

DO WE NEED THE ECOREGIONS IN THE ICCAT CONVENTION AREA FOR SUPPORTING THE IMPLEMENTATION OF ECOSYSTEM-BASED FISHERIES MANAGEMENT? A CRITICAL REFLECTION

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SUMMARY

This scientific article critically examines the necessity, within of the process of adapt the ecosystem-based approach in fisheries management of the International Commission for the Conservation of Atlantic Tunas (ICCAT) Convention area, of integrating ecoregions. Specifically, we compare the proposed ecoregions with the existing Food and Agriculture Organization (FAO) major fishing areas, as well as ICCAT areas for the different species. We argue that the FAO subareas and ICCAT areas align well with proposed ecoregions, providing a comprehensive and data-rich foundation for effective ecosystem-based fisheries management (EBFM). Finally, we conclude that the proposed ecoregion areas may cloud the objectives of the ecosystem group and the species groups, rather than provide practical solutions.

RÉSUMÉ

Cet article scientifique examine de manière critique la nécessité, dans le cadre du processus d'adaptation de l'approche écosystémique dans la gestion des pêcheries de la zone de la Convention de la Commission internationale pour la conservation des thonidés de l'Atlantique (ICCAT), d'intégrer les écorégions. Plus précisément, nous comparons les écorégions proposées avec les principales zones de pêche existantes de l'Organisation des Nations unies pour l'alimentation et l'agriculture (FAO), ainsi qu'avec les zones de l'ICCAT pour les différentes espèces. Nous soutenons que les sous-zones de la FAO et les zones de l'ICCAT s'alignent bien sur les écorégions proposées, fournissant une base complète et riche en données pour une gestion efficace des pêcheries basée sur les écosystèmes (EBFM). Enfin, nous concluons que les zones d'écorégion proposées risquent de brouiller les objectifs du groupe sur les écosystèmes et des groupes d'espèces, plutôt que d'apporter des solutions pratiques.

RESUMEN

Este artículo científico examina críticamente la necesidad de integrar las ecorregiones dentro del proceso de adaptación del enfoque ecosistémico en la ordenación pesquera de la zona del Convenio de la Comisión Internacional para la Conservación del Atún Atlántico (ICCAT). En concreto, se comparan las ecorregiones propuestas con las grandes zonas de pesca existentes de la Organización de las Naciones Unidas para la Alimentación y la Agricultura (FAO), así como con las zonas ICCAT para las distintas especies. Se sostiene que las subzonas de la FAO y las áreas de ICCAT se ajustan bien a las ecorregiones propuestas, proporcionando una base exhaustiva y rica en datos para una ordenación eficaz de la pesca basada en el ecosistema (EBFM). Por último, se concluye que las zonas ecorregionales propuestas pueden enturbiar los objetivos del Subcomité de ecosistemas y de los grupos de especies, en lugar de aportar soluciones prácticas.

KEYWORDS

Areas BIL, areas FAO, Ecoregions, RUM

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1. Introduction

In recent years, the International Commission for the Conservation of Atlantic Tunas (ICCAT) has recognized the need to try to include the ecosystem-based approach in fisheries management within ICCAT convention area. This necessitates translating broad goals into actionable measures aligned with the objectives of the agreement. The application of an ecosystem-based approach in fisheries management (EBFM) is deemed essential for sustainable marine resource utilization. The creation of ecoregions has been proposed as a first step. Various studies, including contribute to refining candidate ecoregions (Juan-Jordá *et al.*, 2018; 2022; Nieblas *et al.*, 2022).

The online workshop refines a baseline ecoregion proposal, resulting in eight candidate ecoregions (Juan-Jordá *et al.*, 2022). Recommendations highlight the importance of SubEco's review and endorsement and emphasize future directions for EBFM implementation (Juan-Jordá *et al.*, 2018; 2022; Nieblas *et al.*, 2022).

However, these previous efforts require new delimitations (which in some cases are not well defined), and other, previously existing options such as FAO sub-units or ICCAT's own sub-units have not been considered.

The main objective of this study was to analyze the ecoregions proposed to date by the Sub-eco and analyze them with the correspondence of other already existing areas or regions and analyze the possible contributions of this proposal.

2. Material and methods

The ecoregions proposed within the ICCAT convention area to support the implementation of an EAFM by Juan-Jordá *et al.* (2018) are based on the Longhurst Biogeographical Provinces (BGCP) (Longhurst, 2007), Spalding Pelagic Provinces of the World (PPOW) (Spalding *et al.*, 2012) (**Figure 1**) and Marine Ecoregions of the World (MEOW) (Spalding *et al.*, 2007) grouping several biogeographic units into larger spatial units characterized by similar biogeographic and oceanographic characteristics, fish communities, and types of fleets operating in the area (**Figure 2**).

The main fishing zones designated by the Food and Agriculture Organization (FAO) for statistical purposes are delineated as regions, with their boundaries established through consultation with international fisheries organizations, taking into consideration several factors, including: (i) natural regional boundaries and oceanic divisions; (ii) existing boundaries of adjacent fisheries statistical bodies as established in intergovernmental conventions and treaties; (iii) prevailing national practices and borders; (iv) the longitude and latitude grid system; (v) the distribution patterns of aquatic fauna; and (vi) the distribution of resources and environmental conditions within the designated area.

The raison d'être of FAO's large fishing areas lies in their alignment, as far as possible, with national jurisdictions and those of fisheries commissions, in particular Regional Fisheries Management Organizations (RFMOs). This framework facilitates data comparison and enhances prospects for collaboration on statistical matters at large. For statistical purposes, these primary fishing areas are termed statistical areas, with each area subject to further subdivision as needed. The prevailing international standard entails the division of a statistical area into one or more statistical subareas, each of which may be further divided into statistical divisions. Presently, a total of 19 FAO major fishing areas have been established globally: Arctic Sea (18); Atlantic Northwest (21); Atlantic Northeast (27); Atlantic Western Central (31); Atlantic Eastern Central (34); Mediterranean and Black Sea (37); Atlantic Southwest (41); Atlantic Southeast (47); Atlantic Antarctic (48); Indian Ocean Western (51); Indian Ocean Eastern (57); Indian Ocean Antarctic and Southern (58); Pacific Northwest (61); Pacific Northeast (67); Pacific Western Central (71); Pacific Eastern Central (77); Pacific Southwest (81); Pacific Southeast (87); Pacific Antarctic (88) (Data sources: © FAO 1990-2024. Coordinating Working Party on Fishery Statistics (CWP). FAO Major Fishing Areas for Statistical Purposes).

In the Atlantic Ocean, there are 8 FAO areas (**Figure 3**), whose entire extension is located within the ICCAT convention area (areas 21, 27, 31, 34, 37, 41, 47 and 48). To achieve greater spatial resolution, it was decided to operate with the subareas of each major area, except in the case of area 31, which does not have established internal subdivisions (**Figure 3**).

We also compared the overlap between FAO areas, and the ICCAT areas BIL sampling areas (a usual division for swordfish and billfishes studies in ICCAT (ICCAT 2006-2016) (for example Coelho *et al.*, 2018), versus the overlap between the potential ecoregions identified in the ICCAT, and the ICCAT areas BIL sampling areas. The same was done for the Atlantic Regional Management Units (RMUs) for *Caretta caretta* (Wallace *et al.*, 2023), an important endangered bycatch in tuna fisheries such examples.

3. Results

The Juan-Jordá *et al.* (2018) proposed ecoregions were overlapped to the Atlantic Ocean FAO Fishing areas and its subareas. The percentage of coverage of each ecoregion in each FAO major area and its corresponding subareas was estimated and the FAO spatial units with the highest percentage of coverage coincided in the same ecoregion were identified (table 1). After grouping FAO spatial units by the proportion of them that were located within an ecoregion (**Figure 4**), the percentage of each ecoregion contained in the proposed groups was estimated (**Table 2**).

The results in the case of the overlap between FAO areas, and the ICCAT areas BIL sampling areas (**Figure 5**) versus the overlap between the potential ecoregions identified in the ICCAT, and the ICCAT areas BIL sampling areas (**Figure 6**), are showed in table 3. In some cases, the BIL area does not cover any FAO unit by more than 50%, so the most covered unit or the one representing the largest proportion of the BIL area was selected. Altogether, the FAO units represent 64% of the BIL areas. For ecoregions, by selecting those that best represent the BIL areas, a representation of 61% is achieved.

On the other hand, in the case of the overlap between FAO areas, and the RUMs for *Caretta caretta* (**Figure 7**), versus the overlap between the potential ecoregions identified in the ICCAT, and the RUMs for *Caretta caretta* (**Figure 8**) are showed in **Table 4**.

Maintaining the selection criterion of FAO areas being covered by more than 50% by the RMUs, the selected FAO unit sets represent, on average, 72% of the RMUs. However, in some cases, the RMUs did not cover more than 50% of the surface of any ecoregion because these ecoregions were larger in size. Ecoregions that best "matched" the surface area of the RMU were selected, achieving an average representation of 74% of the RMUs.

4. Discussion

The FAO subareas were designed considering natural regions, oceanic divisions, international conventions, and distributions of marine fauna. Moreover, FAO subareas usually are based in squared right well-defined geographical coordinates boundaries. Comparative analysis reveals that a significant overlap exists between these subareas and ecoregions, with more than 60% congruence in several instances. Moreover, the historical foundation of FAO subareas, alongside the availability of comparable data, enhances their practicality and utility. In this sense, the question arises as to why design new areas with no historical statistical value?, we could directly using the FAO sub-areas, or any other method of well-defined geographical divisions, such as large 10x10 degree grids, for example.

When we compare the overlap between the ICCAT areas BIL sampling areas both FAO subareas, and the potential ecoregions identified in the ICCAT, and the ICCAT areas BIL sampling areas, a better result is obtained with the FAO areas. In addition, in the case of the Atlantic Regional Management Units for *Caretta caretta*, we observed similar results.

This critical assessment underscores the suitability of employing established FAO subareas as Operational Fishing Units for implementing ecosystem-based fisheries management within the ICCAT convention area. The well-established and comprehensive nature of these subareas, coupled with their historical basis and data comparability, renders them pragmatic choices for monitoring the impact of fisheries on the ecosystem. Embracing FAO subareas aligns with international standards and fosters effective cooperation in statistical endeavors, which is imperative for the sustainable conservation of marine resources.

Identifying the precise set of oceanographic/biological variables defining ecoregions has not been undertaken. Ecoregions proposed by Juan-Jordá *et al.* (2018) stem from the work of Spalding *et al.* (2012), who utilized broader-scale biomes and taxonomic classifications. However, tuna fisheries are mainly impacted by widely distributed pelagic species, in this sense we have also analysed the relationship with sea turtle Marine Turtle Regional Management Units, RUMs (Wallace *et al.*, 2023).

On the other hand, the current structure of the ICCAT statistical areas has allowed the development of work related to megafauna (turtles, birds, sharks) (for example (Taylor and Small, 2009; Coelho *et al.*, 2013a,b; Angel *et al.* 2014), and work that continually incorporates aspects of the ecosystem such as species evaluations with SS3 or new methods that integrate special aspects (GLMM vector spatio-temporal autoregressive (VAST) or Integrated Nested Laplace Approximations (INLA)),

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Table 1. Percentage of the FAO Area or Sub area covered by each Ecoregion.

| <i>FAO AREA</i> | <i>FAO SUBAREA</i> | <i>Northern Temperate</i> | <i>Northern Subtropical</i> | <i>Inter American Seas</i> | <i>Tropical</i> | <i>Mediterranean</i> | <i>Southern Subtropical</i> | <i>Southern Temperate</i> |
|-----------------|--------------------|---------------------------|-----------------------------|----------------------------|-----------------|----------------------|-----------------------------|---------------------------|
| 18 | | 14 | | | | | | |
| 21 | | 79 | 13 | | | | | |
| | 21.0 | 59 | | | | | | |
| | 21.1 | 73 | | | | | | |
| | 21.2 | 100 | | | | | | |
| | 21.3 | 96 | 4 | | | | | |
| | 21.4 | 100 | | | | | | |
| | 21.5 | 100 | | | | | | |
| | 21.6 | 49 | 51 | | | | | |
| 27 | | 69 | 6 | | | | | |
| | 27.2 | 37 | | | | | | |
| | 27.3 | 98 | | | | | | |
| | 27.4 | 99 | | | | | | |
| | 27.5 | 100 | | | | | | |
| | 27.6 | 100 | | | | | | |
| | 27.7 | 100 | | | | | | |
| | 27.8 | 100 | | | | | | |
| | 27.9 | 100 | | | | | | |
| | 27.10 | 69 | 31 | | | | | |
| | 27.12 | 100 | | | | | | |
| | 27.14 | 60 | | | | | | |
| 31 | | 5 | 45 | 30 | 21 | | | |
| 34 | | 1 | 30 | | 69 | | | |
| | 34.1 | 11 | 16 | | 74 | | | |
| | 34.2 | | 91 | | 9 | | | |
| | 34.3 | | 6 | | 94 | | | |
| | 34.4 | | 11 | | 89 | | | |
| 37 | | | | | | 84 | | |
| | 37.1 | | | | | 100 | | |
| | 37.2 | | | | | 100 | | |
| | 37.3 | | | | | 100 | | |
| 41 | | | | | 20 | | 63 | 17 |
| | 41.1 | | | | 61 | | 39 | |
| | 41.2 | | | | | | 100 | |
| | 41.3 | | | | | | 41 | 59 |
| 47 | | | | | 18 | | 62 | 12 |
| | 47.1 | | | | 30 | | 70 | |
| | 47.A | | | | 60 | | 40 | |
| | 47.B | | | | | | 100 | |
| | 47.C | | | | | | 94 | |
| | 47.D | | | | | | 30 | 50 |
| 48 | | | | | | | | 51 |
| | 48.2 | | | | | | | 49 |
| | 48.3 | | | | | | | 100 |
| | 48.4 | | | | | | | 76 |
| | 48.6 | | | | | | | 48 |

Table 2. Percentage of the Ecoregions covered by the proposed FAO Major areas or Subareas.

| <i>FAO unit</i> | <i>Ecoregion</i> | <i>% of Ecoregion</i> |
|-----------------|----------------------|-----------------------|
| 21.0 | Northern Temperate | 83 |
| 21.1 | | |
| 21.2 | | |
| 21.3 | | |
| 21.4 | | |
| 21.5 | | |
| 27.10 | | |
| 27.12 | | |
| 27.14 | | |
| 27.2 | | |
| 27.3 | | |
| 27.4 | | |
| 27.5 | | |
| 27.6 | | |
| 27.7 | | |
| 27.8 | | |
| 27.9 | | |
| 21.6 | Northern Subtropical | 85 |
| 31 | | |
| 34.2 | | |
| 31 | Inter American Seas | 100 |
| 34.1 | Tropical | 63 |
| 34.3 | | |
| 34.4 | | |
| 47.A | | |
| 37.1 | Mediterranean | 99 |
| 37.2 | | |
| 37.3 | | |
| 41.2 | Southern Subtropical | 66 |
| 47.1 | | |
| 47.B | | |
| 47.C | | |
| 41.3 | Southern Temperate | 81 |
| 47.D | | |
| 48.2 | | |
| 48.3 | | |
| 48.4 | | |
| 48.6 | | |

Table 3. Percentage of the overlap FAO and Ecoregions units with BIL areas and percentage of the BIL areas represented by the FAO and Ecoregion units (FAO units with more than 50% of its area covered by BIL area where selected when it was possible).

| <i>BIL</i> | <i>FAO</i> | <i>% of FAO unit covered by BIL area</i> | <i>% of BIL area represented by FAO unit</i> | <i>Total % of BIL area represented by FAO units</i> | <i>ECOREGION</i> | <i>% of Ecoregion covered by BIL area</i> | <i>% of BIL area represented by Ecoregion</i> |
|------------|------------|--|--|---|----------------------|---|---|
| 91 | 31 | 12* | 99 | 99 | Inter American Seas | 40* | 99 |
| 92 | 21.5 | 100 | 5 | 5 | Northern Subtropical | 20* | 57 |
| 93 | 31 | 20* | 100 | 100 | Inter American Seas | 57 | 87 |
| 94A | 21.0 | 59 | 3 | 35 | Northern Subtropical | 38* | 36 |
| | 21.1 | 73 | 6 | | | | |
| | 21.2 | 100 | 5 | | | | |
| | 21.3 | 100 | 11 | | | | |
| | 21.4 | 67 | 5 | | | | |
| | 21.6 | 51 | 5 | | | | |
| 94B | 27.12 | 55 | 9 | 62 | Northern Temperate | 45* | 56 |
| | 27.3 | 98 | 3 | | | | |
| | 27.4 | 99 | 4 | | | | |
| | 27.5 | 100 | 4 | | | | |
| | 27.6 | 100 | 3 | | | | |
| | 27.7 | 100 | 5 | | | | |
| | 27.8 | 100 | 5 | | | | |
| | 27.9 | 100 | 5 | | | | |
| | 34.1 | 100 | 10 | | | | |
| | 34.2 | 50 | 13 | | | | |
| 94C | 34.2 | 50 | 30 | 30 | Northern Subtropical | 22* | 46 |
| 95 | 37 | 99 | 100 | 100 | Mediterranean | 100 | 84 |
| 96 | 41 | 100 | 89 | 97 | Southern Subtropical | 49* | 56 |
| | 48.3 | 100 | 5 | | | | |
| | 48.4 | 75 | 4 | | | | |
| 97 | 34.3 | 54 | 10 | 79 | Southern Subtropical | 51 | 46 |
| | 47.1 | 100 | 6 | | | | |
| | 47.A | 100 | 20 | | | | |
| | 47.B | 100 | 11 | | | | |
| | 47.C | 94 | 17 | | | | |
| | 47.D | 80 | 14 | | | | |

Table 4. Percentage of the overlap FAO and Ecoregions units/ RUMs for *Caretta caretta* and percentage of *Caretta caretta* RMU represented by the FAO/Ecoregion units (only FAO units with more than 50% of its area covered by RMU).

| <i>RMU_CC</i> | <i>FAO</i> | <i>% of FAO unit covered by RMU_CC</i> | <i>% of RMU_CC represented by FAO unit</i> | <i>TOTAL % of RMU_CC represented by FAO unit</i> | <i>Ecoregion</i> | <i>% of Ecoregion covered by RMU_CC</i> | <i>% of RMU_CC represented by Ecoregion</i> | <i>TOTAL % of RMU_CC represented by Ecoregion</i> |
|---------------|------------|--|--|--|--|---|---|---|
| CC_01_ATL_NW | 21.3 | 81 | 5 | 97 | Inter American Seas Northern Subtropical | 99 | 17 | 58 |
| | 21.4 | 78 | 3 | | | | | |
| | 21.5 | 99 | 1 | | | | | |
| | 21.6 | 100 | 5 | | | | | |
| | 27.10 | 100 | 10 | | | | | |
| | 27.8 | 100 | 3 | | | | | |
| | 27.9 | 100 | 2 | | | | | |
| | 31 | 83 | 48 | | | | | |
| | 34.1 | 88 | 5 | | | | | |
| | 34.2 | 84 | 11 | | | | | |
| 37.1 | 99 | 3 | | | | | | |
| CC_02_ATL_SW | 41.1 | 96 | 39 | 73 | Tropical | 35 | 49 | 100 |
| | 41.2 | 70 | 33 | | Southern Subtropical | 32 | 51 | |
| CC_03_ATL_NE | 27.10 | 99 | 12 | 61 | Northern Subtropical Tropical | 71 | 39 | 78 |
| | 27.8 | 100 | 3 | | | | | |
| | 27.9 | 100 | 3 | | | | | |
| | 34.1 | 100 | 6 | | | | | |
| | 34.2 | 100 | 15 | | | | | |
| | 34.3 | 91 | 18 | | | | | |
| | 37.1 | 100 | 4 | | | | | |
| CC_04_MED | 37 | 83 | 94 | 94 | Mediterranean | 98 | 94 | 94 |
| CC_06_IND_SW | 41.2 | 54 | 10 | 38 | Southern Subtropical | 62 | 37 | 37 |
| | 47.2 | 100 | 1 | | | | | |
| | 47.B | 99 | 7 | | | | | |
| | 47.C | 100 | 12 | | | | | |
| | 47.D | 69 | 8 | | | | | |

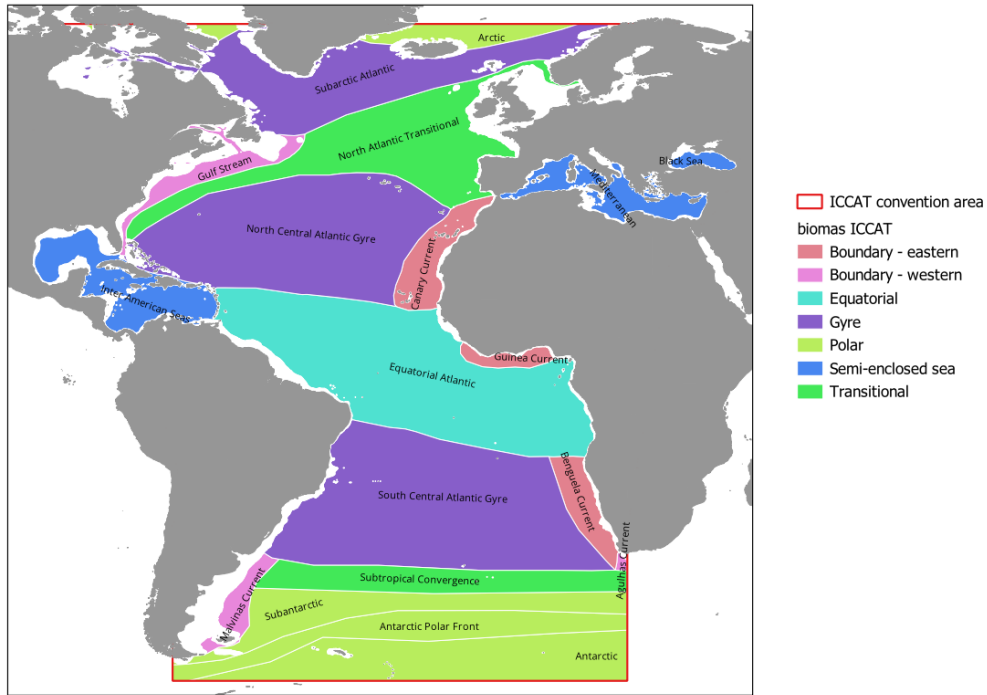


Figure 1. Spalding PPOW areas.

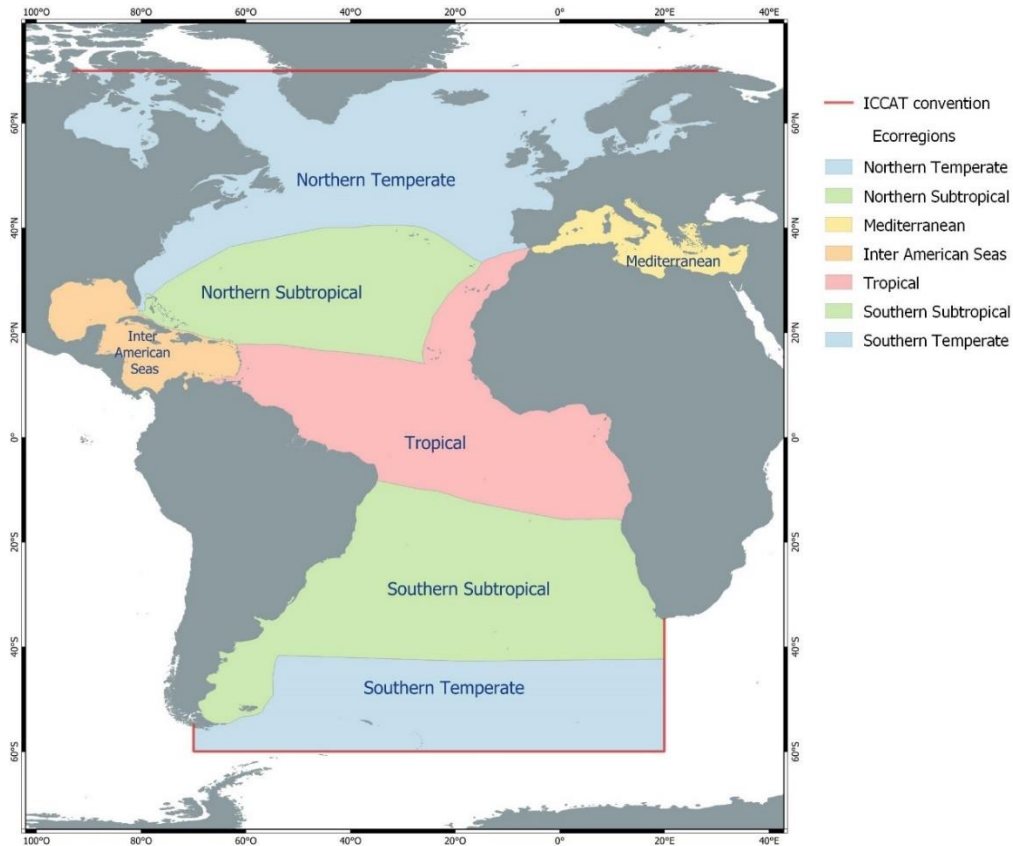


Figure 2. Potential ecoregions identified in the ICCAT Convention area by grouping several Spalding PPOW modified from Juan-Jorda *et al.* (2018).

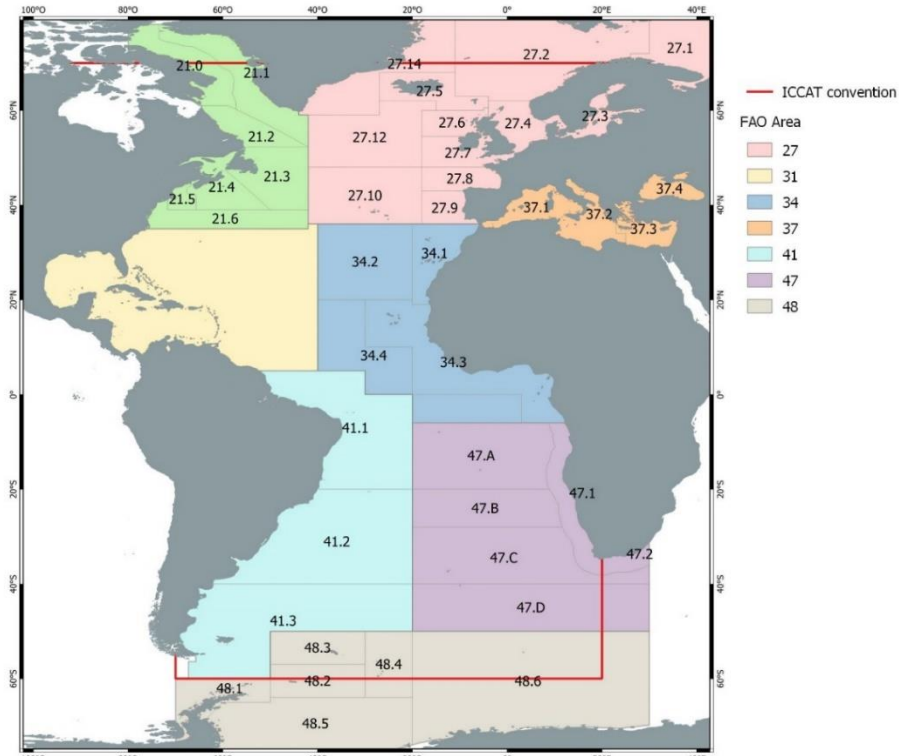


Figure 3. FAO fishing areas end subareas in the ICCAT Convention area.

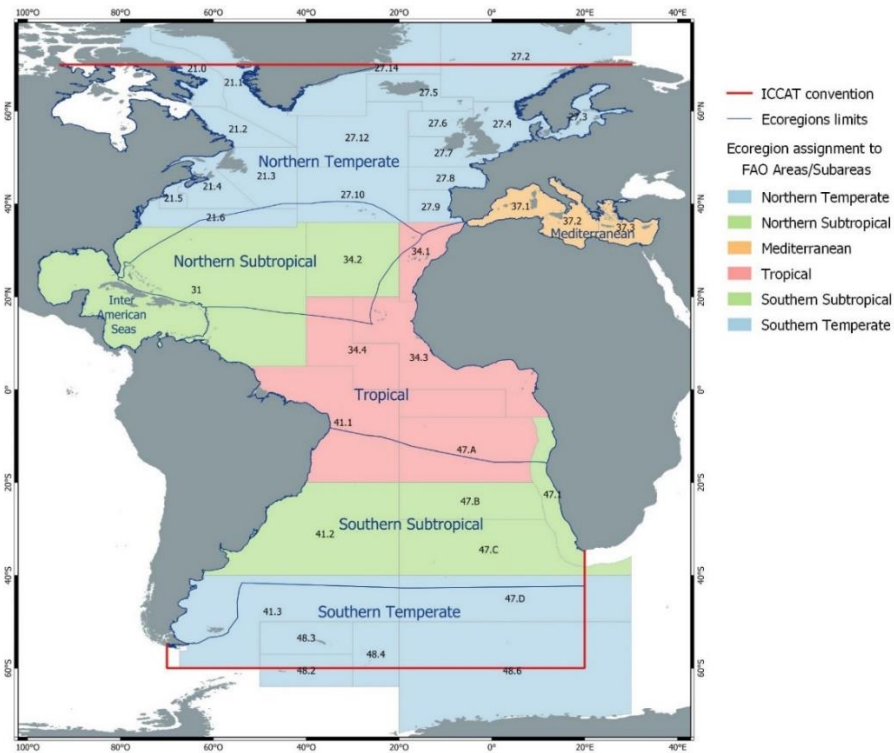


Figure 4. Proposed groups of FAO major areas and subareas representing each ecoregion.

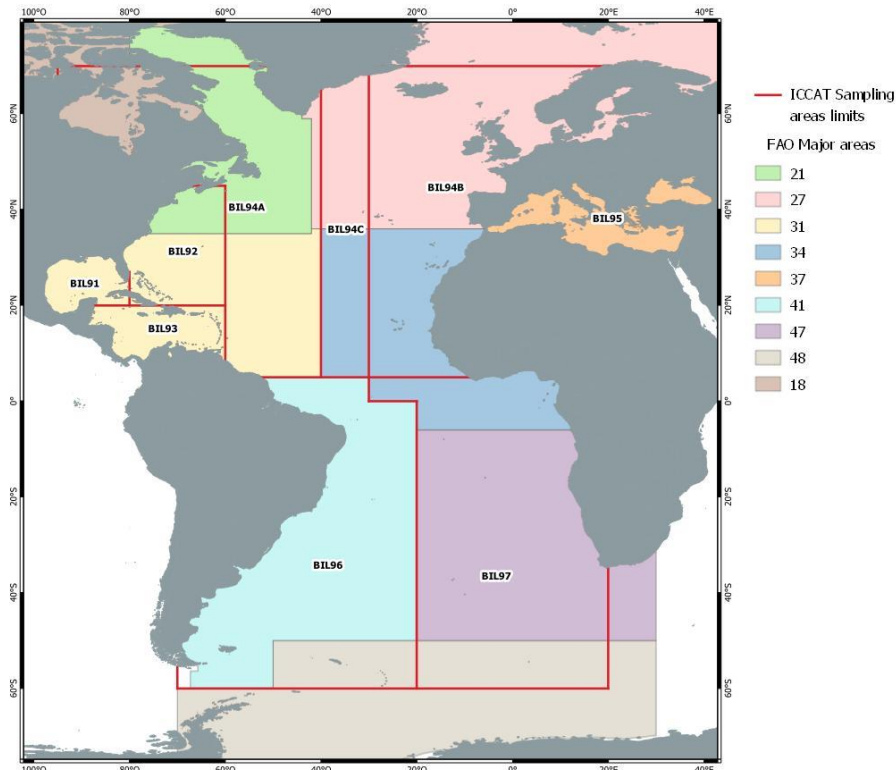


Figure 5. Overlap between FAO areas, and the ICCAT areas BIL sampling areas.

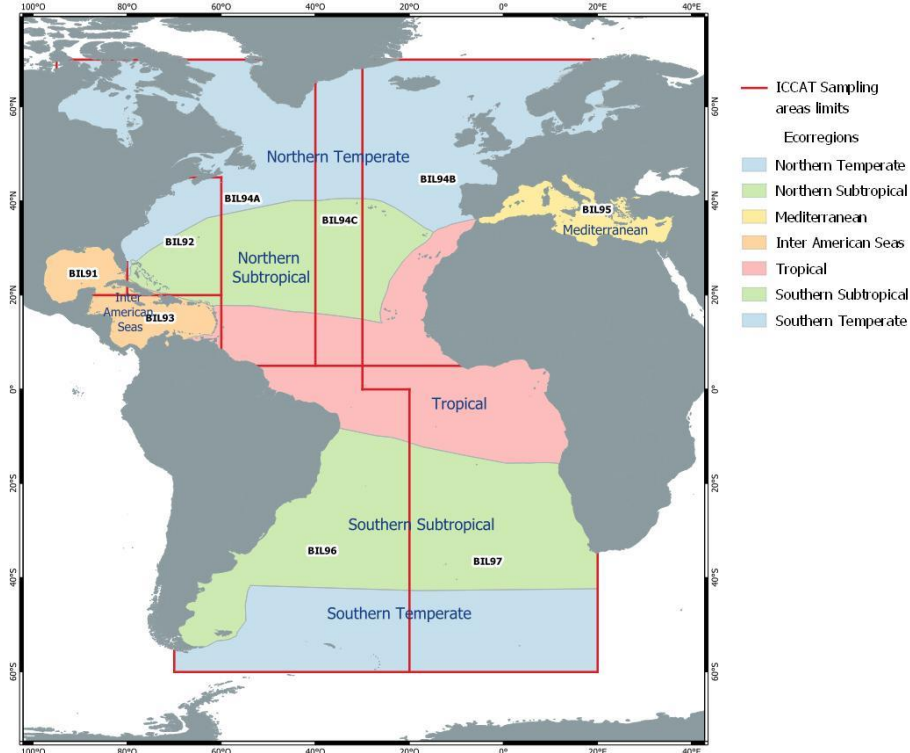


Figure 6. Overlap between the potential ecoregions identified in the ICCAT, and the ICCAT areas BIL sampling areas.

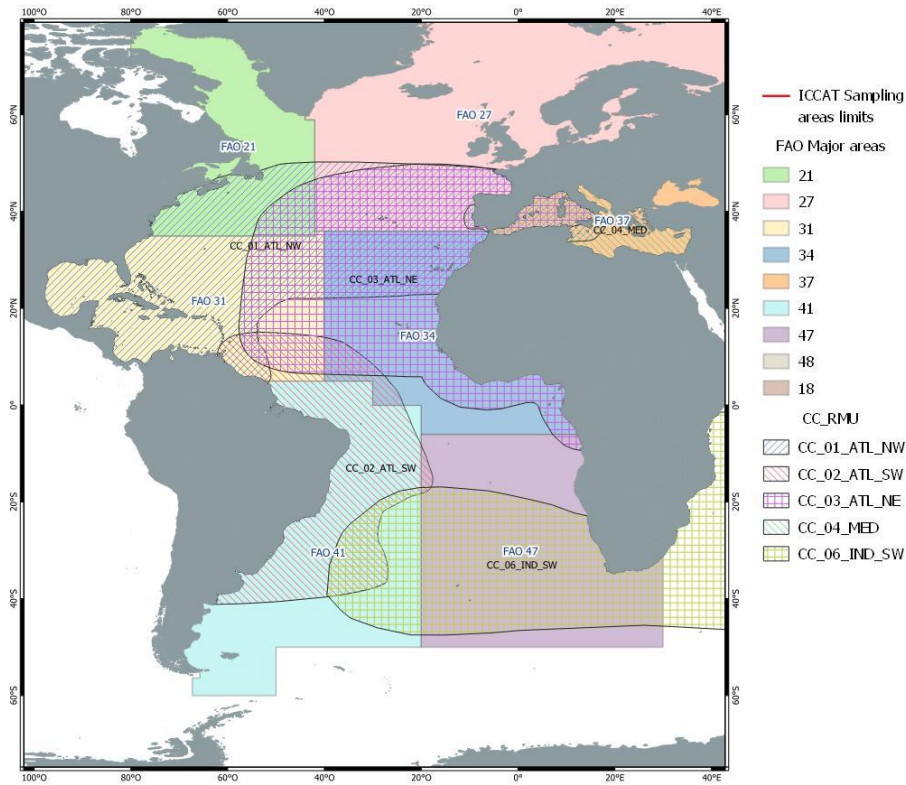


Figure 7. Overlap between FAO areas, and the RUMs for *Caretta caretta*..

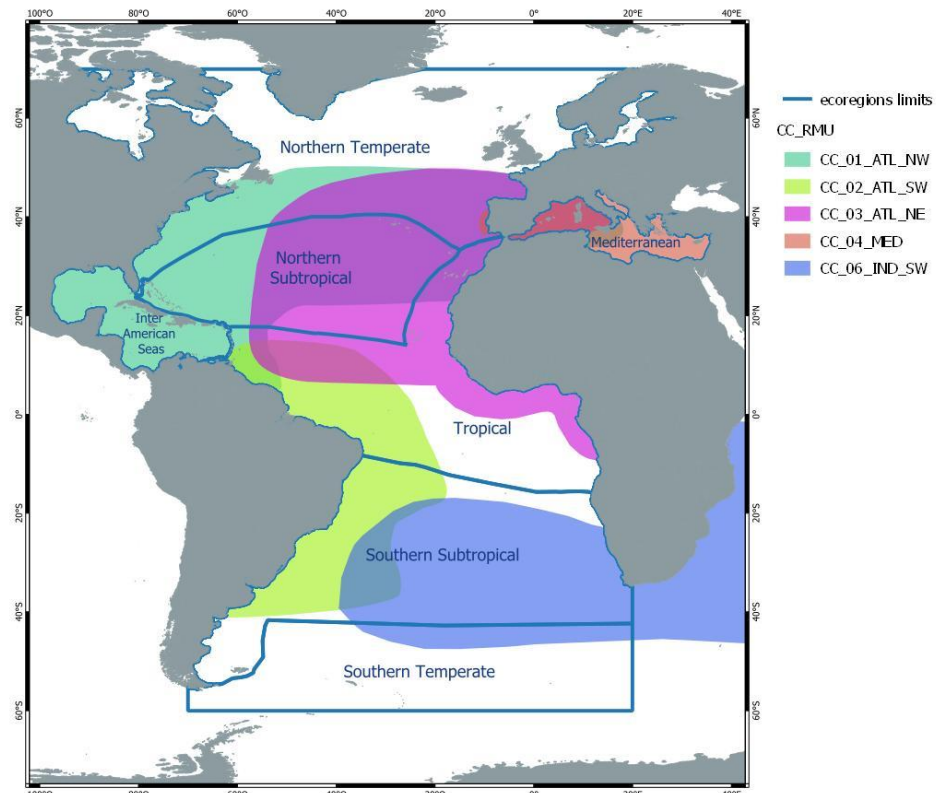


Figure 8. Overlap between the potential ecoregions identified in the ICCAT, and the RUMs for *Caretta caretta*.