Capstone Report

Improving Capacity of Governments and the Fisheries Sector to Conserve Marine Biodiversity Through the Use of "Other Effective Area-based Conservation Measures"

By

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Submitted to the School of Marine and Environmental Affairs

University of Washington

In Partial Fulfillment of the Requirements

for the Master of Marine Affairs

March 13, 2023

Abstract
In 2010, Parties to the Convention on Biological Diversity, following the adoption of Aichi Biodiversity Target 11, recognized the potential for area based management tools (ABMTs) to contribute to biodiversity goals through the use of other effective area-based conservation measures (OECMs) was recognized. Currently, States are unsure how to interpret or apply the OECM concept due to a lack of clarity regarding the OECM identification criteria–particularly the criterion regarding providing evidence of positive biodiversity outcomes–Criterion C. To assist in building State capacity to identify and designate fisheries OECMs, we created the outline for the Fisheries ABMT Biodiversity Outcomes Framework which will will support increased clarity and transparency in identifying what positive biodiversity outcomes are relevant to and can be expected from fisheries OECMs, thus operationalizing OECM Criterion C. To refine the Framework, we organized and executed a workshop held during the 5th International Marine Protected Area Congress (IMPAC5) in February of 2023. This workshop was hosted by the Fisheries and Aquaculture Division (NFI) of the Food and Agriculture Organization of the United Nations (FAO) which has been tasked with creating and disseminating practical guidance on OECMs. This document will outline the process which resulted in identifying the need for the Framework, including our efforts from the spring of 2022 to the winter of 2023. This document will conclude with next steps and individual reflections.

Key Words
Convention on Biological Diversity, OECM, fisheries, area-based management, spatial management, biodiversity conservation

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Introduction

Capstone Plan Overview

The aim of this capstone project was to aid the client in developing relevant OECM guidance. Due to the mercurial nature of the project and the changing needs of the client, the deliverable(s) for our project evolved continuously from spring 2022 (see Appendix I for original Capstone Management Plan from April 2022) to winter 2023. Our group originally planned to aid the client on any number of OECM-related projects, including preparation for regional OECM workshops, development of technical guidance material and the operationalization of data from the 2021-2022 OECM capstone group. As we executed those tasks, it became clear that additional guidance was needed to support evaluation of biodiversity outcomes arising from fisheries ABMTs, to support ongoing discussion of OECMs in fisheries and this became the focus of our capstone project.

Internship Experience

Over the summer of 2022, all capstone group members were able to participate in internships with the fisheries division of the Food and Agriculture Organization (FAO) of the United Nations. Two of us worked in-person with our client in Rome, Italy at FAO HQ while the other worked virtually. The internships spanned roughly June - December and strengthened our understanding of OECMs through exposure to a variety of related projects / products. Through these internships, our foundational understanding of OECMs developed far beyond what it had been in spring 2022 when we took over the project from the previous capstone group.

Over the course of the internship, we worked on projects such as:

- Updating content on spatial management (marine protected areas [MPAs], OECMs) for the redesign of the NFI Assessment and Management Team website;
- Providing editorial and production support for the Fisheries OECM Handbook (FAO, 2022);
- Drafting of material for a Technical Reference Manual document for the eventual accompaniment of the Fisheries OECM Handbook, with individual focus on:
    - Equity and knowledge incorporation into the OECM implementation process (Lucy)
    - Addressing ambiguities of the OECM criteria, such as operationally defining key words and phrases (Sarah);
- Preparing powerpoint presentations for use by our client at international fisheries / conservation / spatial management conferences and meetings;
- Conducting an initial literature review of inland fisheries ABMTs for eventual incorporation into FAO OECM guidance efforts;
- Incorporating data manipulation, organization and visualization into NFI's OECM project through a network analysis methodology;
- Creating accessible ways of exploring NFI's OECM case study data, including the development of an OECM dataset in R and production of visualizations to display the data;
- Reformatting and redesigning data files and applicable figures for additional FAO consultants on their respectives manuscripts; and
- Drafting a Communications Strategy for OECMs.

Overview of Capstone Work

Our initial objective was to use the data from Himes-Cornell et al. (2022) to produce a new document which would report specifically on the alignment of fisheries ABMTs and expected biodiversity outcomes. Himes-Cornell et al. (2022) demonstrated positive biodiversity outcomes associated with fisheries ABMTs, and we wanted to take that analysis further to assess three main questions: (1) what larger “bins” or broad categories could biodiversity outcomes be placed into, (2) which biodiversity outcomes were linked to specific fisheries ABMTs or combinations of fisheries ABMTs, and (3) what were the most frequent combinations of biodiversity outcomes and fisheries ABMTs. Our goal was to use this information and analyses to better inform those interested in evaluating ABMTs against the OECM criteria on what biodiversity outcomes may be relevant to their fisheries ABMTs.

Network Analysis Scoping Exercise

To answer these questions we undertook a scoping network analysis based on the dataset produced during the Himes-Cornell et al. (2022) systematic review. We drew upon their coding of both specific ABMT types and individual biodiversity outcomes, and converted these data into matrices for network analysis. Specific network analyses we undertook using these matrices included calculation of degree centrality and exploration of the individual 1-degree networks, in analogy to the "ego networks" of social relationships, for distinct types of ABMT. The biodiversity/ABMT network scoping exercise was the first and only case of ego-networking, a portion of a network formed for a given individual or category (i.e. Species Diversity). Figure 2 demonstrates on sample ego-network using the bin “Species Diversity”. Based on our initial sorting or binning of biodiversity outcomes, Species Diversity appeared to be the most robust category for this scoping exercise as there was a coherent group of codes that were related to Species Diversity. Methods and background for network analysis, as well as results of the scoping exercise, follow.

Scoping Network Analysis Background

Network visualizations function on representing the structural properties of a given dataset in order to highlight key actors/ links between data points to deduce their relational strengths, community pairings, diffusional patterns, and mapping orientation. For OECMs, network analysis helps understand the structure and behavior of complex systems that are difficult to comprehend by analyzing their individual components in isolation. By analyzing the relationships between ABMTs, we can gain insights into how these systems operate as a whole. In order to understand the functionality of the AMBT networks, we needed to measure the number of relationships for each ABMT to itself and to relevant biodiversity outcomes.

Each network plot relies on two founding data categorizations: nodes and links. Nodes are the plotted points in any network figure (Golbeck, 2015). In other words, nodes are the objects of comparison and in a network dataset should contain the type of node, or object, that it is identified as and its frequency of occurrence, count, within the dataset. In addition, nodes can be further subset into categories if necessary to add any aesthetic comparisons and or color differentiations. Links, also referred to as edges, are the vertices, or associations, between nodes (Golbeck, 2015). Links denote where the connections between nodes are being made and how strong that connection is. In a network dataset, the links should contain the assignment of which nodes connect to each other and how many times one sees the connections between two or more nodes, or weight. The weight between nodes is vital for illustrating strong associations between two objects and it is very important for displaying patterns and levels of priority connections. The network scoping exercise was designed to display the centrality of AMBT nodes. Centrality refers to the measure of a node's importance or influence within a network and their measures are used to quantify how central or influential a node is within a network (Golbeck, 2015).

Degree centrality is one of the simplest and most commonly used measures of centrality, but it is an important measure in network analysis because it provides an intuitive way to quantify the importance of nodes within a network based on their connectivity (Golbeck, 2015). In other words, degree centrality is also a measure of a node's centrality based on the number of links it has with other nodes in a network. A node with high degree centrality has more connections to other nodes in the network than a node with low degree centrality. Often, higher degree centrality denotes important nodes in a network, as they have many connections and are potentially influential to their nodes (Golbeck, 2015). For OECMs, identifying these key nodes can help states and FAO members understand the structure and function of OECMs as they are meant to be used adjacent or in tandem with one another together to promote positive biodiversity outcomes. By identifying these communities of ABMTs, states and organizations can better understand how different OECMs could interact and form relationships within the larger network of area-based management tools.

Methods and Results

Scoping Network Analysis Methods

All network products for this capstone were designed in the R coding software using the ‘network’, ‘sna’, ‘igraph’, and ‘ggraph’ packages. For data sorting and organization, the ‘here’ and ‘tidyverse’ packages are used. We produced one sample ego-network using the bin "Species Diversity," which based on our initial sorting exercise appeared to be the most robust category for initial scoping. There was a coherent group of codes related to species diversity that lent themselves to grouping for a rigorous scoping analysis in conjunction with the ABMT-to-ABMT network plot. See Appendix II for the code of the associations of biodiversity outcomes to AMBTs under the broader bin of Species Diversity.

In all network exercises, the nodes, the objects of desired relationship visualizations, are the type of ABMT and or the biodiversity outcomes that our group assigned to “Species Diversity ". Each node is assigned a node ID and is given a category to allow for coloration in the plot. The count columns denote the size of the node in the figure which was calculated by the frequency of occurrence in the Himes-Cornell et al. (2022) dataset. To ensure proper relational strength, each node is scaled against the denominated ‘ego node’ which accounts for the total frequency of all nodes from the dataset. Within the link list, the assigned node IDs were sorted by their connections and the weights of each link was then calculated. To be able to plot the node and link lists as a figure, the two files were combined into a matrix (Appendix II, Table 4). The matrix command is the final data sorting procedure that grounds the structural properties of the OECMs datasets. Afterwards, the matrices are manipulated into network form via the R graphing packages.

To plot a network figure in R, you can use the ‘ggraph’ package, which is a popular package for analyzing and visualizing network data. Using the aforementioned matrices, the plot function displays a base network layout with any aesthetic modifications. In all network plots, we added several plot parameters to customize the appearance of the graph (Appendix II, Table 5). We changed the color and size of nodes, scaled the node size the the ABMT frequency, added black labels that are slightly repelled from the nodes, and changed the layout of the graph to a circle (Appendix II, Table 5).

In the simplest form, calculation of degree centrality of a node in a network requires counting the number of links that are connected to that node. However, in order to account for differences in network size and density of ABMTs, degree centrality calculations in this case needed to be scaled (i.e. normalized). Scaling degree centrality for ABMTs allows to compare the relative importance of nodes across different networks with different numbers of nodes and edges without jeopardizing the integrity of the value. For the ABMT networks, a proportional scaling was used to calculate the centrality values. For the proportional scaling, the degree centrality of each node is divided by the degree of the most central node in the network.

Degree Centrality = (Number of links connected to the node) / (The highest link number)

This method is more commonly used in directed networks, where nodes can have both incoming and outgoing connections, which will allow for unpredictability in OECM identification (Golbeck, 2015). Proportional scaling ensures that the most central node has a centrality score of 1, while other nodes have centrality scores proportional to their degree relative to the most central node. By scaling degree centrality for ABMTs, we compare the relative importance of nodes across different networks and identify nodes that are important regardless of network size or density. For the centrality figure, the value was calculated and plotted for both ABMT-to-ABMT relationships (Figure 1) and to ABMT-to-Species Diversity connections (Figure 2) since both conditions constitute separate variables of relationality.

Scoping Network Analysis Results

OECMs are still a relatively new concept and there is ongoing discussion about how to effectively identify, manage, and monitor them. Therefore, a network of area-based fisheries management tools that are identified as OECMs can be valuable for achieving sustainable fisheries and maintaining healthy marine ecosystems, as well as supporting the social and economic well-being of fishing communities. The purpose of this capstone is to improve capacity to identify OECMs which can improve the coordination of their development. Thus, Figure 1 illustrates that biodiversity management and conservation can be identified in a variety of connected AMBTs that are not limited to only full protection that are typically found in MPA measures. Full protection AMBTs can be a valuable tool when deemed most necessary, but also we want to promote sustainable use in fisheries. In addition, more frequent AMBTs connect more often to AMBTs of similar frequency (Figure 1). By establishing a network of frequently used area-based fisheries management tools, managers and stakeholders can coordinate their efforts to ensure that fishing activities are sustainable and that the health of the marine ecosystem is maintained. In addition, Figure 1 displays the possibility of linking different types of areas under OECM management. A network of area-based fisheries management tools can create ecological corridors and connections that support the movement of marine species and help maintain healthy ecosystems. States and the fisheries sector should know that an ABMT network is ever-present which can demonstrate the usability and value of OECMs as a policy tool. There is no “one size fits all” measure, which has been highlighted by a network of options that serve as identifiable OECMs.

By linking ABMTs to biodiversity outcomes, we can better understand how these measures are contributing to the conservation of different species and ecosystems. This can help prioritize management actions and increase the overall effectiveness of the ABMTs. In addition, connecting ABMTs to biodiversity outcomes can inform policy and decision-making at higher levels. By demonstrating the importance of ABMTs for a particular biodiversity outcome, states and the fisheries sector can help influence policy and funding decisions that support these measures. Figure 2 displays strong associations between more frequent area-based measures and more frequent biodiversity indices. However, of particular notice are Locally Managed Marine Areas, which were identified 41 times, and have the highest number of connections out of the central nodes (MPA, Marines Reserves) to Species Diversity indices (degree of centrality = 0.67) (Figure 3, Table 7). Network analyses like Figure 2 allows for the identification of less frequent ABMTs that may have a stronger association to a particular biodiversity outcome. In addition, most of the identified AMBTs from the Himes-Cornell et al. (2022) dataset were linked to an index of Species Diversity (Figure 2). As such, the variability and complexity of OECMs can be displayed which demonstrates the importance of these measures for conserving biodiversity. As such, Species Diversity indices such as “increase species richness” and “overall species diversity” represent a large portion of the bin that line up with central nodes, but also most of the other AMBTs. Accordingly, connecting ABMTs to biodiversity outcomes is important for improving sustainable-use effectiveness and the potential for monitoring and evaluation.

Degree centrality finalizes the steps for having a complete network analysis for potential OECMs. ABMTs with a centrality score of 1 were the most central nodes in their respective network analysis. MPA had the most links in the ABMT-to-ABMT network, whereas Marine Reverses had the most links in the Species Diversity ego-network (Figure 3). Both ABMTs were very frequent and in the Himes-Cornell et al. (2022) dataset (MPA; n= 79 , Marine Reserves; n=100) which follows the trend of higher frequency equated to higher degree centrality for ABMTs. Marine reserves, which is the most frequent ABMT in the dataset, and MPAs were also the only other ABMTs to have scored above the 0.75 centrality threshold in both network analyses, which indicates that both ABMTs had a level of connectedness to each other (Figure 3). The second and fourth ranked ABMTs in terms of frequency, respectively, Closed areas (n=86) and Closed season (n=65) did not score higher than a .55 degree of centrality in both networks which indicates a high level in drop off in connectedness after the central nodes (Figure 3). Most often, low levels of frequency in the dataset was attributable to a low level of degree centrality. AMBTs below the 0.25 centrality threshold were typically the ABMTs that appeared the least in the Himes-Cornell et al. (2022) dataset and accordingly held single digit connections to AMBTs and to Species Diversity indices if any at all (Figure 3). The outliers in this case are TURFs and Fisheries Sanctuaries, being identified 11 times in the dataset, but were not connected to any other AMBT or Species Diversity index (Figure 3, Table 7).

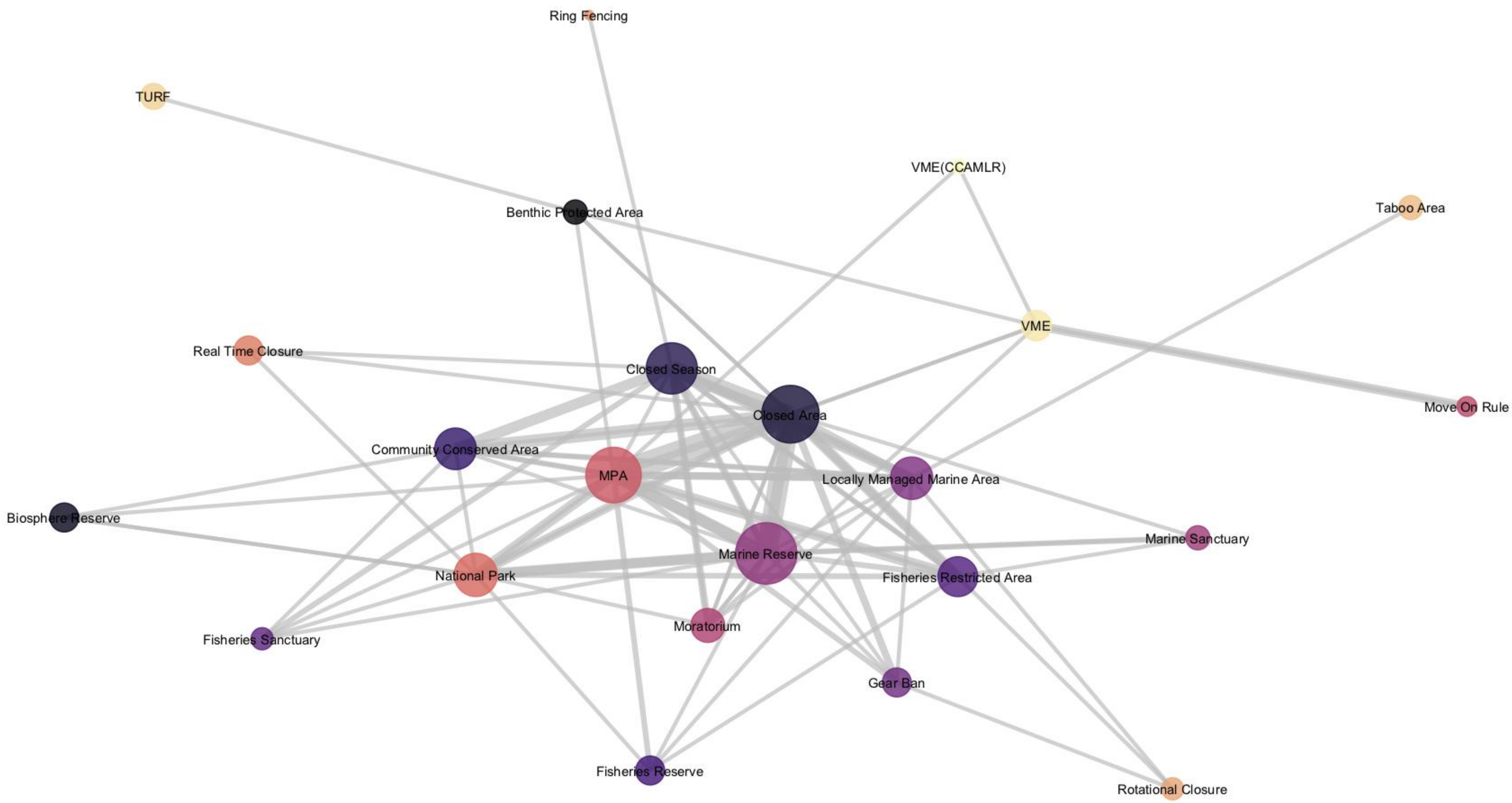

Figure 1: ABMT-to-ABMT network visualization. A larger bubble of an ABMT correlates to its frequency of identification within the typology paper. Thickness of lines also correlates with the frequency to which one or multiple AMBTs were identified together. Additionally, the lines are open to indicate that no one AMBT influences the other; they are not mutually exclusive and can occur simultaneously.

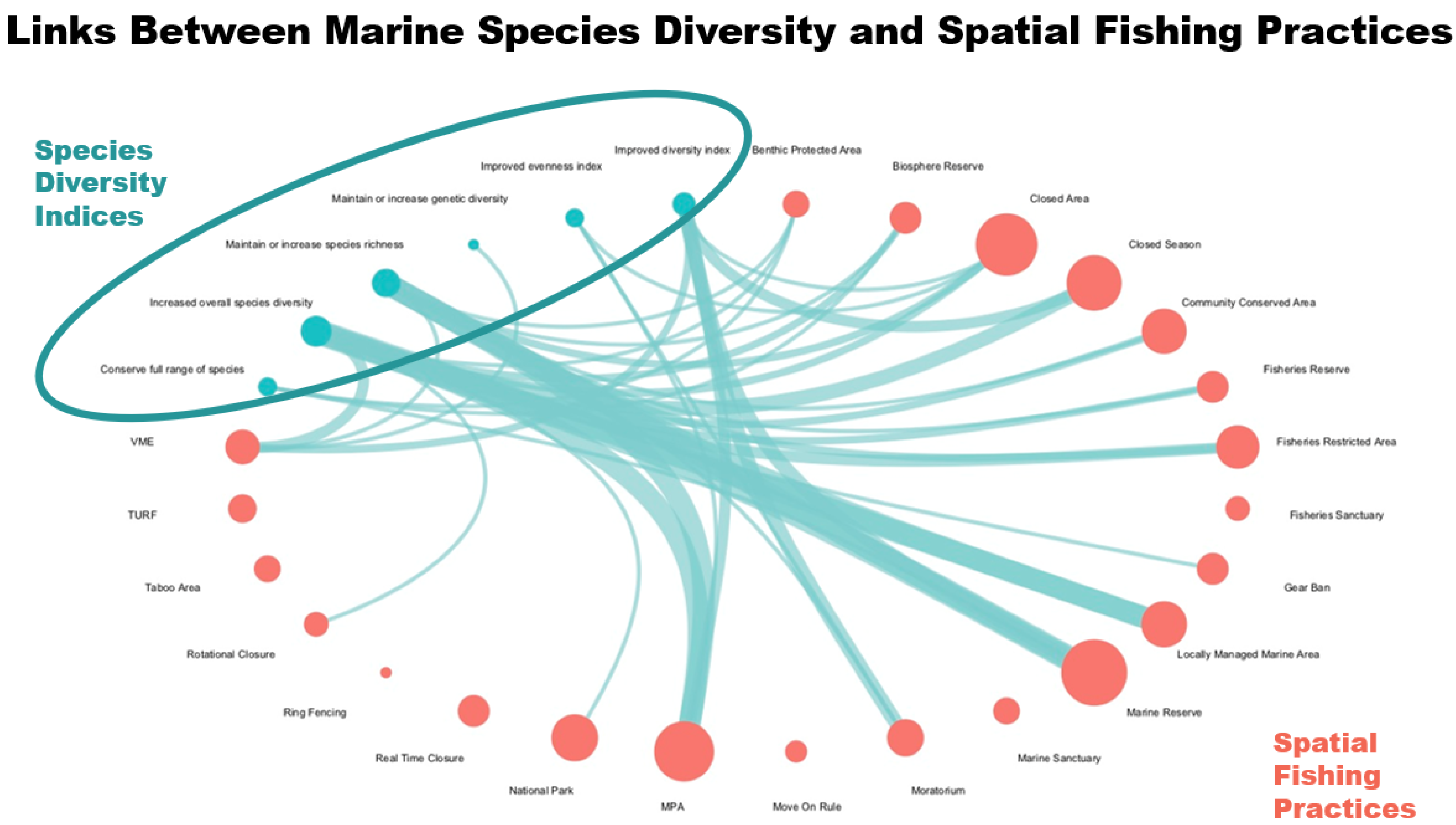

Figure 2: ABMT-to-Species Diversity Network visualization. Figure demonstrates coding for the connections between ABMTs and biodiversity outcomes. Larger node bubbles correlates to higher frequency of ABMT and or Species Diversity index identification. Wider link thickness denotes the frequency an AMBT was attributed to a biodiversity index.

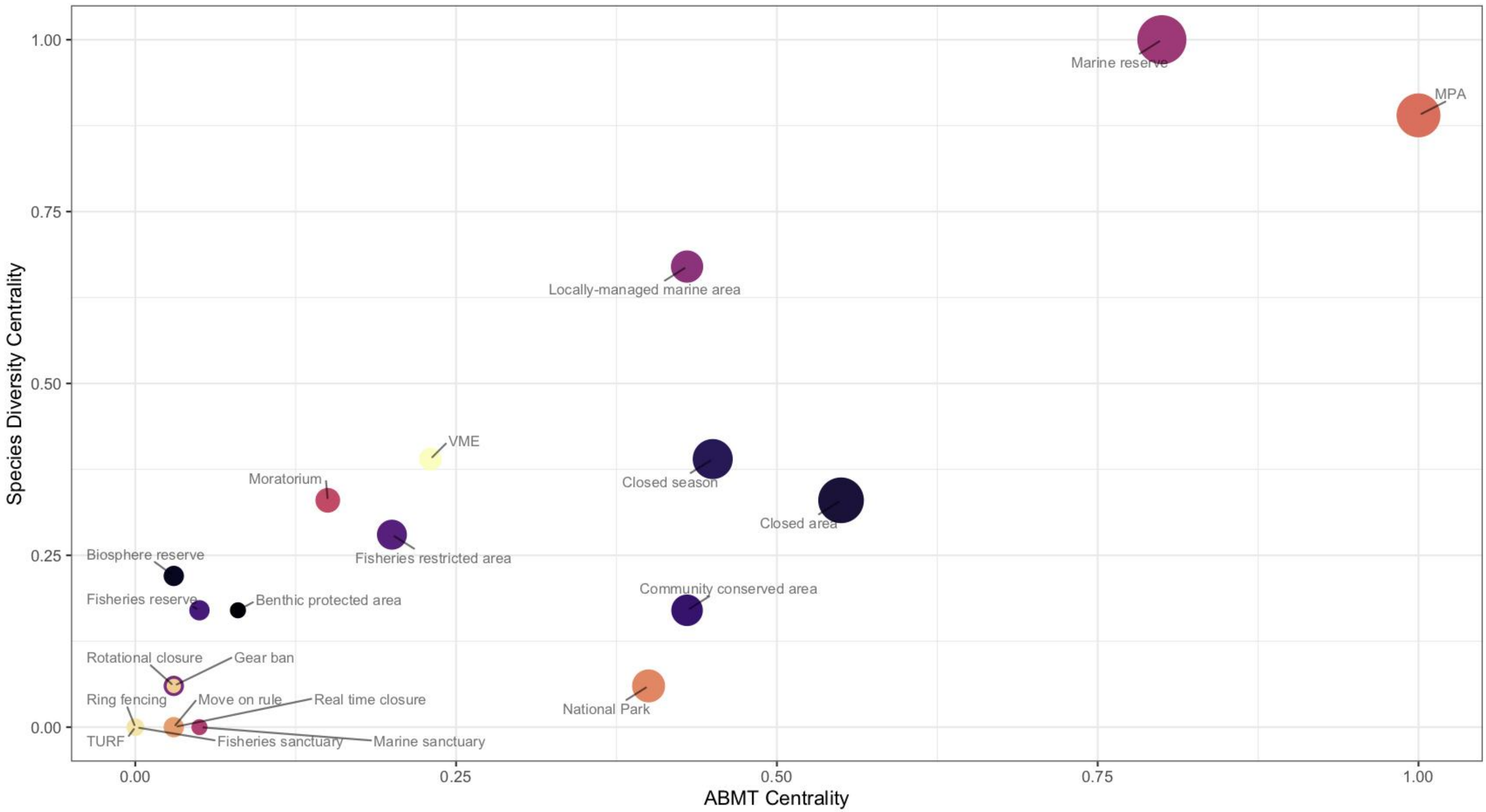

Figure 3: Degree centrality for ABMT nodes from network models. AMBTs constitute the expected cause for biodiversity outcome and thus are assigned to the x-axis for the ABMT-to-ABMT node connectedness. Outcomes associated with Species Diversity constitute the expected effect of ABMT placement which is assigned to the y-axis for the ABMT-to-species Diversity indices node connectedness. Size of ABMT node bubbles denotes the frequency of ABMT designation from Himes-Cornell et al. (2022) dataset. Note: Multiple AMBTs share the same degree of centrality across both network analyses.

Area-based management measures with a higher degree of centrality to biodiversity can have several possible implications. ABMTs that are centrally located within a network of protected areas can be more effective at conserving biodiversity, as they are better connected to other protected areas and can support the movement of species between them. This can increase the overall conservation effectiveness of the network. ABMTs that are centrally located-nodes can also support the functioning of marine ecosystems by maintaining key ecological processes and interactions. Lastly, ABMTs that have a higher degree of centrality to biodiversity could also be most effective to support the social and economic well-being of local communities by providing sustainable livelihoods and supporting cultural and traditional practices associated with marine ecosystems.

However, in exploring these implications we discovered a deficiency in the dataset. The process of attempting to bin existing codes into categories for use in these network analysis enabled us to identify several deficiencies in the existing dataset. The aforementioned structural properties of a dataset need to be reliable in order to have a coherent and robust network figure. In addition, the nodes of a network figure must be meaningful and have a reciprocal relationship to the underlying dataset. This is to say that the nodes being linked must be grounded in a dependable coding framework and decision process that describe and define the decisions made to categorize certain nodes together and to nominate nodes in a particular manner. See the "Identifying a Need for a Revised Coding Framework" section for more details about why this initial scoping exercise did not lead to full analysis of the original dataset.

Identifying the Need For A Revised Coding Framework

As we explored the existing dataset during scoping network analysis, it became clear that we did not have enough information about the codes applied during the original systematic literature review process to allow for robust analysis of biodiversity outcomes. For instance, the Himes-Cornell et al. (2022) Typology had divided biodiversity outcomes between three categories: Species/Populations, Habitat, and Ecosystem; these categories did not align with more detailed typologies of biological diversity, and neither the categories nor the individual biodiversity outcome codes were defined so enable our team to understand their meaning. Consequently, we took a step back from working on the data analysis and turned our focus to determining whether we could repurpose the original codebook from the Himes-Cornell et al. (2022) systematic review effort, or if we could need to revisit coding to enable analysis of relationships between ABMTs and biodiversity outcomes. This process involved 1) Pilot re-coding exercise to understand the potential utility of the original dataset; and when this was determined not to be possible, 2) Development of a revised coding structure. The following subsections provide details of these efforts.

Pilot Re-coding Using Original Codelist

We established a two pronged approach for pilot re-coding. First, we selected five papers from the original Himes-Cornell et al. (2022) systematic review for re-coding. Prioritization of the papers occurred based on the relatively high number of codes that had been assigned to them during the original systematic review process. Our goal was to verify there was content in the papers that merited application of each code (or not) and identify missing codes (if relevant). Second, we selected individual biodiversity outcome codes for which we felt particularly uncertain about their definition, and went back to all papers to which these codes had been applied. Our goal was to determine whether the code had the same meaning across all applications, and whether we therefore could develop a coherent definition for each.

After we re-coded the five papers and reviewed how selected codes had been applied across multiple papers, it was evident that important questions and uncertainties remained regarding the original codelist, and that we would not be able to retroactively define the codes. For instance, the codes conflated biodiversity "outcomes" and biodiversity "indicators"; codes did not always appear to be grouped in the appropriate category (e.g., the habitat, ecosystem, and species-level categories used in the Himes-Cornell et al. (2022) analysis); and codes had inconsistent meanings across multiple papers. These discussions led us to take another step back and consider how the next step in FAO's work on biodiversity outcomes could be most meaningful and relevant.

Development of a Revised Coding Structure

In consultation with the client, we identified the need for a consistent and reliable coding structure that could be used as the basis for future re-coding of the systematic review literature. In addition, the revised coding structure could support development of a meaningful management tool to connect a relevant ABMT / potential OECM to measurable biodiversity outcomes. Given our client's interest in both of these applications, our draft revision to the coding structure also became the basis for a Fisheries Area-Based Management Tool (ABMT) Biodiversity Outcomes Framework that we presented for feedback during the Fifth International Marine Protected Area Congress in February 2023 (IMPAC5). For further details on the Framework and workshop hosted at IMPACs, see the IMPAC5 Side Event Workshop section below.

A core design criterion for the revised coding structure was to ensure that our treatment of biodiversity outcomes would align with larger global conversations about elements of biodiversity that ABMT have the potential to influence. Further, we wanted to ensure our biodiversity outcome codes and categories would be transferable to the conservation sector and meaningful to both conservationists and ecologists, not just fisheries experts. So, we drew upon two existing frameworks: the essential biodiversity variables (EBV) framework (Table 1) and the essential ocean variables (EOV) framework (Table 2). Both of these frameworks fall into the larger discussions on global biodiversity indicators and are ways to monitor change in biodiversity (EBV) and ocean conditions, including biological and ecological variables relevant to biodiversity conversations (EOV). EBV was developed by GEO BON (Group on Earth Observation, Biodiversity Observation Network). As a sub-group of GEO BON, the Marine BON is working to apply the EBV framework in a marine context (Muller-Karger et al., 2018). EOV was developed by the Global Ocean Observing System (GOOS) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. It supports data collection on the status and trends in oceanic ecosystem properties (Muller-Karger et al., 2018).

Table 1. EBV classes and candidate variables. (ConnectinGEO 2016, pp. 15-16)

EBV class	**EBV candidate**
Genetic composition	Co-ancestry
	Allelic diversity
	Population genetic differentiation
	Breed and variety diversity
Species populations	Species distribution
	Population abundance
	Population structure by age/size class
Species traits	Phenology
	Body mass
	Natal dispersion distance
	Migratory behavior
	Demographic traits
	Physiological traits
Community composition	Taxonomic diversity
	Species interactions
Ecosystem function	Net primary productivity
	Secondary productivity
	Nutrient retention
	Disturbance regime
Ecosystem structure	Habitat structure
	Ecosystem extent and fragmentation
	Ecosystem composition by functional type

Table 2. Updated list of EOVs, including biological and ecological ("bio-eco") EOVs.
(Bax et al., 2019, p. 4)

Physics	**Biogeochemistry**	**Biology and ecosystems**
● Sea state ● Ocean surface stress ● Ocean surface heat flux ● Sea ice ● Sea surface height ● Sea surface temp ● Subsurface temperature ● Surface currents ● Subsurface currents ● Sea surface salinity ● Subsurface salinity	● Oxygen ● Inorganic carbon ● Transient tracers ● Particulate matter ● Nutrients ● Nitrous oxide ● Dissolved organic carbon ● Ocean color ● Stable carbon isotopes	● Phytoplankton biomass and density ● Zooplankton biomass and diversity ● Fish abundance and distribution ● Marine turtles, birds and mammals abundance and distribution ● Hard coral cover and composition ● Seagrass cover and composition ● Mangrove cover and composition ● Macroalgal cover and composition ● Microbe biomass and diversity (emerging) ● Invertebrate abundance and distribution (emerging) ● Ocean sound

Draft Coding Structure

Our drafted coding structure is presented below in Table 3. It represents our attempt to connect ABMT type with the relevant ecosystem element(s), biodiversity variables, biodiversity indicators and biodiversity outcomes.

Table 3. Coding structure draft including ABMT type, EOV, EBV, indicators, and outcomes and their definitions.

Component	Definition
ABMT Type	Identify what ABMT type is in place and the dimension(s) is it constrained by (e.g., time, space closed, and activities)
EOV	Identify what ecosystem element(s) is influenced by the ABMT. This includes coding for biodiversity attributes and EOVs listed in Table 2.
EBV	Identify what biodiversity variable(s) is influenced by the ABMT. This includes coding for EBVs listed in Table 1.
Indicators	Identify what indicator(s) are used to understand the influence of the ABMT on the EOV in terms of the EBV
Outcomes	Characterize biodiversity outcomes as positive (= maintain or improve status depending on the context) or negative (= declining status, unknown, etc.).

Using the existing EBV framework in particular helped us group biodiversity outcomes into EBV classes and EBV candidates. The draft coding structure incorporated both EBV and EOVs; however, we sought feedback from experts to determine if our proposed framework was headed in a direction worth pursuing moving forward. Ultimately, this led us to the planning of a side event workshop during IMPAC5 where we obtained expert input and feedback on our proposed Framework and the work we had done thus far.

IMPAC5 Side Event Workshop

Collaborative Refinement Workshop at IMPAC5

As discussed earlier, the revised coding structure became a core element of a draft Fisheries ABMT Biodiversity Outcomes Framework that was presented for feedback during the IMPAC5 conference in February 2023. The purpose of this Framework was to provide common ground for discussions of net positive biodiversity outcomes associated with fisheries ABMTs. In response to the newly adopted Target 3 of the post-2020 global biodiversity framework, governing authorities and entities need assistance in determining what should count and should not count towards this target. So, characterizing the range of potentially relevant biodiversity outcomes from fisheries ABMTs in our proposed Framework could serve as a tool for increased clarity and shared understanding in discussions of the implementation of fisheries OECMs. The Framework would help countries triage where they should dedicate their resources and time in the assessment of potential OECMs.

In February 2023, alongside our client, we hosted a transdisciplinary collaborative refinement workshop that brought together ecologists, conservationists, fisheries social scientists, and Indigenous leaders to provide feedback on the draft Framework, based heavily on our draft coding structure. The workshop utilized Word Café methodology, combined with an invitation for experts to submit written feedback on improving the draft Fisheries ABMT Biodiversity Outcomes Framework. The following sections describe our involvement in workshop planning, facilitation at the workshop, and post-workshop reporting.

Workshop Planning / Preparation

IMPAC5 was a global forum that brought together ocean conservation professionals and high-level officials to inform, inspire and act on marine protected areas. Held in Vancouver BC during the first week in February, our whole capstone group attended alongside our FAO client team: Amber Himes-Cornell and her consultant, Kristin Hoelting. Our FAO side event workshop was entitled "Participatory refinement of FAO's fisheries ABMT biodiversity outcomes framework" and the material presented as a handout to all participants is found in Appendix III.

The role of our capstone team largely focused on creating Table 4, which is also referred to as Table 4 in the workshop handout (Appendix III). This table lists examples of biodiversity indicators categorized by EBV variables and drafts of their definitions, methods used to measure them, and definitions of what a 'positive outcome' might mean for each. To categorize the indicators by EBVs, we first identified the relevant EBVs based on the biodiversity outcomes reported in the Himes-Cornell et al. (2022) dataset. These examples were pulled from the literature and used as a launching point for discussions that would occur during the workshop. This provided insight into how we were thinking about biodiversity outcomes and indicators in addition to how we were attempting to incorporate the EBVs.

Table 4: EBV sample variables with associated indicator examples, definitions of indicators, data collection methodology and a definition of what a positive outcome would look like.

EBV Variable	Indicator (Examples)	Indicator Definition	Data Collection Methods	Definition of "Positive Outcome"
Population Abundance	**Larval abundance**	The number or quantity of larval organisms of a given species, within plankton samples.	• Plankton samples collected via bongo nets and stored in ethanol	Stable or increasing larval abundance of a species indicates maintenance or increase in reproductive activity, or maintained or increased number of adults that have reached reproductive age.
Population Age Structure / Size Class	**Abundance of certain body lengths (1)**	The number or quantity of organisms at a given length for a population.	• Trawl and net surveys • Visual reef surveys	Increased or maintained diversity of body lengths indicate positive outcomes for population structure by age/size class.
	Abundance of certain body lengths (2)	The number or quantity of organisms at a given length for a population.	• Fisher interviews • Sampling of catches for sale at fish markets.	Increased or maintained diversity of body lengths indicate positive outcomes for population structure by age/size class.
Taxonomic Diversity	**Shannon-Wiener Diversity Index**	**Shannon Wiener Diversity Index (H')**: An estimate of species diversity that considers number of species (richness) and relative abundance (evenness).	• Fish visual rapid census • Fish stationary plot survey • Towed diver	A stable or increasing H' value suggests maintained or improved community structure in terms of species diversity.
Ecosystem Extent / Fragmentation	**Larval dispersion**	Exchange of larva among marine populations.	• Direct and indirect methods using geochemical and genetic markers • Coupled biophysical models	Maintenance or even increase in larval dispersion supports population connectivity.
Ecosystem Composition / Functional Type	**Catch mean trophic level (MTL)**	Average trophic level of commercial catch, weighted by biomass of each trophic level.	• Catch data • Fisher observations	Declining MTL (decreased abundance of higher trophic level organisms) is generally interpreted as an indicator of deteriorating trophic structure. NOTE: **catch MTL** has recently come under scrutiny as not tracking with other measures of MTL.
	Ecosystem mean trophic level (MTL)	Average trophic level of fish and invertebrate organisms, weighted by biomass of each trophic level.	• Long-term trawl surveys • Stock assessment	Declining MTL (decreased abundance of higher trophic level organisms) is generally interpreted as an indicator of deteriorating trophic structure.

Workshop Facilitation

The workshop began with an introductory presentation that provided an overview of the work we had been doing and how the workshop would run. Background information on the post-2020 Global Biodiversity Framework and OECMs was provided to ensure all workshop participants understood why OECMs were relevant to global biodiversity conversations. OECMs were then placed in the fisheries sector and the potential for fisheries AMBTs to be identified as fisheries OECMs. Next steps illustrated the need for the side event workshop as there is still confusion surrounding biodiversity outcomes. The Fisheries ABMT Biodiversity Outcomes Framework was then introduced and the four Framework components (ABMT, EOV, EBV, and outcomes) were reviewed in detail. Finally, the instructions for the discussion tables were presented, and participants then dispersed to their first discussion table.

The workshop was set up in a World Café style. There were five discussion tables, each with their own topic. The five tables included: (1) indicators focused on ecosystems, (2) indicators focused on community composition, (3) indicators focused on species populations, (4) the overall Framework, and (5) incorporation of diverse knowledge systems and knowledge holders. Participants chose which topics they wanted to discuss, and they circulated between tables for a total of three sessions. Large poster paper was present at each table where participants could add any ideas, comments, concerns, questions, etc. via post-it notes. With every session, participants were able to see what was written by the past group and could add/remove/edit/move any of the post-its. By the end of the three sessions, the posters displayed a culmination of ideas presented during each session (Fig. 4).

Because our focus had been on developing the coding structure for biodiversity outcomes, the three of us each facilitated one of the indicator tables: Sarah facilitated the ecosystem indicators table, Xavier facilitated the community composition indicators table, and Lucy facilitated the species populations indicators table. As facilitators, we introduced the topics of our tables for each session, took notes of and recorded each session, and guided participants during discussions. Participants were informed that sessions would be recorded and recordings were only used for the purpose of transcribing notes for the workshop report. We each became experts on our given table topic, and this allowed us to provide specific feedback to our client about next steps for the refinement of the draft coding structure produced during Fall Quarter 2022.

A. B.

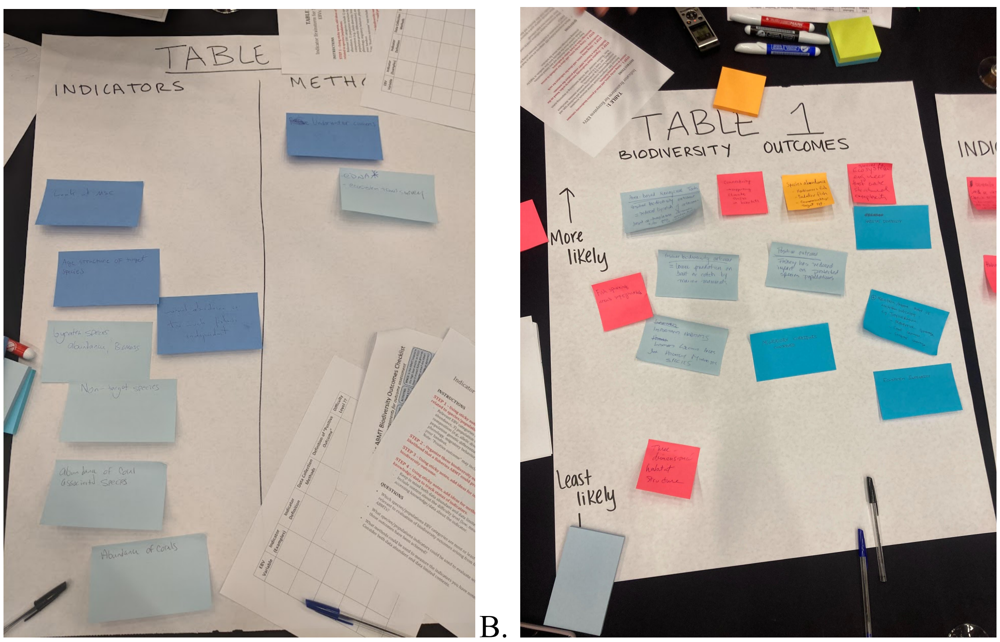

Figure 4. Example images from indicator tables that display post-it notes that capture discussions from all three sessions. A. Table 3: indicators for species populations. B. Table 1: indicators for ecosystems.

Workshop Takeaways

A full summary of workshop discussion takeaways is included in Appendix IV. Here we present an abbreviated summary of common themes and key takeaways from workshop discussion, including salient questions and comments, as well as a visual representation of workshop themes.

Common Themes

Common themes linking discussions across tables were the topics of feasibility and context-specificity. Much discussion veered from the Framework itself to (fisheries) OECMs more broadly, as participants grappled with understanding the challenges and strengths of the proposed Framework. In addition, many participants felt that understanding the “burden of proof” to be expected from OECMs is paramount. In this vein, it must be clarified how a sufficient level of evidence can be reconciled across the diverse types of knowledge likely to be used in the OECM process.

Key Takeaways

A sample of important questions and comments which arose from discussion at the workshop is included here, divided into three sections.

Feedback on indicators and outcomes relevant to coding structure refinement:

- There should a “top 3” or a priority list of outcomes / indicators / methods based on the type of data or knowledge that is generally accessible across the board (in fisheries management) for more effective operationalization of this Framework
- Habitat structure was viewed as the most likely outcome to occur at ecosystem level from fisheries ABMT
  - Percent cover as indicator
  - Abundance of ecosystem-building species as indicator
  - Multitude of methods possible for assessing indicators
- Discussion about catch per unit effort (CPUE) as a measurement method was that in spite of offering accessible data, it should not be used on it’s own to for indicator assessment of biodiversity outcomes
- If a non-target species, bycatch species, and/or depleted/threatened/endangered species is protected by a spatial fisheries measure, that could be considered an outcome
  - The abundance of those species may be used as indicators for species populations with the clarification that they must be affected by the fisheries measure
  - The benefits for those species would be considered a biodiversity outcome
  - The species of interest matters (aka not all species are created equal - i.e., top predators, migratory species), and their use of the area and the amount of time that are within the OECM boundary matters
  - Debate on if bycatch alone would be a strong enough indicator
- Participants did not like larval abundance as an indicator because it is too fisheries independent and the stock has to be really low in order to see an impact on it

Overall strengths and weaknesses of the Framework:

- Using existing frameworks such as EBV / EOV is a strength of the Framework and lends "credibility" and some structure to our processes, as can using data monitoring systems that already exist (in or out of fisheries contexts)
- One identified weakness (OECMs in general, not just the Framework) is how hard it is to manage and address multi-sectoral threats, if those do exist within the OECM area However, since biodiversity will need to be assessed within the OECM area, perhaps areas with too much multi-sectoral pressure will necessarily exclude themselves
- An area of improvement for the Framework could be to include language of "biocultural diversity" as that way be more inclusive than biodiversity, alleviating discomfort in coastal community-based and/or Indigenous fishing areas

Knowledge considerations:

- A common point of discussion was on the topic of data / knowledge "standardization" vs "reconciliation"
    - Many participants agreed that there is not a need for information to be standardized (and this would be an unrealistic goal)
    - However, many participants discussed how knowledge from Indigenous peoples and local communities (IPLC), while diverse, could/should be treated as "parallel systems" thus enabling "reconciliation"
- Question: Can we include timeframes to account and allow for different contexts?

Visual Representation of Themes

Xavier created a visual representation of the outcome, indicator and method post-it notes that were the product of discussions at the ecosystem-, community- and species-level (Fig. 5). The dark blue circles represent the topics from each of the indicator tables; the outcomes, indicators, and methods mentioned at each table branch out from there. Threat and bycatch reduction as outcomes, abundance as an indicator and eDNA as a method of indicator measurement are examples of where overlap in discussion occurred at all three tables. The two tables focused on ecosystems and community composition had large amounts of overlap during discussions (e.g., trophic structure, species diversity, local knowledge, drones, CPUE, etc.) whereas species populations had little overlap with ecosystems (e.g., video surveillance, trawl surveys) and no overlap with community composition alone. All in all, Figure 5 demonstrates how the discussions that occurred at each indicator table were broad and variable. Lots of indicators, methods, and outcomes were discussed and to varying degrees. It is clear that discussions held during the side event workshop contribute a small piece to the much larger discussion on global biodiversity conservation outcomes.

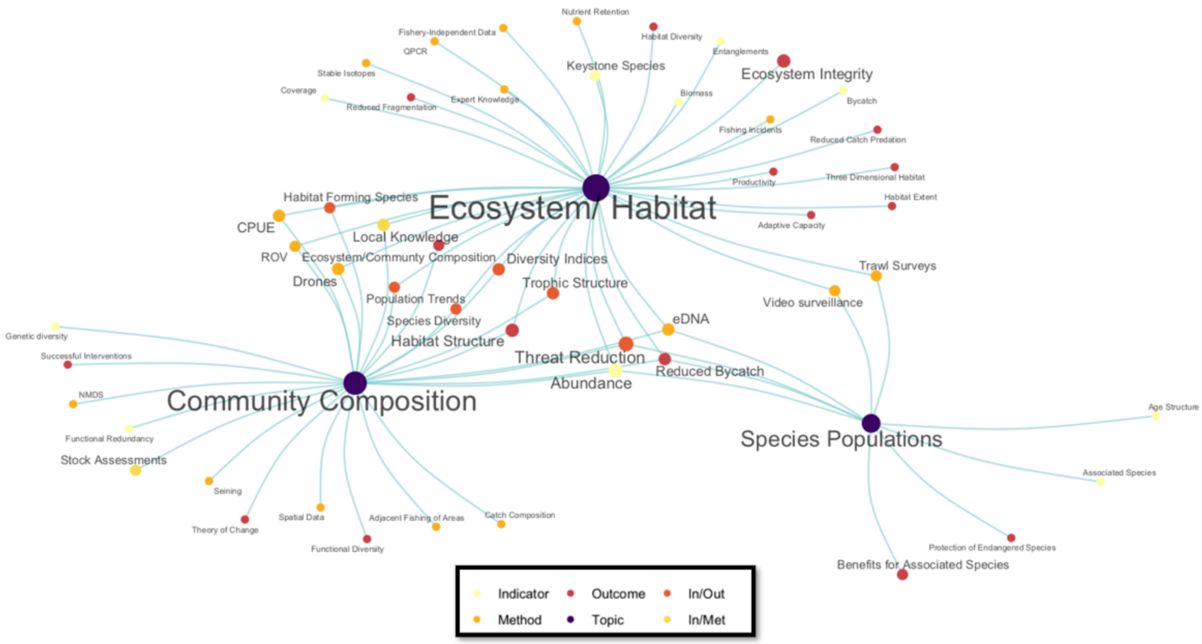

Figure 5. Visual representation of IMPAC5 side event workshop takeaways from tables focused on species, community and ecosystem level biodiversity outcomes, indicators and methods.

Capstone Presentation

On February 24, 2023 we completed a presentation on our capstone project for partial fulfillment of the MMA degree requirements as dictated by SMEA. This presentation was attended by SMEA faculty and students and was approximately 20 minutes long, with time for 10 minutes of Q and A. Drafting / presenting the slides was equally split between all three capstone members and the slides used in our presentation are available in Appendix V.

Next Steps

Continuation of Our Efforts

Throughout the upcoming spring quarter (April - June 2023), Lucy and Xavier will continue working on the IMPAC5 side event workshop report as an Independent Study. Sarah will graduate at the end of winter quarter (March 2023) and will continue this work as an FAO consultant. Our ultimate goal will be to publish a workshop report. We also will continue to develop the biodiversity outcomes Framework itself, which was the topic of our IMPAC5 side event workshop. Once completed, the Framework will outline what biodiversity outcomes can be expected for a suite of ABMTs and what outcomes should be assessed in order for ABMTs to be recognized as OECMs. This will, in turn, allow for us to refine and operationalize a codebook which we can apply to relevant literature to make informed statements about the expected biodiversity outcomes associated with fisheries ABMT. This work should allow us to achieve our ultimate goal of operationalizing OECM criterion C so that interested governments and fishery managers better understand how to implement OECMs.

In addition, work will continue on producing a report which summarizes how topics of sustainable use, fisheries and OECMs were discussed at IMPAC5. It is our goal that the IMPAC5 report will also be published as well, potentially in a journal such as *Marine Policy*.

SMEA Capstone Involvement
The upcoming capstone group (2023-2024) will continue working with the client to produce OECM guidance material. One possible area of focus for the next capstone is inland fisheries, with the new group of students conducting a literature review of inland fisheries ABMTs to assess against the OECM criteria. In addition, upcoming capstone students will probably liaise with our capstone group to coordinate their efforts. It is possible their deliverables regarding producing OECM guidance will shift over the upcoming months, as did ours.

Reflections

It is our view that the ever-evolving nature of this capstone project allowed us to gain valuable, hands-on professional experience. The opportunity to work with a client from a large international and intergovernmental organization provided us with experience working in international marine policy. In particular, we cultivated skills in task management, critical thinking and problem-solving. The dynamic nature of working on an emerging topic prompted us to be flexible and adaptable with the direction of our project and encouraged us to openly communicate and coordinate with one another. Furthermore, we were able to network with people from other institutions and organizations such as World Wildlife Fund (WWF), International Union for Conservation of Nature (IUCN), regional fishery management organizations (RFMOs), and more. As such, our personal networks grew throughout the duration of this project.

Overall, we are happy with our capstone project product and grateful to have built a positive working relationship with both our client and our advisor. We cannot thank them enough for all of their guidance and support throughout this process.

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Appendices

Appendix I: SMEA CAPSTONE PROJECT MANAGEMENT PLAN

Capstone Information

Capstone title: "Improving the capacity of governments and the fisheries sector to conserve marine biodiversity through the use of "other effective area-based conservation measures"

Faculty advisor: Dave Fluharty, fluharty@uw.edu

Client: Amber Himes-Cornell, Amber.HimesCornell@fao.org

Collaborators: Sarah Davidson, Xavier Nelson-Rowntree, Lucy Bowser

Capstone Project Description and Timeline

The client's goals for this capstone are to create a functional deliverable to aid FAO's ongoing efforts to provide education about OECMs (other effective area-based conservation measures). The overall project goals are to create a deliverable(s) that will improve the capacity of governments and the fisheries sector to conserve marine biodiversity through the use of "other effective area-based measures". The OECM concept allows for a variety of sustainable use sectors, including fisheries, to contribute to meeting global biodiversity targets through their own area-based management initiatives. This can result in two significant steps forward in achieving biodiversity conservation: 1) mainstreaming biodiversity conservation objectives in the management of natural resource use; and 2) ensuring that the objectives of sustainable use sectors are included in biodiversity conservation discussions and decisions. FAO's role in the CBD is to help countries meet their production needs while keeping their commitments to conserving biodiversity through the use of area-based management tools (ABMTs) and sustainable resource use.

A key aspect of FAO's work will be to provide policy guidance that assists FAO Members and regional fisheries bodies (RFBs) in the formulation of spatial management tools that can qualify as OECMs. This will be accomplished through three main activities: (1) FAO will solicit expert input and prepare guidance on the identification, evaluation, monitoring and reporting of OECMs in the fisheries sector. (2) FAO will provide capacity development at regional/national level to develop and implement fisheries spatial management approaches that deliver biodiversity co-benefits with the aim of increasing OECM coverage. (3) FAO will support FAO Members, RFBs and Parties to the CBD in applying the CBD's criteria for OECMs to existing and new area-based fisheries management measures. During this capstone project, students will contribute to these three activities, including the planning and preparation of regional workshops expected to occur in 2022 and the development of the OECM guidance. In addition, there will be the possibility to contribute to peer-reviewed articles on the subject.

The potential hurdles of this capstone will stem from the “moving target” of the deliverables established by our client at FAO. Flexibility will be needed by the capstone teammates as we work together to develop our capstone topic into clear deliverables that align with the wants of our client, Amber.

During spring quarter, we plan to meet once weekly to check in on client/project developments. We plan to continue reading papers on OECMs for further background knowledge and plan to meet once more with Clay and Caroline (last year’s capstone team on the same topic) to touch base on the status of their capstone and “receive the torch,” so to speak.

The client has asked us to be prepared to work on any number of OECM-related projects with the specifics to be determined by fall of 2022. In addition, due to the mercurial nature of the project and the changing needs of the client, we expect there to be potential changes to the deliverables of the project as we proceed through the process. We plan to divide up the tasks to work to the strengths of our team members while dividing the effort required by each person as evenly as possible throughout the fall and winter of 2022-2023. Our proposed timeline is: spring 2022 (0 credits, introduction to OECMs and prep work), summer, (0 credits, currently no expectations), fall 2022 (5 credits), winter 2022 (4 credits). We will meet weekly or bi-weekly with Dave. Our meeting schedule with our client, Amber, has not yet been determined. While exact deliverable dates have not yet been determined, the bulk of our work will fall within the fall quarter of 2022 and winter quarter of 2023. As such, we can estimate that our deliverables should be completed by the end of winter quarter 2023. There is no proposed curriculum, as of yet, that our advisor or client has suggested the members of the capstone team follow. Our current plan is to continue taking the necessary core and elective classes, using our own discretion to decide which specific classes shall fulfill our program requirements. If it becomes apparent that a certain course will aid in our capstone efforts, the capstone team will discuss and decide upon enrolling in the course.

Appendix II: Data management and figure development in R coding software

Table 5: Coding Process to Design Network Matrices for both AMBT and Species Diversity Figures

```
#Import Data
OECM_net <- read.csv(here("data", "OECM_network.csv"), header = T, na.strings=c("","NA"))
Biodiv_net <- read.csv(here("data", "BioDiv_network.csv"), header = T, na.strings=c("","NA"))

#Select Edges
ABMT1 <- OECM_net %>%
  select(CORRECTED_Type_ABMT_1)
ABMT2 <- OECM_net %>%
  select(CORRECTED_Type_ABMT_2)
ABMT3 <- OECM_net %>%
  select(CORRECTED_Type_ABMT_3)
ABMT4 <- OECM_net %>%
  select(CORRECTED_Type_ABMT_4)

#make edgelist df
OECM_edge <- data_frame(ABMT1,
                        ABMT2,
                        ABMT3,
                        ABMT4)


my_OECMnet <-graph.data.frame(OECM_edge)
plot(my_OECMnet)

plot(my_OECMnet, edge.arrow.size=.2, edge.color="orange",
vertex.color="orange", vertex.frame.color="#ffffff",
vertex.label=V(my_OECMnet)$ABMT1 , vertex.label.color="black")

l <- layout_in_circle(my_OECMnet)
plot(my_OECMnet, layout=l,
            edge.arrow.size=.2,
            edge.color="orange",
            vertex.color="blue",
            vertex.frame.color="#ffffff",
            vertex.label.color="black")

Z <- layout_on_sphere(my_OECMnet)
plot(my_OECMnet, layout = Z)

Y <- layout_with_fr(my_OECMnet)
plot(my_OECMnet, layout=Y)


#make adjacency matrix
my_OECMmatrix<- get.adjacency(my_OECMnet)
my_OECMmatrix

adj_table <- OECM_edge %>%
  pivot_longer(cols = -CORRECTED_Type_ABMT_1) %>%
  count(CORRECTED_Type_ABMT_1, value) %>%
```

```
  pivot_wider(names_from = value, values_from = n, values_fill = list(n = 0))

adj_table%>%
  write.csv(.,file = "/Users/XavierN-R/Desktop/SMEA/SMEA 586 - S22/output/OECM_adj_table.csv")

### BioDiv Network ###

#edges
ABMT1 <- Biodiv_net %>%
  select(CORRECTED_Type_ABMT_1)
ABMT2 <- Biodiv_net %>%
  select(CORRECTED_Type_ABMT_2)
ABMT3 <- Biodiv_net %>%
  select(CORRECTED_Type_ABMT_3)
ABMT4 <- Biodiv_net %>%
  select(CORRECTED_Type_ABMT_4)

Div1 <- Biodiv_net %>%
  select(Index_1)
Div2 <- Biodiv_net %>%
  select(Index_2)
Div3 <- Biodiv_net %>%
  select(Index_3)
Div4 <- Biodiv_net %>%
  select(Index_4)
Div5 <- Biodiv_net %>%
  select(Index_5)
Div6 <- Biodiv_net %>%
  select(Index_6)

#make dataframe
Biodiv_edge <- data_frame(ABMT1, ABMT2, ABMT3, ABMT4,
                          Div1, Div2, Div3, Div4, Div5, Div6)

my_Biodivnet <-graph.data.frame(Biodiv_edge)
plot(my_Biodivnet)

#make adjacency matrix
my_Biodivmatrix<- get.adjacency(my_Biodivnet)
my_Biodivmatrix

Div_adj_table <- Biodiv_edge %>%
  pivot_longer(cols = -CORRECTED_Type_ABMT_1) %>%
  count(CORRECTED_Type_ABMT_1, value) %>%
  pivot_wider(names_from = value, values_from = n, values_fill = list(n = 0))

Div_adj_table%>%
  write.csv(.,file = "/Users/XavierN-R/Desktop/SMEA/SMEA 586 - S22/output/BioDiv_adj_table.csv")
```

Table 6: Coding Process to Design and Modify ABMT and Species Diversity Network Figures

```
#Import Data
nodes2 <- read.csv(here("data", "OECM_NODES.csv"), header=T, as.is=T)
links2 <- read.csv(here("data", "OECM_EDGES.csv"), header=T, row.names=1)
bionodes <- read.csv(here("data", "BioDiv_nodes.csv"), header=T, as.is=T)
bionodes2 <- read.csv(here("data", "BioDiv_nodes.2.csv"), header=T, as.is=T)
biolinks <- read.csv(here("data", "BioDiv_edges.csv"), header=T, as.is=T)

# Plot with curved edges (edge.curved=.1) and reduce arrow size:
# Note that using curved edges will allow you to see multiple links
# between two nodes (e.g. links going in either direction, or multiplex links)

plot(net2, edge.arrow.size=.4, edge.curved=.1)

net2
plot(net2, vertex.label=NA)


V(net2)$color <- c("steel blue", "orange")[V(net2)$type+1]
V(net2)$shape <- c("square", "circle")[V(net2)$type+1]


V(net2)$label <- ""
V(net2)$label[V(net2)$type==F] <- nodes2$ABMT_ANSWER_1[V(net2)$type==F]
V(net2)$label.cex=.6
V(net2)$label.font=2

plot(net2, vertex.label.color="black", vertex.size=(1-V(net2)$type)*8)

plot(net2, vertex.label= NA, vertex.size=5, layout=layout.bipartite)

l <- layout_with_fr(net2)
c <- layout_in_circle(net2)
k <- cbind(1:vcount(net2), c(1, vcount(net2):2))
g <- layout_with_graphopt(net2)
plot(net2, vertex.shape="none", vertex.label=nodes2$ABMT_ANSWER_1,
        vertex.label.color=V(net2)$color, vertex.label.font=2,
        vertex.label.cex=.6, edge.color="gray",  edge.width=2, layout = c)

ggraph(net2) +
  geom_edge_link() +
  geom_node_point()

ggraph(net2, layout = 'linear') +
  geom_edge_arc(color = "orange", width=0.7) +
  geom_node_point(size=5, color="gray50") +
  theme_void()

### NEWER FIGURES ###

net <- graph_from_data_frame(d=links.new, vertices=nodes.new, directed=T)
net
plot(net)
```

```
net <- simplify(net, remove.multiple = F, remove.loops = T)
plot(net, edge.arrow.size=.4,vertex.label=NA)

c2 <- layout_in_circle(net)
g2 <- layout_with_graphopt(net)

plot(net, edge.arrow.size=.2, edge.color="#cccccc",
        vertex.color="#fc8d59", vertex.frame.color="#ffffff",
        vertex.label=V(net)$ABMT_ANSWER_1,
        vertex.label.font=2, vertex.label.color="gray40",
        vertex.label.cex=.5, vertex.label.color="black", layout=layout_with_lgl)

V(net)$size <- V(net)$ANSWER_1_Count/5
V(net)$label <- V(net)$ABMT_ANSWER_1
E(net)$width <- E(net)$Weight/6
E(net)$arrow.size <- .3
E(net)$edge.color <- "gray80"
graph_attr(net, "layout") <- layout_with_lgl
plot(net,vertex.color="#fc8d59", vertex.label.font=2, vertex.label.color="black",
        vertex.label.cex=.4)

#ggplot
ggraph(net,  layout = 'lgl') +
  geom_edge_link(alpha = .7, color="grey", aes(width = Weight)) +
  geom_node_point(color="orange", aes(size = ANSWER_1_Count)) +
  geom_node_text(alpha = .7, aes(label = ABMT_ANSWER_1), size=2.5, color="black", repel=F) +
scale_size(range = c(2,15)) +
  theme(panel.border = element_rect(color = "black", fill = NA, size = .5)) +
  labs(size = "ABMT Count") +
  theme_void(base_size = 10)

### BIODIV FIGURES ###

net3 <- graph_from_data_frame(d = biolinks, vertices = bionodes, directed=T)
net3
plot(net3)

net3 <- simplify(net3, remove.multiple = F, remove.loops = T)
plot(net3, edge.arrow.size=.4,vertex.label=NA)

plot(net3, edge.arrow.size=.2, edge.color="#cccccc",
        vertex.color="#fc8d59", vertex.frame.color="#ffffff",
        vertex.label=V(net3)$ABMT_ANSWER_1,
        vertex.label.font=2, vertex.label.color="gray40",
        vertex.label.cex=.5, vertex.label.color="black", layout=layout_with_lgl)


#ggplot biodiv
Ego.1 <- ggraph(net3, layout = "linear", circular = T) +
  geom_edge_arc(alpha = .7, color="darkslategray3", aes(width = Weight)) +
  geom_node_point(aes(size = ANSWER_1_Count, color = Category)) +
  scale_size(range = c(2,15)) +
  theme(plot.margin = margin(1.5, 5.5, 5.5, 1.5, "cm"),
        plot.title = element_text(hjust = .5)) +
```

```
  labs(size = "ABMT Count",
          title = "Ego-Network of Species and Genetic Diversity") +
  theme_graph()

Ego.1 +
  geom_node_text(aes(label = ABMT_ANSWER_1), size = 1.9,
          nudge_x = Ego.1$data$x * .2,
          nudge_y = Ego.1$data$y * .2)

Ego.2 <- ggraph(net3) +
  geom_edge_diagonal(alpha = .7, color="darkslategray3", aes(width = Weight)) +
  geom_node_point(aes(size = ANSWER_1_Count, color = Category)) +
  scale_size(range = c(2,15)) +
  guides(size = "none") +
  theme_graph()
net5 <- graph_from_data_frame(d = biolinks, vertices = bionodes2, directed=T)

Ego.3 <- ggraph(net4) +
  geom_edge_diagonal(alpha = .7, color="darkslategray3", aes(width = Weight)) +
  geom_node_point(aes(size = ANSWER_1_Count, color = Category)) +
  scale_size(range = c(2,25)) +
  theme(plot.margin = margin(1.5, 5.5, 5.5, 1.5, "cm")) +
  guides(size = "none") +
  theme_graph()

Ego.3 +
  geom_node_text(aes(label = ABMT_ANSWER_1), size = 2, repel = T)
```

Table 7: Degree of Centrality Calculations for both Network Analyses

AMBT	ABMT Frequency	AMBT Links	Species Diversity Links	ABMT Centrality	Diversity Centrality
Benthic protected area	9	3	3	0.08	0.17
Biosphere reserve	15	1	4	0.03	0.22
Closed area	86	22	6	0.55	0.33
Closed season	65	18	7	0.45	0.39
Community conserved area	39	17	3	0.43	0.17
Fisheries reserve	15	2	3	0.05	0.17
Fisheries restricted area	35	8	5	0.20	0.28
Fisheries sanctuary	7	0	0	0.00	0.00
Gear ban	15	1	1	0.03	0.06
Locally-managed marine area	41	17	12	0.43	0.67
Marine reserve	100	32	18	0.80	1.00
Marine sanctuary	9	2	0	0.05	0.00
Moratorium	23	6	6	0.15	0.33
Move on rule	5	1	0	0.03	0.00
MPA	79	40	16	1.00	0.89
National Park	43	16	1	0.40	0.06
Real time closure	15	1	0	0.03	0.00
Ring fencing	1	0	0	0.00	0.00
Rotational closure	7	1	1	0.03	0.06
TURF	11	0	0	0.00	0.00
VME	19	9	7	0.23	0.39

Appendix III: Handout and reference material from IMPAC5 side event workshop: "Participatory Refinement of FAO's Fisheries ABMT Biodiversity Outcomes Framework"

Food and Agriculture Organization of the United Nations

Participatory Refinement of FAO's Fisheries ABMT Biodiversity Outcomes Framework

IMPAC5 Side Event: Monday February 6th, 6:00 – 9:00 pm

Contact: Amber Himes-Cornell, FAO Fishery Officer (NFI) – Amber.HimesCornell@fao.org

WORKSHOP PURPOSE & OBJECTIVES

There is confusion around when and how area-based management tools (ABMTs) in marine areas may qualify as "other effective area-based conservation measures" (OECMs) and count towards Target 3 of the Post-2020 Global Biodiversity Framework. This confusion stems in part from lack of clarity around the types of biodiversity outcomes that may arise from application of ABMTs by marine sectors, such as fisheries, and lack of consensus around the type and the extent of biodiversity outcomes expected for recognition as an OECM.

Additional guidance is needed to support evaluation of biodiversity outcomes arising from fisheries ABMTs, to support ongoing discussion of OECMs in fisheries. As a supplement to FAO's new Fisheries OECM Handbook, we are developing a Fisheries ABMT Biodiversity Outcomes Framework consisting of steps to systematically identify how a site's important biodiversity attributes are influenced by a fisheries ABMT, i.e. What specific biodiversity variables characterise the net positive biodiversity outcome? This resource is further envisioned to catalogue diverse indicators and methods useful for understanding and tracking the influence of a fisheries ABMT on distinct biodiversity attributes.

We welcome your contributions at this early stage of conceptualization.

WORKSHOP TIMELINE

6:00 – 6:35 pm	Welcome and Orientation
6:35 – 6:50	*Food & Drink Break*
6:50 – 7:15	World Café Session 1 (25-minute table rotation)
7:20 – 7:45	World Café Session 2 (25-minute table rotation)
7:45 – 8:00	*Food & Drink Break*
8:00 – 8:25	World Café Session 3 (25-minute table rotation)
8:25 – 9:00	Group Discussion & Closing
OPTIONAL	*Continued socialising until 9:30 pm*

Step/Component 1: Fisheries ABMTs

Fisheries management employs diverse spatial management measures, a.k.a. fisheries ABMTs (Table 1), which have the potential to contribute to preserving or enhancing biodiversity. The type and extent of biodiversity outcomes that may arise from a fisheries ABMT will depend on the ABMT's characteristics, including where it occurs (Space Dimension), when it occurs (Time Dimension), and what activities may be restricted (Activities Dimension).

Table 1. Types of fisheries ABMT, and the dimensions most commonly constrained by each. (Rice et al. 2018, pp. 11-12)

	DIMENSIONS CONSTRAINED									
	TIME				SPACE CLOSED				ACTIVITIES	
	Permanent	Temporary	Seasonal	Real Time	High Seas	EEZ	Fishing grounds	Partial	Total closure	Partial closure
Total gear ban	■				■	■	■		■	■
Zoning	■					■				■
Reserve/Sanctuary	■							■	■	
Territorial use rights in fisheries	■							■		■
Vulnerable marine ecosystem/ Benthic protected area	■				■			■	■	■
Fisheries restricted area	■				■					■
Ring fencing	■					■	■			■
Moratorium	■				■	■	■			■
Locally marine managed area/ Community conserved area/Marine managed areas		■						■		■
Rotational		■				■		■		■
Closed season			■		■	■	■	■		■
Real-time incentive/spatial management				■				■		■
Move-on rule				■	■	■	■	■		■

Step/Component 2: Essential Ocean Variables (EOVs)

The Global Ocean Observing System (GOOS) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO is developing a framework of Essential Ocean Variables (EOVs). The EOV framework is intended to support assessment of status and trends in ocean ecosystem properties. The EOV framework is made up of physical, biogeochemical, biological, and ecological EOVs. The latter two categories – "bio-eco EOVs" – are relevant to understanding marine biodiversity. We are exploring how the EOV framework could support systematic linking of important biodiversity attributes within the area of a fishery ABMT to globally vetted functional group categories. Table 2 provides a recently updated list of bio-eco EOV categories, including emerging categories, such as microbe biomass and diversity, and invertebrate abundance and distribution. Some debate continues regarding species and habitats that should be included in the list.

Table 2. Updated list of EOVs, including biological and ecological ("bio-eco") EOVs. (Bax et al. 2019, p. 4)

Physics	Biogeochemistry	Biology and ecosystems
• Sea state • Ocean surface stress • Ocean surface heat flux • Sea ice • Sea surface height • Sea surface temp • Subsurface temperature • Surface currents • Subsurface currents • Sea surface salinity • Subsurface salinity	• Oxygen • Inorganic carbon • Transient tracers • Particulate matter • Nutrients • Nitrous oxide • Dissolved organic carbon • Ocean color • Stable carbon isotopes	• Phytoplankton biomass and density • Zooplankton biomass and diversity • Fish abundance and distribution • Marine turtles, birds and mammals abundance and distribution • Hard coral cover and composition • Seagrass cover and composition • Mangrove cover and composition • Macroalgal cover and composition • Microbe biomass and diversity (emerging) • Invertebrate abundance and distribution (emerging) • Ocean sound

Step/Component 3: Essential Biodiversity Variables (EBVs)

The Essential Biodiversity Variables (EBV) framework is a project of GEO BON (Group on Earth Observation, Biodiversity Observation Network). As a sub-group of GEO BON, the Marine BON is working to apply the EBV framework in a marine context. We are exploring how the EBV framework could support improved clarity and transparency when discussing biodiversity outcomes arising from fisheries ABMTs. Table 3 provides the latest list of EBV candidate variables, which fall under six overarching EBV classes. A study by Himes-Cornell et al. (2022) found that fisheries ABMTs were most frequently linked to biodiversity outcomes under five of these EBV candidates: 1) Population abundance, 2) Population structure by age/size class, 3) Taxonomic diversity; 4) Habitat structure, and 5) Ecosystem extent and fragmentation.

Table 3. EBV classes and candidate variables.
(ConnectinGEO 2016, pp. 15-16)

EBV class	EBV candidate
Genetic composition	Co-ancestry
	Allelic diversity
	Population genetic differentiation
	Breed and variety diversity
Species populations	Species distribution
	Population abundance
	Population structure by age/size class
Species traits	Phenology
	Body mass
	Natal dispersion distance
	Migratory behavior
	Demographic traits
	Physiological traits
Community composition	Taxonomic diversity
	Species interactions
Ecosystem function	Net primary productivity
	Secondary productivity
	Nutrient retention
	Disturbance regime
Ecosystem structure	Habitat structure
	Ecosystem extent and fragmentation
	Ecosystem composition by functional type

5

Step/Component 4: A Resource for Evidencing Outcomes

Developing a Methods & Indicators Supplement

The Fisheries ABMT Biodiversity Outcomes Framework is envisioned as a supporting resource following FAO's Fisheries OECM Handbook. It draws together disparate framework components to support clear identification of the specific variables involved in ABMT biodiversity outcomes. In addition, we envision that this resource will catalogue available biodiversity indicators and methods relevant to distinct EBV variables. As a jumping off point for brainstorming, Table 4 provides some preliminary examples of indicators that may be suitable for a selection of EBV variable, . We welcome comments on these examples and suggestions of indicators for all EBV variables from Table 3.

Table 4. Example indicators for selected EBV variables, including information about what would constitute a "positive outcome" for each indicator.

EBV Variable	Indicator (Examples)	Indicator Definition	Data Collection Methods	Definition of "Positive Outcome"
Population Abundance	**Larval abundance**	The number or quantity of larval organisms of a given species, within plankton samples.	• Plankton samples collected via bongo nets and stored in ethanol	Stable or increasing larval abundance of a species indicates maintenance or increase in reproductive activity, or maintained or increased number of adults that have reached reproductive age.
Population Age Structure / Size Class	**Abundance of certain body lengths (1)**	The number or quantity of organisms at a given length for a population.	• Trawl and net surveys • Visual reef surveys	Increased or maintained diversity of body lengths indicate positive outcomes for population structure by age/size class.
	Abundance of certain body lengths (2)	The number or quantity of organisms at a given length for a population.	• Fisher interviews • Sampling of catches for sale at fish markets.	Increased or maintained diversity of body lengths indicate positive outcomes for population structure by age/size class.
Taxonomic Diversity	**Shannon-Wiener Diversity Index**	**Shannon Wiener Diversity Index (H')**: An estimate of species diversity that considers number of species (richness) and relative abundance (evenness).	• Fish visual rapid census • Fish stationary plot survey • Towed diver	A stable or increasing H' value suggests maintained or improved community structure in terms of species diversity.
Ecosystem Extent / Fragmentation	**Larval dispersion**	Exchange of larva among marine populations.	• Direct and indirect methods using geochemical and genetic markers • Coupled biophysical models	Maintenance or even increase in larval dispersion supports population connectivity.
Ecosystem Composition / Functional Type	**Catch mean trophic level (MTL)**	Average trophic level of commercial catch, weighted by biomass of each trophic level.	• Catch data • Fisher observations	Declining MTL (decreased abundance of higher trophic level organisms) is generally interpreted as an indicator of deteriorating trophic structure. NOTE: **catch MTL** has recently come under scrutiny as not tracking with other measures of MTL.
	Ecosystem mean trophic level (MTL)	Average trophic level of fish and invertebrate organisms, weighted by biomass of each trophic level.	• Long-term trawl surveys • Stock assessment	Declining MTL (decreased abundance of higher trophic level organisms) is generally interpreted as an indicator of deteriorating trophic structure.

References:

- Bax, N.J. et al. 2019. A response to scientific and societal needs for marine biological observations. Front. Mar. Sci. 6, 395.
- ConnectinGEO 2016. Deliverable D2.2 – EVs current status in different communities and way to move forward. Version 1.0.0. EU Framework Program for Research and Innovation (SC5-18a-2014 - H2020), Project Nr: 641538.
- Himes-Cornell, A., et al. 2022. Reaching global marine biodiversity conservation goals with area-based fisheries management: a typology-based evaluation. Front. Mar. Sci. 9, 932283.
- Rice, J. et al. 2018. Other Effective Area-Based Conservation Measures (OEABCMs) Used in Marine Fisheries: A Working Paper. Background Information Document for the CBD Expert Workshop on Marine Protected Areas and Other Effective

Appendix IV: IMPAC5 SIDE EVENT SUMMARY

TABLE 1: ECOSYSTEM / HABITAT
Facilitator: Sarah

Participants agreed that the ecosystem / habitat theme of Table 1 presented the most challenges, with a discussion centering on the need to separate the ecosystem and habitat levels from one another. In addition, participants agreed that perhaps the habitat level is a more pertinent area of focus than the ecosystem level, as fisheries ABMT generally have inordinate impacts on the one area of the water column where the fishery pressure is being managed.

Key take-aways also included:

- The framework needs to be menu-style for outcomes / indicators / methods, with a suite of options which depend on factors such as feasibility, cost, resources and capacity.
- Context-specificity must be a key consideration.
- There exists a need for more diverse voices in this conversation, particularly so that Indigenous knowledge and science can be more fully incorporated into the suite of options
- In spite of the menu-style of options, there does need to be a minimum standard for what constitutes a positive outcome
    - Example: a country with low capacity does not get to submit an OECM with lower standards for biodiversity outcomes simply because their capacity is lower. Instead, they need to turn to other options within the Framework to find adequate tools that do fall within their capacity.
- There should "top 3" or a priority list of outcomes / indicators / methods based on the type of data or knowledge that is generally accessible across the board (in fisheries management)
- Habitat structure was viewed as the MOST LIKELY outcome to occur at this level from fisheries ABMT
    - Percent cover as indicator
    - Abundance of ecosystem-building species as indicator
    - Multitude of methods possible for assessing indicators
- CPUE noted as a measurement method that while accessible, should not be used on it's own to for indicator assessment of biodiversity outcomes
- One participant noted that the constructive discussions held at the side event changed her opinions of how the process is going (towards understanding OECMs, fisheries-derived biodiversity). Notes that it is "really cool" that we (FAO facilitators) are thinking about all the same things the participants think about in their jobs, in terms of metrics and case-specific considerations, etc. Thinks about ambition reflects how hard their jobs really are, but that it shows how powerful collaboration can be!

TABLE 2: COMMUNITY COMPOSITION
Facilitator: Xavier
Across all sessions, participants questioned which biodiversity outcomes and indicators would be most applicable to positive outcomes for community composition. Participants agreed that it is less feasible to measure an entire habitat's composition and diversity, thus dividing marine community structures into functional groups and indicator species would be an effective measure to capture the diversity and outcomes in particular cases. In addition, a key takeaway was to not nominate community composition under 'rigid' terms. Measuring outcomes associated with communities should be flexible as different regions and areas across marine spaces vary widely in the degree of richness, abundance, population distributions, and histories of degradation. Therefore, the framework should define those differences and be mindful of evolving cases and to refrain from blanketed, 'one-size-fits-all' approaches.

Key Takeaway also included:

- Relevant indicators for community composition; are size change and population abundance enough?
- Cheap, east data collection methods probably work best for communities, i.e. eDNA
- Species Diversity & structure vs Functional diversity & structure of the marine community is an important factor to consider; need for habitat forming species as well as an abundance of species
- Functional Redundancy could be key for community composition; a variety of species that fulfill the same niche/ function in ecosystem → increased ecosystem resiliency
- Simply abundance of vital functional, habitat forming species can be an outcome → effects of presence have been studied → cases where prior knowledge of community can be used in biodiversity framework
- What are indicators for function? Age, size-class, population structure? Need indicators to prove function
- Theory of Change is vital for the community to understand when the marine community was and to see where it can go → ancillary data necessary for that approach and univariate metrics to represent assemblage composition, or community communication
- Theory of change needs to understand trends; what are the upward and downward trends that can occur over time?
- Level of accountability and guidance to ensure a level of biodiversity improvement

- Caution for community composition against confounding factors; need to be sure that measured effects are coming from community and not outside factors like climate change and spillover
- Bycatch could indicate how healthy a community is. Data from indicator species have relevant implications for communities
- Relevance of fisheries in data collection. If fisheries sector leaves an area, then how do you obtain reliable data since they are the ones collecting it? → Confusion about the definition of OECM as it relates to fisheries
- Data rich and data limited methods; need for a case by case framework that does not exclude communities that are meant to be a part of OECMs. Local ecological knowledge (LEK) has important implications and should not be ignored
- Question of incentives. Community members will need incentives to qualify a location as an OECM and to protect certain communities.

Key Questions asked:

- Are all species created equal? How do we distinguish between what needs the most protection? Is it a biodiversity outcome when it's not even under threat at the scale of the management you measure diversity?
- Who decides biodiversity as an outcome? In some cases it seems like fisheries sectors get to adopt biodiversity outcomes when it is convenient. Is fish count enough to be biodiversity?
- How do you ensure proper and reliable governance of OECM policy? Who will make sure that the community is in fact showing positive outcomes?

TABLE 3: SPECIES POPULATIONS

Facilitator: Lucy

Across all three rounds of discussion, participants questioned whether assessing a single species, or using a species approach, is adequate enough to represent biodiversity outcomes. It was clear that the focus should be on non-targeted species that are affected by a fisheries management measure and a multi species approach would be preferred.

Key takeaways and questions also included:

- The approach should be a multi species approach in which the outcome would be that multiple species benefit from a fishery measure. The ecosystem should benefit, not just a single species.
- Any one indicator alone wouldn't be sufficient for demonstrating true biodiversity conservation; it would be multiple indicators that are needed to demonstrate this. A single species or multiple species may be used as indicators, but the degree to which that is possible is uncertain.

- It was important to clarify who would be measuring potential indicators, and it was agreed on that there was a discrepancy between what a fishery manager would measure compared to a governmental entity or a scientist.
- There is support that if a non-target species, bycatch species, and/or depleted/threatened/endangered species is protected by a spatial fisheries measure, that could be considered an outcome.
    - The abundance of those species may be used as indicators for species populations with the clarification that they must be affected by the fisheries measure
    - The benefits for those species would be considered a biodiversity outcome
    - The species of interest matters (aka not all species are created equal - i.e., top predators, migratory species), and their use of the area and the amount of time that are within the OECM boundary matters
    - There was some debate on if bycatch alone would be a strong enough indicator
    - Conversely, the reduction in mortality of bycatch could be an indicator for the increase of a population of a species. This brought up the questions of the level at which average mortality would be reduced and what amount of reduction in mortality would be enough to create a positive impact. It was clear that the mortality reduction should occur within the ABMT.
- The context within the indicators is critical to account for (e.g., natural fluctuations of populations, temporal variations, spatial variations, manageable versus unmanageable threats, climate change impacts like warmer water temperatures, bias of catch data). Furthermore, the question of how to account for gaps/biases/limitations of indicators themselves was discussed. There was agreement that indicators are specific to the management put in place, and indicators for fisheries OECM should be tied to things fisheries can have an effect on.
- The scope of the biodiversity benefit in relation to the movement of a species (e.g. migratory species) is an important factor.
- Providing layers of protection could strengthen a weak measure.
- Lots of discussion on the timeline (and timeframes) for expecting biodiversity benefits. It was agreed that those differ depending on species type (e.g., mobile versus sessile/benthic). The question of when an area is designated as an OECM - before observable benefits or after - was mentioned which gets into the idea of reasonable expectation for positive biodiversity outcomes from OECMs.
- There were questions relating to baselines and recovery states. What happens if an area has been completely destroyed and recovers to a state that was different from what was there before? There was some opinion that mentioned if that state of the area was getting better in some way, that should be rewarded. There was some debate on whether the baseline should be the area without the fishery management measure and if that is enough.

- Participants noted other areas to help identify indicators with the caution that indicators are context specific and cannot be copied and pasted. Those sources include the MSC and MPA indicators (CA network as the primary example).
- There was mention of overlap between other targets (three, five, and ten) with concepts of sustainability and ecosystem services.
- There was mention of the potential for discrepancies between different ways information on indicators is obtained (local knowledge vs scientific research vs fisheries data).
- Participants did not like larval abundance as an indicator because it is too fisheries independent and the stock has to be really low in order to see an impact on it.
- There was discussion on where the "burden of proof" for monitoring and measuring indicators should be placed - on the fishery sector or the higher governance authority. It will require coordination between the fishery sector and higher governing authority.

Relevant Questions

- Is benefitting a single species good enough to be considered a biodiversity outcome?
- Can we include timeframes within the indicators to account and allow for different contexts?
- How does the genetic diversity of a single species factor in?
- Is fisheries performance equal to ecological performance?
- How to account for success and how to determine/justify when success has been achieved?
- At what spatial scale should the benefit be achieved? At the ABMT level (within its boundaries)? The management unit? At the stock level? At the population level? At the species level?

TABLE 4: SWOT ANALYSIS
Facilitator: Diana
Strengths will come from the Framework's call for exhaustive and comprehensive information, though this will be a challenge too! Participants think there are benefits to the proposed Framework structure (decision-tree, check-list, transparency, making space for reproducibility, clarity). Ultimately, it can be a tool for OECMs deriving from other sectors, not just fisheries.

Using existing frameworks such as EBV / EOV are strengths as well and lend "credibility" and some structure to our processes, as can using data monitoring systems that already exist (in or out of fisheries contexts).

Another strength in the framework is the way it addresses things beyond just fisheries management benefits (ecosystem services, biodiversity, etc.), which likely center around single-species. Further, the understanding that outcomes and indicators need to be ranked and prioritized based on a range of factors (feasibility, capacity, import) is a strength.

Weaknesses derive from the high standards set for OECMs. MPAs do not have criteria or strict definitions as OECMs do, which can be a strength for OECMs. Another identified weakness is the current lack in the Framework for understanding the level of biodiversity benefit needed.

- For example: Is it just the target outcome or additional outcomes that should be included / assessed?
- "(Joachim) doesn't see in the different steps any accommodation or reference to the additional benefits that are expected in addition to fisheries management outcomes"
- General lack of clarity about extent within management area that outcomes should be accessed (Example: "What's the limit of what you measure?") and again, comparing target outcomes with additional outcomes

One identified weakness (OECMs in general, not just the Framework!) is how hard it is to manage and address multi-sectoral threats, if those do exist within the OECM area. However, since biodiversity will need to be assessed within the OECM area, perhaps areas with too much multi-sectoral pressure will necessarily exclude themselves.

In addition, it must be clear that one indicator is not enough to inform an outcome. Sometimes, multiple indicators can point to the same outcome, but just using one to justify an outcome would be a weakness.

An ***area of improvement*** could be to include language of "biocultural diversity" as that way be more inclusive than biodiversity, alleviating discomfort in coastal community-based and/or Indigenous fishing areas. Thinks that capturing ecosystem services more fully in the Framework would provide the link between biodiversity and cultural diversity. Another suggestion is to further contextualize and add weight to different factors of the Framework. In addition, some adjustment of expectations of what we/this Framework can provide may be necessary ("tempering expectations").

Lots of discussion at this table veered towards an exploration and critique of the OECM definition and criteria as participants tried to better understand the OECM context. So, some of the conversation did not center on a SWOT analysis of the Framework itself. Rather, it became a SWOT analysis of OECMs and how likely it will be to assess biodiversity outcomes arising from fisheries measures where those biodiversity outcomes were not the original target or within the scope of monitoring.

TABLE 5: FORMS OF EVIDENCE AND KNOWLEDGE
Facilitator: Rina

The foundation of much discussion at this table stemmed from a general lack of understanding of the OECM criteria / definition. In addition, differing interpretations of Criterion C triggered debate around the use of different forms of evidence / knowledge. This criterion was regarded as challenging, as many potential OECM areas will likely struggle with lack of data / knowledge as well as differing opinions about what biodiversity actually is (e.g. fisheries managers will focus on particular fish whereas biodiversity "experts" will likely think more broadly). Also, what "long term" means could very likely differ amongst policymakers, fishers, indigenous groups, etc. For example, one participant thought that for fishers, "long-term" must mean more than one generation.

A common point of discussion was on the topic of data / knowledge "standardization" vs "reconciliation". Many participants agreed that there is not a need for information to be standardized (and this would be an unrealistic goal). However, many participants discussed how knowledge from IPLC, while diverse, could/should be treated as "parallel systems" thus enabling "reconciliation". This conversation often led to the question of: how much [of any type of data / knowledge / information] is enough? Generally, the responses were that one should not use only one data / knowledge source (...index, indicator, etc.) to justify an OECM and that having an awareness of baseline conditions is paramount. Some participants did not think using local knowledge alone (regardless of the amount of local knowledge) was enough to justify or evidence an OECM, but it is extremely helpful for identifying trends or for using as a starting point from which to further investigate. Others thought that especially if located in an IPLC area, local knowledge should be considered efficient, but still a minimum standard or amount of local knowledge should be expected. One participant suggested using the Delphi process when data is absent in order to use expert opinion as an indicator or to identify a trend. Another noted that a common data (or knowledge) requirement should not be needed, as the forms and scale of evidence will vary based on the impact of the fisheries in question.

A pertinent note is that many IPLC who have access to diverse knowledge beyond Western-science (data) may not be seeking an OECM designation in the first place.

Take-aways:

- Concern about understanding sufficient levels of knowledge for evidencing an OECM, regardless of knowledge type (need for baseline, likely should never use just on index)
- For using IPLC knowledge, reconciliation and not standardization should be kept in mind
- For data gathered in the Western-science style, there is often still a need to standardize (e.g. differences in CPUE reported by NE fishers than fisheries-independent data)
- Generally, we need to be prepared for "conflicts across indices"

Questions:

- Where does the need for "evidence" come from in the OECM definition?

- What will the 3rd party assessment (IUCN Site Assessment Tool) methods / standards consist of when a non-government entity submits an OECM to WD-OECM?
- Can procedural or process variables be considered for assessing effectiveness? (Patrick Christie)
- Can the “burden of proof” vary? (If in an Indigenous area, sufficient LEK should be enough, but will this cause conflict?)

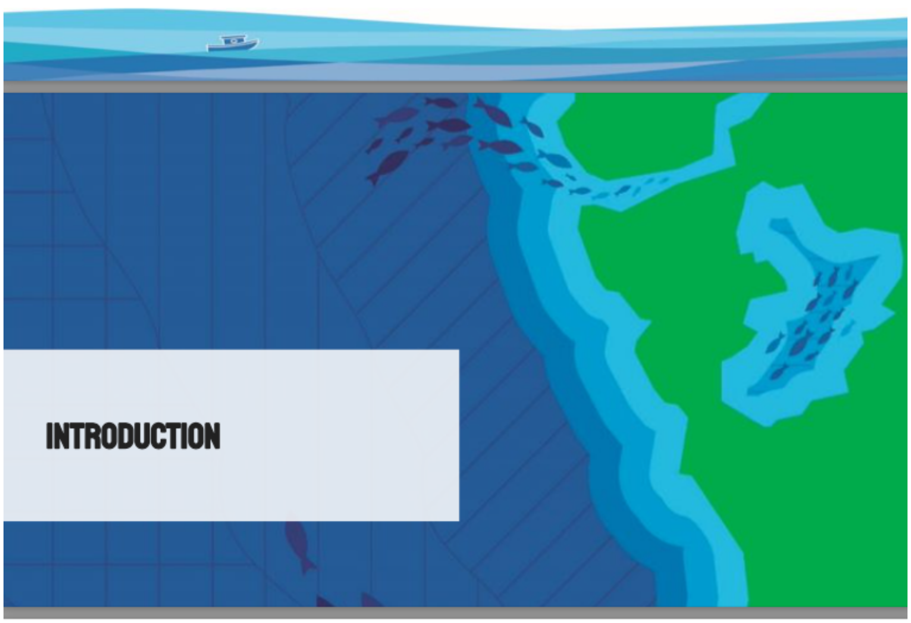
OVERVIEW

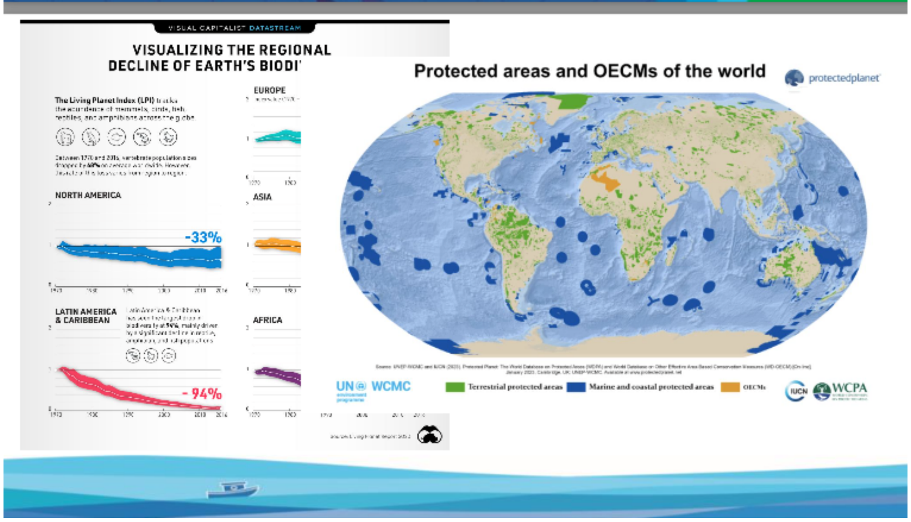
Common themes linking discussions were the topics of feasibility and context-specificity. Much discussion veered from the Framework itself to (fisheries) OECMs more broadly, as participants grappled with understanding the challenges and strengths of the proposed Framework. In addition, many participants felt that understanding the “burden of proof” to be expected from OECMs is paramount. In this vein, it must be clarified how a sufficient level of evidence can be reconciled across the diverse types of knowledge likely to be used in the OECM process.

Appendix V: Capstone presentation (Hybrid), presented by Sarah Davidson, Lucy Bowser and Xavier Nelson-Rowntree on February 24, 2023 to SMEA faculty and students.

IMPROVING THE CAPACITY OF GOVERNMENTS AND THE FISHERIES SECTOR TO CONSERVE MARINE BIODIVERSITY THROUGH THE USE OF 'OTHER EFFECTIVE AREA-BASED CONSERVATION MEASURES' (OECM)

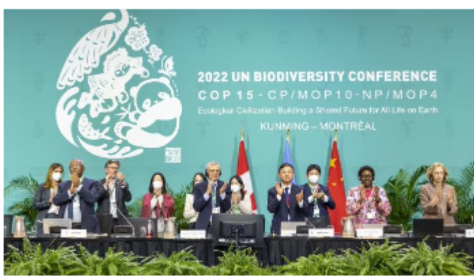
Sarah Davidson, Xavier Nelson-Rowntree, Lucy Bowser
With Amber Himes-Cornell, Kristin Hoelting and Dave Fluharty





WHAT IS AN OECM?

OECMS IN THE BROADER CONTEXT



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COMMENT | 26 July 2021

Biodiversity needs every tool in the box: use OECMs

To conserve global biodiversity, countries must forge equitable alliances that support sustainability in traditional pastoral lands, fisheries-management areas, Indigenous territories and more.

"A NEW POLICY TOOL"

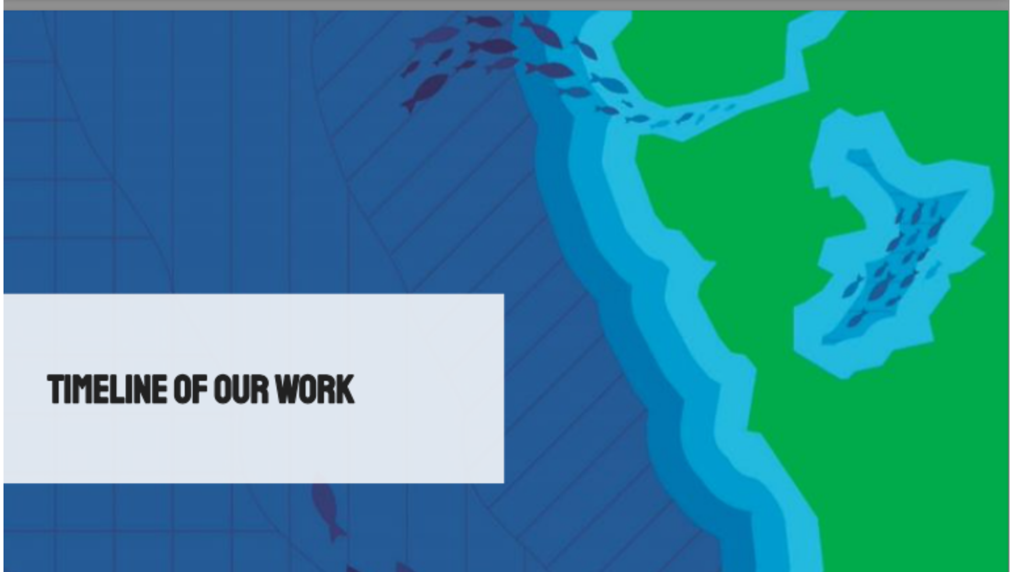
OECM DEFINITION & CRITERIA

Table 1. Criteria included in Section B of Annex III to Decision 14/8 relevant for the identification of OECMs.

Criteria	Sub-criteria
Criterion A: Area is not currently recognized as a protected area	• Not a protected area
Criterion B: Area is governed and managed	• Geographically defined space • Legitimate governance authorities • Managed
Criterion C: Achieves sustained and effective contribution to *in situ* conservation of biodiversity	• Effective • Sustained over long term • *In situ* conservation of biological diversity • Information and monitoring
Criterion D: Associated ecosystem functions and services and cultural, spiritual, socio-economic and other locally relevant values	• Ecosystem functions and services • Cultural, spiritual, socio-economic and other locally relevant values

PROJECT GOAL

Operationalize OECM *Criterion C* and investigate what positive biodiversity outcomes are relevant to fisheries OECMs



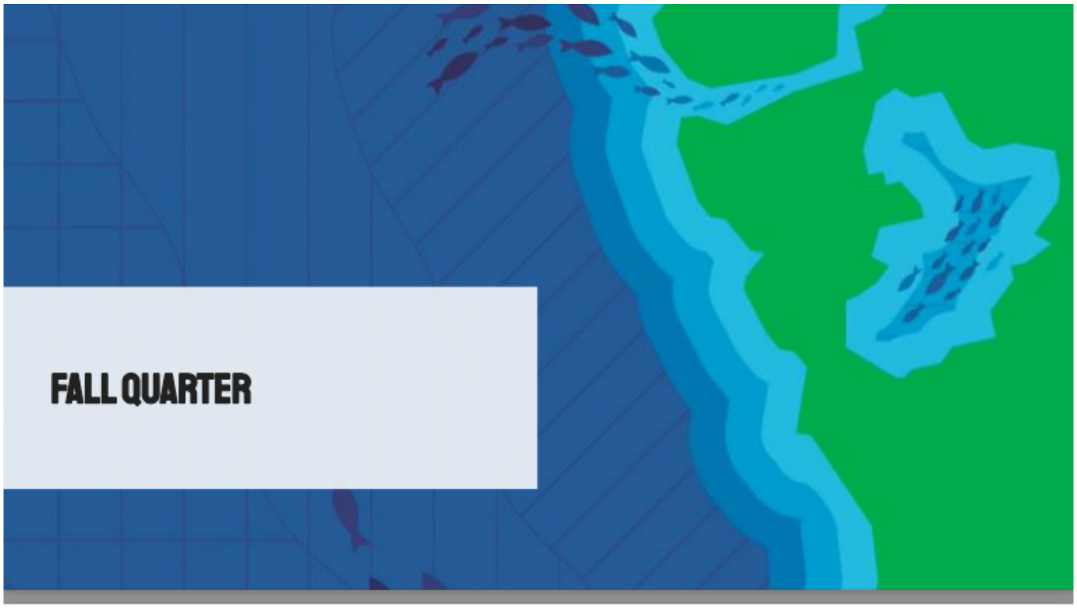
Spring 2022 — Previous capstone created a typology paper which become the foundation for our work

Summer 2022 — Summer Internships

Early - Mid Fall 2022 — Process of developing a coding structure and codebook from the typology paper literature data

Mid-Late Fall 2022 — Need for identifying indicators of biodiversity that are relevant to ABMTs

Winter 2023 — IMPAC5 Workshop preparation and gathering expertise on indicators of biodiversity



BUILDING OFF OF CAPSTONE 2021-2022

frontiers | Frontiers in Marine Science

SYSTEMATIC REVIEW
published: 22 July 2022
doi: 10.3389/fmars.2022.932283

Reaching Global Marine Biodiversity Conservation Goals With Area-Based Fisheries Management: A Typology-Based Evaluation

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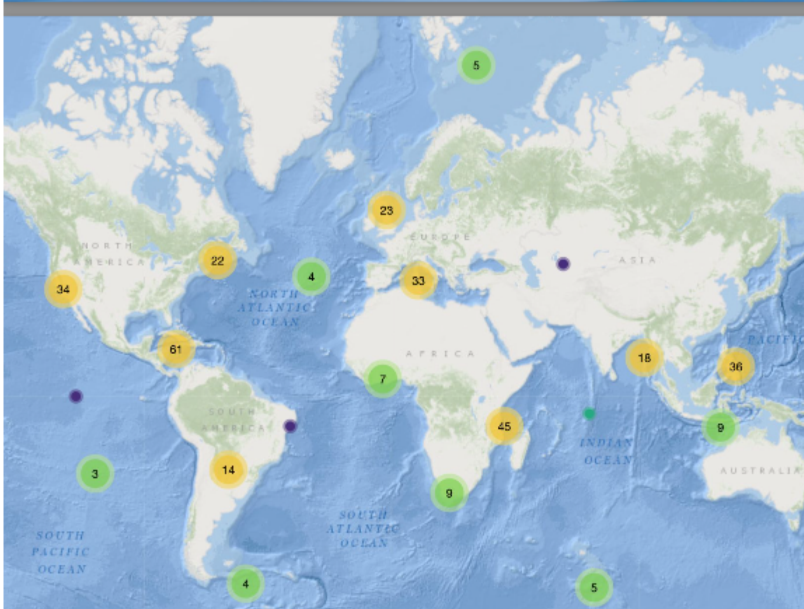
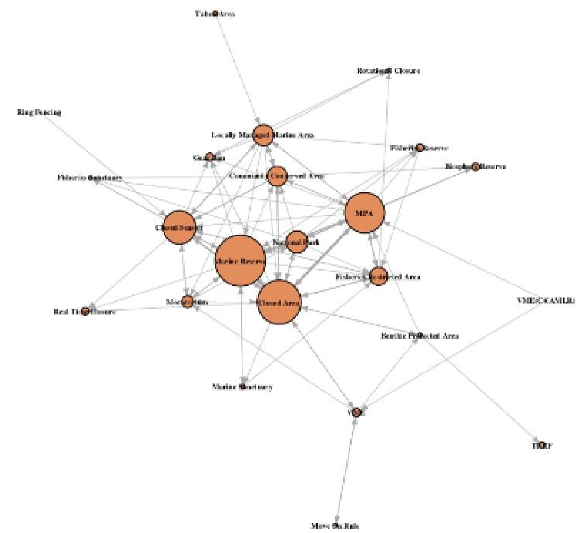
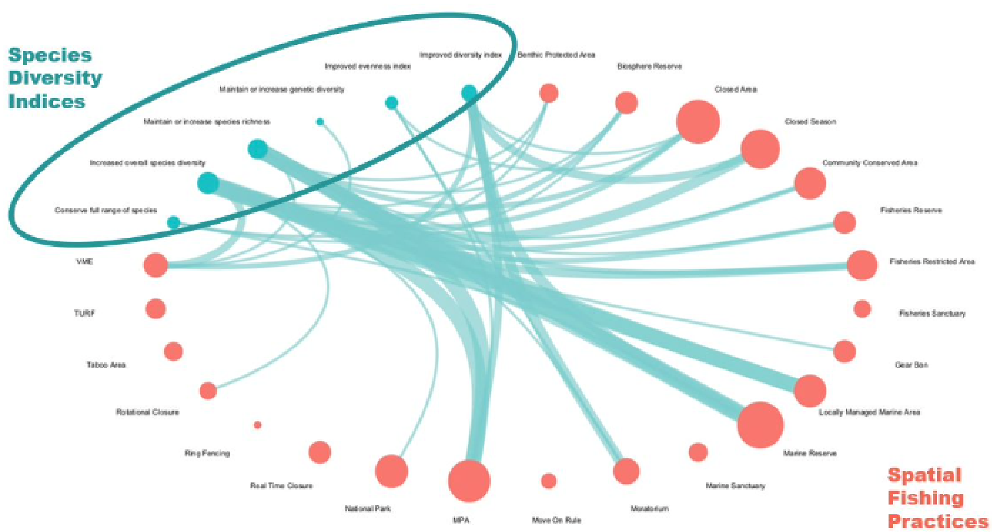


SPATIAL PLANNING



NETWORK ANALYSIS

Links Between Marine Species Diversity and Spatial Fishing Practices



FITTING BIODIVERSITY INDICATORS AND OUTCOMES INTO FRAMEWORKS

Question: How do we ensure that the biodiversity outcomes relevant to fisheries OECMs are *meaningful?*

Linking of EBV and EOV frameworks to aid in increasing understanding of *Criterion C* within fisheries

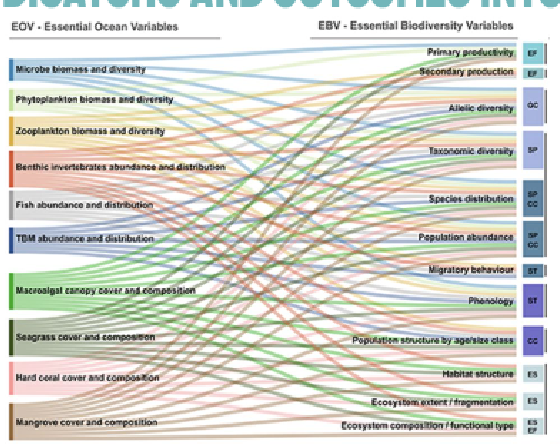


Image from: Muller-Karger, Frank E., et al. (2018) Advancing Marine Biological Observations and Data Requirements of the Complementary Essential Ocean Variables (EOVs) and Essential Biodiversity Variables (EBVs) Frameworks. Front. Mar. Sci. (5) https://doi.org/10.3389/fmars.2018.00211

WINTER QUARTER

IMPAC 5

FIFTH INTERNATIONAL MARINE PROTECTED AREAS CONGRESS | CINQUIÈME CONGRÈS INTERNATIONAL SUR LES AIRES MARINES PROTÉGÉES

VANCOUVER • CANADA

WORKSHOP PREP - WHAT DID WE DO?

EBV Variable	Indicator (Examples)	Indicator Definition	Data Collection Methods	Definition of "Positive Outcome"
Population Abundance	**Larval abundance**	The number or quantity of larval organisms of a given species, within plankton samples.	• Plankton samples collected via bongo nets and stored in ethanol	Stable or increasing larval abundance of a species indicates maintenance or increase in reproductive activity, or maintained or increased number of adults that have reached reproductive age.
Population Age Structure / Size Class	**Abundance of certain body lengths (1)**	The number or quantity of organisms at a given length for a population.	• Trawl and net surveys • Visual reef surveys	Increased or maintained diversity of body lengths indicate positive outcomes for population structure by age/size class.
	Abundance of certain body lengths (2)	The number or quantity of organisms at a given length for a population.	• Fisher interviews • Sampling of catches for sale at fish markets.	Increased or maintained diversity of body lengths indicate positive outcomes for population structure by age/size class.
Taxonomic Diversity	**Shannon-Wiener Diversity Index**	**Shannon Wiener Diversity Index (H')**: An estimate of species diversity that considers number of species (richness) and relative abundance (evenness).	• Fish visual rapid census • Fish stationary plot survey • Towed diver	A stable or increasing H' value suggests maintained or improved community structure in terms of species diversity.
Ecosystem Extent / Fragmentation	**Larval dispersion**	Exchange of larva among marine populations.	• Direct and indirect methods using geochemical and genetic markers • Coupled biophysical models	Maintenance or even increase in larval dispersion supports population connectivity.
Ecosystem Composition / Functional Type	**Catch mean trophic level (MTL)**	Average trophic level of commercial catch, weighted by biomass of each trophic level.	• Catch data • Fisher observations	Declining MTL (decreased abundance of higher trophic level organisms) is generally interpreted as an indicator of deteriorating trophic structure. NOTE: **catch MTL** has recently come under scrutiny as not tracking with other measures of MTL.
	Ecosystem mean trophic level (MTL)	Average trophic level of fish and invertebrate organisms, weighted by biomass of each trophic level.	• Long-term trawl surveys • Stock assessment	Declining MTL (decreased abundance of higher trophic level organisms) is generally interpreted as an indicator of deteriorating trophic structure.

WHAT POSITIVE BIODIVERSITY OUTCOMES CAN WE EXPECT FROM FISHERIES OECMS?

"PARTICIPATORY REFINEMENT OF FAO'S FISHERIES ABMT BIODIVERSITY OUTCOMES FRAMEWORK"

WORKSHOP PURPOSE & OBJECTIVES

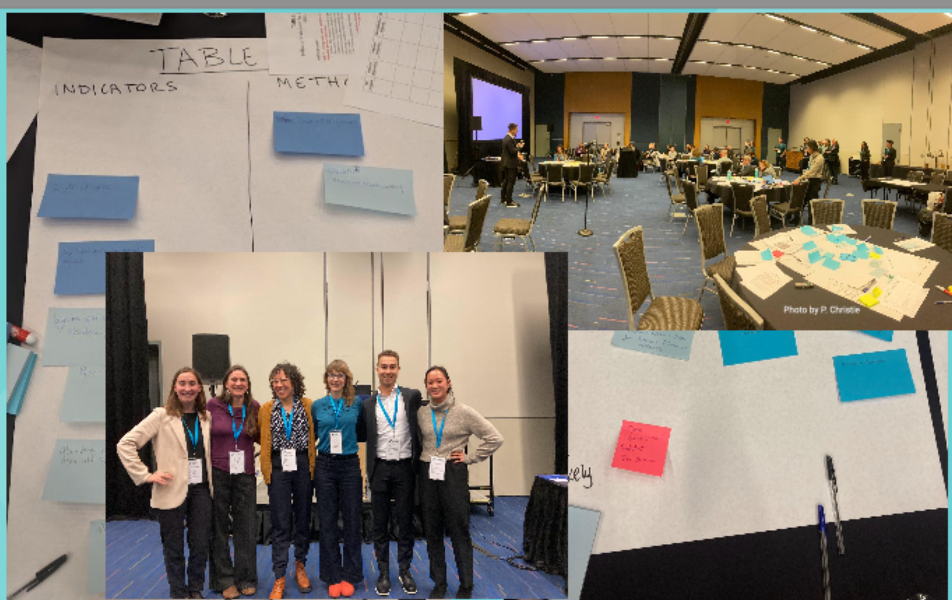
There is confusion around when and how area-based management tools (ABMTs) in marine areas may qualify as "other effective area-based conservation measures" (OECMs) and count towards Target 3 of the Post-2020 Global Biodiversity Framework. This confusion stems in part from lack of clarity around the types of biodiversity outcomes that may arise from application of ABMTs by marine sectors, such as fisheries, and lack of consensus around the type and the extent of biodiversity outcomes expected for recognition as an OECM.

Additional guidance is needed to support evaluation of biodiversity outcomes arising from fisheries ABMTs, to support ongoing discussion of OECMs in fisheries. As a supplement to FAO's new Fisheries OECM Handbook, we are developing a Fisheries ABMT Biodiversity Outcomes Framework consisting of steps to systematically identify how a site's important biodiversity attributes are influenced by a fisheries ABMT, i.e. What specific biodiversity variables characterise the net positive biodiversity outcome? This resource is further envisioned to catalogue diverse indicators and methods useful for understanding and tracking the influence of a fisheries ABMT on distinct biodiversity attributes.

We welcome your contributions at this early stage of conceptualization.

WORKSHOP TIMELINE

6:00 – 6:35 pm	Welcome and Orientation
6:35 – 6:50	*Food & Drink Break*
6:50 – 7:15	World Café Session 1 (25-minute table rotation)
7:20 – 7:45	World Café Session 2 (25-minute table rotation)
7:45 – 8:00	*Food & Drink Break*
8:00 – 8:25	World Café Session 3 (25-minute table rotation)
8:25 – 9:00	Group Discussion & Closing
OPTIONAL	*Continued socialising until 9:30 pm*



STEPS FORWARD

Side event **discussions, analysis, & report** will aid FAO:

(1) **Design** and **develop** the Fisheries Biodiversity Outcomes **Framework**

(2) **Support** future **guidance documents** in the Fisheries OECM series