertidal, neritic, and pathypelagic biomes. They are spatially recognizable units, that are expected to be biologically distinctive, that are nested within provinces having high levels of associations between organisms. They should be related to biodiversity patterns but are not biodiversity in themselves.

Context should be updated for MPA planning to reflect recent national advice, which will be out soon. I'm not sure if you can do this if it isn't out before the meeting…"The appropriate scale is designated by the ecological functions the region is trying to protect."

There is some confusion in the context. All management needs vs. MPA needs. Do you really talk about how this framework is contributing to resource management and habitat management decision needs? What are some example decisions that will be made and how will these layers contribute to these decisions? What scale do they need to be? Do you really need to map at the habitat scale to begin to achieve the management needs you've described, like MPA planning?

We are asked to assess the capacity of the framework to capture habitat and biotic diversity based on ecological criteria including representivity, connectivity, replication and adequacy and viability. Some of these obviously need to be addressed separately with research: connectivity, adequacy (then replication) and viability.

Text on trade-offs between approaches and how to choose an option is necessary:

- Delphic or data driven approaches
- Single species (species distribution or habitat suitability)
- Abiotic habitat mapping (not distribution modeling, as we are creating actual classifications using segmentation)
- Biotic habitat mapping or classification
    - Associations determined afterwards
    - Biological data included from the start

Framework

1. Consider species and habitat diversity within the pelagic and benthic realms
    a. This should come after "Identify management objectives and spatial requirements"
    b. It doesn't necessarily need a separate heading
2. Identify management objectives and spatial requirements
    a. Scale should be explicit here (an ecological hierarchy should be included). Scale and extent could be a separate step in the process??
    b. Consider benthic and pelagic should come afterwards.
    c. The framework should compare and contrast scales of some common management decisions (habitat decisions, MPA planning, MPA boundary

delineation, commercial fishery habitat suitability modeling (by-catch habitat suitability modeling)

3. Identify and apply tools to map species and habitat distributions
    a. "Identify appropriate method to create or infer species diversity and distribution patterns (to achieve the management goal)?"
    b. How are you going to choose?
    c. Expert-based approaches could be taken out as a separate decision in the process? Expert processes can also use data driven approaches, but the decisions are made by the experts…makes it difficult to use as a heading within this section.
        i. Species distribution modeling or single species habitat suitability modeling
        ii. Ecological classification approaches
            1. Surrogate-based or 'abiotic' habitat mapping
            2. Habitat mapping
4. Identify data requirements for distribution models, expert approaches and classification systems
    a. "Identify data requirements to create the appropriate ecological layers"
    b. "Identify data requirements necessary for the selected method"

Proposed Framework

1. Identify management objectives
2. Identify ecosystem of concern, including spatial extent and scale
3. Identify appropriate method(s) to create or infer species diversity and distribution patterns
4. Identify data requirements to create the appropriate ecological layers necessary

More notes

When discussing the choice between methods, accuracy of methods that validate data vs. purely physically based approaches should be discussed.

Differences are not captured between mapping for capturing special features, and mapping for representation.

In the section describing the limitations of the many approaches it is not apparent that these data have and will still be used for many management decisions, as they are already created and sometimes use the best available data. Some of the methods described (BCMEC) are in line with DFO national guidance on how to begin to subdivide bioregions for MPA planning purposes (Using physical enduring features). There is no acknowledgement that this is a process, and some of these datasets will be able to be used in their current state to establish a first cut for management decisions you've outlined in the document already. National guidance suggests that as finer scale classifications incorporating biological data become available they should be incorporated. You should essentially be acknowledging and establishing a process with this framework, with the finest level of detail the goal in the long term.

I like the suggestions to adopt and apply the CMECS classification at the higher levels. Just a word of caution about applying the standard all the way down to the lower habitat levels. At the roots level classification standards such as CMECS or EUNIS are biologically driven exercises

that require detailed biological descriptions for the habitat components. I am sure that this level of detail will not be possible for some time, and would limit us from moving forward if we were to require this level of classification for progress with decision making even in regions with the best data.

Reviewer #2: Mary Yoklavich, National Marine Fisheries Service, Southwest Fisheries Science Centre, La Jolla, California.

Working Paper: Robinson, C., J. Boutillier, Doug Biffard, Jessica Finney, Ed Gregr, Mike Foreman, Vaughn Barrie, Karin Bodtker, Jo Smith, Joey Bernhardt, Jennifer Spencer, and Tom Therriault. A framework for the application of ecological classification and modeling systems used to describe marine biodiversity in Pacific Canada bioregions. CSAP Working Paper, 2012/P45.

The seven objectives listed on p. 2 of this report are all critical to understanding and implementing spatial management in the ocean (including design/monitoring of MPAs, as well as many other management needs). The co-authors have compiled a great deal of information relevant to the development of a framework to describe marine biodiversity off Pacific Canada. The discussion associated with each of the key elements of such a framework was comprehensive, and several useful case studies were considered. This document is a very good review of the many topics relevant to a framework, including ecosystem classification schemes and species distribution models. However, I found that a practical framework itself, one that managers could easily refer to in their deliberations on marine spatial planning, might have been more clearly presented. It seems there is too little specific guidance being offered to the target audience (managers) to assist in deciding how to proceed with planning. Although the framework elements are discussed in the document, they are not all fully tracked through to the section on recommendations and gaps. Perhaps improved organization and identification of the key points of the large amount of information associated with the key elements of the framework would help, as well as the inclusion of a clear summary section (executive summary) of the recommended framework.

Here are a few additional comments:

1. Section 1 clearly recognizes the need for information and management on various spatial scales (as per objective #4). This section, and the rest of the document as well, could more thoroughly consider the value of collecting data on various temporal scales, and the importance of maintaining time series. Perhaps this could be an additional objective?
2. It might be of interest to the authors to explore an emerging tool (integrated ecosystem assessments; IEAs) that the US (NMFS) is using to consider interactions among fish predators and prey, habitats, effects of environment/climate/weather, and anthropogenic processes (Levin et al. 2009. Integrated ecosystem assessments: developing the scientific basis for ecosystem-based management of the ocean. PLoS Biology 7(1)). Two developing IEAs (in Puget Sound and California Current) could be particularly relevant to the Pacific Canada bioregion.
3. The report (including Figure 1 and Figure 22) is missing any mention of interactions between the ecological information and the management needs and potential impacts. Identifying needs, ecological services, existing spatial management boundaries, and potential ecosystem impacts will inform the decision-making, particularly as relevant to design and monitoring of MPAs. Understanding the distribution of fishing fleets, debris, pollutants, climate change, etc. in relation to the species and habitat distribution, and documenting change in condition of habitats (as well as extent of the habitats and the relation to fish populations) will be important considerations relevant to MPAs.

4. In the discussion of species distribution models and abiotic models, there is no mention of the use of spatially explicit ecosystem models (such as Atlantis; Fulton et al. 2005). Recognizing that the usefulness of these models will be limited by data availability (as are all models), the authors might consider their value within the framework, particularly in terms of transitioning from single-species to ecosystem management (particularly in the context of MPAs).
5. Also regarding the discussion on species distribution models (2.2.3.1), presence/absence and presence only are not the only types of models being developed. The value of predictive models using species densities and abundance could be considered.
6. This Pacific Canada framework might be informed by the framework of the Pacific Fishery Management Council's 5-year reviews of essential fish habitats (EFH) for both Pacific salmon and Pacific groundfish. These recent comprehensive reports can be found on the PFMC web site under salmon and groundfish tabs. In addition, considering the framework and extensive process developed to implement a network of marine protected areas along the entire coast of California (associated with California's Marine Life Protection Act) could be useful to your endeavors.
7. Figure 22: there could be a connection made between species models and abiotic models (the output from abiotic models can be input into the biological models).
8. Figure 22 also could include boxes that represent the uncertainty associated with these models and maps (as per objective #3 on p. 2 of the paper).
9. Some consideration might be given to the linkage (interaction) between the seabed and pelagic realms, rather than only considering these realms separately.
10. The figure with two colored ovals on p. 67 needs clarification. As it stands, I cannot figure out what it means.
11. Also on p. 67, I fully agree that high-resolution seafloor mapping is a top priority for marine spatial planning (and for improving stock assessments of various species). I wouldn't agree that mapping in shallow waters is necessarily more important than mapping in deep depths (which is where most of the commercial fishing effort has occurred). Perhaps the authors can re-consider that statement.
12. p. 67: Data management, storage, and accessibility are clearly important topics. Some consideration could be given to the steps needed to integrate and serve disparate data sets having a variety of temporal and spatial resolutions, and to coordinate these efforts among interested agencies.