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

Canadian Science Advisory Secretariat (CSAS)

Proceedings Series 2017/030

National Capital Region

Proceedings of the National Peer Review of the Delineation of Significant Areas of Cold-Water Corals and Sponge-Dominated Communities in Canada's Atlantic and Eastern Arctic Marine Waters

March 8-10, 2016
Halifax, Nova Scotia

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July 2017

Canada

Foreword

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

Published by:

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

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ISSN 1701-1280

Correct citation for this publication:

DFO. 2017. Proceedings of the National Peer Review of the Delineation of Significant Areas of Cold-Water Corals and Sponge-Dominated Communities in Canada's Atlantic and Eastern Arctic Marine Waters; March 8-10, 2016. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2017/030.

Aussi disponible en français :

MPO. 2017. Compte rendu de l'examen national par les pairs de la délimitation des zones importantes de communautés dominées par les coraux et les éponges d'eau froide dans les eaux marines du Canada atlantique et de l'est de l'Arctique; du 8 au 10 mars 2016. Secr. can. de consult. sci. du MPO, Compte rendu 2017/030.

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SUMMARY

These proceedings summarize the relevant discussions and key conclusions that resulted from the Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) national peer review meeting on the delineation of significant areas of cold-water corals and sponge-dominated communities in Canada's Atlantic and Eastern Arctic marine waters. This meeting was held March 8-10, 2016 in Halifax, Nova Scotia. This meeting was attended by representatives from DFO Ecosystems and Oceans Science, Oceans Management, and National Fisheries Policy as well as academia, industry, and environmental non-governmental organizations.

Coral and sponge concentrations in Canadian waters have been identified as ecologically and biologically significant areas. DFO Ecosystems and Fisheries Management requested science advice to refine the delineation of significant areas of corals and sponges and information on the fishing activity in relation to these significant areas. The main objectives of the meeting were to refine the delineation of significant areas of corals and sponges, produce maps of these areas, and quantify the spatial overlap of the fishing effort with these areas. The study area for this analysis was the entirety of Atlantic Canada and Eastern Arctic marine waters. The taxa analyzed were sponges, large and small gorgonian corals, and sea pens. Kernel density estimation and species distribution models were used to delineate significant benthic concentrations of cold-water corals and sponges in the Atlantic and Eastern Arctic marine waters and maps of these areas were produced. The distribution and intensity of fishing effort was estimated using logbook information and Vessel Monitoring System data. The spatial overlap of the fishing effort with the significant areas of corals and sponges was quantified.

The conclusions and advice resulting from this meeting are provided in the form of a Science Advisory Report which is available on the CSAS website. Supporting Research Documents reviewed and discussed at the meeting will also be made available on the CSAS website.

SOMMAIRE

Le présent compte rendu résume les discussions pertinentes et les principales conclusions de la réunion nationale d'examen par les pairs du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada (MPO) sur la délimitation des zones importantes de communautés dominées par les coraux et les éponges d'eau froide dans les eaux marines du Canada atlantique et de l'est de l'Arctique. Cette réunion a eu lieu du 8 au 10 mars 2016, à Halifax, en Nouvelle-Écosse. Y assistaient des représentants de Sciences des écosystèmes et des océans, de Gestion des océans et de Politique nationale sur les pêches, ainsi que du milieu universitaire, de l'industrie et des organisations non gouvernementales de l'environnement.

Les concentrations de coraux et d'éponges dans les eaux canadiennes ont été désignées comme étant des zones d'importance écologique et biologique. Gestion des écosystèmes et des pêches du MPO a demandé un avis scientifique afin de préciser la délimitation des zones importantes de coraux et d'éponges, ainsi que des renseignements sur les activités de pêche dans ces zones importantes. Les principaux objectifs de la réunion étaient de préciser la délimitation des zones importantes de coraux et d'éponges, de produire des cartes de ces zones et de quantifier le chevauchement spatial de l'effort de pêche avec ces zones. La zone à l'étude pour cette analyse était l'ensemble des eaux marines du Canada atlantique et de l'est de l'Arctique. Les taxons analysés étaient les éponges, les grandes et petites gorgones et les pennatules. Des estimations de la densité par la méthode du noyau et des modèles de répartition des espèces ont été utilisés pour délimiter les fortes concentrations benthiques de coraux et d'éponges d'eau froide dans les eaux marines de l'Atlantique et de l'est de l'Arctique et des cartes de ces zones ont été produites. La répartition et l'intensité de l'effort de pêche ont été estimées à l'aide des renseignements des journaux de bord et des données du système de surveillance des navires. Le chevauchement spatial de l'effort de pêche avec les zones importantes de coraux et d'éponges a été quantifié.

Les conclusions et avis découlant de cette réunion sont présentés sous la forme d'un avis scientifique qui est disponible sur le site Web du SCCS. Les documents de recherche à l'appui qui ont été examinés et discutés lors de la réunion seront également publiés sur le site Web du SCCS.

SIGNIFICANT BENTHIC AREAS: BACKGROUND, TERMS, AND DEFINITIONS

Presenter: Mariano Koen-Alonso

ABSTRACT

The United Nations General Assembly Resolution 61/105 “calls upon States to take action immediately, individually and through regional fisheries management organizations and arrangements, and consistent with the precautionary approach and ecosystem approaches, to sustainably manage fish stocks and protect vulnerable marine ecosystems, including seamounts, hydrothermal vents and cold-water corals, from destructive fishing practices, recognizing the immense importance and value of deep sea ecosystems and the biodiversity they contain” (United Nations 2006).

In response to these demands, the Fisheries and Oceans Canada (DFO) Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas (the Policy) was developed to provide an approach to addressing these issues in Canadian fisheries. The purpose of this Policy is to help DFO manage fisheries to mitigate impacts of fishing on Sensitive Benthic Areas or avoid impacts of fishing that are likely to cause serious or irreversible harm to sensitive marine habitat, communities and species.

To address its purpose, the Policy requires the assessment of the data and information to determine the ecological and biological significance of the benthic features and the determination of the risk of serious or irreversible harm that fishing activity may cause to these features. According to the Policy, Sensitive Benthic Areas are areas that are vulnerable to a proposed or ongoing fishing activity (DFO 2009). Vulnerability will be determined based on the level of harm that the fishing activity may have on the benthic area by degrading ecosystem functions or impairing productivity. What defines a Sensitive Benthic Area is the combination of ecological/biological characteristics of the area and the fishing activity to which that area is (or is going to be) exposed. This also implies that the larger area which has the appropriate significant ecological and biological characteristics defines a Significant Benthic Area.

Although other documents such as DFO’s Ecological Risk Assessment Framework for Coldwater Corals and Sponge Dominated Communities (ERAF) focus the attention of the implementation of the Policy on cold-water corals and sponges, the Policy itself is not restricted to these specific taxa. The Policy could be applied to any significant ecological and biological benthic feature.

Compared to the work done by the Northwest Atlantic Fisheries Organization (NAFO) in the Northwest Atlantic outside of the Economic Exclusive Zone (EEZ), in reference to corals and sponges in a structure-forming habitat context, the concept of Vulnerable Marine Ecosystem (VME) used in NAFO is equivalent to the concept of Significant Benthic Areas at DFO. This allows the use of tools and analysis developed by NAFO in domestic waters without major shortcomings, as well as provides common ground for compatible management approaches within and outside the EEZ.

Given the similarity between some of these terms (e.g., Sensitive Benthic Areas and Significant Benthic Areas), it is important to provide clear operational definitions for them as well as for other related concepts. The following definitions were proposed:

Significant Benthic Area: With respect to cold-water corals and/or sponges, a regional habitat that contains these taxa as a dominant and defining feature. These habitats are structurally complex, characterized by higher diversities and/or different benthic communities, and provide a platform for ecosystem functions/processes closely linked to these characteristics.

Sensitive Benthic Area: an area that is vulnerable to a proposed or ongoing fishing activity. Vulnerability will be determined based on the level of harm that the fishing activity may have on the benthic area by degrading ecosystem functions or impairing productivity.

Significant Benthic Area indicator taxa: These are species/taxa that meet one or more of the Food and Agriculture Organization of the United Nations' Guidelines criteria for possible Vulnerable Marine Ecosystems/Significant Benthic Areas. Their simple presence is not an automatic indication of a Significant Benthic Area, but when found in significant aggregations with conspecifics, or other Significant Benthic Area indicator species, can constitute a Significant Benthic Area.

High concentration location of Significant Benthic Area indicator taxa: These are specific locations where there are individual records of Significant Benthic Area indicator taxa at densities at or above a threshold value that, for a specific Significant Benthic Area indicator taxa, are associated with the formation of highly aggregated groups of that species/taxa. A set of high concentration locations within an area can define a Significant Benthic Area.

METHODOLOGY PRESENTATION – KERNEL DENSITY ESTIMATION, ENVIRONMENTAL DATA, SPECIES DISTRIBUTION MODELLING

Presenter: Ellen Kenchington

ABSTRACT

Significant Benthic Areas are defined in DFO's ERAF as "significant areas of cold-water corals and sponge dominated communities", where significance is determined "through guidance provided by DFO-lead processes based on current knowledge of such species, communities and ecosystems" (DFO 2013). These organisms are broadly distributed throughout Atlantic Canada and the Eastern Arctic and analyses were undertaken to identify areas where aggregating species formed structural biogenic habitats. This presentation detailed the analytical approaches followed to familiarize participants with the data presentations. The locations of significant concentrations of corals and sponges on the east coast of Canada were produced through quantitative analyses of research vessel trawl survey data, supplemented with other data sources where available.

The analyses were conducted following a bio-regionalization approach in order to facilitate modeling of similar species, given that many of the multispecies surveys do not record coral and sponge catch at species level resolution. The taxa analyzed are sponges (Porifera), large and small gorgonian corals (Alcyonacea), and sea pens (Pennatulacea). All of these groups are vulnerable to bottom contact fishing gears and images were shown of the quantities that can be removed when their habitat is trawled.

An approach called kernel density estimation (KDE) was followed to create a modelled biomass surface for each of those taxa in each bioregion, and an aerial expansion method using the kernel surface was used to identify significant concentrations. The details of these analyses were explained to the meeting participants, including the strengths and weaknesses of the approaches. KDE utilizes spatially explicit data to model the distribution of a variable of interest. It is a simple non-parametric neighbour-based smoothing function that relies on few assumptions about the structure of the observed data. It has been used in ecology to identify hotspots, that is, areas of relatively high biomass/abundance. With respect to marine benthic invertebrate species, it was first applied to the identification of significant aggregations of sponges in the NAFO Regulatory Area in 2009 and published in the primary literature applied to VME indicators in 2014. The borders of the areas identified can be refined using knowledge of

null (zero) catches and species distribution models (SDM) that predict species presence-absence and/or biomass using environmental data. Two very different approaches were followed for the SDM. The first approach used a machine learning technique to create predictive probability models of the presence/absence and biomass for each group. The technique is called Random Forest (RF), and is a non-parametric machine learning technique, where multiple regression or classification trees (usually $\geq$ 500) are built using random subsets of the data. Regression trees are used for response variables consisting of continuous data (biomass) and classification trees for factor variables (+/-). RF is a robust statistical method requiring no distributional assumptions on covariate relation to the response in comparison to other classical statistical models such as generalized linear models or generalized additive models (GAM). It can handle a large amount of input variables effectively without variable deletion and can also account for correlation as well as interactions among variables. The GAM models were also applied in some cases and the method was similarly explained to the meeting.

DISCUSSION

Participants asked about applying KDE on a year to year basis, aggregating data points over years, and changing sampling effort over the years. The presenter reminded participants that they are working with really long-lived species that are not expected to shift as much as species with shorter life spans. Also, they are not very mobile. It was asked if between what was done in 2010 and 2016 there was a large change in threshold values for species or a change in catch distribution. The presenter replied that there were no large changes in these. There were really good data in 2010 and there are more now. Most of the differences are in the Eastern Arctic where there were less 2010 data but for the other areas it is fairly consistent. It was asked if they split the data to test the models. The presenter replied that all data were utilized in the model but they validated the model with other data where possible (camera, fishery observer data, etc.).

A participant asked how they can know that in the future the areas identified would remain the same. For example, some polygons identified in 2010 have changed. The presenter responded that KDE is a biomass at a certain position. For a large change to occur, it would likely mean that more data were collected around an area and showed it wasn't a hot spot. There is strong congruence between the main areas currently but the validity in the future is unknown. Environmental impacts can affect the model outcomes. In deeper waters where the environment is more stable and there is little fishing it will likely be more stable.

The presenter was asked to comment on the catchability of trawl gear for sea pens, corals, etc. In 2010 the catchability of trawl gears was compared and there was a lot of variability. Therefore, different gears were analyzed separately. As an example, in the Arctic the same areas were identified when analyzing two different trawl types. A participant asked if a change in threshold could explain the change in size and number of polygons, given the threshold is important in defining the polygon. The presenter replied that for now, not to focus on the specific boundaries but to focus on the habitat. KDE gives the general area and location and then another method was used to further refine the boundary.

A participant commented that with research vessel surveys, things are lumped into general categories and asked if when they identify Significant Benthic Areas they go back to these areas to identify these species with more taxonomic rigour or look more closely at the environment that these species provide. The presenter replied that they have gone with *in situ* cameras to some of these areas to document diversity.

A participant commented that for sea pens bottom salinity is more important in some areas than others and questioned why this is the case. The presenter responded that some things that are

a concern in one area aren't in others, there are different current regimes and different species compositions and that is why the parameters were optimized on a regional basis. A participant asked if they looked at calcification for the Arctic region. The presenter explained that a lot of the biochemical data was too poor and inadequate to extrapolate from. The models performed well and they tried to get the best variables for prediction so adding more variables may not be necessary. There was a suggestion to add fishing effort as a covariate to see if this influenced distribution.

FISHERIES OVERLAY – PRELIMINARY RESULTS

Presenter: Mariano Koen-Alonso

ABSTRACT

Fishing activity layers were created to examine the overlap with the previously identified Significant Benthic Areas in the following biogeographic units: Scotian Shelf, Gulf of St. Lawrence, Newfoundland and Labrador Shelves, and portions of the Eastern Arctic and Hudson Bay Complex. The layers represented the extent (i.e. fishing footprint) and intensity of fishing vessel activities based on fishing locations which were derived from two data sources: logbook and Vessel Monitoring System (VMS) data between 2005 and 2014. Logbooks are records kept by fishers with details on the vessel, effort, and catch characteristics, whereas VMS data is positional information that is transmitted automatically from fishing vessels at regular intervals via satellite. Data from VMS provide high resolution positions recorded at higher frequencies compared to logbooks, however, VMS may not be available for some fisheries depending on region, gear type, directed species, and vessel size.

Because bottom impacts of gear vary greatly across fisheries, fishing activity was grouped into categories with similar gears, target species, and general areas of operation. A total of 13 fisheries classes were defined, which encompassed 98% of all the fishing activity recorded in fisheries logbooks across Atlantic Canada and the Eastern Arctic. The remaining 2% was grouped in a single fisheries class labelled "Other". Some of these classes corresponded to well-defined fisheries (e.g., shrimp), while others represented aggregates that encapsulate some general features across several fisheries (e.g., pelagic).

For comparative purposes, effort was standardized by converting fishing intensities to percentiles using vessel days for logbook data, and hours fished per unit area for VMS data. This procedure allows identifying hotspots of fishing activities and standardizing across data sources (logbooks and VMS), thereby providing a way to integrate these data sources.

Within each biogeographic unit, overlap between Significant Benthic Areas and fishing activities was evaluated in two ways: the percentage of the fishing activity area that overlapped Significant Benthic Areas and the percentage of Significant Benthic Areas that overlapped the fishing activity area. Overlaps were calculated for each individual fisheries class, as well as for aggregates of fisheries classes. These overlaps provided a basic measure of spatial co-occurrence only and did not measure the impact.

Considering the overlaps between Significant Benthic Areas and areas of higher fishing activity, a total of 29 areas of concern were highlighted in the Atlantic Canada and Eastern Arctic biogeographic units. In terms of numbers, the Gulf of St. Lawrence has the most areas of concern (11), followed by Newfoundland and Labrador (8), Scotian Shelf (7), and lastly Eastern Arctic (3). However, these numbers should not be considered an index of relative concern across regions. These areas of concern involved drastically different Significant Benthic Area

sizes and the absolute surfaces of the overlaps involved in each one of them are also very different.

The overlaps estimated in this analysis only reflect the fishing activity that has positioning data, which represents 23% of the total fishing effort in the study area. Even though this figure seems low, the lobster fisheries class, which typically operates in waters up to 50 metres depth, accounts for most of the effort without positioning. Taking into account that most Significant Benthic Areas are in offshore waters, the limitations associated with positioning are most likely to impact the results in the Gulf of St. Lawrence, but less likely in the other biogeographic units.

These areas of concern simply highlight general locations where interactions between fishing activities and Significant Benthic Areas are more likely to occur. It is the overall extent of these interactions, the level of harm involved, and the specific role of that Significant Benthic Area type towards contributing to overall ecosystem functioning that would determine the actual adverse impact of these interactions. Determination of impact is beyond the scope of this meeting.

Overall, the amount of overlap between fishing activity and Significant Benthic Areas in all biogeographic units, with the exception of Eastern Arctic, appeared high. High overlap values are a result of the cumulative effect of multiple fisheries classes.

Conversely, the fishing area that is overlapped by Significant Benthic Areas tends to be low, with the highest overlap being observed for sponge and sea pen Significant Benthic Areas. Furthermore, fishing activity shows, across all biogeographical units and fisheries classes, a concentration pattern where a large fraction of the activity was exerted in a relatively small fraction of the footprint.

DISCUSSION

Participants asked if there is a method to determine where the fishing is likely to go and if it can be predicted from historical fishing patterns. The presenter explained that they are looking at where the fishing is now and that there currently isn't a method for projecting how the fishing may change. The historical information does not have enough details to predict this at this time. A participant commented that in logbooks it's really only the starting position that is recorded; they do not record the direction of the tows. In many areas there is trawling over the same spot. Some of the sensitive areas are quite small, so at the resolution being used there could be fishing in an area that doesn't actually affect the sensitive area. Looking at the actual tracks before, they often avoided the significant areas. The presenter explained that they are trying to characterize the amount of effort in one square kilometre but are not going into the details of the tracks or directions of the tows. The problem is not the resolution of the fishing data; the issue is how well we can define Significant Benthic Areas on the bottom. It was suggested that soak time for fixed gear could be a variable added to fine-tune the effort. The presenter commented that there is information on soak time but the reliability of this information is very variable. There was some concern over the term 'fishing effort' and that it might not accurately represent the data. Participants discussed using other terms such as fishing activity or fishing footprint but overall, it was felt that neither was appropriate as the information included both the area fished and a level of intensity. It was agreed that what is meant by fishing effort needs to be clearly explained in the meeting documents. A participant commented that it would be interesting to compare the centre of gravity of fishing effort and the center of gravity of Significant Benthic Areas and see how they are shifting year to year and how close they are. There was a comment that while mobile gear poses the highest risk to Significant Benthic Areas, fixed gears are important to consider because they can be placed in areas where there isn't any mobile gear fishing. It can have large impacts on the bottom that should not be overlooked.

A participant commented that multiple fisheries and their combined fishing activity should be highlighted. Consideration of pelagic fisheries was discussed. As some types of pelagic gear contact the bottom, it was suggested that it is important to show where this fishing is taking place. A participant commented that on the west coast, managers are concerned about the impact of pelagic gears and mid-water trawls on glass sponges. It was recommended that the report only look at bottom-contacting gear.

A participant commented that we should not equate effort to value. Some fisheries are highly profitable and have low effort, and vice versa. Therefore, we shouldn't draw conclusions that something is not as important because of the small area of fishing effort. When looking at specific polygons and the fishing that overlaps with them, it is important to consider the value of the fishery. It was explained that the purpose of the analysis is to draw attention to areas of fishing activity and Significant Benthic Area overlay. This analysis will be a first piece of advice and after there will be more work done to zoom in on specific areas and incorporate more data before any management decision is made. A comment was made that although the red areas may represent concentrated areas of interaction, corals and sponges are very vulnerable and often the first pass through can cause significant permanent damage. Often it is the overall area that can become important and not how many times that area was fished. A presenter commented that the biggest challenge with doing the overlaps is not in mapping the effort but it is how we delineate the Significant Benthic Area. The highest uncertainty is in the Significant Benthic Area and not the effort on top of them. A representative from industry commented that when they map the fishing effort the area of the footprint is a lot smaller. The presenter replied that at the moment the footprint is quite coarse.

IDENTIFICATION OF CORAL AND SPONGE SIGNIFICANT BENTHIC AREAS IN THE MARITIMES REGION

Presenter: Lindsay Beazley

ABSTRACT

KDE generated on catch data of sponges, sea pens, and large and small gorgonian corals collected by DFO's multispecies trawl surveys was used to identify significant concentrations of these taxa in DFO's Maritimes Region. These analyses updated those previously performed in 2010 by DFO to delineate significant concentrations of these coral and sponge groups. SDM using the machine-learning technique RF were generated to predict the probability of occurrence and biomass distribution of each group. These models utilized 66 environmental variables and response data from different data sources including the DFO multispecies trawl surveys used for KDE analysis and *in situ* benthic imagery observations. The RF models identified areas of suitable habitat for each group, the predictive surfaces of which were used to refine the boundaries of the KDE polygons denoting significant concentrations of these taxa during the CSAS national peer review meeting. The RF models were particularly useful in capturing the slope areas to approximately 2000 m for the gorgonian corals.

DISCUSSION

A participant asked if supplementing the research vessel data set with scientific observations might skew the data towards areas looked at. The presenter responded that they do have models with just the trawl survey data, but it was a concern not including areas that trawlers would avoid. Therefore they thought it was best to include additional presences for more accurate data. It was asked that closure areas be indicated on the maps because of the effort near these areas.

IDENTIFICATION OF CORAL AND SPONGE SIGNIFICANT BENTHIC AREAS IN THE GULF OF ST. LAWRENCE

Presenter: F. Javier Murillo

ABSTRACT

A presentation was made on the results of the KDE approach and SDM applied to the research vessel trawl survey data collected in the Gulf of St. Lawrence. In this region, data from Quebec and Gulf Regions of DFO were analyzed separately due to the different catchability of the survey gears. Only sea pens and sponges were present, with the gorgonian corals not appearing in the catches. These results, including catch records from up to five additional years of trawl survey data, updated the previous analysis performed in 2010 by DFO to delineate significant concentrations of corals and sponges. SDM of probability of occurrence applied to the whole region, and predicted biomass analyzed separately for each survey, were created using an RF machine-learning technique. Response data were derived from the same data used in the KDE analysis and the predictors were drawn from 78 environmental data layers. The results from the SDM analysis were later used to refine the borders of the polygons defining significant concentrations of these taxa identified through the kernel density analyses. Maps of the location of significant concentrations of sea pens and sponges and predicted distribution models were shown. Together, these distribution maps were used in the meeting to identify significant concentrations of sea pens and sponges in the Gulf of St. Lawrence; an essential first step in the identification of Significant Benthic Areas.

DISCUSSION

A participant questioned why a lot of the fishing effort is long and narrow instead of wider or rounder. It was explained that this may be because of trawling and that sometimes fisheries are aimed at specific depths and may follow contours.

SPECIES DISTRIBUTION MODELLING OF CORALS AND SPONGES IN THE NEWFOUNDLAND AND LABRADOR REGION FOR USE IN THE IDENTIFICATION OF SIGNIFICANT BENTHIC AREAS

Presenter: Lindsay Beazley

ABSTRACT

KDE generated on catch data of sponges, sea pens, and large and small gorgonians corals collected by DFO's multispecies trawl surveys was used to identify significant concentrations of these taxa in DFO's Newfoundland and Labrador Region. These analyses updated those previously performed in 2010 by DFO to delineate significant concentrations of these coral and sponge groups. SDM using the machine-learning technique RF were generated to predict the probability of occurrence and biomass distribution of each group. These models utilized 66 environmental variables and response data collected from the DFO multispecies trawl surveys, DFO/industry northern shrimp surveys, and Spanish trawl surveys conducted in the region. The RF models identified areas of suitable habitat for each group, the predictive surfaces of which were used to refine the boundaries of the KDE polygons denoting significant concentrations of these taxa during the CSAS national peer review meeting.

IDENTIFICATION OF CORAL AND SPONGE SIGNIFICANT BENTHIC AREAS IN THE EASTERN ARCTIC AND HUDSON STRAIT

Presenter: F. Javier Murillo

ABSTRACT

KDE based on research vessel trawl survey data collected from DFO was used to identify significant concentrations of corals and sponges in the Eastern Arctic. Catch records for the Eastern Arctic Region were derived from Alfredo, Campelen, and Cosmos trawl data, although small and large gorgonian corals were not found in the Cosmos surveys. KDE analyses were run separately on data from each of the three gear types and the survey time series ran from 1999 to 2014. SDM of probability of occurrence and predicted biomass were created using an RF machine-learning technique for these taxa. Response data were derived from the same data used in the KDE analysis and the predictors were drawn from 54 environmental data layers. Presence/absence models combined data from all gear types while biomass models were run separately for each gear type. In Hudson Strait, there were too few records to apply KDE to the large or small gorgonian corals and sea pens. KDE analyses were conducted on sponges within Hudson Strait and Ungava Bay in the eastern portion of the Hudson Bay Complex Biogeographic Zone. The RF model was generated on sponge presence and absence records from both Campelen and Cosmos trawl surveys combined. As for the other regions, maps of the location of significant concentrations of corals and sponges and predicted distribution models were presented to the meeting.

DISCUSSION

One of the authors commented that some variables like ice cover may need a closer look, but the models still performed well. Ice cover is an available layer that they may be able to introduce. A comment was made that overall there are not a lot of overlaps in the Eastern Arctic, suggesting that it is in relatively good shape.

A participant asked if there are any other types of corals that should be considered in Significant Benthic Areas. An author replied that other important corals do exist, but at this time they went with Food and Agriculture Organization of the United Nations' guidelines (VME qualifiers). For something such as black coral, they could not do KDE because it is widespread but at low density, and not aggregating.

A participant asked for clarification of objective five in the terms of reference related to the presentation of a preliminary analysis that overlays the fishing activity with areas of benthic concentrations of corals and sponges. It was explained that this objective was interpreted as the deliverables being a map of Significant Benthic Areas and a map of potential Sensitive Benthic Areas.

REFINING THE SIGNIFICANT AREAS OF COLD-WATER CORALS AND SPONGE-DOMINATED COMMUNITES IN CANADA'S ATLANTIC AND EASTERN ARCTIC MARINE WATERS

Before beginning the refinement of the significant areas of cold-water corals and sponge-dominated communities in Canada's Atlantic and Eastern Arctic marine waters, the following points were explained to meeting participants:

- KDE polygons identify the location and spatial extent of Significant Benthic Areas as they exist today. Boundaries of KDE polygons do not reflect fine scale details.

- SDM estimate the probability of a given location to be suitable for a given taxa, based on the variables considered in the model. A high probability area does not ensure that the Significant Benthic Area is actually there.
- If additional information existed about the presence of Significant Benthic Areas in a location not highlighted by the KDE analysis (e.g., because the data was not suitable for inclusion like remotely operated vehicle records), the combination of the SDM results and the additional information was used to define a new Significant Benthic Area location.
- If no additional information exists, then SDM were used to refine the boundaries of KDE polygons to define a more realistic boundary for the Significant Benthic Area.
- If refinement was not possible, the boundaries of the KDE polygon stood.
- Fishing effort information was not used to refine boundaries.
- The refinement of Significant Benthic Area boundaries is independent from any management action related to Significant Benthic Areas; management considerations are not part of the refinement process.

For the refinement, meeting participants were separated into two groups. Each of the groups was responsible for performing the refinement for specified regions. Once completed, all meeting participants came back to plenary and representatives from the groups presented the refinements, how these refinements were performed, and any issues that came up.

POLYGON REFINEMENT – NEWFOUNDLAND AND LABRADOR SHELVES

For sponges, only one polygon was clipped. This polygon was trimmed to the 250 m depth contour. Some other polygons were flagged for clipping, such as a large sponge polygon on the Labrador Slope.

For sea pens, one polygon was clipped. For this polygon there was a band of absence predicted by the presence-absence SDM and it was trimmed across the absence edge. It was noted that many isolated, discontinuous polygons are located along the slope/shelf bed in areas predicted as presence of sea pens. These areas identify a broader habitat that is suitable for sea pens that the KDE polygons did not capture. There was some discussion about an area following the shelf edge where there are no KDE polygons. However, there are high catches in the observer dataset and there is presence indicated by the presence-absence SDM. It was suggested that in some cases these high sea pen catches (in observer data) may be occurring due to long sets in the turbot fishery operating in this region.

For large gorgonians, three polygons were clipped. These polygons were trimmed along the edge of the absence model. The group noted a large gorgonian coral habitat on the shelf on Saglek Bank. This is partially covered by the KDE analysis, but not fully covered as identified by the presence-absence models. The biomass model for large gorgonians here was not given as much weight as it didn't perform that well (R^2=~0.2).

For small gorgonians, three polygons were clipped. Two were trimmed along the edge of the presence-absence model and one was trimmed to the 400 m contour. Small gorgonian Significant Benthic Areas are generally found below the 400 m contour line. It was noted that many polygons fall along a continuous, long habitat feature that likely promotes the occurrence of small gorgonians. There was no biomass model for small gorgonians because it didn't perform well.

POLYGON REFINEMENT – SCOTIAN SHELF

None of the sponge polygons were trimmed on the Scotian Shelf. KDE polygons overlay well with the balanced presence/absence RF model, with presence probability spanning between several KDE polygons. Three areas were noted for underlying connectivity: the eastern shelf along the Laurentian Channel, the Emerald Basin, and the western shelf.

Sea pen KDE polygons were not trimmed. Similar to sponges, underlying presence probability suggested connected habitat between KDE polygons in the Emerald Basin area. It was noted that the deeper polygons on the slope would likely be expanded with further sampling as sea pens are known to be aggregated on soft bottom.

Large gorgonian polygons were not trimmed. The eastern portion of the Scotian Shelf which was originally included in the Newfoundland and Labrador Shelves KDE analysis was incorporated to modify the 'Haldeman Canyon polygon', expanding it eastward in agreement with RF predictions. It was agreed that the presence/absence model is considered more reliable than the KDE polygons in slope areas due to inclusion of benthic imagery data.

There were no KDE polygons for small gorgonian corals due to small sample sizes therefore assessment used the balanced presence/absence RF model. The most influential environmental variables of this model are depth and slope, and predicted presence prevalence follows closely the 200 m depth contour along the shelf slope. It was recommended that the region between the 200 m contour and the RF extrapolation boundary be considered a Significant Benthic Area for small gorgonian corals.

POLYGON REFINEMENT – GULF OF ST. LAWRENCE

For sponges, sharp depth and sediment gradients in the northern Gulf, such as west of Anticosti Island, were encompassed by some polygons, which may not be meaningful. Trimming was done on two polygons.

For sea pens, there was strong connectivity in the Significant Benthic Area habitat due to their shape. All polygons in the northern Gulf set were within the predicted absence area and were not altered. One area in the southern Gulf survey was considered for clipping (eastern extent) to the 200 m depth contour.

POLYGON REFINEMENT – EASTERN ARCTIC

No changes were made to most polygons. However, there was a large gorgonian section of predicted presence within the NAFO Division 0A Narwhal Overwintering and Coldwater Coral Zone. A participant recommended that this portion be added to the large gorgonian Significant Benthic Area set. An observation was made by examining the observer data in the south. The observer data was in agreement with the predictions from the RF models. RF can create small absence areas within larger presence areas (a marbled pattern), but a reviewer cautioned that these should be down-weighted (due to uncertainty in the model and potential over-fitting) and general patterns should be observed.

OVERLAP BETWEEN SIGNIFICANT BENTHIC AREAS AND FISHING EFFORT - FINAL RESULTS

Presenter: Mariano Koen-Alonso

ABSTRACT

The overlap analyses were re-run using the final delineation of Significant Benthic Areas for each bioregion emerging from the work on polygon refinement and discussion at this CSAS meeting. Additional effort layers were also produced to represent additional fishery-related considerations. These new layers included the top 20, 40, and 60% of the effort by each individual fisheries class. This additional layer was intended to highlight prime fishing areas for all individual fisheries classes, while preventing the fisheries class with the higher total effort from dominating the aggregate picture.

The updated results indicated that exposure of Significant Benthic Areas to fishing activities in Atlantic Canada and Eastern Arctic is important. The percent Significant Benthic Areas overlapping with total fishing activity ranged from 37.3 - 77.5% (except in the Eastern Arctic, which ranged from 6.6 – 9.0%). This range reduced to 28.2 - 72.2% when pelagic fisheries were excluded. This comparison indicates that the additional co-occurrence of Significant Benthic Areas with fishing activities associated with pelagic fisheries was relatively modest, but not entirely negligible. The proportion of Significant Benthic Areas exposed to fishing activity by specific fisheries ranged from 0 - 68.9%, except in the Eastern Arctic where this range was 0.02 - 7.1%.

The percent area of Significant Benthic Areas overlapping with individual fisheries classes was, in most cases, considerably lower than the overlaps observed when all fisheries classes were considered together. This indicated that assessing the impacts of fishing on Significant Benthic Areas would require considering all fisheries in an integrated analysis. Independent analyses by individual fisheries classes would risk masking the actual magnitude of fishing impacts on Significant Benthic Areas, which would be defined by the cumulative impacts of all fisheries operating in a given area.

Significant Benthic Areas across regions comprised a median of 5.5% of the overall fished area, although this was up to 15.5% in some areas. This indicated that in most cases Significant Benthic Areas are a relatively small proportion of the fishing footprint of the different fisheries classes.

The examination of the overlaps in relation to the concentration of fishing effort indicated that for the Scotian Shelf, the Gulf of St. Lawrence, and the Newfoundland and Labrador Shelves biogeographic units, Significant Benthic Areas did not appear to overlap strongly with the areas of highest fishing activity concentration. Conversely, in the Eastern Arctic Significant Benthic Areas appeared to be core fishing areas (areas with the highest intensities of fishing activities), especially sea pen Significant Benthic Areas, and to a lesser degree sponge Significant Benthic Areas. The reasons for this difference were unknown, but it could be related to the history and developmental stage of fisheries in these areas. This issue requires further investigation.

These analyses identify areas of co-occurrence between fishing activities and Significant Benthic Areas, indicating potential Sensitive Benthic Areas. Different fishing gears would have different impacts on Significant Benthic Areas. Mobile bottom-contacting gears are typically considered more harmful than fixed gears, while pelagic gears, depending on how likely the specific gear type is to contact the bottom, may or may not impact Significant Benthic Areas. This implied that the frequency and intensity of fishing would also contribute to define the impact

level. Even though the analyses presented here did not estimate impacts, they provided necessary elements for future impact assessment.

DISCUSSION

A participant requested that the top 80% of fishing effort be added to the figures and that the entire overlap should be looked at. Others agreed that the entirety of activity should be considered for the meeting but that the quantiles are important for understanding the impacts of fishing in Significant Benthic Areas to the fishery. There was general agreement that percentiles of fishing effort should be included but that total overlap of fishing effort needs to also be included. Participants requested that Marine Protected Areas (MPAs) be shown on the maps. There was discussion of the damage caused by the first impact and it was highlighted that the spatial layout of the effort was therefore important.

There was considerable discussion about how the data were presented and the methods used to calculate the fishing effort. The presenter explained that the data were correct for the methods used and further explained the methods. These methods will be clearly explained in the Science Advisory Report and Research Document. Some participants suggested the numbers for the overlays should not be included in the Science Advisory Report but instead should be included in a Research Document. There was concern that some of the numbers would not be interpreted correctly. It was explained that these tables are important to include in the report but detailed methods clearly indicating the limitations will be included. It was also suggested that every table should include a clear explanation of what the numbers actually reflect. Participants were also reminded that there was no assessment of impact at this point recognizing that fisheries act differently and other factors need to be considered. Others expressed that it is useful to get an idea of which fisheries potentially have the most impact on different taxa which could be useful in directing future work.

SCIENCE ADVISORY REPORT DRAFT

An outline of the Science Advisory Report (SAR) for this meeting was presented. Discussion was focused on what should be included in the report and how the information should be presented. Participants were reminded that after the meeting the SAR would be circulated for review and comments.

Participants commented that the SAR should include information on how the polygons were refined. It was suggested that an example of how the KDE and RF were used to make the decision to clip a polygon be shown. For Significant Benthic Areas that are suggested to be connected, putting the presence absence or biomass layer below it may be informative. Participants wanted fishing effort and the period of time for this effort to be clearly defined in the report. There was discussion about explaining that the measure of fishing effort is an indicator for the impact on a Significant Benthic Area, an indicator of where a Sensitive Benthic Area may be but will require further analysis since impact is dependent on many factors. Participants were reminded that because a fishery overlaps with a Significant Benthic Area does not mean it negatively impacts it. A participant recommended that other taxonomic groups that might be good indicators of Significant Benthic Areas also be examined in the future. A participant did not want there to be reference to core fishing areas based on the percentiles because the cut off for this is arbitrary and does not take into account many other things that might make something a core fishing area, such as landings and value. There was a further comment about the table showing percentages of fishing effort stating that it is inappropriate given the limitations stated previously. Others generally agreed that the maps and tables all contain a lot of very important

information and should not be removed from the report. It was decided that the tables would be included with limitations and caveats clearly explained as discussed previously.

REFERENCES CITED

DFO 2009. Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas. (accessed 8 March 2016).

DFO. 2013. Ecological Risk Assessment Framework (ERAF) for coldwater corals and sponge dominated communities. Sustainable Fisheries Framework (SFF): Policy to manage the impacts of fishing on sensitive benthic areas. (accessed 8 March 2016).

United Nations, Resolution adopted by the General Assembly on 8 December 2006. (A/RES/61/105)

APPENDIX A. TERMS OF REFERENCE

Delineation of Significant Areas of Cold-Water Corals and Sponge-Dominated Communities in Canada's Atlantic and Eastern Arctic Marine Waters

National Peer Review - National Capital Region

March 8-10, 2016
Halifax, NS

Chairpersons: Lisa Setterington and Christie Whelan

Context

In 2009, Fisheries and Oceans Canada (DFO) published the Policy on Managing the Impacts of Fishing on Sensitive Benthic Areas to provide a more systematic, transparent, and consistent approach to mitigate fishery impacts on benthic habitats, species and communities. Subsequently, DFO produced two guidance documents (i.e., DFO's Ecological Risk Assessment Framework (ERAF) for cold-water corals and sponge dominated communities (DFO 2013), Guidance for Implementation of the Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas) to apply the policy but advice on the delineation of significant areas (concentrations) of corals and sponges is still lacking.

Coral and sponge concentrations in Canadian waters have been identified as ecologically and biologically significant areas (EBSAs) using domestically established criteria. The Canadian Science Advisory Secretariat (CSAS) published a Science Advisory Report (DFO 2010) which provided the foundation for the identification of such concentrations by providing maps of the known locations of corals and sponges. However, clear guidance on how to use these location data to delineate significant areas of these species is still needed.

In order to further advance the implementation of the Policy and ERAF, Ecosystems and Fisheries Management is seeking science advice to refine the delineation of significant areas of corals and sponges and information on the fishing activity in relation to these significant areas. The delineation of significant areas of corals and sponges and the overlay of the fishing footprint of bottom contact fisheries on maps of these significant coral and sponge areas are both needed to apply the Policy.

While the focus will be on the Atlantic and Eastern Arctic, the Pacific Region will also be engaged to ensure a nationally consistent approach, based on current science from all Regions.

Objective

The specific objectives of this National Peer Review are to:

1. Review the terms associated with delineating Significant Benthic Areas of cold-water corals and sponge-dominated communities.
2. Update the kernel density estimation (Kenchington et al. 2010; Kenchington et al. 2014) used to delineate significant benthic concentrations of cold-water coral and sponge species within the Atlantic and Eastern Arctic waters of the Canadian exclusive economic zone (EEZ). This includes incorporating species distribution models to further delineate these concentrations for corals and sponges with the data currently available for the Atlantic and Eastern Arctic waters.
3. Produce maps delineating all the significant concentrations of corals and sponges, and the probability of their occurrence, within the Atlantic and Eastern Arctic waters of the Canadian EEZ.

4. Provide recommendations on best approaches and methods to update the delineations of these significant areas as more data become available on coral and sponge distribution.
5. Present a preliminary analysis that overlays the fishing effort with the areas of benthic concentrations of corals and sponges and provide recommendations on how this type of analysis may be considered in evaluating coral and sponge distributions.

Expected Publications

- Proceedings
- Research Document
- Science Advisory Report

Participation

- DFO – Ecosystems and Oceans Science sector (regional and NCR)
- DFO – Ecosystems and Fisheries Management sector (regional and NCR)
- Academia or academics
- Fishing Industry
- Other invited experts (e.g., environmental non-governmental organizations)

References

DFO. 2010. Occurrence, susceptibility to fishing, and ecological function of corals, sponges, and hydrothermal vents in Canadian waters. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/041.

DFO. 2013. Ecological Risk Assessment Framework (ERAF) for coldwater corals and sponge dominated communities. Sustainable Fisheries Framework (SFF): Policy to manage the impacts of fishing on sensitive benthic areas.

Kenchington, E., Lirette, C., Cogswell, A., Archambault, D., Archambault, P., Benoit, H., Bernier, D., Brodie, B., Fuller, S., Gilkinson, K., Lévesque, M., Power, D., Siferd, T., Treble, M., and Wareham, V. 2010. Delineating coral and sponge concentrations in the biogeographic regions of the east coast of Canada using spatial analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/41. v + 204 p.

Kenchington, E., Murillo, F.J., Lirette, C., Sacau, M., Koen-Alonso, M., Kenny, A., Ollerhead, N., Wareham, V., and Beazley L. 2014. Kernel density surface modelling as a means to identify significant concentrations of vulnerable marine ecosystem indicators. PLoS ONE. 9(10):e109365. doi:10.1371/journal.pone.0117752

APPENDIX B. AGENDA

Delineation of Significant Areas of Cold-Water Corals and Sponge-Dominated Communities in Canada's Atlantic and Eastern Arctic Marine Waters

March 8-10, 2016
Halifax, NS

Co-Chairs: Lisa Setterington and Christie Whelan

Day 1 – March 8, 2016

8:45 – Welcome and Introductions

9:15 – Review the terms associated with delineating Significant Benthic Areas of cold-water corals and sponge-dominated communities and process for identification. (Mariano Koen-Alonso)

10:15 – BREAK

10:30 – Methodology presentation (Ellen Kenchington)

- Kernel Density Estimation
- Environmental Data
- Species Distribution Modelling

12:00 – LUNCH

1:00 – Methodology presentation (Mariano Koen-Alonso)

2:00 – Presentation of Results

Scotian Shelf (Lindsay Beazley)

Fishing Effort (Mariano)

2:30 – Presentation of Results

Gulf of St. Lawrence (Javier Murillo)

Fishing Effort (Mariano)

3:00 – BREAK

3:15 – Presentation of Results

Newfoundland and Labrador (Lindsay Beazley)

Fishing Effort (Mariano)

4:00 – Presentation of Results

Eastern Arctic including Hudson Strait (Javier Murillo)

Fishing Effort (Mariano)

Day 2 – March 9, 2016

9:00 – Review of Day 1

9:30 – Overlay and refining the significant areas of cold-water corals and sponge-dominated communities in Canada's Atlantic and Eastern Arctic Marine Waters (in groups)

10:15 –BREAK

10:30 – Overlay and refining the significant areas of cold-water corals and sponge-dominated communities in Canada's Atlantic and Eastern Arctic Marine Waters (in groups)

12:00 – LUNCH

1:00 – Results from morning session (Group 1)

2:30 – BREAK

2:45 – Results from morning session (Group 2)

Day 3 – March 10, 2016

9:00 – Review of Day 1 and 2

9:30 – Recommendations and next steps

10:15 – BREAK

10:30 – Uncertainties

12:00 – LUNCH

1:00 – Drafting Science Advisory Report

2:30 – BREAK

2:45 – Drafting Science Advisory Report continued

APPENDIX C. PARTICIPANTS

Last Name	Given Name	Affiliation
Beauchamp	Brittany	DFO Science
Beazley	Lindsay	DFO Science
Benoit	Hugues	DFO Science
Boudreau	Michelle	Fisheries Council of Canada
Bourdages	Hugo	DFO Science
Brillant	Sean	Canadian Wildlife Federation
Chapman	Bruce	Canadian Association of Prawn Producers
Clemens	Marc	DFO Fisheries Policy
Curtis	Janelle	DFO Science
Dunham	Jason	DFO Science
Edinger	Evan	Memorial University of Newfoundland
Favaro	Corinna	DFO Science
Fenten	Derek	DFO Oceans
Fuller	Susanna	Ecology Action Centre
Gilkinson	Kent	DFO Science
Guijarro-Sabaniel	Javier	DFO Science
Hedges	Kevin	DFO Science
Hurley	Geoff	Canadian Association of Petroleum Producers
Kenchington	Ellen	DFO Science
King	Marty	DFO Oceans
Koen-Alonso	Mariano	DFO Science
Lebeau	Amy	Arctic Fisheries Alliance
Lirette	Camille	DFO Science
McMillan	Andrew	University of Ottawa
Mercer	Dawn	DFO Oceans
Metaxas	Anna	Dalhousie University
Murillo	Javier	DFO Science
Ollerhead	Neil	DFO Science
Peramacki	Liisa	DFO Science
Rooper	Chris	National Oceanic and Atmospheric Administration
Sainte-Marie	Bernard	DFO Science
Setterington	Lisa	DFO Fisheries Policy, Co-Chair
Snelgrove	Paul	Memorial University of Newfoundland
Tanaka	Kisei	University of Maine at Orono
Templeman	Nadine	DFO Science
Tompkins-MacDonald	Gabrielle	DFO Science
Vascotto	Kris	Groundfish Enterprise Allocation Council
Wareham	Vonda	DFO Science
Whelan	Christie	DFO Science, Co-Chair
Young	Rachelle	Oceana