REPORT OF THE SECOND IOTC ECOREGION WORKSHOP ON

"THE IDENTIFICATION OF REGIONS IN THE IOTC CONVENTION AREA TO INFORM THE IMPLEMENTATION OF THE ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT"

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ABSTRACT

In 2019 the Working Party on Ecosystems and Bycatch (WPEB) recommended a second IOTC ecoregion workshop to advance the identification of ecologically meaningful regions (ecoregions) in the IOTC convention area to support the implementation of the ecosystem approach to fisheries management (EAFM). Ecoregions may provide a spatial framework to support regional ecosystem planning and prioritization, incentivized ecosystem research and the development of integrated advice products for informing fisheries management-decisions. This online workshop took place the 19-21 of January 2022 and gathered around 30 participants with a wide range of expertise in IOTC species, fisheries and oceanography of the Indian Ocean. Prior to the workshop, a consultant was hired to prepare a background report where Group discussions and feedback received during the first ecoregion workshop were addressed to be presented and discussed at the second workshop. During the workshop, the Group discussed the potential benefits and potential uses of ecoregions in the context of IOTC species and fisheries, and provided feedback on the technical aspects, the data and methodologies used in the derivation of a refined ecoregion proposal. The workshop resulted in a refined proposal of nine candidate ecoregions within the IOTC convention area. The Group requests that (i) the WPEB reviews and comments on the ecoregion delineation process and the refined proposal of candidate ecoregions within the IOTC convention area, (ii) the WPEB communicates with the rest of the WPs and the SC, and SC to the Commission, the ongoing ecoregion process to receive further feedback, (iii) the WPEB supports further refinements of the ecoregion process and establishes a mechanism to progress this work, and (iv) the WPEB continues endorsing the candidate ecoregions to develop pilot projects to test their usefulness and utility as a tool to progress on EAFM implementation in IOTC.

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INTRODUCTION 3

Background and purpose of this workshop 3

Objectives and structure of the second IOTC ecoregion workshop 4

WORKSHOP TASKS 6

Task 1: Potential role and uses of ecoregions in IOTC 6

GROUP DISCUSSION 6

Task 2: Criteria to guide ecoregion delineation and expected qualities of ecoregions 7

GROUP DISCUSSIONS 9

Task 3: Data collation and quality evaluation 9

GROUP DISCUSSIONS 10

Task 4: Analytical model for deriving a baseline ecoregion proposal 13

GROUP DISCUSSIONS 14

Task 5: Interpretation of baseline ecoregions and refinement based on expert knowledge 16

GROUP DISCUSSIONS 18

Task 6: Ecoregion validation and testing 23

GROUP DISCUSSIONS 23

CONCLUSIONS AND FUTURE STEPS **Error! Bookmark not defined.**

ACKNOWLEDGEMENTS 25

REFERENCES 26

APPENDIX 1. LIST OF PARTICIPANTS 30

APPENDIX 2. WORKSHOP AGENDA 31

INTRODUCTION

Background and purpose of this workshop

The Ecosystem Approach to Fisheries Management (EAFM) is a place-based approach rather than a species-based approach (Fogarty 2014). It requires a move away from an emphasis on individual species and elements that comprise an ecosystem to a more integrative and holistic perspective, requiring a spatial context within which ecosystems can be described, monitored and reported on (Trenkel 2018, Garcia et al. 2003, Fogarty 2014). Therefore, one of the starting points and fundamental requirements to effectively implement EAFM is the delineation of spatial units or ecologically meaningful regions, i.e. ecoregions (Staples et al. 2014, Fletcher et al. 2010). Ecoregions are geographically defined areas exhibiting relatively homogeneous ecosystems, and are designed to be units of analysis to support ecosystem planning, incentivized ecosystem research, integrated ecosystem assessments, and decision-making for the integrated management of natural resources (Ormernik and Bailey 1997, Ormernik 2004). Regionalization of the Indian Ocean Tuna Commission (IOTC) convention area into areas that are ecologically meaningful, yet large enough to be practical, could provide a foundation for developing a wide range of integrated scientific and advice products. These may include the production of integrated ecosystem assessments, ecosystem risk assessments, and large-scale ecological modeling, among others, to assist in the production of more integrated ecosystem-based advice to the Commission (Zador *et al.* 2017; Koen-Alonso *et al.* 2019, Rice et al. 2011). Yet, it is not clear at what spatial and regional scales integrated research and advice products would be potentially useful to guide EAFM operationalization in the context of IOTC species and fisheries.

Ecoregion mapping is an interdisciplinary endeavor that requires the integration of knowledge of multiple disciplines including but not limited to geography, ecology, oceanography, and resource management. In practice, the derivation of ecoregions requires the classification or regionalization of the seaspace into a number of regions to reduce complexity to a manageable and understandable number of units. Ecological regionalizations or biogeographical regionalizations are processes that generally use biological and physical data or knowledge to identify broad patterns of co-occurrence of species, habitat and ecosystem processes (Spalding et al 2007). These are then used to delineate geographically distinct units of homogenous ecological characteristics at a specified scale that are relatively distinct from adjacent areas (UNESCO 2009). There are several international organizations that have successfully derived and are using ecoregions as tools to guide ecosystem-based research, planning and management advice (e.g. North Atlantic Fisheries Management Organization (NAFO), the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), International Council for the Exploration of the Sea (ICES), the North Pacific Fisheries Management Council in Alaska, USA). The use of ecoregions as a tool to provide more integrated and ecosystem based advice is now being explored in tuna Regional Fisheries Management Organizations such as IOTC (Juan-Jordá et al 2019) and in ICCAT (Juan-Jordá et al 2022). Though highly migratory with wide-spread spatial distributions, tuna and tuna-like species have been shown to have distinct, geographical assemblages in response to broad oceanographic patterns and processes occurring at ocean-basin scales (Reygondeau et al 2012); and thus, ecoregions could be potentially developed and used as a tool to advance integrated research and guide planning and advice to support the application of the EAFM in these organizations.

In 2018, initial work towards a broad-scale delineation of the IOTC convention area was presented to the IOTC 14th Session of the Working Party on Ecosystems and Bycatch (WPEB), as a conceptual scientific exercise to discuss its potential utility and to explore avenues for future work. The ensuing discussion of the WPEB group led to the recommendation that a workshop be convened in 2019 to provide advice on the identification of draft ecoregions based on a revised set of criteria and to foster discussions on the operationalization of the EAFM in the IOTC convention area (IOTC-WPEB14). This IOTC workshop took place in September 2019 with the participation of CPC national scientists and external experts (Juan-Jordá et al. 2019). Prior to the workshop, a baseline draft proposal of ecoregions was prepared, which was presented and discussed at the workshop by all the participants (Nieblas et al. 2019). The baseline proposal was used in the workshop to present preliminary analyses and guide discussions towards deriving draft ecoregions within the IOTC convention. This process resulted in a draft proposal of seven ecoregions (Figure 1) within the IOTC convention area (Juan-Jordá et al. 2019).

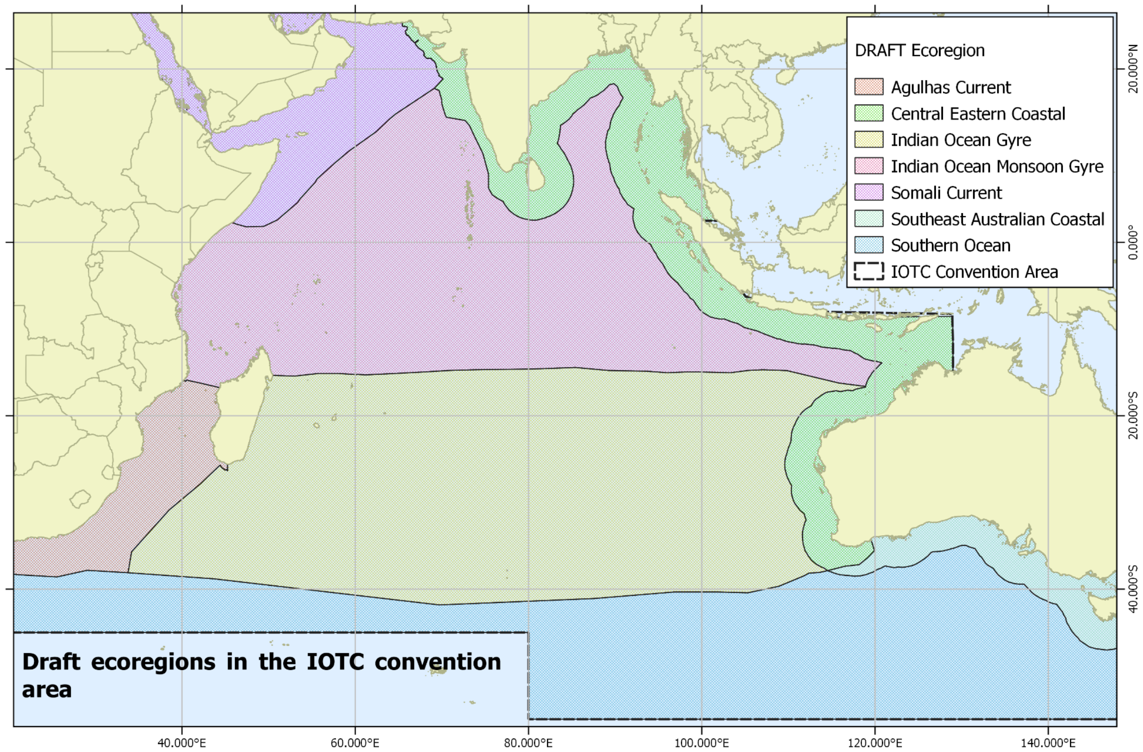

Figure 1. Draft ecoregion proposal produced in the first IOTC ecoregion workshop and the IOTC convention area (dashed black line) (Juan-Jordá et al. 2019).

Another important output of the first ecoregion workshop was the constructive and technical discussions that took place in framing the general process of ecoregion delineation (Figure 2), from defining the main purposes and uses, main principles, rules and criteria to guide the regionalizations, to evaluating data inputs and analytical methods, and examining and refining candidate ecoregions based on expert knowledge within the IOTC convention area. During this first workshop, the participants provided valuable feedback on the data sets and methods used to delineate the ecoregions to be considered in future revisions of the work. The draft proposal of seven ecoregions derived in this first IOTC ecoregion workshop were presented at the WPEB15 in September 2019. In 2019, the WPEB15 recommended a second IOTC Ecoregion workshop to refine the process based on the expert advice and feedback received in the first IOTC ecoregion workshop (IOTC-WPEB15). The second IOTC Ecoregion Workshop took place in January 2022 resulting in a refined process for guiding the delineation of ecoregions and in a refined proposal of ecoregions for the IOTC convention area. This report summarizes the main outputs and discussions that took place in the second IOTC Ecoregion Workshop.

Objectives and structure of the second IOTC ecoregion workshop

A three-day online workshop entitled **"2nd Ecoregion Workshop - Identification of regions in the IOTC convention area to inform the implementation of the ecosystem approach to fisheries management"** was held the 19-21 of January 2022. The workshop gathered around 30 researchers, including researchers from IOTC Member States and external experts from other research institutions and international organizations having a wide range of expertise in IOTC species and fisheries, ecology, fisheries management and oceanography of the Indian Ocean. A **list of participants** is included in Appendix 1.

The **Welcome Session** presented the main objectives, main motivation and expected outputs of the workshop. The **overall goal** of the second IOTC ecoregion workshop was to refine the process of ecoregion delineation considering the expert advice and feedback received at the first IOTC ecoregion workshop, and also prepare a refined draft proposal of ecoregions in the IOTC convention area. In preparation for the second IOTC Ecoregion Workshop, a consultant (Dr. Anne-Elise Nieblas) prepared a **background report** describing the actions taken in preparation for this workshop, which were presented to the Group during the three-day workshop to inform open discussion and refine the ecoregion delineation process in IOTC (Nieblas et al 2022).

The second IOTC Ecoregion Workshop was structured following the following **main six tasks** which were organized within a general framework that guides the entire ecoregion delineation process (Figure 2). The delineation of ecoregions requires the implementation of multiple steps, each of them supported by multiple activities and decisions along the way (Loveland and Merchant 2004, Mackey et al. 2008). This general framework was used to increase clarity about the process, the replicability of the process, and to encourage a participatory and iterative process. For further details on each of the steps of this framework see Nieblas et al 2022.

Main tasks addressed at the second IOTC ecoregion workshop:

- **Task 1:** Purpose and uses and ecoregions
- **Task 2:** Criteria to guide ecoregion delineation and the expected qualities of ecoregions
- **Task 3:** Data collation and quality evaluation
- **Task 4:** Analytical model for deriving a baseline ecoregion proposal
- **Task 5:** Interpretation of results, derivation and expert refinement of the baseline ecoregion proposal
- **Task 6:** Ecoregion validation and testing

The progress on each Task was presented followed by a general Group discussion. The presentations and the key discussion points for each Task are summarized below. All workshop presentations are available online for download.

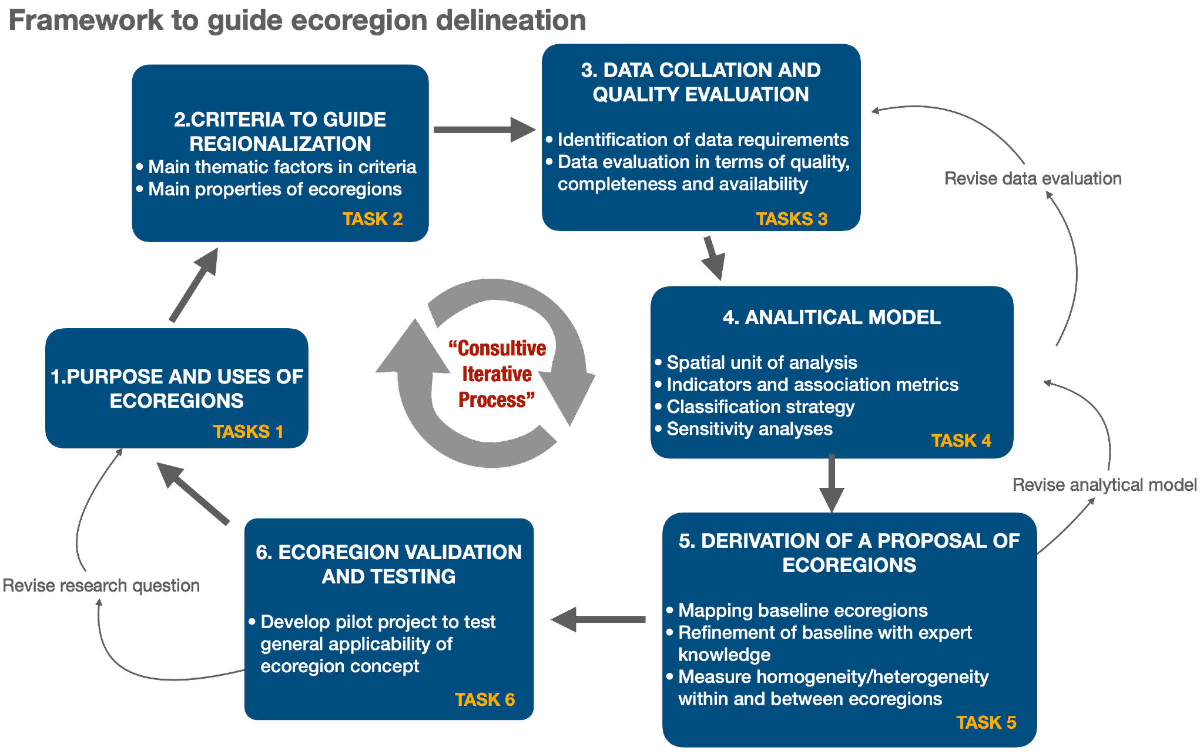

Figure 2. General framework with main steps and key activities guiding the delineation of ecoregions to support implementation of the EAFM in the context of international tuna fisheries (adapted from Mackey et al. 2008). Main tasks addressed in this report are mapped to this framework.

WORKSHOP TASKS

Task 1: Potential role and uses of ecoregions in IOTC

In the first IOTC ecoregion workshop, the Group advised on the importance of providing a strong rationale of what might be the potential benefits and uses of ecoregions in the context of IOTC species and fisheries. This presentation provided an overview of **potential purposes and intended uses of ecoregions as tools to guide EAFM implementation** in the IOTC for the Group to discuss. These are:

- **Planning and prioritization tool** - Ecoregions can provide a spatial framework for assessing needs and risks at the scale of specific regions which can be used to inform planning and prioritization of resources, data collection and research.
- **Research and monitoring tool** - Ecoregions can steer research for the development of multiple concrete **scientific products and integrated approaches** (e.g. ecosystem overviews, fishery overviews, integrated ecosystem assessments, ecosystem models, etc…). The ecoregion units can provide a regional framework for assessing status, trends and threats and for addressing multi-fishery and multi-taxa interactions and emergent trade-offs. This may include (1) monitoring and reporting the state and trend of the environment and possible ecosystem responses to climate change, (2) monitoring and reporting the state and trends of bycatch and vulnerable species and responses to mitigation measures, (3) support broad-scale ecological modeling to enhance understanding of ecosystem structure and function and predict cumulative responses derived from fishing and the environment, (4) identification and visualization of emerging trade-offs in multi-species and multi-fishery interactions, (5) planning and directing future research in poorly-understood regions, among others.
- **Advice tool**: Ecoregions can provide a **spatial framework for structuring advice** (integrated advise) to address regional management challenges. The ecoregion can provide a spatial framework for integrating ecological and socio-economic information and visualize emerging trade-offs between multiple management objectives.

GROUP DISCUSSION

The following main points were made during the discussion:

- The Group noted that the **EAFM definition** based on the FAO EAFM guidelines presented to the Group (Garcia et al 2003) makes reference to implementing EAFM in a defined geographic area and it queried whether this explicit mention to a specific geographic area is a fundamental part of EAFM itself. It was explained that while EAFM implementation may require to define *a priori* the geographic area to apply management, the spatial scale of the implementation will depend on the species, fisheries and region being under management. This workshop aims to assist in the identification of what spatial scale would be the most practical to support EAFM implementation in the context of IOTC species and fisheries.

- The Group discussed **whether EAFM implementation should be treated differently in tuna RFMOs and other non-tuna RFMOs**. The Group noted that tuna RFMOs are just lagging behind compared to other organizations in using complementary tools (such as ecoregions) to support EAFM implementation, and that until now, the management advice provided in tuna RFMOs have mostly been done at the species and fisheries level, with no need or requests to provide regionally-integrated advice. It was discussed how other organizations (e.g. ICES and NAFO) are moving towards providing regional-based advice using ecoregions as the spatial framework for providing more integrated advice in response to addressing EAFM implementation. It was also noted that the main historical drivers to implement EAFM were relatively limited in scope, i.e. to address pollution in the Baltic sea (for ICES) and seafloor impacts from trawling fisheries (for ICES and NAFO); yet these organizations have widen the scope of EAFM implementation to cover a range of drivers, pressures and their impacts within their area of work. **Although tunaRFMOs manage highly-migratory species in broad areas, the Group agreed that the process of EAFM**

implementation would be similar between tuna and non-tunaRFMOs. The Group further noted ecoregions and their intended derived products in IOTC should seek to support and complement existing single-species advice rather than eliminate or undermine the existing advice-making in IOTC.

- The Group noted the **potential use of ecoregions as a planning, prioritization and research tool with the aim of informing and improving advice (i.e., an advice tool)** in the context of IOTC species and fisheries. It was also noted that when developing ecoregions for planning and research purposes, it would be important to distinguish between IOTC neritic/coastal species (e.g. bullet tunas) and oceanic species (e.g. yellowfin tuna) and their different management needs, and similarly also differentiate between coastal and oceanic regions as they may be affected by different drivers and pressures within the IOTC convention area. It was also noted that one of the essence of the ecoregions is in fact to highlight the different regional drivers and issues within the IOTC convention area so management is adjusted to regional needs. It was noted that for coastal species and areas, large marine ecosystems (LME, an existing biogeographic classification of coastal waters) have already been mapped with the purpose of informing planning, prioritization and research to support EAFM implementation. It is less clear how a spatial framework may assist in supporting EAFM advice for oceanic migratory species since they might occupy extensive ocean areas, yet past work suggest tuna and billfish species distributions associate more strongly to specific oceanographic areas than others suggesting some type of spatial partitioning (latitudinally and by depth) (Reygondeau et al 2012).

- The Group noted the **importance of establishing the potential uses of ecoregions *a priori*** since this determines the spatial scale of the ecoregions (ideally aiming for a relatively small number of large ecoregions). It was noted that ICES, for example, started this process 15 years ago, and that it just recently, around 2016, started to produce advice products using ecoregions as their spatial framework. Therefore, the Group advised on the importance of having early discussions on the potential uses and roles of ecoregions within the IOTC community to inform the spatial scales of ecoregions to serve IOTC needs, as well as follow lessons learned in other fisheries organizations when relevant.

Task 2: Criteria to guide ecoregion delineation and expected qualities of ecoregions

This presentation provided an updated criteria based on the Group feedback in the first IOTC ecoregion workshop, which establishes the main thematic factors used to guide the ecoregion delineation, and the expected qualities of the ecoregion based on the chosen criteria (Table 1). The criteria now includes three thematic factors that together drive the ecoregion classification presented in this workshop.

The **first thematic factor** seeking to inform the delineation of ecoregions is the **oceanography and biogeography of the pelagic waters in the Indian Ocean**.

The **second thematic factor** seeks to use **the spatial patterns of the distribution of main IOTC species (oceanic tuna and billfish species, neritic species) and the ecological communities they form** to contribute to the delineations of ecoregions.

The **third thematic factor** seeks to use **the spatial patterns of the main IOTC fisheries and their fishing grounds** to contribute to the delineation of ecoregions.

Table 1: Refined criteria for evaluating and guiding the delineation of ecoregions in IOTC. This table includes the main thematic factors informing the classification analysis and also the expected qualities of the resulting ecoregions.

Criteria	
Thematic factors	**Expected qualities**
Oceanography and biogeography of the Indian Ocean	•The boundaries of proposed ecoregions appropriately demarcate areas with a clear oceanographic/biogeographic justification •The proposed ecoregions are characterized by distinct environmental/oceanographic conditions •It should be possible to link ecosystem research, assessment and monitoring of environmental/climate effects to effectively provide integrated advice and support integrated management
The distribution of the main IOTC species and the spatial composition of the ecological communities they form (biogeography of tuna and billfish communities)	•The proposed ecoregions demarcate the core distribution of IOTC tuna and billfish species (including both neritic and oceanic species) •The proposed ecoregions are characterized by distinct communities of tuna and billfish species
The spatial patterns of the fishing grounds of the main IOTC fisheries	•The proposed ecoregions demarcate the core distribution of major IOTC fisheries (artisanal and industrial) operating in the convention area •The proposed ecoregions are characterized by distinct IOTC fisheries •It should be possible to link ecosystem research, assessment and monitoring of fishing impacts to effectively provide integrated advice and support integrated management (e.g. mixed fisheries scenarios, cumulative impacts of fisheries)

The presentation also summarized a list of expected **properties of ecoregions** which were used to guide all the steps in the ecoregion delineation process. These are:

- Ecoregion boundaries should be considered **static** for use as a practical tool for resource assessment and management. However, it is a common practice to differentiate between the **core and periphery** of an ecoregion (Loveland and Merchant 2004). The homogeneity of ecoregion will be most manifested at the core; by contrast, transition areas will manifest at the periphery. Therefore, ecoregions will have boundaries that are generalized and not precise, and should be interpreted as gradients and transition zones rather than precise boundaries or management lines (Rice et al. 2011).
- Ecoregions should be relatively **few in number** to make them a practical tool to inform EAFM implementation. The spatial scale at which ecoregions are defined can have an important impact on their potential uses, therefore the ideal versus practical number of ecoregions may be considered to inform the delineation of ecoregions.
- Ecoregion classifications may consider involving some type of **nested hierarchy** to account for issues of scale and ecoregion extent (Loveland and Merchant 2004). The intended use and applicability of the ecoregions must be used as a guide in dealing with issues of scale and ecoregion extent, including whether hierarchical subdivisions are needed.
- Ecoregions should be **geographically distinct** to guide EAFM implementation. Ecoregions with similar characteristics, but in geographically diverse areas should be treated separately.

GROUP DISCUSSIONS

The following main points were made during the discussion:

- **The Group agreed to use these three core thematic factors as the main criteria to continue the delineations of ecoregions in IOTC.** The Group noted how the three thematic factors combined are used to inform potential boundaries of ecoregions and that **ecoregions at the end are a compromise among these three thematic factors**.
- While the three factors are seen as relevant to delineate ecoregions in IOTC, the Group also noted how t**he three factors are also in part a reflection of the limitations in the current data availability in IOTC**. Furthermore, it was noted that the IOTC ecoregion process started with a simple criteria (with three thematic factors), later moved to a more complex criteria increasing the number of thematic factors, but in the end, for simplicity and practicality, the initial simpler core criteria were readopted using the three main thematic factors presented here.
- The Group noted that the **distributions of bycatch species were not considered as part of the criteria to guide the delineation of ecoregions** and queried how bycatch species are treated as part of the ecoregion delineation process and also in the potential products that might be derived in the future at the ecoregion level. It was explained that the intent here is only to use the core distributions of main target tunas and billfish species (and their fisheries) to inform ecoregion delineation (together with oceanography), and after the ecoregions are defined, then to use them as the spatial framework to describe and monitor the impacts of the tuna fisheries on bycatch species at the ecoregion level. Therefore, the distribution of bycatch species are not used to delineate the boundaries and the number of potential ecoregions within the IOTC convention area, and instead bycatch species are seen as the end users of ecoregions. Bycatch species are impacted by main IOTC fisheries, so the idea is to capture and summarize fishing impacts on bycatch species at the ecoregion level.
- The Group noted that ecoregion boundaries, while known to be dynamic because of decadal and interannual oceanographic variability, **the ecoregion boundaries should be treated as static and interpreted as transition zones conceptually and for practical reasons** between one ecoregion and the adjacent ecoregion (as opposed to sharp boundaries and hard management lines). Yet ecoregion boundaries could be evaluated and re-analyzed if needed in the future since climate change might be changing the core distribution of main IOTC species and fisheries as new information comes available.

Task 3: Data collation and quality evaluation

Based on the Group feedback in the first IOTC ecoregion workshop, the existing datasets were updated and reevaluated based on their availability, quality and completeness and the key data layers that best characterize each of the main thematic factors included in the criteria (Table 1) were chosen to guide the delineation of ecoregions. This presentation reviewed:

(i) the biogeographic classifications chosen to capture the regional oceanography of the Indian Ocean,

(ii) the spatial distribution of catches for IOTC species to identify the core distributions and co-occurrence of species assemblages in the Indian Ocean, and

(iii) the spatial distribution of catches of major IOTC fisheries to identify their core fishing grounds.

Under **thematic factor 1–oceanography**, the combined MEOW and PPOW classification was identified as the most useful in capturing the regional oceanography of the Indian Ocean and guiding the development of ecoregions in IOTC. We revised the number of biogeographical provinces derived from combining the MEOW and PPOW biogeographic classifications and also reduced the number of provinces from 24 to 15 based on objective rules (Nieblas et al 2022). These 15 provinces were retained for their inclusion into the spatial analysis presented in Task 4.

Under **thematic factor 2–spatial distribution of IOTC species,** we used the spatial distribution of the main IOTC species catches (georeferenced raised catches for the main five oceanic tuna and billfishes provided by IOTC secretariat, georeferenced catch and effort data for IOTC neritic tuna and also shark species available in IOTC website) to identify the core distributions of species and co-occurrence of species assemblages to inform the delineation of ecoregions. Similar to 2019, we found the updated **georeferenced raised catch data for the five main oceanic species of tunas and billfishes were "good" in terms of availability, quality and completeness, and they were retained to represent the spatial distribution and abundance of oceanic tuna and billfish species in the IOTC** in the spatial analysis conducted under Task 4. We also found **the updated catch data for neritic species, while easily available, were still incomplete and of low quality, and they were not retained for further analyses under Task 4.** Based on the examination of the updated shark catches, **we also found the shark data were still patchy and incomplete, and for these reasons, shark data were not retained for further analyses under Task 4.**

Under **thematic factor 3– fishing grounds of the major IOTC fisheries,** we used the spatial distribution of catches (georeferenced raised catches for main five oceanic tuna and billfishes provided by IOTC secretariat) to identify the core distributions of main IOTC fisheries as a proxy to determine the main fishing grounds of each fishery and spatial co-occurrence of fisheries assemblages to inform the delineation of ecoregions. Upon examination of the data, we refined the grouping of the IOTC fishery codes seeking to better capture the major fisheries and gear types operating in IOTC (including both coastal and high-sea fisheries), while limiting the number of different fisheries to be included in the spatial analyses. The regrouping of gear codes were done as follow: (1) we distinguished the large gear groupings (LL, PS, GILL, LINE, BB, OT, and DSEI), (2) we distinguished the operation type (industrial or artisanal) as determined by IOTC secretariat, and (3) we distinguished whether the fisheries were targeting specific species, i.e. swordfish and shark (Nieblas et al 2022). **In the end, we end up with 14 different fisheries to be included in the spatial analyses under Task 4.**

GROUP DISCUSSIONS

The following main points were made during the discussion:

- Regarding thematic factor 1 – oceanography:
    - The Group agreed the **combined MEOW-PPOW classifications as a data layer was a good start** (and a recommendation from the first workshop) **to capture the thematic factor of oceanography, and to retain this layer for further analysis under Task 3**. Yet, it was noted that while the Spalding's classification captures well in general terms the main oceanographic features of the pelagic environment in the Indian Ocean, in some cases, this classification does not capture well some regional oceanographic features known to be important to tuna and tuna like species. For example, it was suggested that the western and eastern areas of Madagascar should not be treated as one single homogeneous province (as suggested by Spalding's MEOW province), since it is well known that the Mozambique channel in western Madagascar is a very productive area with rich mesoscale features supporting productive tuna fishing grounds compared to the eastern Madagascar area which is characterized by oligotrophic waters. It was also suggested that the Somalia Current region and the Arabian Sea region should not be treated as one single homogeneous province (as suggested by Spalding's PPOW province) since this region also has subregional differences in terms of oceanographic characteristics and tuna fishing grounds. In response, the Group agreed to use expert knowledge to capture the relevant

regional oceanographic features and the ecology of tuna species in the resulting ecoregion classifications.

  - While the Group agreed to continue using the Spalding classification to inform the spatial analysis under Task 4, it also suggested using **the Longhurst biogeographic classification to inform the Group discussions when the final resulting ecoregion classification is adjusted and refined based on expert knowledge**. It was noted that the boundaries of the PPOW provinces (oceanic classification) and the Longhurst oceanic provinces are very similar, as well as differences between the MEOW provinces (coastal provinces) and the Longhurst classification in coastal areas. The Group also noted that the outer extent of the MEOWs are defined by the EEZ while the Longhurst coastal regions have a better oceanographic justification.
  - The Group also discussed that an **alternative analysis** would be to produce a new pelagic classification from scratch to quantitatively derive pelagic regions relevant to tuna and billfish species using fine scale temporal and spatial environmental variables. This option might be considered in future analyses depending on future priorities and needs of the ecoregion delineation process in IOTC.

- Regarding thematic factor 2 – spatial distribution of IOTC species:
  - The Group noted that **the catch data analyzed to capture the distributions of neritic species and shark are not adequate to quantitatively include them in the spatial analysis carried out under Task 3,** yet it noted their relevance for informing ecoregions boundaries and suggested to find alternative ways to include them in the delineation process, and therefore not exclude them entirely from the analysis. It was noted that at the present stage, the MEOW provinces are used as proxies of the distributions of coastal species in order to differentiate coastal and oceanic habitats within IOTC. Alternatively, it was suggested to use the nominal catches of neritic species by flag (not usually georeferenced) and assign them spatially within the EEZ of flag states or within MEOW provinces to capture the distribution and the relative abundance of neritic species within the IOTC convention area, and use this as a data layer to inform the quantitative spatial analysis under Task 4.
  - For IOTC target species of sharks, such as blue shark, the Group noted the greater difficulties to include them as a quantitative data layer given the current low quality of the georeferenced catches available in IOTC. However, the Group suggested accounting for shark distributions in a qualitative way using expert knowledge when interpreting the resulting draft ecoregions derived from the spatial analysis. The Group also suggested using presence and absence data to capture the distribution of relevant shark species, because it is well known the catch data reported for sharks is biased and quite incomplete at the present stage, yet the current spatial analysis requires both presence/absence information and catch data as a proxy of abundance.
  - The Group noted one of the **strengths of the quantitative analysis** is that we can objectively derive a proposal of draft ecoregions based on an established criteria and the chosen data layers to inform the criteria. It was noted that the **application of expert knowledge to refine the quantitative proposal** of ecoregions may lead to losing some of the objectivity. Noting this, the Group advises to **follow this hybrid approach to derive a proposal of ecoregions** by combining quantitative analyses with expert knowledge, as expert knowledge may be critical to account for data gaps and limitations in the current analysis.

    - The Group also acknowledged the difficulty of including the distribution of bycatch species as data layers for informing the quantitative analysis, given the potential high number of bycatch species interacting with IOTC species and the poor knowledge and data on their distributions. The Group agreed to **treat the bycatch species as end users of the ecoregion products** for now, meaning once the ecoregion are delineated, integrated bycatch assessments could be developed at the ecoregion level.
    - The Group noted that it is also **important to highlight the data gaps and limitations** identified during the ecoregion analysis, as it is an important result of the workshop itself, and a way to encourage better data collection and reporting of fishery statistics by member states of the IOTC.
    - The Group noted that the **southern bluefin tuna species** was not considered in the current analysis and suggested its **inclusion in future analyses** since it will help to better delineate the ecoregions in the southern Indian Ocean. The Group agreed to include southern bluefin tuna in future analysis as georeferenced catch data might be easily requested to CCSBT.

- Regarding thematic factor 3 – fishing grounds of the major IOTC fisheries:
    - The Group agreed to **use the georeferenced raised catch data to capture the main fishing grounds of major IOTC fisheries**. Yet it raised concerns about some limitations in the dataset, particularly that it only includes five main oceanic tuna and billfish species. It was noted that these data better represent the fishing grounds of industrial fisheries than the artisanal coastal fisheries, as neritic tuna catches are not included in the georeferenced raised catch data set provided by the IOTC secretariat.
    - The Group queried how **industrial and artisanal fisheries** were classified. It was explained that the major fishing gears were characterized as either being industrial or artisanal following the advice of the IOTC secretariat, and these were determined based on whether the gears operate on the high seas or just coastal areas and based on the size of the vessels. Generally, vessels that are less than 20 meters long and operate in the coastal areas are considered artisanal fisheries.
    - The Group also advised **revising the data for some of the fisheries** included in the analysis. For example, the Group noted handline and trolling catches off Oman, Pakistan in the north western India which could not be accurate since gillnet is the only main fishery in this area. The Group advised to check with the IOTC secretariat to revise the raising procedure (and assumptions made) that produced the georeference raised catches for the handline and trolling fisheries in this region.
    - The Group also advised not to use the longline experimental gear (LLEX) in the analysis since it may not characterize a relevant commercial gear and instead it may be considered an opportunistic survey for research purposes.
    - The Group also advised not using combined gears (LG and GL, e.g. Sri Lankan fishery using gillnet and longline gears in the same trips) in the analysis as the dominance of one gear over the other is not known and because these data are not considered reliable.
- General comments:
    - The Group emphasized the importance of **improving the data collection and reporting of georeferenced catch data in IOTC**, especially for coastal

species and fisheries and oceanic sharks, since these are relevant datasets to inform the ecoregion analysis.

Task 4: Analytical model for deriving a baseline ecoregion proposal

This task had the objective of conducting a refined classification analysis based on the criteria outlined in Task 2 and the selected datasets outlined in Task 3 for **developing a baseline ecoregion proposal**.

The presentation summarized the refined classification analysis for deriving a baseline ecoregion in three steps:

(1) A spatial overlapping analysis between the selected biogeographic classifications (MEOW-PPOW combination) and spatial catches by species and fisheries was conducted and no further refinements were required,

(2) a specificity and fidelity indicator analysis was performed that measures the dominance (i.e. specificity) and spatial prevalence (i.e. fidelity) of individual species and fisheries within the provinces of the selected biogeographic classification. This analysis required further refinements, including improved visualization of major graphic outputs and results, investigating the potential bias due to the size of the biogeographic provinces on the fidelity indicators, and the investigation of potential thresholds to improve the calculation of the fidelity indicator based on the persistence and the quantities of the catches over time.

and (3) a hierarchical clustering analysis was performed to cluster biogeographic provinces according to their degree of similarity in terms of species and fisheries composition based on the specificity and fidelity indicators. This analysis also required further refinements to ensure different versions of the Specificity-Fidelity Indicator (SF indicator) indicators are evaluated for their impact on the resulting classifications.

The first analysis reached the following conclusions:

- The combined **MEOW-PPOW classification represented the spatial distribution of the major tuna and billfish species and fisheries** in the IOTC convention area well enough to warrant further investigation and inclusion in subsequent spatial analyses.
- The **Specificity-Fidelity Indicator (SF Indicator)** was used to characterize the dominance and spatial prevalence of each species and type of fishery in each MEOW-PPOW province. The SF indicator gives an indication of the community composition of a province in terms of its species or fisheries, highlighting those species and fisheries most dominant and prevalent in a province.
- The **application of thresholds on the fidelity indicator** aimed to evaluate the inclusion or exclusion of grid cells into the calculation of the fidelity indicator, in order to remove the rare or unrepresentative grid cells from the fidelity indicator. The thresholds were developed to filter the fidelity of species or a fishery to a province based on 1) the number of years a species or a fishery is present in a grid cell, hereafter referred to as the persistence threshold, and 2) the amount of catch in each grid cell, hereafter referred to as the catch threshold.
- **Based on the preliminary SF indicator analysis, it was found that the community assemblage of a province was best represented by both the species and the fisheries that occupy and operate in that province**. It was also found that the high catch and persistence thresholds helped to identify the most spatially prevalent species and fisheries in each province (spread broadly within the province with relatively high catches that persist over time). These thresholds also helped to filter out from the spatial analysis those provinces with little or no information, allowing clearer spatial patterns to be resolved. Therefore, it was concluded that the combined SF indicator, which includes both the specificity and fidelity of a species and fishery for a province filtered by high catch and persistence threshold levels, is the most representative method for spatially representing community composition in terms of species and fisheries, and **this combined SF Indicator was used as the input for the clustering algorithm**.

- A **hierarchical clustering algorithm** was run on the SF indicator values, including the specificity and the fidelity indicator with the high catch and persistence thresholds applied for species, fisheries and both species and fisheries combined for the MEOW-PPOW biogeographical classification. This resulted in **three clustering analyses** for species, fisheries, and both species and fisheries combined (Figure 3).

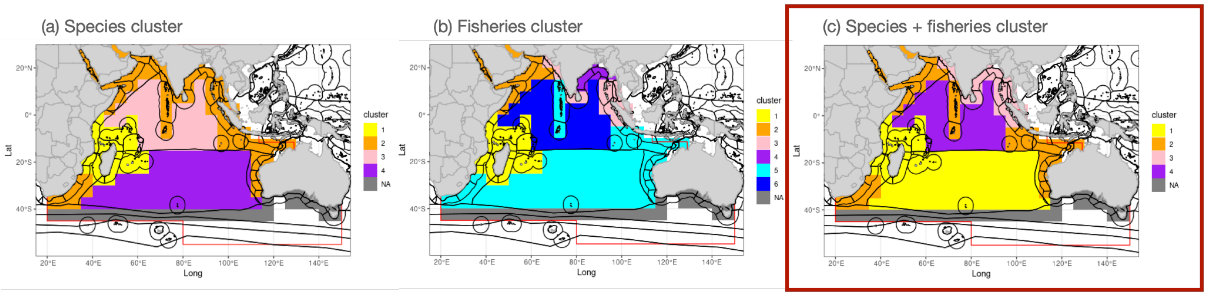

Figure 3. The cluster analysis results for the high threshold scenario for the (a) species-based SF indicator, (b) the fishery-based SF indicator, and (c) the combined (species and fishery) SF indicator. Panel c shows the clustering analysis used as the baseline proposal to start discussions about expert based refinements (see further details on methods in Nieblas et al 2022).

GROUP DISCUSSIONS

The following main points were made during the discussion:

- General comments:
  - The Group discussed the **importance of discussing and refining every step in the ecoregion process** (Figure 2) **to ensure transparency and reproducibility in the process and the importance to keep the process iterative over time**. Yet it also stressed the importance of informing current discussions using the ecoregion proposal produced during workshop 1 and all the Group discussions that went into producing this first proposal. It was explained that the current draft proposal produced during the first workshop will be an integral part of the discussions when refining the new proposal during day 3 of the workshop.
  - In addition to the refined quantitative analysis produced under task 4, the **Group suggested to also quantitatively evaluate the ecoregion proposal produced during the 1st workshop (and in fact the new proposal derived in this second workshop) to examine to what degree the ecoregions proposed within IOTC convention area are relatively homogeneous** within (or distinct to each other) in terms of oceanographic properties, core species distributions and core fishery distributions (following Criteria and expectations in Table 1). It was explained that the validation step under task 6 in part has attempted to do this quantitative evaluation for the first ecoregion proposal to test the similarity/differences among the proposed ecoregions, and that this could be further developed in future analyses (see Task 6). It was noted that this type of evaluation would allow us to measure how confident we are in using the proposed ecoregions for their intended uses, e.g. to develop integrated research and advice products (e.g. ecosystem assessments) at the ecoregion level.
  - The Group queried the temporal scale of the catch data used to inform the analysis and the robustness of the indicator and cluster analysis in response to the potential temporal variability (yearly and seasonally) of the catches within the IOTC region. It was noted that the analysis used only the median

annual mean of the 15 years of the georeferenced raised catch data in order to minimize annual and seasonal variability in the catches and capture the overall trend in species and fisheries distribution. It was also noted that the ecoregion analysis seeks to draw static ecoregion boundaries for practical reasons but that these should be interpreted as transition zones because of the inherent variability of marine ecosystems.

- Regarding the SF indicator analysis:
    - The Group discussed the **usefulness of the thresholds applied to the fidelity indicator to better understand and capture the core distributions of species and fisheries,their spatial prevalence and their association with specific provinces** and noted that the higher thresholds applied to the fidelity indicator better captured the core distributions of the species and fishery. The Group agreed that the fidelity indicator with thresholds applied was more representative of the core distributions of species and fisheries.
    - The Group suggested **including the southern bluefin tuna species to the SF indicator analysis** to better cover the southern provinces of the Indian Ocean since many of the southern provinces were dropped from the analysis after applying the higher thresholds to the fidelity indicator. The Group agreed to include this species in future analyses but noted that there are strict catch limits on southern bluefin tuna and that these may have an impact when inferring the spatial distribution of southern bluefin tuna in the southern ocean provinces based on the reported catch data.
    - The Group agreed to use the SF indicator of species, fisheries and species-fisheries combined with the high thresholds of persistence and catch to inform the cluster analysis and group provinces based on their similarity in species and fishery composition. The Group was asked to ensure that the SF indicator of species, fisheries and species+fisheries shown in Figure 27 (Nieblas et al 2022) characterizes well the species and fisheries in each province. Furthermore, it was noted that the **combined SF indicator, which includes both the specificity and fidelity of a species or fishery for a province, is the most representative method for spatially representing community composition in terms of species or fisheries.**

- Regarding the cluster analysis:
    - The Group discussed the **pros and cons of using the MEOW provinces as inputs for the cluster analysis**. One of the reasons the MEOWS were chosen in the first place was because their coastal extent was used as a proxy to capture the distribution of the neritic species and as a proxy to capture the distribution of the more coastal fisheries that target neritic species. However, the Group noted that using the MEOWs as inputs heavily constrain the analysis and could introduce bias in the analysis as some of the MEOWs, specifically in the Western Indian Ocean, may be too large and heterogeneous to be treated as a unique province. It was also noted that the Longhurst provinces better capture the oceanography and species/fishery composition in the Western Indian Ocean and some other coastal regions, and therefore the Longurst provinces should be taken into account when refining the ecoregions. However, one of the reasons the Longhurst provinces were not chosen as the oceanographic layer in the first place was because they did not include coastal areas of some island regions (e.g. Maldives). It was also noted that the Western Indian Ocean MEOW province was discussed in detail in the first

workshop and that the Group adjusted and refined it based on the expert knowledge.

- The Group also proposed that instead of using established biogeographic classifications (e.g., MEOW, PPOW, Longhurst) as inputs for the ecoregion analysis, a small number of environmental variables relevant to the ecology of tuna and tuna species could be used as inputs to inform the clustering analysis and to derive the baseline ecoregion proposal (as an **alternative analysis**). It was discussed how this type of full quantitative analysis of environmental data could complement the existing analysis. Yet it was noted that while analyzing environmental data from scratch may better represent the oceanography of the Indian Ocean (and the resulting clusters of large ocean regions), there are still limitations in the species and fishery catch datasets, as the only good georeferenced catch data (spatial resolution of 5°x5°) available are for 5 tuna and billfish species.
- The Group noted that the cluster analysis attempts to aggregate large ocean areas of relative homogeneous characteristics (in terms of oceanography and species and fisheries composition) for practical reasons. However, this may oversimplify and hide some of the regional patterns within some of the ecoregions. The Group agreed that **while we should strive to obtain a relatively small number of large ecoregions we also need to make sure that they make ecological sense to the extent possible so the advice products are ultimately useful.**
- The Group was reminded that **both the SF indicator and cluster analysis are mostly informed by the catches of only 5 species (4 oceanic tunas and swordfish), excluding information on catches for neritic species and sharks,** and that this needs to be taken into account when interpreting the cluster outputs. The Group decided that a good way to move forward was to discuss the suitability of the baseline proposal and refine and adjust those areas that do not match well the current knowledge on oceanography and the distribution of IOTC species (including neritic, shark and oceanic species) and the fisheries targeting them.
- The Group discussed that while there are clear benefits in attempting to refine the quantitative analysis (and data inputs that went into it) to come up with a better baseline proposal of ecoregions, it also emphasized that **the proposal of draft ecoregions derived here, even if not completely satisfactory, may already be sufficient to begin developing pilot case studies of ecosystem products** (see validation step under Task 6).
- The **cluster analysis** was discussed by the Group with no further suggestions on the methods used.

Task 5: Interpretation of baseline ecoregions and refinement based on expert knowledge

This task has the objective of **refining the baseline ecoregion proposal using expert knowledge**. The presentation introduced a baseline ecoregion proposal to the Group. The pre-workshop preliminary analysis suggested that the cluster analysis based on the combined SF indicator using the MEOW-PPOW provinces for the high threshold scenario best (1) represented groups with distinct species and fisheries composition and (2) adhered to the criteria and the main properties of ecoregions (Figure 3, panel c, using both species and fishery SF indicators). One of the main properties of the ecoregions agreed upon by the Group is that each ecoregion should be geographically distinct. Adhering to this guideline, the four resulting clusters (Figure 3, panel c) were disaggregated into seven geographically distinct clusters (Figure 4). It was noted that the high threshold scenario excludes the southernmost provinces due to lack of data, and it was suggested that these provinces be treated as a single ecoregion as well. In the end, the baseline ecoregion proposal comprised eight different ecoregions (Figure 4).

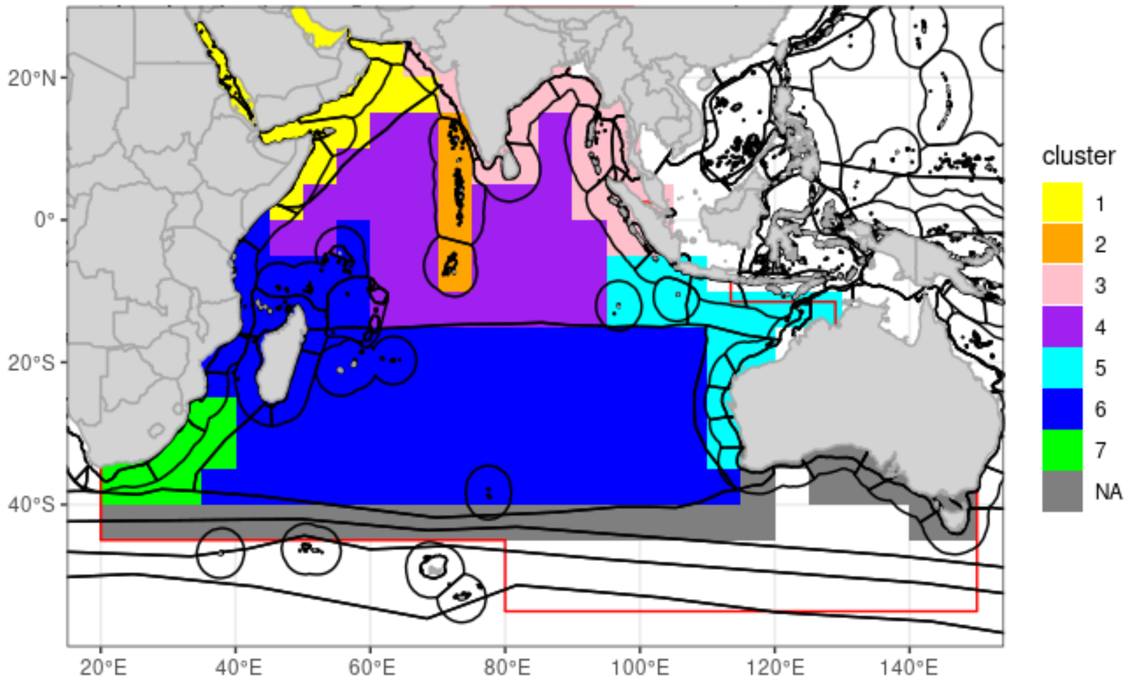

Figure 4. The baseline ecoregion proposal was derived from the cluster analysis on the combined species- and fishery-based SF indicator for the MEOW-PPOW provinces (Figure 3, panel c), which was selected as the most representative clustering result that adheres best to the criteria (Table 1) and main properties of ecoregions for this study. The cluster in Figure 3 panel c was further modified for geographically continuity, and the southernmost cluster is proposed as an additional ecoregion. The final baseline ecoregion proposal comprises eight different ecoregions.

The Group was asked to develop a **refined proposal of candidate ecoregions both** using the baseline ecoregion proposal (Figure 4) and the draft ecoregion proposal derived in the first ecoregion workshop (Figure 1) as a starting point to be **refined with expert knowledge**. Expert knowledge was used to refine the cluster groupings and address any potential misclassifications and errors based on poor or incomplete data inputs (e.g. distribution of neritic tunas and targeted sharks). Expert knowledge was also used to refine the boundaries of the baseline ecoregions to ensure that the final candidate ecoregions comply with the expected qualities of the ecoregions based on the agreed upon criteria (Table 1).

Miro, a visual collaboration platform (miro.com), was used to structure the Group discussions and keep record of all the suggestions and proposed refinements to the baseline ecoregion proposals based on expert knowledge. Essential information including the biogeographic classifications, indicator analyses for species and fisheries, and clustering results were displayed together in the MIRO platform to inform the Group discussions (Figure 5).

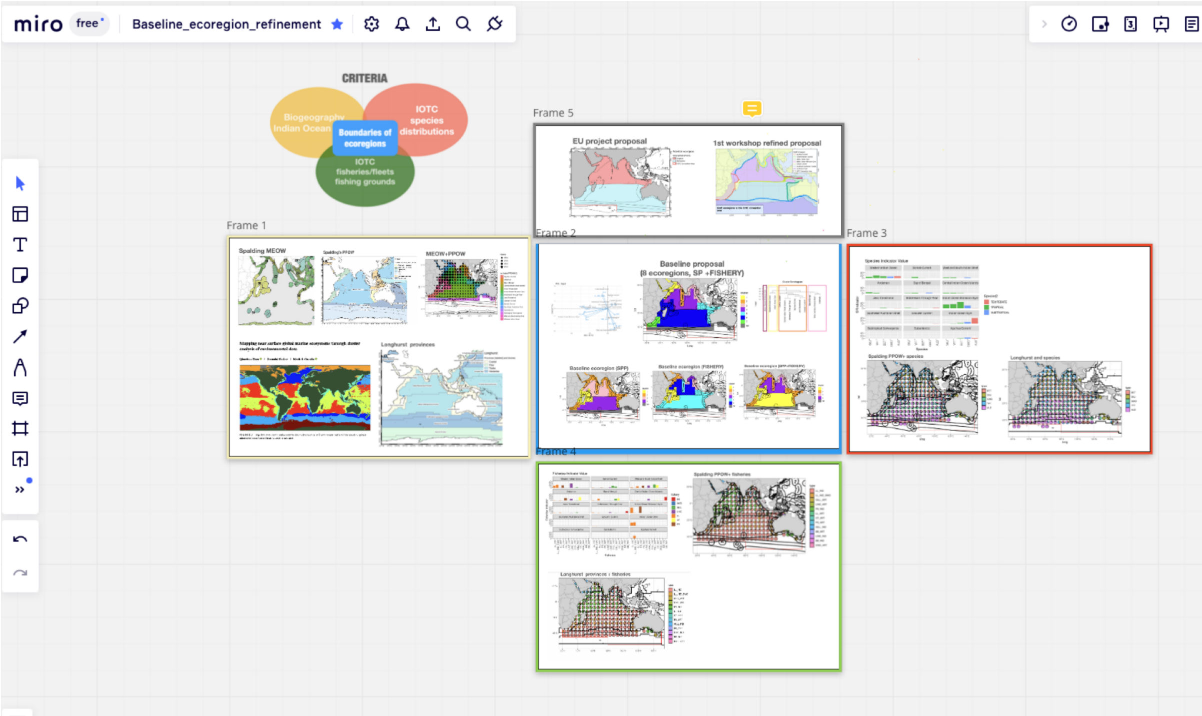

Figure 5. Essential information including the biogeographic classifications, indicator analyses for species and fisheries, clustering results and previous ecoregion proposals were displayed together in the MIRO platform to inform the Group discussions.

GROUP DISCUSSIONS

The following points summarize the main discussions and group decisions that led to a refined proposal of candidate ecoregions:

- In preparation for the workshop, the temporal variability of the catches as well as the variability of the specificity, fidelity and SF indicators within and between the final clusters included in the baseline proposal were investigated to test homogeneity/heterogeneity in the clusters. The Group noted that this analysis should be interpreted with caution since it is well known that the catches for coastal areas are underreported and that this may be introducing some bias in the analysis. It was also noted that this analysis was based only on the georeferenced raised catch data of the five main species with all their limitations (e.g., taxonomic and spatial bias in the catches). Furthermore, in interpreting the temporal variability of the catches it was noted that the year 2005 is considered the "golden year" with the highest catches of tropical tuna in the Indian Ocean. It was also explained that the piracy events in the northwest region have relocated some of the fishing activity (mostly longliners) to other regions in the Indian Ocean and other oceans, which also introduces some bias in the interpretation of the variability of the catches over time.

- While the temporal variability of the catches was examined within and between the resulting baseline ecoregions, the Group noted that the median of catches within the last 15 years of data (which are considered a good overview of main species and fisheries in the region) are used to inform the main cluster analysis. Therefore, it was explained that the reason why the annual catches were not used to produce multiple interannual clusters (one cluster for each year of data) to explore the stability of the clusters over time, was because the gaps in the catch data (for many pixels and years) for species and fisheries, and that an average of the last 15 years of data provides a better overview of the catches by species and fishery in the region. It was also noted that the application of the threshold to the calculation of the indicator, which removed anomalous years and data, helped in reducing the interannual variability and got to the core of the species distributions and fishing grounds of major fisheries.

- The Group noted again **the importance of aiming for a small number of relatively large ecoregions within IOTC area for its implications in the developing research and advise products**, yet it highlighted the importance of differentiating between coastal and oceanic areas due to their distinct peculiarities (for example, coastal areas tend to experience the highest variability in fisheries and species catches and exhibit a larger diversity of fisheries and species catch composition than oceanic areas). The Group was reminded that the cluster proposal is based on the catches of only the five oceanic species and this is the reason expert knowledge will be needed to adjust and refine the baseline proposal especially in the more coastal neritic areas.

- The Group was reminded that during the first ecoregion workshop the Group had limited time to discuss in detail and refine according to expert knowledge the baseline ecoregion proposal. For example, more time was dedicated to refining the ecoregions in the western part of the Indian Ocean than the eastern part. Furthermore, two regions were not discussed in detail during the first workshop, the western coast of Australia and the coastal areas off Kenya and Tanzania, and it had been advised to discuss these regions in more depth in the second workshop.

- While acknowledging all the caveats (e.g. data gaps, limitation of the catch data used), the Group also noted the **importance of agreeing on a refined candidate proposal of ecoregions in this second workshop**. It was noted that this second ecoregion proposal would allow the search for funding and resources to test the usefulness of ecoregions by developing pilot products (e.g. integrated bycatch assessments) in the context of IOTC species and fisheries.

- The Group requested as a **future analysis to prepare a semiquantitative analysis to compare quantitatively several ecoregion outputs that have been produced over time**: (1) the draft ecoregions produced during the first workshop, and (2) the refined proposal generated in this second workshop, in order to examine improvements made in the refinement process. It was also suggested to compare quantitatively the baseline proposals (which are the cluster outputs) with the expert-refined ecoregion proposal, in order to examine improvements made in the refinement process.

- **The Group agreed to initiate discussions and the refinements based on expert knowledge using the draft ecoregion proposal endorsed in the first workshop while also taking into account the refinement analysis produced in the second workshop.** The Group was invited to use the Miro platform to suggest potential refinements and it was reminded that decisions made based on expert opinion should be recorded and clearly justified to enable traceable, identifiable, verifiable and validated decision-making. It was also reminded that while distinct boundaries need to be drawn in the final ecoregion proposal, these should be interpreted as transition zones, and instead focus the discussion on the main characteristics of each ecoregion and what differentiates one ecoregion from the adjacent ecoregion.

- The Group suggested several modifications for refining the draft ecoregion proposal derived in the first workshop (Figure 1). Their proposals and justifications are summarized below:

    - **Agulhas Current Ecoregion:** The Group suggested extending the northern boundaries of this ecoregion (ecoregion derived in the 1st workshop, Figure 1) to include the coastal areas of Mozambique and part of Tanzania. The new northern boundary (around 8-9 degrees south) better follows the boundaries of the Longhurst coastal province. This region is split into two coastal provinces following the South Equatorial Current splitting into a northern and southern branch along the coast in this region. With its extended boundaries at the north, the Agulhas Current Ecoregion now includes all the Mozambique Channel, which is characterized by an upwelling of nutrient-rich productive waters supporting important tuna fishing grounds. Furthermore the Group notes that the fisheries in this area (off Kenya and Tanzania) are not well documented and reported in the data sets used, so the Group justified that expert refinement was needed for this area.

    - **Somali Current Ecoregion.** The Group noted the original Somali Current Ecoregion (following the first ecoregion workshop, Figure 1) follows the PPOW classification and noted a good correspondence between this PPOW province and the Longurst coastal province in the same region, yet it suggested to refine the southern and northern boundaries of the Somali Current PPOW province. In the Southern part, the boundary was extended to 8-9 degrees South including some of the Kenyan coastal areas and connecting it with the northern boundaries of the newly proposed Agulhas Current Ecoregion. In the northern boundary, the boundary was extended all the way to the Indian coast to include the most northern waters of western India/Arabian Sea.

    - **The Maldives Ecoregion:** In our analysis, the Central Indian Ocean Islands MEOW, i.e., the coastal waters off Maldives and the British Indian Ocean Territory, clustered either with the adjacent coastal region or as one unique cluster. The Group agreed to keep this area as a unique ecoregion in part because it is characterized by an unique and important baitboat fishery which distinguishes this area from the rest, but also due to the distinct diversity of coastal fisheries and catch composition. The Group also suggested not to use the EEZ boundaries, but instead use the boundaries of the continental shelf to delimit the ecoregion.

    - The Group suggested refining the Central Eastern Coastal ecoregion (ecoregion derived in the first workshop, Figure 1) and splitting it into three ecoregions:
        - **The North Central Coastal Ecoregion:** This coastal ecoregion now extends all the way from the northern west coast of India to the northern edge of the Andaman Sea off Myanmar. The Group noted the importance of distinguishing between the northern, more productive areas of the Bay of Bengal (included now in this ecoregion) from the more oceanic and less productive areas of the Andaman Sea which clusters better with the Indian Ocean Monsoon Gyre Ecoregion. For the boundaries of this ecoregion, the Group suggested using the continental shelf to delimit this ecoregion.
        - **The Northeast Coastal Ecoregion.** This coastal ecoregion extends from the northern Andaman Sea all the way to the northern edge of the Indonesian Through-flow. The Group also suggested using the boundaries of the continental shelf to delimit this ecoregion

- **The Leeuwin Current Ecoregion:** The Group suggested treating the Leeuwin Current PPOW province as a single ecoregion.

- **The Indian Ocean Monsoon Gyre Ecoregion.** The Group suggested treating the Indian Ocean Monsoon Gyre PPOW province as a single ecoregion given its unique oceanographic patterns, tropical climate, its predominant industrial fisheries (mostly purse seiners and also longline fisheries targeting topical tuna species) and oceanic species composition (mostly tropical tuna species including skipjack, yellowfin and bigeye tuna) of this region. Yet the Group suggested some adjustments in the eastern area where it connects with the Indonesian Through-flow. The Group suggested connecting the Indonesian Through-flow with the adjacent ecoregion in the south (i.e., the Indian Ocean Gyre Ecoregion) and not with this ecoregion, as this area is an important spawning ground for southern bluefin tuna and other tuna species (e.g. yellowfin and bigeye tuna), and the oceanic fisheries operating here are more characteristic of the southern region.

- **The Indian Ocean Gyre Ecoregion.** The Group also suggested treating the Indian Ocean Gyre PPOW province as a single ecoregion given its unique oceanographic patterns, subtropical climate, its predominant industrial fisheries (mostly longliners targeting albacore and swordfish) and oceanic species composition (mostly albacore and swordfish) of this region. The Group also suggested connecting this region with the Indonesian Through-flow PPOW because of its oceanic nature and biogeochemical characteristics that are more similar to the Indian Ocean Gyre than the Indian Ocean Monsoon Gyre Ecoregion. It also suggested modifying the southern border of the ecoregion to look more similar to the Longhurst Southern Subtropical Gyre Province.

- **The Southern Ocean Ecoregion.** The Group suggested keeping the Southern Ocean Ecoregion (following the first ecoregion workshop, Figure 1), which combines the Subtropical Convergence PPOW, the Subantarctic PPOW and the Atlantic Polar Front PPOW, yet with some modifications. It suggested connecting the Southern Australian Coastal region with the Southern Ocean Ecoregion. This ecoregion has unique oceanographic characteristics and the fishery in this region is essentially southern bluefin tuna.

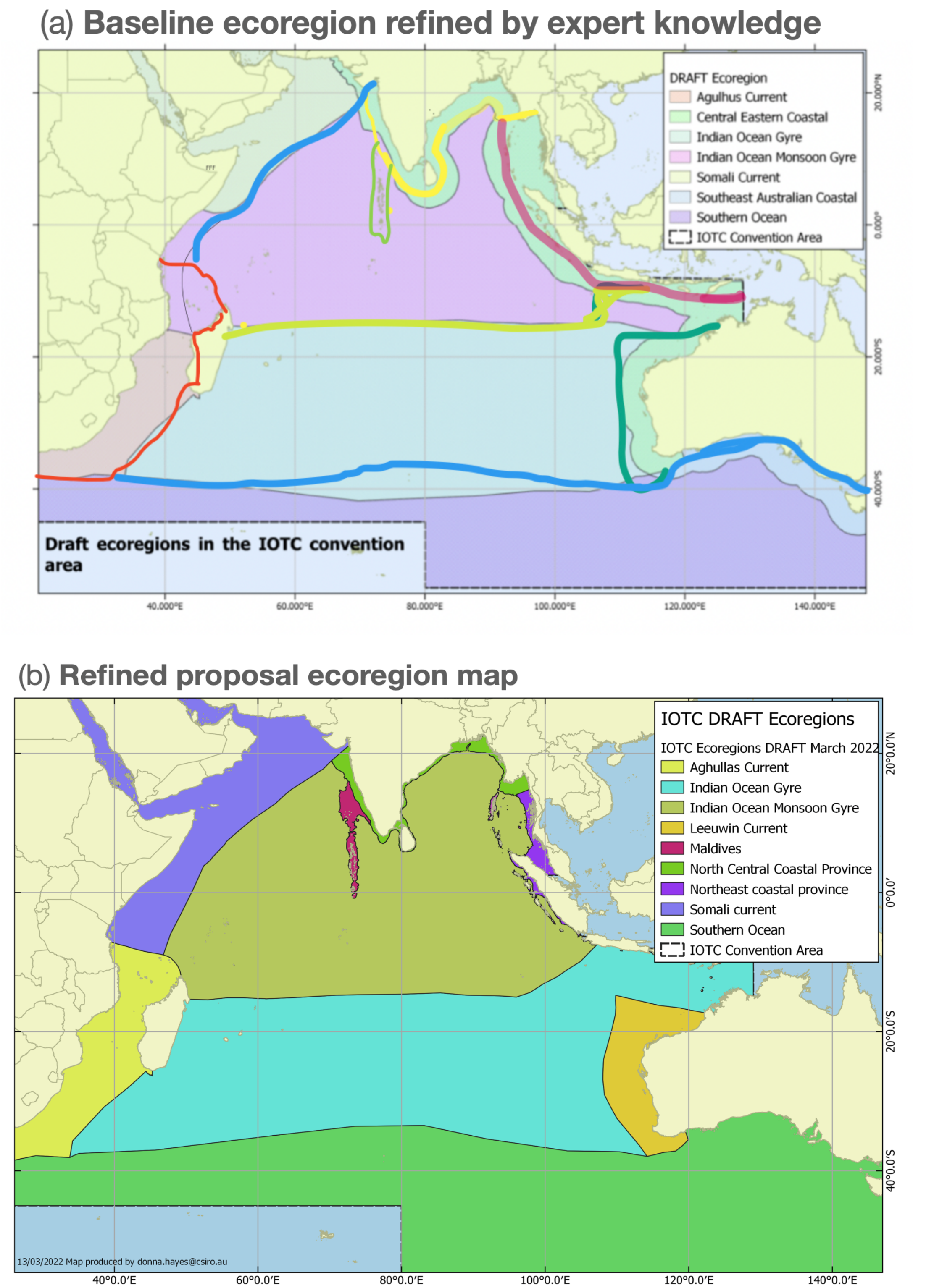

Figure 6. (a) Baseline ecoregion refined by expert knowledge during the workshop using the MIRO platform. (b) The refined proposal ecoregion map prepared as a shapefile using Geographic Information System (GIS). Map produced by Donna Hayes, CSIRO, Australia.

Task 6: Ecoregion validation and testing

The quantitative proposal of baseline ecoregions produced under Task 4 and adjusted by expert knowledge in the course of the workshop under Task 5 should be considered a working hypothesis to be tested, validated and refined before they are used for resource planning, research and management (Bailey 1983, Loveland and Merchant 2004). Task 6 has for its objective the validation and testing of the draft ecoregions against their intended use (as described in Task 1).

The presentation introduced two ways ecoregions could be validated (Bailey 1983, Loveland and Merchant 2004). One way would be to validate them **statistically by evaluating the hypothesis underlying the regionalization and the expected qualities** of the resultant ecoregions (see Table 1), so that the core areas and boundaries of the ecoregions can be objectively evaluated. A second common practice is to **develop pilot products to test the general applicability for the intended uses of the ecoregions**. The ultimate test of the utility of ecoregions as tools for resource planning, research, assessment and provision of advice may be the extent to which they meet the end user needs (Bailey 1983, Loveland and Merchant 2004). It was presented that there is interest in developing a pilot study to validate and test the draft ecoregion proposal derived in this second workshop. The pilot study still to be funded has multiple objectives: (1) testing the concept of ecoregion and utility, and (2) test the usefulness and identify the advantages and challenges of having ecoregions as “reporting units” for regional assessments (e.g. impact and risk assessments). For further details on the ongoing pilot case study see Nieblas et al 2022.

GROUP DISCUSSIONS

The following main points were made during the discussion:

- The Group agreed on the **importance of spending the resources and time to test the usefulness of ecoregions, particularly developing pilot studies** (as discussed under Task 1). The Group suggested to use the refined ecoregion proposal derived in this second workshop to support the pilot studies. The Group noted the importance of identifying concrete case studies and pilot studies to test the ecoregions, and that these pilot studies could be presented as concrete examples to the IOTC Scientific Committee and Commission to show the potential benefits of using ecoregions as tools for better ecosystem planning, prioritizations, research and provision of integrated advice.
- The Group queried the timeline for the development of the idea presented for a pilot study, the regional bycatch assessment presented under Task 6. It was explained that the core **Group is trying to obtain some funds to support a pilot study** which will determine the timeline of the work. The Group asked to use the ecoregion developed during this second workshop in the pilot study.
- The Group suggested trying to **explore funding opportunities** in IOTC using European funds and recommended preparing a project proposal to present to EU DG MARE. The Group also invites the wider IOTC community to participate in the development of pilot products to test the usefulness of ecoregions and highlights the importance of keeping an open participatory process to ensure a wider range of inputs and ideas are received. The Group suggested making available the refined ecoregion map produced in this workshop to the wider IOTC scientific community. The shapefiles of the refined ecoregion proposal can be downloaded here (version August 17th 2022).
- The Group suggested starting with **simple descriptive semi-quantitative pilot studie**s (similar to the fisheries and ecosystems overviews produced by ICES) where the main oceanographic patterns and processes, as well as the main activities of interest (main fisheries and species composition, bycatch impacts) could be described at the ecoregion level and be compared among them. This would allow testing the appropriateness of the ecoregions proposed at this stage and test potential difficulties (e.g. data limitations) in developing this type of product.

- As part of the Group discussion, an additional talk was presented to the group with the objective of increasing awareness on the potential user's need for the ecoregion tool to support EAFM implementation in IOTC. The talk introduced the key characteristics of the tuna RFMOs to be taken into account when developing products to support EAFM implementation and also some of the essential requirements for EAFM implementation. It highlighted the need to have full participation of key stakeholders in the development of EAFM products, in particular managers and fishers, as well as to get involved with the Scientific Committee and Commission as early as possible in the process and development of EAFM products. It also highlighted that any supporting tool (e.g. ecoregion tool, ecosystem assessments) need to fit the needs of the target users, here the Commission. It was suggested and the Group agreed that when engaging with the Commission it is important (1) to be extremely clear of what can be delivered using ecoregions as tools to support EAFM implementation and their potential benefits (avoid vague ideas, and focus on concrete examples), (2) to ensure there is a common understanding on the definition of ecoregion and how boundaries are interpreted (being transition zones and not hard management lines), (3) to show that ecoregions are a complementary tool for the Scientific Committee to provide more integrated advice with no intention to override the current management system and (4) to show that there is no intention to change the current data collection requirements.

CONCLUSIONS AND FUTURE STEPS

- The Group noted that **an important output of this workshop was the constructive and technical expert Group discussions that took place for refining the entire ecoregion delineation process** (Figure 2), from discussing the potential roles of ecoregions, to establishing the guiding criteria, principles and methods to derive a proposal of candidate ecoregions within the IOTC convention area. The Group noted the ecoregion development at this stage should be seen as an **iterative and adaptive open process** that would need to be revisited several times by the Group. The Group recognized the achievement and outputs produced in the two IOTC ecoregion workshops and suggested to work forward as a group in a coordinated way incorporating effectively the input and feedback of the larger IOTC community into the ongoing process.

- This workshop resulted in **a proposal of nine candidate ecoregions within the IOTC** convention area (Figure 6). The preliminary analysis produced for this workshop together with the expert knowledge was used to refine the ecoregion proposal derived in the first workshop (Figure 1). It was recognized that expert advice is needed to mitigate the inherent limitation of the datasets used to develop the data-driven classification proposal and that the whole process is full of compromises.

- The Group acknowledged the **importance of consulting and engaging the Scientific Committee and Commission early on in the process to establish clear objectives** for guiding the potential uses of ecoregions as a planning, prioritization, research and advice tool, and measure their interest and seek their feedback. It also highlighted the **need to be clear about language use when communicating the process and ensure there is a common understanding on the definition of ecoregions as EAFM tools** (e.g. spatial units to frame research and advice where boundaries are interpreted as transition zones not hard management lines) **as well as their intended uses** (e.g. support regional integrated planning and research) within the IOTC Scientific Community.

- The Group recommended the use of the refined **proposal of candidate ecoregions produced in this workshop to develop concrete case studies/pilot studies to test the usefulness and utility of ecoregions for their intended purpose** as tools for better ecosystem planning, prioritizations, research and provision of integrated advice towards the implementation of the EAFM in the regions. It also encourages seeking potential funding sources to support this type of work.

- The Group noted that **ecoregions should be seen as an additional and complementary tool seeking to strengthen current practices in the IOTC Scientific Community** for integrated planning and research, ultimately to improve the provision of the scientific advice to the Commission.

- The Group requests that this **Workshop Report** be presented to the 2022 WPEB meeting and makes the following **requests to the WPEB**:
    - **The Group requests that the WPEB review and comment on the ecoregion delineation process and the proposed refined candidate ecoregions within the IOTC convention area and invites the WPEB to provide future directions.**
    - **The Group also requests the WPEB to communicate with the rest of the WPs and the SC, and SC to the Commission, and to solicit feedback on the revised candidate ecoregions within the IOTC convention area.**
    - **The Group requests that the WPEB supports further refinements of the ecoregion process based on the suggestions described in this report as well any suggestion received from the SC and Commission. It requests that the WPEB establishes a mechanism to progress refining the ecoregion process and the work on the delineation of ecoregions (e.g. supporting future workshops/meetings, establishing a sub-group of the WPEB to ensure progress in a coordinated way).**
    - **The Group requests that the WPEB endorses the proposed refined candidate ecoregions to develop pilot projects to test usefulness and utility of the ecoregions as a tool to progress on EAFM implementation in IOTC.**
    - **The Group requests that the WPEB includes the development of concrete pilot projects/case studies using the agreed ecoregions to test their utility as a priority in its work plan to facilitate the acquisition of funding to support the work.**

ACKNOWLEDGEMENTS

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REFERENCES

Bailey, R. G. 1983. Delineation of Ecosystem Regions. Environmental Management 7:365–373.

Bryce, S. A., J. M. Omernik, and D. P. Larsen. 1999. Ecoregions: A Geographic Framework to Guide Risk Characterization and Ecosystem Management. Environmental Review: 1:141–155.

Dickey-Collas, M. 2014. Why the complex nature of integrated ecosystem assessments requires a flexible and adaptive approach. ICES Journal of Marine Science 71:1174–1182.

Dufrene, M., and P. Legendre. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs 67:345–366.

Fay, A. R., and G. A. McKinley. 2014. Global open-ocean biomes: mean and temporal variability. Earth System Science Data Discussions 7:107–128.

Fletcher, W. J., and G. Bianchi. 2014. The FAO – EAF toolbox: Making the ecosystem approach accessible to all fisheries. Ocean & Coastal Management 90:20–26.

Fletcher, W. J., J. Shaw, S. J. Metcalf, and D. J. Gaughan. 2010. An Ecosystem Based Fisheries Management framework: the efficient, regional-level planning tool for management agencies. Marine Policy 34:1226–1238.

Fogarty, M. J. 2014. The art of ecosystem-based fishery management. Canadian Journal of Fisheries and Aquatic Sciences 71:479–490.

Fonteneau. 1997. Atlas of tropical tuna fisheries. World catches and environment. ORSTOM editions, Paris.

Garcia, S. M., A. Zerbi, C. Aliaume, T. Do Chi, and G. Lasserre. 2003. The Ecosystem Approach to Fisheries. Issues, Terminology, Principles, Institutional Foundations, Implementation and Outlook. FAO Fisheries Technical Paper. No 443, FAO, Rome.

Hodges, J. S., and J. . Dewar. 1992. Is it you or your model talking?: A framework for model validation. Santa Monica, CA: Rand.

ICES. 2021. Definition and rationale for ICES ecoregions. ICES ecoregions. Published 20 May 2020. Version 2: 8 June 2021:1–12.

IOTC–WPEB14. 2018. Report of the 14th Session of the IOTC Working Party on Ecosystems and Bycatch. Cape Town, South Africa 10 – 14 September 2018 IOTC–2018–WPEB14–R[E]: 106pp.

IOTC–WPEB15. 2019. Report of the 15th Session of the IOTC Working Party on Ecosystems and Bycatch. La Saline Les Bains, Reunion Island 3 – 7 September 2019 IOTC–2019–WPEB15–R[E]: 112 pp.

Juan-Jordá, M. J., H. Murua, P. Apostolaki, C. Lynam, A. Perez-Rodriguez, J. C. Baez-Barrionuevo, F. J. Abascal, R. Coelho, S. Todorovic, M. Uyarra, E. Andonegi, and J. Lopez. 2019. Selecting ecosystem indicators for fisheries targeting highly migratory species. Final Report. European Commission. Specific Contract No. 2 EASME/EMFF/2015/1.3.2.3/02/SI2.744915 under Framework Contract No. EASME/EMFF/2016/008. pp. 1 - 395.

Juan-Jorda, M. J., A.-E. Nieblas, H. Murua, P. De Bruyn, F. Fiorellato, E. Chassot, S. Bonhommeau, M. Koya, and M. Tolotti. 2021. CONCEPT NOTE FOR the 2nd IOTC ECOREGION WORKSHOP "Identification of regions in the IOTC convention area for supporting the implementation of the ecosystem approach to fisheries management.” IOTC-2021-WPEB17(AS)-22:1–5.

Juan-jordá, M. J., A. Nieblas, H. Murua, E. Andonegi, L. Kell, A. Guillermo, R. Coelho, A. Domingo, J. C. Báez, and A. Hanke. 2021. CONCEPT NOTE FOR ICCAT ECOREGION WORKSHOP “ Identification of regions in the ICCAT convention area for supporting the implementation of ecosystem based fisheries management .” Collective Volume of Scientific Papers - ICCAT 78:122–125.

Juan-Jordá, M., A. E. Nieblas, H. Murua, P. De Bruyn, S. Bonhommeau, M. Dickey-Collas, M. Dalleau, F. Fiorellato, D. Hayes, I. Jatmiko, P. Koubbi, M. Koya, M. Kroese, F. Marsac, P. Pepin, U. Shahid, P. Thoya, S. Tsuji, and A. Wolfaardt. 2019. Report of the IOTC workshop on Identification of regions in the IOTC Convention Area to Inform the Implementation of the Ecosystem Approach to Fisheries Management. La Reunion, 29 August- 1 September 2019. IOTC-2019-WPEB15-INF01.

Juan-Jorda, M. J., A. Nieblas, A. Hanke, S. Tsuji, E. Andonegi, A. Di Natale, L. Kell, G. Diaz, D. Alvarez-Berastegui, C. Brown, D. J. Die, H. Arrizabalaga, O. Yates, D. Gianuca, F. Niemeyer Fiedler, B. E. Luckhust, R. Coelho, S. Zador, M. Dickey-Collas, P. Pepin, and M. Hilario. 2022. Report of the ICCAT workshop on “identification of regions in the ICCAT convention area for suporting the implementation of ecosystem-based fishereis management.” SCRS/2022/107:1–42.

Koen-Alonso, M., P. Pepin, M. J. Fogarty, A. Kenny, and E. Kenchington. 2019. The Northwest Atlantic Fisheries Organization Roadmap for the development and implementation of an Ecosystem Approach to Fisheries: structure, state of development, and challenges. Marine Policy 100:342–352.

Longhurst, A. 1995. Seasonal cycles of pelagic production and consumption. Progress in Oceanography 36:77–167.

Longhurst, A. 2007. Ecological Geography of the Sea. Academic Press, San Diego. Second edition.

Loveland, T. R., and J. M. Merchant. 2004. Ecoregions and Ecoregionalization : Geographical and Ecological Perspectives. Environmental Management 34:1–13.

Mackey, B. G., S. L. Berry, and T. Brown. 2008. Reconciling approaches to biogeographical regionalization : a systematic and generic framework examined with a case study of the Australian continent. Journal of Biogeography 35:213–229.

Nieblas, A. E., M. J. Juan-Jordá, H. Murua, F. Fiorellato, and P. De Bruyn. 2019. Draft ecoregions for the IOTC convention area in preparation for the 2019 IOTC Workshop: “Identification of regions in the IOTC convention area to inform the implementation of the ecosystem approach to fisheries management.” IOTC-2019-WPEB15-INF02.

Nieblas, A., H. Murua, P. De Bruyn, E. Chassot, F. Fiorellato, and M. Juan-Jordá. 2022. Pre-workshop analysis in preparation for the 2022 IOTC Ecoregions Workshop "Identification of regions in the IOTC convention area to inform the implementation of the ecosystem approach to fisheries management ". IOTC.

Nieblas, A., H. Murua, and M. J. Juan-Jordá. 2022. Pre-workshop analysis in preparation for the 2022 ICCAT Ecoregion Workshop: Identification of regions in the ICCAT convention area for supporting the implementation of ecosystem based fisheries management. SCRS/2022/062:1–73.

Omernik, J. M. 2004. Perspectives on the Nature and Definition of Ecological Regions. Environmental Management 34:27–38.

Omernik, J. M., and R. G. Bailey. 1997. Distinguishing between watersheds and ecoregions. Jounal of the American Water Resources Association 33:935–949.

Pepin, P., A. Cuff, M. Koen-Alonso, and N. Ollerhead. 2010. Preliminary Analysis for the Delineation of Marine Ecoregions on the NL Shelves. SC WG on the Ecosystem Approach to Fisheries Management. NAFO SCR Doc. 10/72.

Pepin, P., J. Higdon, M. Koen-Alonso, M. Fogarty, and N. Ollerhead. 2013. Application of ecoregion analysis to the identification of Ecosystem Production Units (EPUs) in the NAFO Convention Area. SC Working Group on Ecosystem Science and Assessment. NAFO SCR Doc. 14/069.

Reygondeau, G., A. Longhurst, E. Martinez, G. Beaugrand, D. Antoine, and O. Maury. 2013. Dynamic biogeochemical provinces in the global ocean. Global Biogeochemical Cycles 27:1046–1058.

Reygondeau, G., O. Maury, G. Beaugrand, J. M. Fromentin, A. Fonteneau, and P. Cury. 2012. Biogeography of tuna and billfish communities. Journal of Biogeography 39:114–129.

Rice, J., K. M. Gjerde, J. Ardron, S. Arico, I. Cresswell, E. Escobar, S. Grant, and M. Vierros. 2011. Policy relevance of biogeographic classification for conservation and management of marine biodiversity beyond national jurisdiction, and the GOODS biogeographic classification. Ocean and Coastal Management 54:110–122.

Sherman, K., and L. Alexander. 1986. Variability and Management of Large Marine Ecosystems. In: Sherman, K. and Alexander, L.M., Eds., American Association for the Advancement of Science Selected Symposium 99, Westview Press, Inc., Boulder, CO, 300.

Sherman, K. 1991. The large marine ecosystem concept: research and management strategy for living marine resources. Ecological Applications 1:349–360.

Sherman, K. 1994. Sustainability , biomass yields , and health of coastal ecosystems : an ecological perspective. Marine Ecology Progress Series 112:277–301.

Spalding, M. D., H. E. Fox, G. R. Allen, N. Davidson, Z. A. Ferdaña, M. Finlayson, B. S. Halpern, M. A. Jorge, A. Lombana, S. A. Lourie, K. D. Martin, E. Mcmanus, J. Molnar, C. A. Recchia, and J. Robertson. 2007. Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas. Bioscience 57:573.

Spalding, M. D., V. N. Agostini, J. Rice, and S. M. Grant. 2012. Pelagic provinces of the world: A biogeographic classification of the world's surface pelagic waters. Ocean & Coastal Management 60:19–30.

Staples, D., R. Brainard, S. Capezzuoli, S. Funge-Smith, C. Grose, A. Heenan, R. Hermes, P. Maurin, M. Moews, C. O'Brien, and R. Pomeroy. 2014. Essential EAFM. Ecosystem Approach to Fisheries Management Training Course. Volume 1 – For Trainees. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand, RAP Publication 2014/13.

Todorovic, S., M. J. Juan-Jordá, H. Arrizabalaga, and H. Murua. 2019. Pelagic Ecoregions: operationalizing an ecosystem approach to fisheries management in the Atlantic Ocean. Marine Policy 109:103700.

Trenkel, V. M. 2018. How to provide scientific advice for ecosystem-based management now. Fish and Fisheries 19:390–398.

UNESCO. 2009. Global Open Oceans and Deep Seabed (GOODS) biogeographic classification. Paris, UNESCO-IOC. (IOC Technical Series, 84.).

Uriarte, A., L. Zarauz, M. Aranda, M. Santurtun, A. Iriondo, P. Berthou, J. Castro, S. Delayat, J. M. Falcon, J. Garcia, M. Gaspar, J. F. Gonzalez, S. Jimenez, C. Lordan, G. Morandeau, F. Sanchez, M. T. G. Santamaria, and N. Villegas. 2014. Guidelines for the definition of operational management units. .2014. AZTI Report of Project GEPETO. 69pp.

Worm, B., M. Sandow, A. Oschlies, H. K. Lotze, and R. A. Myers. 2005. Global patterns of predator diversity in the open oceans. Science 309:1365–1369.

Zador, S. G., K. K. Holsman, K. Y. Aydin, and S. K. Gaichas. 2017. Ecosystem considerations in Alaska: the value of qualitative assessments. ICES Journal of Marine Science 74:421–430.

Zhao, Q., Z. Basher, and M. J. Costello. 2019. Mapping near surface global marine ecosystems through cluster analysis of environmental data:327–342.

APPENDIX 1. LIST OF PARTICIPANTS

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APPENDIX 2. WORKSHOP AGENDA

2nd IOTC Ecoregion Workshop
"IDENTIFICATION OF REGIONS IN THE IOTC CONVENTION AREA TO INFORM THE IMPLEMENTATION OF THE ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT"

Online meeting, 19th-21st January 2022

1. Meeting information

The second IOTC ecoregion workshop will take place on the 19th-21st of January 2022 from 12:00 to 16:30 pm Mahe Time (each day 4.5 hours long).

2. Teams link to the meeting

https://teams.microsoft.com/l/meetup-join/19%3ameeting_ODE1MjVjNGUtNWYwNi00ZjUzLWJkODgtYTUzOWI2YjJmYWE1%40thread.v2/0?context=%7b%22Tid%22%3a%226219f119-3e79-4e7f-acde-a5750808cd9b%22%2c%22Oid%22%3a%2262d5067a-1496-4dcf-b0d4-27b9a936e34c%22%7d

2. Tentative agenda

session	time
WEDNESDAY, 19th JANUARY	
Welcome session	***12:00-12:30***
· Welcome · Main objectives and expected outputs · Logistics · Agenda · Background and structure of workshop (presentation)	
session 1: purpose and uses of ecoregions	**12:30-13:30**
· Potential uses of ecoregions as tools for supporting EAFM implementation in IOTC (presentation)	
session 2: Criteria to guide ecoregion delineation	**13:30-14:00**
· Criteria for guiding ecoregion delineation and main properties of ecoregions (presentation)	
coffee break	**14:00-14:30**
session 3: data collection and quality evaluation	***14:30-16:30***
· Criteria 1 -Data layers to describe the oceanography and biogeography patterns in Indian Ocean (presentation) · Criteria 2 – Data layers to describe the spatial distributions of main IOTC species (presentation) · Criteria 3 – Data layers to describe the spatial distributions of main IOTC fisheries (presentation)	
THURSDAY, 20th JANUARY	

session 4: analytical model for deriving a baseline proposal of ecoregions	**12:00-14:00**
· Refinement of specificity and fidelity indicators of species and fisheries to a province(presentation)	
coffee break	***14:00-14:30***
session 4: continuation	**14:30-16:30**
· Refinement of clustering analysis for deriving baseline ecoregions (presentation)	
FRIDAY, 21st JANUARY	
session 5: derivation of refine proposal of ecoregions	**12:00-14:00**
· Mapping and proposal of baseline ecoregions (presentation) · Adjustment of baseline ecoregions based on expert knowledge (group discussion)	
coffee break	**14:00-14:30**
session 5: Continuation	**14:30-15:30**
· Adjustment of baseline ecoregions based on expert knowledge (group discussion)	
session 6: Ecoregion validation and testing	**15:30-16:00**
· Pilot study to validate ecoregions (presentation) · User's side requests to the IOTC eco-region as EAFM supporting tool (presentation)	
session 7: Synthesis and future steps	**16:00-16:30**
· Synthesis · Future steps	

3. Workshop materials

All workshop materials will be shared in the following Dropbox folder link:

https://www.dropbox.com/sh/j8hiy09vyygpsat/AABqu32S1-huScCh77Kt4__za?dl=0