

Report of the 2024 ICCAT Yellowfin Tuna Data Preparatory Meeting

(hybrid/Madrid, Spain, 8-12 April 2024)

SUMMARY

In 2023 the SCRS prepared a workplan for 2024, prioritizing a new stock assessment for yellowfin tuna. During the April 2024 Data Preparatory meeting the Group revised the historical catches, size and tagging data, as well indices of abundance and other relevant biological and fisheries information to the assessment. In addition, the Group reviewed models to be used during the assessment, including surplus production models and Stock Synthesis models, and made recommendations for their structure and parameterization in order to capture a range of model assumptions and complexity. The Group also reviewed progress made to advance the Tropical Tuna MSEs. Finally, recommendations were made to collate and analyze additional information required for stock assessment.

RÉSUMÉ

En 2023, le SCRS a préparé un plan de travail pour 2024, en donnant la priorité à une nouvelle évaluation du stock d'albacore. Au cours de la réunion de préparation des données d'avril 2024, le Groupe a révisé les prises historiques, les données de taille et de marquage, ainsi que les indices d'abondance et d'autres informations biologiques et halieutiques pertinentes pour l'évaluation. En outre, le Groupe a examiné les modèles à utiliser au cours de l'évaluation, y compris les modèles de production excédentaire et les modèles Stock Synthesis, et a formulé des recommandations concernant leur structure et leur paramétrage afin de tenir compte d'un éventail d'hypothèses et de complexité des modèles. Le Groupe a également examiné les progrès réalisés pour faire avancer les MSE sur les thonidés tropicaux. Finalement, des recommandations ont été formulées à l'effet de recueillir et d'analyser les informations additionnelles requises pour l'évaluation des stocks.

RESUMEN

En 2023, el SCRS preparó un plan de trabajo para 2024, dando prioridad a una nueva evaluación del stock de rabil. Durante la reunión de preparación de datos de abril de 2024, el Grupo revisó los datos históricos de captura, talla y marcado, así como los índices de abundancia y otra información pesquera y biológica pertinente para la evaluación. Además, el Grupo revisó los modelos que se utilizarán durante la evaluación, incluidos los modelos de producción excedente y los modelos de Stock Synthesis, y formuló recomendaciones sobre su estructura y parametrización con el fin de captar una gama de supuestos del modelo y su complejidad. El Grupo también revisó los progresos realizados para avanzar en las MSE para los túnidos tropicales. Por último, se formularon recomendaciones para recopilar y analizar la información adicional necesaria para la evaluación de stock.

RESUMEN

En 2023, el SCRS preparó un plan de trabajo para 2024, dando prioridad a una nueva evaluación del stock de rabil. Durante la reunión de preparación de datos de abril de 2024, el Grupo revisó los datos históricos de captura, talla y marcado, así como los índices de abundancia y otra información pesquera y biológica pertinente para la evaluación. Además, el Grupo revisó los modelos que se utilizarán durante la evaluación, incluidos los modelos de producción excedente y los modelos de Stock Synthesis, y formuló recomendaciones sobre su estructura y parametrización con el fin de captar una gama de supuestos del modelo y su complejidad. El Grupo también revisó los progresos realizados para avanzar en las MSE para los túnidos tropicales. Por último, se formularon recomendaciones para recopilar y analizar la información adicional necesaria para la evaluación de stock.

1. Opening, adoption of agenda and meeting arrangements

The hybrid meeting was held in person at the ICCAT Secretariat in Madrid Spain, and online, from 8 to 12 April 2024. Dr Shannon Cass-Calay (U.S.), Yellowfin Tuna Rapporteur and meeting Chair, opened the meeting and welcomed participants (“the Group”). Mr Camille Manel, ICCAT Executive Secretary, welcomed the participants and wished them success in their meeting.

The Chair proceeded to review the Agenda which was adopted with some changes (**Appendix 1**). The List of participants is included in **Appendix 2**. The List of papers and presentations presented at the meeting is attached as **Appendix 3**. The abstracts of all SCRS documents and presentations presented at the meeting are included in **Appendix 4**. The following participants served as rapporteurs:

Sections	Rapporteur
Items 1 and 11	M. Ortiz
Item 2	S. Cass-Calay, D. Angueko
Item 3	C. Mayor, F. Fiorellato, J. Garcia, M. Ortiz
Item 4	M. Nuttall, G. Diaz, A. Kimoto
Item 5	M. Lauretta, G. Merino
Item 6	R. Sant’Ana, G. Merino
Item 7	S. Wright, M. Neves dos Santos
Item 8	D. Die, M. Ortiz
Item 9	S. Cass-Calay
Item 10	S. Cass-Calay, C. Brown

2. Review of historical and new information on biology

a. AOTTP Program Update

No new information on analyses from the AOTTP Program data was presented.

b. Natural Mortality

Document SCRS/2024/037 presents estimates of natural mortality (M) of yellowfin tuna (*Thunnus albacares*) in the Atlantic and Indian Oceans. The authors combined 4 empirical estimators, including one based on longevity, two based on growth, and one based on taxonomy. M values varied according to the estimators used for this species in the two oceans. The basic composite values of M obtained were estimated at 0.46 yr^{-1} and 0.47 yr^{-1} for this species in the Atlantic and Indian Oceans, respectively. Furthermore, for the case of Atlantic Ocean yellowfin tuna, values derived from M -at-age were higher than those considered by ICCAT in the latest (2019) Yellowfin Tuna Stock Assessment (Anon., 2019), which assumed a baseline M value of 0.35 yr^{-1} after following the equation of Then *et al.* (2015) and using a maximum age (A_{MAX}) = 18 yr (Anon., 2020).

The authors highlighted current information gaps. These gaps prevent more accurate estimates of M . Therefore, it was recommended that a broader biological sampling of yellowfin tuna could help reduce uncertainties associated with this parameter. Also, focusing sampling on the largest size ranges available could be particularly useful for estimating A_{MAX} from otolith samples, as well as focusing on areas where fishing mortality is low and areas where fishing pressure is known to be high.

With regard to the results of document SCRS/2024/037, the Group recognized the value of the attempt to more fully explore M estimation and its uncertainty using a variety of empirical approaches, and also the recommendations provided. The Group generally did not support the M obtained from the application of the von Bertalanffy growth curve from Pacicco *et al.* (2021), because that growth curve did not have a good representation of the growth of young ages 0 and 1. For this reason, it was rejected in favor of Richards growth function (Richards, 1959). Similarly, the Group expressed concerns regarding the Then *et al.* (2015) approach to estimate natural mortality from longevity because it has since been improved upon and superseded by Hamel and Cope (2022). Finally, the Group expressed concerns about the Fish Base database approach as it used only one estimate of the maximum observed age of yellowfin tuna from the Pacific, which was very low (9) compared to the Atlantic (18), and it was from a population experiencing significant fishing pressure. Of the models presented, the most reliable empirical estimate was based on longevity with an A_{MAX} of 18, resulting in a base $M = 0.3$ (Hamel and Cope,

2022). During the meeting, it was also noted that the relationship between A_{MAX} and M was determined by fitting estimates from populations that were mostly unfished or where the fishing impact has been small, excluding heavily exploited populations.

A related presentation was provided (SCRS/P/2024/012) concerning the recommendations from a workshop on best practices from the Center for the Advancement of Population Assessment Methodology (CAPAM). A keynote presentation by Hoyle on natural mortality during the Tuna Stock Assessment Best Practices Workshop focused on global yellowfin tuna assessments and emphasized that the 2019 ICCAT Atlantic yellowfin tuna assessment was closely aligned with current best practices (<https://capamresearch.org/recordings-tuna-stock-assessment-good-practices-workshop>; <https://www.youtube.com/watch?v=eJFmOOt3MUk&list=PLKeH-azh54PVgOjmJ1Gw4gmaCBQ0PDrz3&index=5>). The authors concluded that Hamel and Cope's (2022) study on estimating natural mortality was most consistent with the best practices, as described by the CAPAM workshop, and recommended that this approach ($M = 5.40/A_{MAX}$) be used whenever reasonable estimates of A_{MAX} are available. Furthermore, the authors noted that the conclusions of the Pacicco *et al.* (2021) study also support the base M obtained using the Hamel and Cope (2022) estimator, at least as applied to age, growth, and mortality estimates of yellowfin tuna in the northern Gulf of Mexico.

Finally, a summary of the external review of the 2019 Yellowfin Tuna Stock Assessment was presented (Methot, 2020). The Group was reminded that the reviewer emphasized an important innovation of the 2019 assessment on the application of a Lorenzen approach to estimate M -at-age using a base M based on the Then *et al.* (2015) estimator and an A_{MAX} of 18. In conclusion, the presenter suggested the Group continue following the best practice recommendations for tuna stock assessments (e.g. Lorenzen M , with base M based on longevity). To better inform its decisions, the Group requested additional information about the interpretation of maximum age, as the maximum age of 18 in the 2019 Yellowfin Tuna Stock Assessment raised questions about the representativeness of this age in the population.

Following the presentation and a consultation with two experts on the estimation of M in stock assessment (Pers. Comm, Hoenig and Cope), the Group decided to estimate the base M using the Hamel and Cope (2022) estimator with an A_{MAX} of 18 and scaling the M -at-age assuming a Lorenzen function internally in stock synthesis (SS3). Additionally, to incorporate uncertainty around base M , the Group recommended drawing from a lognormal prior distribution. This approach allows correlated parameters to be estimated consistently and internally in the stock assessment model. The Group also noted that this approach would be consistent with the method applied to the 2023 Atlantic Albacore Stock Assessment (Anon., 2023).

c. Age and growth

A study on the age and growth of yellowfin tuna in the U.S. Gulf of Mexico and Western Atlantic was published in 2021 (Pacicco *et al.*, 2021). The age estimate was based on the reading of sections from over 3,000 otoliths from the U.S. recreational fishery and the U.S. Pelagic Observer Program for longline vessels.

Age determination in this study took into account the updated criteria defined at the International Workshop on the Ageing of Yellowfin and Bigeye Tuna in 2019 (Allman *et al.*, 2020), on the fact that if the margin is narrow and translucent, the number of rings equals the calendar age (every month). Concerning sex-specific growth, the likelihood ratio tests indicated that growth curves from males and females were statistically different in both size-modified models (Richards: $P < 0,001$; VBGM: $P < 0,001$) with males reaching a greater asymptotic length (L_{∞}), and similar L_{∞} compared to other studies were annual ages were estimated from sectioned otoliths. The maximum age has been validated as 16-18 for six individuals. The Richards model (Richards, 1959) was the most parsimonious growth model with the size-modified growth being most appropriate given the large amount of fishery-dependent data collected. Also, sex-specific natural mortality was similar since longevity estimates were similar. The author recommended scaling natural mortality by age class.

A preliminary version of this document was used to define the Richards growth function used in the 2019 Yellowfin Tuna Stock Assessment. The author noted that this information has been updated, peer-reviewed, and published since the 2019 Yellowfin Tuna Stock Assessment, but that there had been little change to the reported growth functions. Therefore, the Group decided to retain the 2019 growth function for the continuity model, but that growth estimation within SS3 will be attempted to best account for the various fleet selectivities.

d. Reproduction

A study by Pacicco *et al.* (2023) on the reproductive biology of yellowfin tuna (*T. albacares*) in the northcentral U.S. Gulf of Mexico was presented. Most (93%) of the samples were from the recreational fishery and gonads were processed using standard histological procedures. The results suggest that the maturity threshold plays a potentially significant role when estimating size at maturity for yellowfin tuna. To this purpose, the author recommends that a functional maturity threshold (i.e. vitellogenic 1 and 2) is the most appropriate to be used when estimating length at maturity (L_{50}) for stock assessment purposes (Pacicco *et al.*, 2023). According to the author, yellowfin tuna females can spawn daily, especially during peak spawning months.

A preliminary version of this document was available during the 2019 Yellowfin Tuna Stock Assessment (Anon., 2020). The author noted that the information has been updated, peer-reviewed, and published since then, but there has been little change in the results, which still support the maturity ogive and L_{50} value used in the 2019 assessment (Diaha *et al.*, 2016). During the meeting, it was noted that the L_{50} value of 115.1 cm does not appear in the document Diaha *et al.* (2016), but the Group confirmed that it corresponds to the vitellogenic 1 and 2 threshold, functional maturity as recommended by Pacicco *et al.* (2023).

3. Review of fishery statistics/indicators

The Group examined the latest information provided by the Secretariat regarding yellowfin tuna fishery statistics, including Task 1 nominal catches (T1NC), Task 2 catch & effort (T2CE), Task 2 size samples (T2SZ) and reported catch-at-size (T2CS), as well as tagging data. The SCRS catalogue for yellowfin tuna stock was also presented and is available in **Table 1**. The Group reiterated the importance of the SCRS catalogues as tools to identify gaps and inconsistencies by CPCs in both Task 1 and Task 2 datasets.

The Group was informed of the Secretariat's efforts to automatically produce the catalogues for Task 1 and Task 2 datasets, which now include computed metadata useful for cross verifying the information contained within the ICCAT database. Additionally, the Group was presented with the most recent CATDIS estimates on tropical species covering the period from 1950 to 2022.

After a thorough review, all information was adopted by the Group for assessment purposes, and all updates were recorded in the ICCAT database system (ICCAT-DB). During the meeting, the Group reviewed updates on fisheries statistics provided by CPCs and proposed estimates for identifying missing yellowfin tuna catch data.

Six documents were also presented in this section to the Group updating information on fisheries which resulted in the improvements of Atlantic yellowfin Task 1 and Task 2 statistics. These are briefly discussed below.

SCRS/2024/038 provided Estimation of Ghana Tasks 1 and 2 purse seine and baitboat catch 2019 – 2022: data input 2024 Yellowfin Stock Assessment. The document discusses the use of data from the AVDTH Ghana database to estimate fisheries statistics for the Ghanaian tuna baitboat and purse seine fisheries from 2019 to 2022. Catch and landing data collected by the Marine Fisheries Research Division (MRFD) of Ghana from 2005 to 2022 were also utilized. Total Ghana catches, catch composition, and quarterly spatial distribution were estimated following recommendations from the SCRS Tropical Tunas Species Group. Sampling methods for species composition and size distribution were reviewed to ensure appropriate sampling for different components of the Ghana fleets based on major gear types.

SCRS/2024/045 provided statistics of the French purse seine fishing fleet targeting tropical tunas in the Atlantic Ocean (1991-2022). This document provides a current overview of the French purse seine fleet's activities targeting tropical tunas in the Atlantic Ocean. It includes details regarding drifting FAD (dFAD) data, which will be integrated into a designated section of the ICCAT statistics report. The statistics cover the period 1991-2022 and focus on the fishing activities of 2022.

SCRS/2024/051 provided fisheries statistics of the Spanish tuna fleets in the tropical Atlantic Ocean (1990-2022). The data presented concern the Spanish tropical fleet, detailing fishing areas, catches, effort, performance (CPUEs), and size distribution for purse seiners and baitboats.

The document indicated that the fleet deployed more purse seine sets on FADs than on free schools. Fishing effort declined initially in 2019 but recovered afterwards, notably in Gabon's EEZ in 2022. Yellowfin tuna dominated purse seine catches, peaking at 40% in 2020. Additionally, the Group noted a decrease in the number of Spanish-

flagged baitboat vessels operating in the area, from 7 in 2019 to 3 in 2020. This decline was mainly due to the establishment of a Marine Protected Area (MPA) that impeded access to live bait. The MPA, established in 2019 under special legislation from the Senegalese government, grants access to the area to smaller, artisanal vessels only.

SCRS/2024/047 presented a revision of historical catch statistics of yellowfin tuna caught by the Mexican fishing fleet in the Gulf of Mexico. This document outlines the background and outcomes of a revision of yellowfin tuna catch statistics from the Mexican longline fishery in the Gulf of Mexico using observer data collected in the Longline Tuna Fishery Information System (SIA). The revision aims to update the ICCAT-DB catch series from 1993 to 2021 by identifying Mexico's data sources and correcting historical catches. The revision replaces longline data (2002-2021) with minimal catch differences, integrating cruises spanning two years. The Group acknowledges Mexico's ongoing efforts to ensure consistent, updated, and harmonized data provision to ICCAT for tuna species, including historical information.

SCRS/2024/046 provided conversion factors for tropical tunas caught with purse seine in the Atlantic Ocean, as an update of Fily and Duparc (2023). The paper suggests updating the length-weight relationship for major tuna species caught by tropical purse seine fisheries, a conversion that has not been updated in over 40 years. They tested an additional predictor, fishing mode, and conducted analyses to show the robustness of the new relationship. While fishing mode had some impact, it was minimal compared to other factors. Their findings support using a simple length-weight relationship for converting length to weight in tropical purse seine fisheries.

The discussions from the Group revealed uncertainties in the current L-W relationship that must be further investigated. The Group agreed that further research is needed before the current yellowfin tuna L-W relationship adopted by the SCRS is replaced.

a. Task 1 catches and discards data and spatial distribution of catches

The Secretariat informed the Group that only minor yellowfin tuna data updates were made to TINC since the 2023 SCRS annual meeting, and that only catches for the period 1950-2022 were analyzed. Following the 2021 SCRS recommendation, the Secretariat also presented the TINC dashboard (screenshot **Figure 1**) with interactive querying facilities aiming to simplify the exploration of the TINC dataset. During the presentation of the statistics, following the issue of attributing catches to the YFT-E and YFT-W regions, the Group agreed to present yellowfin tuna fishery statistics as a single Atlantic-wide stock including the Mediterranean Sea.

While analyzing the nominal catches presented to the Group, significant purse seine catches reported by Brazil in 2022 were observed, indicating a potentially emerging fishery that requires clarification on operations and areas in collaboration with national scientists. Additionally, it was noted that Liberia reported substantial (1730 t) yellowfin tuna catches in 2020 from two industrial purse seiners (flagged by Ghana in 2022), but there were no catches reported by the same fishery before 2020, only 9 t in 2021 and no catches in 2022. This prompted discussions on estimating catches for 2021 and 2022, leading to the agreement of repeating catches from 2020 for 2021 only instead of performing a three-year carryover estimation. The Group received information that the Liberian purse seine fleet did not operate in 2022.

Furthermore, the Group identified a gap in reported catches for Grenada's longline and troll line fisheries from 2011 to 2014, which represented significant portions of the overall catches. While a three-year carryover to reconstruct missing catch levels was proposed for consistency, the Group recalled the recommendation by the Subcommittee on Statistics (SC-STAT) to develop a standardized method for such approaches across all species.

Efforts by Ghana and the Secretariat to enhance the accuracy of catch statistics for tropical tunas were acknowledged, highlighting the combination of two components of catches from Ghana: one from a national fleet of smaller vessels and another from larger Ghana-flagged industrial vessels, reported separately. The Group also noted a higher proportion of yellowfin tuna catches in areas closer to the coast within fishing grounds but with seasonal variability in species composition and individual size, particularly on FAD sets.

The Secretariat informed the Group about the revision of TINC for yellowfin tuna (YFT) from the Venezuelan artisanal fishery (2018 to 2022), known for its use of drift gillnets and focus on billfishes within the La Guaira billfish hotspot.

The Group was informed that the historical catch estimates of the so-called "faux-poisson" allocated to the "Mixed Trop" (2015-2020) have been reviewed by several CPCs that have now provided specific catch updates of this component (EU-Spain, EU-France, Cabo Verde). Other CPCs with tropical catches of purse seine (PS) fleet(s) had indicated that catches of aggregated catches of *faux-poisson* were already reported as part of their Task 1 INC catch reports (Guatemala, Panama, El Salvador, Belize, and Curaçao) as indicated during the 2022 Skipjack Stock

Assessment (Anon., 2022). Since 2021, Guatemala, Panama, El Salvador, Belize, and Curaçao have also reported length frequency samples for this component as well as the disaggregated Task 1 component of *faux poisson*. Therefore, to avoid potential double counting of some catches, the Group decided to update the estimates of the yellowfin tuna “Mixed Trop” estimates 2015-2020 discounting from this fleet the catch reports from EU-Spain, EU-France, and Cabo Verde. This update of the “Mixed Trop” was also applied to bigeye and skipjack as the initial estimates applied to all 3 species. The Group encourages CPCs to complete the disaggregation of *faux poisson* from the historical Task 1NC submitted.

The Group was informed that at present all landed catches from tropical tuna fisheries are being monitored and reported, although the methodology and estimation of the catch component of *faux poisson* may differ among CPCs. The Secretariat also clarified that in Task 2 it is possible to define size measures for *faux poisson* sampling source.

The adopted total catches of yellowfin tuna are presented in **Table 2**. The yellowfin tuna catch trends by gear are presented in **Figure 2**. The temporal-spatial distribution of yellowfin tuna catches (CATDIS 1950-2022) is shown by gear and decade 1950-2023 (**Figure 3**).

b. Task 2 catch/effort and size data

All the existing information on T2CE, T2SZ, and T2CS was made available to the Group. This included detailed catalogs with important metadata on each series, the very data in standard SCRS formats, and specific, custom extractions (e.g. T2CE detailed dataset with PS catches by fishing mode fish aggregating device (FAD) / free-swimming school (FSC) as required by the Tropical Tunas Species Group.

The Group recalled how catches of Brazilian handlines in the last 10 years were high, while size-frequency data for the fishery in the same period are lacking, with information only available for 3 years. As this is the only fishery of this kind in the western Atlantic Ocean, the Group agreed on the importance of liaising with national statistical correspondents to determine if historical size data could be recovered.

The Secretariat also informed the Group that updated information was received for Task 2 specifically size data from Mexico for the years 1993 to 2021 (SCRS/2024/047), size data from Senegal for the years 2021 to 2022, updates of Task 2 Catch and Effort (T2CE) and size data (T2SZ) from Ghana (SCRS/2024/038), which have all been incorporated into the ICCAT database.

c. Tagging data

The Secretariat presented a summary of yellowfin tuna conventional and electronic tagging updates, including the last recoveries of 2024 and a summary of the extension of the Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP) tagging project in the Northwest Atlantic.

Table 3 shows releases and recoveries per year and **Table 4** shows the number of recoveries grouped by number of years at liberty. Four additional figures summarized (geographically) the yellowfin tuna conventional tagging data available in ICCAT. The density of releases in 5x5 squares (**Figure 4**), the density of recoveries in 5x5 squares (**Figure 5**), and the yellowfin tuna apparent movements (arrows from release to recovery locations) are shown in **Figure 6**. **Figure 7** represents the release points (triangles) and the apparent movements (lines) of the update database, differentiating in colour red those of the AOTTP project and in blue the rest. As well as the dots (in yellow) of the yellowfin tunas tagged during the extension of the AOTTP project in the Northwest Atlantic.

Additionally, two yellowfin tuna dashboards were prepared to examine dynamically and interactively the tagging data. The first one (**Figure 8**) with conventional tags, showed a summary of released and recovered tags. The second one (**Figure 9**) with electronic tags, showed a summary with data extracted from the meta-database held in ICCAT. The dashboards for the conventional tagging and electronics tags metadata are published on the ICCAT website. The Secretariat thanked scientists for supporting the presented dashboards.

The Secretariat updated the Group on an agreement made with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) (UK) last year to utilize Lotek internal electronic tags from the AOTTP programme. Most of these tags were reused, having been deployed for only a few days and still in good condition, while a few were new replacements for failed tags. Out of 30 tags sent, 15 have already been deployed in Sta Helena, with one recovered so far, and the remaining tags expected to be deployed in the coming months. CEFAS is also working on creating tracks for electronic tags recovered from the AOTTP project in Sta Helena. Additionally, efforts to enhance conventional tagging information will continue alongside the maintenance and improvement of the

conventional tagging database (CTAG) and the development of a new electronic tagging database (ETAG). The main aim of the ETAG project is to integrate all information obtained from electronic tags and associated metadata into a centralized relational database system (PostgreSQL).

d. Updates to US tagging statistics

The Secretariat informed the Group of the current difficulties in the incorporation of the conventional tagging data reported by the U.S. between 2009 and 2019 (all species including yellowfin tuna) due to several reasons. Aiming to solve this situation in the mid-term, collaborative work has begun involving the Secretariat and the U.S. tagging correspondents, to work on the full cross-validation of both conventional and electronic tagging databases, with the main objective of correcting all the discrepancies and missing information across all species. As a result, around 1500 new conventional tags from the cooperative Tagging Program (NOAA) and Billfish Foundation were added to the ICCAT database.

e. New information from the AOTTP program

A review of the available tagging data was conducted to consider the use of AOTTP tag recapture information to estimate natural mortality directly in the stock assessment. A major assumption to model the tagging data is the ability to accurately age the fish at the time of release, which requires age-length keys, cohort slicing, or an alternative approach. It was demonstrated that the range of fish sizes released can span multiple age classes, making the application of cohort slicing problematic since there is a high overlap in the size distribution across those ages. Since no age-length keys or other approach is available to age the tag releases, it will not be possible to incorporate the AOTTP data in the assessment to model mortality. Additionally, the high proportion of short-term recaptures and relatively low return rates at longer times-at-liberty, combined with uncertainty in reporting rates across fleets prevents accurate estimation of mortality.

4. Review of available indices of relative abundance by fleet

The Group was provided with standardized longline indices from multiple CPCs and a multi-national joint standardized index. After reviewing all provided information related to longline fisheries, the Group agreed to use the joint CPUE Longline index between Japan, U.S., Brazil, Korea, and Chinese Taipei for the 2024 stock assessment, namely that developed for Region 2 with no subsampling (SCRS/2024/036).

The Group also recommended using a standardized index from the EU Purse Seine fleet targeting free-swimming schools of adult yellowfin tuna (SCRS/2024/041) and a refined index developed from echosounder buoy acoustic data assuming to represent juvenile yellowfin tuna abundance (SCRS/2024/044).

The Group made suggestions to improve novel indices developed for the Venezuelan Purse Seine (SCRS/2024/042) and Bait Boat fleets (SCRS/2024/043), the latter of which may be considered as a sensitivity analysis if provided before the stock assessment meeting in July 2024. As an additional sensitivity analysis, the Group also recommended consideration of the juvenile index constructed from EU Purse Seine data for those vessels operating around fish aggregating devices (FADs), as estimated from the generalized linear mixed models (GLMM) approach (SCRS/2024/052). A number of novel indices were also reviewed that have more explicit treatment of spatiotemporal trends than traditional approaches (SCRS/2024/034, SCRS/2024/049, SCRS/2024/052), but the presented work from these studies was preliminary and not ready for consideration in the 2024 stock assessment.

Document SCRS/2024/036 presented a standardized index of abundance (CPUE) estimated using a delta-lognormal approach from operational (set) level data collected from Brazilian, Japanese, Korean, Chinese-Taipei, and U.S. Longline fleets between 1959-2022 across the Atlantic Ocean. Joint CPC indices were developed for three unique regions, each estimated from generalized linear models (GLMs) applying two modeling components: 1) probability of presence of yellowfin tuna in catch using a logistic link function and binomial error distribution and 2) log-transformed yellowfin tuna catch rates (CPUE) over positive sets using a normal distribution.

The Group observed that the trends in the joint index were similar to those from the individual (CPC) indices for each region, although some small differences were noted. The updated index was also similar to that produced for the 2019 yellowfin tuna assessment.

The Group discussed the different sub-sampling schemes used to treat the data and there was a general agreement to support the use of the indices estimated using all available data with no-sub-sampling. It was also noticed that the CPUE index for region 1 increased towards the end of the time series, which seems driven by data from Chinese Taipei. The Group agreed that the joint CPUE better deals with the conflicting trends of the individual CPUEs and highlighted that these types of concerns are part of the motivation for generating joint indices.

The authors recommended only using the Region 2 index for stock assessment purposes, as this region represents the core habitat of the stock and where fishing is most concentrated. The Group discussed that only using the indices from Region 2 might result in some hyper-stability, but acknowledged that this is somewhat speculative. Additionally, absolute effort has also been more variable in Regions 1 and 3, as compared to that in Region 2, which has been relatively consistent, and so including indices from Regions 1 and 3 may be problematic in the assessment models that do not include spatial considerations. In conclusion, the Group agreed to use the index from Region 2 with no subsampling as a continuity. The Group also agreed that this index should be used in place of any of the individual CPC indices.

Document SCRS/2024/034 presented a standardized index of abundance (CPUE) estimated from vector autoregressive spatiotemporal (VAST) generalized linear mixed models (GLMMs) fit to data collected from the Brazilian, Japanese, Korean, Chinese Taipei, and U.S. Longline fleets between 1979-2022 across the Atlantic Ocean. This work is meant to more explicitly model the spatial and temporal aspects of yellowfin tuna catch rates, as compared to the Joint Longline index (SCRS/2024/036).

The Group agreed that this is an excellent ongoing work that can be useful in the future to understand changes in spatial/temporal distribution. The Group agreed that the amount of available data is adequate to advance a VAST analysis. However, VAST analyses required significant computational time which limited the ability of the authors to explore all diagnostics and to further explore model behavior, identify which aspects of the current models are failing to converge and identify appropriate solutions. While the approach is very promising, the Group agreed that in its present state, the index is not ready for use in the stock assessment. The Group recommended that this work continue intersessionally, as development is likely to be iterative and take time.

Document SCRS/2024/049 presented a standardized index of abundance (CPUE) estimated using a Bayesian approach with Integrated Nested Laplace Approximations (INLA) from operational (set) level data collected between 1998 and 2022 from the Brazilian and Uruguayan Longline fleets, which operate in the southwestern Atlantic Ocean.

The authors noted that there is a moderate correlation between set-level observations vs. predictions, but the overall predictive power of the approach appears appropriate. There also appear to be patterns in the included spatiotemporal variables, which seem to be changing over time and space.

The Group discussed the appropriate spatial/temporal resolution for this analysis. The authors indicated that a seasonal and 1x1 degree resolution was used and that they found a high correlation between 1x1 degree cells at this level of resolution. Therefore, it was suggested that a lower resolution could be used which would still maintain the autocorrelation within the larger cells and no information would be lost. The Group also asked the authors to clarify whether the chosen spatiotemporal structure is consistent across seasons, but variable among years, and the authors confirmed it.

While the Group agreed that the index appears to be overall sufficient for consideration in this assessment, it was also agreed that this index should not be used in place of the Joint Longline Index (see SCRS/2024/036). The authors indicated that this index was produced to introduce the applied method as a potential tool in investigating fine-scale CPUE data for spatiotemporal patterns, which could then inform modeling in subsequent analyses (e.g., using fixed effects vs. interaction terms).

The analysis described in this document is similar to that of VAST (SCRS/2024/034), which is also trying to control for spatiotemporal trends in catch rate, but in a more stable and less computationally expensive modeling framework. The Group also discussed how consistent updates of indices using VAST can be, because inconsistencies could be problematic in an MSE framework. It was agreed that in an MSE framework, there is a need to produce stable indices which can be achieved with temporal-spatial GLMs like the ones used in this document.

The Group recognized the potential value of applying this approach in future assessments and management strategy evaluations and recommended that this approach be further discussed by the Working Group on Stock Assessment Methods (WGSAM). Furthermore, the Group acknowledged the significant contribution of this document about the importance of spatial-temporal autocorrelations in understanding variability in CPUE.

Document SCRS/2024/035 presented a standardized index of abundance (CPUE) estimated using a delta-lognormal approach from operational (set) level data collected from the Japanese distant water Longline fleet between 1959 and 2022 across the Atlantic Ocean. The overall aim of this paper was to compare the resultant index to previous indices and to the Joint Longline index (SCRS/2024/036), which includes data from and is meant to represent the Japanese Longline fleet. Indices were developed for three unique regions (SCRS/2024/035 Figure 2), each estimated from generalized linear models (GLMs) applying two modeling components: 1) probability of presence of yellowfin tuna in catch using a logistic link function and binomial error distribution and 2) log-transformed yellowfin tuna catch rates (CPUE) over positive sets using a normal distribution.

The Group evaluated the indices during the discussion of the CPUE table. Concern was raised that while the authors tried to account for changes in selectivity/catchability, there may be other factors that influence CPUE for which data are unavailable and so unaccounted for. The Group acknowledged that the authors followed best practices, for example using clustering approaches to identify targeting and associated catch rates, which is likely the best that can be done. In conclusion, the Group did not support the use of these indices given the availability of the Joint Longline abundance index (see SCRS/2024/036).

Document SCRS/2024/056 presented a standardized index of abundance (CPUE) estimated from operational (set) level data collected from the Chinese Taipei distant water Longline fleet between 1995 and 2022 across the Atlantic Ocean. Indices were provided for three separate regions using a delta-lognormal approach.

The Group agreed not to use this index in favor of the Joint Longline index (SCRS/2024/036).

Document SCRS/2024/041 presented a standardized index of abundance (CPUE) estimated using a delta-lognormal approach from free-swimming school sets (FSCs) of the EU (France and Spain) Purse Seine data collected in all months between 1993 and 2022 across the Atlantic Ocean. Indices were developed from generalized additive mixed-effects models (GAMMs) applied to three modeling components using two different approaches.

The Group inquired which one of the indices presented in the document is recommended to use in the stock assessment. The authors recommend approach 1 as the preferred option due to concerns with the beta distribution predicting the observed proportions of tropical tuna catch that is composed of adult yellowfin tuna, which tended to be zero or one. The Group then requested the authors to provide a table with the values of the recommended standardized index and include the estimated annual CVs.

The Group inquired how the ‘adult’ stage was defined since that information is important for inclusion in the integrated assessment models. It was indicated that ‘adults’ were defined as fish heavier than 10 kg. If ultimately included in the assessment model, the Group recommends that this index be fit using a selectivity mirrored from the purse seine fleet, with a cut-off over 10 kg.

The Group asked about the species composition of the PS catches over time. It was observed that in the early part of the time series, large components of FSC catches were mostly composed of skipjack. But over time, skipjack became less abundant and the proportion of yellowfin tuna in the PS sets significantly increased. After controlling for spatiotemporal effects, the marginal effect plot (effect of year-month) shows larger effects on 2008+ and so may somewhat account for this “disappearance” of skipjack.

The Group discussed the quantile–quantile (Q-Q) plot of component 1, which showed residuals with high divergence in the upper quantile that the authors attributed to too many multi-set days. This divergence is a “rare event” in the dataset and so should have a relatively minor impact on the final standardized index, but the Group did suggest looking into this issue a bit closer (e.g. perhaps look to see if these residuals have a temporal component). While the authors expressed no concerns regarding the Q-Q plot, they agreed that the temporal component should be further explored. The Group also suggested an additional analysis to investigate the potential effects of closure period and time-zones on FSC encounter rates and tuna catch rates.

The Group indicated that generalized additive mixed models (GAMMs) can become relatively unstable when fit to sparse data, and under this condition GAMMs are not good predictors. The authors indicated that while a decline in effort has occurred, the absolute amount of set observations is still high. The authors also noted that spatial strata with patchy/limited data were removed to ensure indices are estimated from strata with adequate data.

The Group also discussed that the Index shows some instability in the southern region of the study area (i.e. Angola/Gabon). It was hypothesized that this effect might be the result of the school composition of both species and sizes being mixed and not just adult yellowfin tuna in this region. The author agreed that the southern area used in the analysis is different from the rest and that might explain some of the instability observed in the models.

The Group also noted the increase in the fraction of positive FSC sets with adult yellowfin tuna in 2010, which the authors indicate may coincide with technological advancements that would allow for selective targeting of FSCs (SCRS/2024/041). The Group concluded that the proposed indices might be improved by incorporating such drivers into the standardization (e.g. increased FAD fishing).

Document SCRS/2024/042 presented a standardized index of abundance (CPUE) estimated using a delta-lognormal approach from operational (set) level data collected in all months between 1987-2022 from the Venezuelan Purse Seine fleet, which largely operates in the Caribbean and adjacent waters of the western central Atlantic. Indices were developed from generalized linear models (GLMs) applied to two modeling components: 1) probability of presence of yellowfin tuna in catch using a binomial error distribution and (2) yellowfin tuna catch rates (CPUE) over positive sets using a lognormal distribution.

The Group raised concerns regarding the unit of effort that was defined as a 'set' and that search time may not be properly accounted for in the index. This approach might result in hyper-stability of the index. In addition, the Group was also concerned regarding the inconsistency in effort units amongst vessels that differ in their respective fishing strategies (e.g. short trips with lots of sets vs. longer trips with less frequent sets). To further evaluate the index, the Group requested that the authors provide summaries on the 1) number of vessels, 2) number of sets/vessel/month, and 3) number of boats per purse seiner-category over time. As requested by the Group, the authors verified that there was no sampling in Area 2 after 2016. The authors also showed that the number of vessels and the number of sets/year has consistently declined. However, the average number of sets per vessel and relative composition of large vs. small/medium vessels has remained relatively stable.

The Group acknowledged that this is valuable work, but at this time does not support the use of this index in the assessment. In addition to hyperstability, the Group is concerned that because the assessment model is not spatial, the indices included in the model should represent the entire range of the population. The Group also recognized that the number of vessels that are providing these data is relatively small. Additionally, this index is somewhat redundant with the Venezuelan Baitboat index (SCRS/2024/043), which operates in the same general area.

The Group also recognized that this concern of hyperstability is not limited to this index, and is a concern in all Purse Seine indices. As a specific example, the Group decided to recommend the use of the EU purse seine FSC index in the base model of this assessment (SCRS/2024/041), however, this PS index includes an offset to account for search time. The Group highlighted the need to be consistent in the criteria being applied in deciding which Purse Seine indices to include/exclude from consideration in ICCAT stock assessments.

Document SCRS/2024/043 presented a novel, standardized index of abundance (CPUE) estimated using a delta-lognormal approach from operational (set) level data collected in all months between 1987 and 2022 from the Venezuelan Baitboat fleet, which largely operated in the Caribbean and adjacent waters of the western central Atlantic. Indices were developed from generalized linear models (GLMs) applied to two modeling components: 1) probability of presence of yellowfin tuna in catch using a binomial error distribution and 2) yellowfin tuna catch rates (CPUE) over positive sets using a lognormal distribution.

The Group noted that since 2003 the standardized CPUE was higher than the nominal CPUE in all years. The Group inquired if the authors had any sense of what might be causing this divergence. The authors indicated that such divergence might be due to some factor not being available during this period, particularly that there was no fishing in Area 2 after 2003 (e.g. if "Area 2" is more productive with higher catch rates, the lack of fishing in this area would explain this trend). The authors further explained that the lack of fishing in Area 2 after 2003 was most probably due to economic reasons since it's more expensive to fish in these areas. The Group noted that this divergence may therefore be real, which the index is appropriately capturing.

The Group also requested that the authors expand their diagnostic plots to include residuals across all the factors included in the standardization, which the authors provided. Given that the unit of effort was defined as a 'fishing operation', the Group inquired whether the fishing operation may have changed over time (e.g. number of poles, bait type, vessel capacity, etc.) and whether the applied units of effort in the standardization have remained stable. The authors noted the number of days fished has not changed much over time, but they will have to check on fishing power (e.g. number of anglers or poles).

It was noted that the number of vessels operating in the baitboat fishery significantly declined in the final years of the time series (i.e. 2 vessels after 2018). It was noted that some baitboat conducted joint fishing operations with purse seine vessels. Since the baitboat index only included vessels that did not fish together with purse seiners, the Group inquired if the reduction in the number of baitboat participating in the fishery was due to an increase in the number of vessels fishing jointly with purse seiners. Given the very low number of baitboat vessels operating towards the end of the time series, the Group also discussed removing index values after 2018 or 2019. However, no final decision was made about this suggestion. To potentially account for changes in fishing operations over time, the Group requested the authors to include vessel ID as a factor in the standardization procedure. The authors indicated that such analyses will be conducted intersessionally.

The authors showed that the number of vessels and number of sets/year have shown declines since 2003. The average number of operations/vessels also shows a decline, although this decline is not as strong as that in the other two. The Group noted that these trends are fine as the unit of effort in the CPUE response variable is an individual fishing operation, and so it does not matter if the number of operations has changed, but biases can be introduced if changes are occurring within a given fishing operation (e.g. changes in number of poles). The authors acknowledge that such data have not been traditionally collected in this fishery, but did note some variability in the size of baitboats over time, which is being included as a factor in the standardization and so accounted for. Regardless, the authors acknowledge that some technological creep may be occurring, but this fishery is not associated with FADs and so believe such effects may have a relatively minor effect on the associated catch rates. The authors also noted that these fisheries have operated in the same general area and used the same basic fishing strategies over time. However, as the number of vessels has decreased in recent years, communication may have improved over vessels, driving up catch rates for the few vessels still in operation. Overall, the authors acknowledge that some changes in effort could be possible in this fleet, but believe it is unlikely to have a large effect on the index.

In conclusion, the authors indicated that a revised index including vessel ID as a factor in the standardization procedure will be made available to the Group intersessionally. The Group agreed to consider the inclusion of the revised index as a sensitivity run as part of the stock assessment. The selection of an appropriate selectivity trend will be explored once the revised index has been provided and can be tested within the assessment model. The Group also recommends that the last few years of the index be truncated when only a couple of baitboats were in operation.

Document SCRS/2024/044 presented a standardized index of abundance (CPUE) for juvenile yellowfin tuna estimated from echosounder buoy data collected between 2010 and 2023 across the eastern Atlantic Ocean. These acoustic data were combined with associated ICCAT fishery (catch and size) data to obtain specific indicators for yellowfin tuna. Given the low percentage of echosounder measurements with biomass less than 0.1 t, indices were developed from a generalized linear mixed model (GLMM) that assumed a lognormal distribution.

The authors noted a steady increase in the standardized index over the time series but highlighted that acoustic data for the analysis have been relatively limited over the last two years. The Group also highlighted the relatively high index estimate for 2023 quarter 3, which may be anomalous given the low sample sizes that appear to be coming from a single area. This estimate could be further investigated (e.g. to see if it is well supported by the data), but it may also be treated as a sensitivity in the final assessment model.

The Group also asked about the relatively high values of the standardized index over the middle of the time series, over which time the authors noted that there was a reduction in the number of observations. The Group inquired that while the document described 5 different buoy types used by the PS fleet, the analysis showed that only 3 levels of the 'buoy' factor were used. The authors explained that some buoy types have similar technical specifications and, therefore for analysis purposes, they were grouped into 3 categories.

Regarding the FOB colonization, the authors clarified that the 20-35 day colonization assumption was the same across the entire dataset, and does not change, for example, by area to account for spatial patterns in species abundance. The Group expressed some concern that the authors were inadvertently removing some of the abundance signals from the index, which is not the case.

As a rough estimate, the authors stated that about 30% of the data was provided by the highest resolution strata (i.e. $1^\circ \times 1^\circ$ spatial grids by month), about 30% at the second strata (i.e. $1^\circ \times 1^\circ$ spatial grids by quarter), and the remaining 40% at the third strata (i.e. regional strata by quarter). While acknowledging the data limitations, at the same time the Group expressed concern regarding this approach and indicated that this aspect needs to be further investigated. This is a critical aspect of the analysis because species composition can differ significantly at different strata levels.

The authors recommended the use of this index in the assessment, but they also identified several potential improvements that could be made in constructing future indices (e.g. geospatial approaches, and machine learning). Given that the index estimated quarter/year values, the Group inquired if annual estimates could be estimated. The authors indicated that they could provide an index at an annual time step if needed. However, it was then confirmed that this index was only used in the Stock Synthesis platform in a quarterly time step. Therefore, no additional changes were requested to the temporal resolution of this index.

The Group asked the authors what is the range of ages covered by this recruitment index. The authors indicated that they needed to investigate this issue. However, the Group was informed that in the 2019 assessment, the size selectivity of the PS fleet using floating objects (FOBs) was applied to the BAI index. The Group indicated that this approach is good if the spatial operation of these fleets is similar to those fleets operating on FOBs and it was agreed that this was the case.

The Group agreed to the use of this index in the continuity case, which is estimated from data collected from the core habitat of juvenile yellowfin tuna and so appears suitable as a recruitment index. As was done in the 2019 assessment, the Group recommends mirroring the selectivity of the purse seine FAD fleet for this index.

Document SCRS/2024/052 presented a novel, standardized index of abundance (CPUE) estimated from data collected from EU purse seine vessels targeting floating objects (FOBs) across all months between 2010 and 2022 across the eastern Atlantic Ocean. Indices were constructed using multiple approaches: 1) delta-lognormal GLMMS, 2) delta-lognormal generalized additive model (GAMs), and 3) spatiotemporal GLMMs (sdmTMB), which includes the construction of a spatial random field. By their nature, FOB fleets tend to target smaller fish than FSC fleets and so the FOB index is being considered as a recruitment index.

In approach 3, the Group clarified that authors excluded zero sets so the associated index may be hyper stable. The authors indicated that the proportion of zero sets in the data was very low (~3%) so this exclusion had little effect on the overall dataset. However, hyperstability is still a concern with this index, given the vast majority of records are positive sets and so the fitted data provide little information on presence/absence (i.e. encounter rates).

The Group also asked for clarification on some of the candidate variables, namely the number of buoys and mean buoy density across a certain distance, and how these could be calculated at a set level to match the associated resolution of the purse seine data. The authors clarified that these data come from position data provided by the fleet, which include the position of buoys across the entire fleet which have been interpolated into spatial maps at an hourly resolution. The Group also expressed concern that the candidate variables for buoys are not strictly independent. The authors responded that they considered the variance-inflation factors for these variables, which were not high.

The Group inquired if management regulations were taken into consideration when constructing these indices. The authors indicated that management regulations should not affect the estimation of the delta-lognormal GLMM and GAM indices. Similarly, the spatial/temporal models are not affected either because they can use information from before the closures. However, the authors acknowledged the need to further explore the potential effect of management measures on CPUEs.

The Group discussed that the large concentration of fishing effort off Gabon due to access agreements could have a large influence on the results. The authors replied that further exploration of the spatial/temporal component could consider this concentration of effort. Alternatively, future iterations of these indices could exclude data from this area.

The Group also discussed the general approach to estimating the indices described in this document. Historically, what has been done in index standardization is that year effects are predicted as a proxy for annual trends in stock abundance (i.e. density covariates). Conversely, the proposed approach predicts CPUEs using the observations and based on a variety of catchability covariates. The authors clarified that this was not the case, as the provided CPUE indices are being generated from accepted best practices (Hoyle *et al.*, 2024) that use externally defined

prediction grids to construct abundance indices (i.e. not contingent on the observed data). Fishery-dependent data are not random, so they try to remove factors that can affect catchability like areas, season, gear, etc., and expect that the remaining trend will reflect stock biomass. But when using models like GAMs we can fit the data very well but cannot test if we are removing the effects of such factors. Catch per set and sets are almost always positive, there is still a potential issue with hyperstability in this index.

The Group agreed with the authors that highlighted that results from the spatial/temporal GLMM model are preliminary and, therefore, should not be considered for the assessment. However, the Group agreed to use the delta-lognormal GLMM index as a sensitivity during the stock assessment. Selectivity for this index should be mirrored from the purse seine FAD fleet.

The Group also recognized the potential value of the spatial-temporal approach being developed in this study (i.e. approach 3) and identified a number of potential improvements. The Group recommended expanding these models to include density covariates (e.g. yellowfin tuna concentrate in high chlorophyll-a areas) and to account for potential improvements in echosounder technology or changes in vessel configurations. The authors also identified a need to isolate the temporal effect from (for example) time-area interactions, which complicate associated predictions that are only specific to time. The authors also plan on exploring the use of vessel ID information in their standardization (vs. vessel size/age) and compare future iterations of their index to the base recruitment index (BAI, SCRS/2024/044).

Discussion on CPUE selection

Based on the revisions of the CPUE documents presented above, the Group discussed the CPUE evaluation criteria for each series (**Table 5**). The annual estimates of relative abundance, and the coefficients of variation for available CPUE time series are provided in **Table 6**. The Group further discussed which CPUEs among all available indices should be used in the 2024 stock assessment, and the following indices were recommended (**Table 7**):

- Initial runs
 - Joint Longline index Region 2 no subsampling: 1959 – 2022
 - Bouy derived FOB index: 2010 – 2022
 - EU PS Free School index: 1993 – 2022
- Sensitivity analysis
 - EU PS FOBs index: 2010 – 2022
 - Venezuela BB index with Vessel ID factor: 1987 – 2022

A comparison of the available indices from the 2019 assessment and current available indices is shown in **Figures 10 and 11**.

5. Review of assessment models for evaluation, specifications of data inputs, and modeling options

The Group discussed the assumptions to be applied to the 2024 yellowfin tuna stock assessment models, and outlined the following protocols:

- A seasonal, one-area, combined-sex model will be constructed in Stock Synthesis 3 (SS3) covering a timeframe from 1950 to 2022.
- Annual time-step biomass surplus production models (JABBA and MPB) may also be used for comparison, validation, and consideration for advice.
- Initial stock biomass in 1950 will be assumed to be in an unfisher, virgin stock condition.
- Fleet structure will be comprised of 25 fleets, including eleven purse seine fleets, a Ghana baitboat and purse seine combined fleet, four baitboat fleets, six longline fleets, two handline fleets, and one fleet for other gears combined (**Table 8**).
- The fleet structure definitions are similar to the 2019 yellowfin tuna assessment and consistent with the stock assessments for Atlantic bigeye and eastern Atlantic skipjack tunas to facilitate the multi-stock management strategy evaluation.

A continuity model will be updated following the assumptions of the 2019 assessment and will be modified as outlined by the SCRS to integrate the alternative assumptions and configurations described below. The following sections list the primary data and parameterization assumptions for the SS3 and biomass surplus production models.

Indices of abundance

The indices of abundance and associated selectivity will be consistent with the 2019 assessment. Three abundance indices will be modeled, 1) the Joint CPC Longline index for the tropical Atlantic (region 2) broken into two periods 1959-1978 and 1979-2022, 2) the Seasonal Acoustic Echosounder Buoy index associated with FADs covering the period 2010-2022, and 3) the Free School Purse Seine index covering the period 1993-2022. The Joint LL index will be assumed to have a selectivity of older fish, equivalent to the Japan longline fleet in the tropical Atlantic (fleet 17, **Table 8**). The acoustic buoy index will be assumed to have the same selectivity as the purse seine fleet operating on FADs in the recent period season 1 (fleet 7, **Table 8**). The Free School Purse Seine index will be assumed to have the same selectivity as the free school purse seine fleet in the recent period (fleet 3, **Table 8**). Index CVs will initially be scaled to an average CV = 0.2 or higher if required across the time series while retaining the relative interannual variability estimated by the standardization models (i.e. CVs will be normalized to a mean = 0.2). The three indices will be modeled in SS3 and surplus production models.

Length composition

Length data for each fleet, year, and season will be provided by the Secretariat after all CPC size data updates are completed following the data preparatory meeting. Length compositions will be input as the number of fish observed per 4cm size bin. Other bin sizes (e.g. 2 cm bins) may be considered as needed to facilitate growth estimation within SS3. The effective sample sizes will be equal to the log₁₀ (of number of observations), to reduce the effect of pseudo-replication in sampling and decrease weighting in the overall model likelihood. This approach is consistent with the treatment of size composition data for the other tropical tuna assessments and the 2019 assessment for yellowfin.

Size and weight-at-age

The assumption of growth will remain unchanged from the previous assessment, modeled as a combined-sex Richards curve published by Pacicco *et al.* (2021). Growth parameters were fixed in the 2019 assessment model due to the difficulty encountered in direct parameter estimation, but growth estimation in SS3 will be attempted with the conditional size-at-age observations input into the model. Informative priors will be included as required to allow some flexibility in growth estimation while maintaining model stability. This is particularly important to account for potential gear selectivity bias from fishery sampling. Weight in kilograms will be estimated from straight fork length (cm) converted to weight assuming the current SCRS length-weight relationship for yellowfin tuna (Caverivière, 1976) $Wt = (2.1527e-05) * FL^{2.976}$.

Maturity and fecundity

Maturity and fecundity assumptions will remain unchanged from the 2019 assessment. Fecundity will be modeled as a direct relationship to female body weight. Maturity will be assumed to follow a logistic function of fish body size, with an assumed 50% maturity at 115 cm straight fork length (Diaha *et al.* 2016, Pacicco *et al.*, 2023).

Natural mortality (M)

Consistent with the 2019 assessment, age-specific natural mortality will be modeled assuming a Lorenzen function (Lorenzen, 2005) to account for decreasing mortality with increased age. The estimate of base natural mortality rate will be equal to 0.3, based on the Hamel and Cope (2022) longevity estimator with an assumed maximum age estimate of 18 years old (Andrews *et al.*, 2020; Pacicco *et al.*, 2021). The base estimate of 0.3 M will be modeled as the median across fully selected ages, which can be considered age 2, 3, and 6-10 years old, provisionally, based on the selectivity estimates from the 2019 assessment. To incorporate uncertainty around the base M estimate, it was suggested to model M using a lognormal prior distribution with a CV=0.31 (Hamel and Cope, 2022), and potentially integrate the full distribution in the stock assessment using Monte Carlo resampling (at least 100 iterations). Natural mortality-at-age will be parameterized in SS3 (as opposed to a fixed input vector) to allow for model flexibility to alternative assumptions and consistent parameterization of M across trials. The distribution of M-at-age will be incorporated in the growth rate r parameter priors for surplus production models.

Fleet selectivity

The initial selectivity parameterization will follow the assumptions of the 2019 assessment (**Table 8**). Selectivity will be estimated directly for fleets 1-3, 7, 11-14, 16-17, 19-20, and 23-25. A cubic spline function will be fit to compositions for fleets 1-3, 7, and 11 to model multimodality of length observations. Fleets 12-14, 16, 19, and 23-25 will be modeled as double normal functions. Fleets 17 and 20 will be assumed to have asymptotic logistic selectivity. To reduce model complexity the following fleet selectivities will be mirrored: fleet 4 mirrored to fleet 1, fleet 5 mirrored to fleet 2, fleet 6 mirrored to fleet 3, fleets 8-10 mirrored to fleet 7, fleet 15 mirrored to fleet 14, fleet 18 mirrored to fleet 16, fleet 21 mirrored to fleet 19, and fleet 22 mirrored to fleet 14. The fleet selectivity assumptions may be modified when necessary to improve model fit to length compositions, convergence, parsimony, or overall performance.

Stock recruitment

Stock recruitment will be modeled with the Beverton-Holt function with virgin recruitment (R_0) and log-mean recruitment deviation (σ_R) freely estimated across a range of fixed steepness ($h=0.7, 0.8, \text{ and } 0.9$), which will define the axis of the uncertainty grid. Annual recruitment deviations will be initially estimated for the period 1974 to 2021, and modified, when necessary, based on model diagnostics. The lognormal bias correction ($-0.5\sigma^2$) for the mean stock recruitment will be applied following the recommendations of Methot and Taylor (2011).

Data weighting

The final model will apply a data reweighting procedure for the fleet length compositions following the method of Francis (2011), consistent with the approach of the 2019 assessment and other tropical tunas (bigeye tuna and skipjack). Indices of abundance will be equally weighted.

Intersessional work calendar

The Group agreed to the following schedule for the intersessional work tasks in preparation for the assessment meeting:

- 26 April - Provision of size and catch data by fleet by the Secretariat to be posted for modeler teams by the Secretariat.
- 20 May - To revise the progress of the assessment models and if required a possible informal online intersessional meeting.
- 20 May - CPCs to provide CAS to the Secretariat for the 3 species.
- 30 June - CAS of the 3 species completed and validated (1 week before the yellowfin tuna stock assessment).
- 1 July - SCRS documents and presentations to be submitted to the Secretariat.

6. Review progress toward tropical tuna Management Strategy Evaluations

The two ongoing MSE processes for Atlantic tropical tunas were discussed under this item of the agenda, the western skipjack MSE (SKJ-W MSE) and the multi-stock MSE for eastern skipjack, bigeye and yellowfin tunas.

a. Progress of SKJ-W MSE

SCRS/2024/050 presented a summary of the First Intersessional Meeting of Panel 1 on Western Skipjack MSE in February 2024 and proposed an updated workplan for further developments of the SKJ-W MSE. The authors emphasized the importance of continuing the SKJ-W MSE development by the Group. To seek transparency in the process of the SKJ-W MSE methodology and analysis, the authors proposed a series of meetings with different themes that should be discussed this year, and to start discussion within the Tropical Tunas Technical Sub-group on MSE.

Among the main discussion points, as a start, it was suggested to the Group that the Tropical Tunas Technical Sub-group on MSE could discuss which indices will be used for each CMP to generate the total allowable catch (TAC) in the closed-loop simulations including the actual TAC for the first management cycle. However, for these discussions to take place, the Group understands that the structure of the Tropical Tunas Technical Sub-group on MSE needs to be better defined first.

The Group felt that it has not been providing sufficient feedback to the SKJ-W MSE team due to the workload during the assessments, despite several opportunities for discussion. The Group recommended the Tropical Tunas Technical Subgroup on MSE as a solution to receive more timely and detailed feedback as the MSE is finalized this year.

b. Progress of tropical tuna multi-stock MSE

For this MSE, the first development of the simulation framework was presented noting that it was at preliminary stages. The focus was on describing how the three most recent stock assessments for tropical tunas were integrated into a multi-stock framework. The Group provided feedback for the next stages of development for this MSE, including the development of a trial specification document similar to what was done for bluefin, albacore and swordfish MSE processes.

Options for provisional multi-stock management objectives were discussed by the Group, with an understanding that the three tropical tunas stocks should remain at or above B_{MSY} . The Group will request specific input from the Commission on management objectives for the multi-stock MSE, including probabilities and timelines.

The Group agreed that the Tropical Tunas Technical Sub-group on MSE must be better structured and with responsibilities well defined. The general idea of this ad hoc working group is to monitor the steps in developing the MSE simulation frameworks under the Tropical Tunas Species Group. Thus, as a form to try to achieve this minimal organization, there was a small meeting with the Tropical Tunas Species Group scientists interested in contributing and participating in this ad hoc working group. During this intersessional meeting, a general term of reference was presented, discussed, and accepted by the Group to be used as a guide to the Tropical Tunas Technical Sub-group on MSE (**Appendix 5**). The Group recommends that a chair for the Tropical Tunas Technical Sub-group on MSE be nominated.

SCRS/2024/017 presented a summary of the workshops for capacity building for MSE that were focused on tropical tunas and took place in 2023. Two one-day online workshops, one for scientists in June and one for managers in October, were attended by participants from 20 ICCAT CPCs. Workshops were meant to provide an introduction to management procedures, management strategy evaluation, the current state of development of these for tropical tunas, and some exposure to practical tools aimed at understanding the MSE process. The paper also presented recommendations for future capacity building based on participants' responses to the workshop surveys.

The Group discussed the recommendations made about capacity training presented in SCRS/2024/017 and agreed it would be beneficial to provide broader access to the SCRS of the materials presented in ICCAT sponsored training workshops. This could be done by providing links to these materials on the ICCAT webpage, e.g. by having a new training TAB on the webpage. As these workshops have been approved by the SCRS and funded by the Commission there is no need to seek additional approvals for providing such access. Providing this access and modifying the ICCAT webpage will have some cost (e.g. software licenses for learning platform and surveying tools) that should be considered by the SCRS.

The Group also supported the recommendation about including in the Terms of Reference (ToRs) of capacity building for MSE a request to develop a new programme that would facilitate the training of selected scientists through their incorporation in the existing ICCAT MSE technical development teams. The Group discussed that building technical capacity for the implementation of MSEs requires a significant amount of time to be devoted to it. It is therefore important to recognize that participation in such training will have financial implications. Other recommendations for future MSE training included in the presentation of SCRS/2024/017 are consistent with previous recommendations from this Group about the need for training in MSE for tropical tunas.

It was also pointed out that if CPC scientists take an active role in the development of MSEs and Management Procedures (particularly when going beyond reviewing the work to participate in the development), this represents a very substantial commitment in terms of time and labour cost. Also, there are costs involved in the long-term commitments of maintaining and reviewing MPs, and potential problems that may be encountered in maintaining contracts over the long term (e.g. dealing with the limitation of 1 year contracts, maintaining contractors if the contractors are responsible for maintaining the operating models and the analysis tools). It was suggested that this issue be taken up by the Working Group on Stock Assessment Methods; all SCRS Officers are encouraged to participate in the meetings of the Working Group on Stock Assessment Methods.

7. Development of Tropical Tuna Research Plan

7.1 *Tropical Tuna Research Plan*

SCRS/P/2024/015 presented a workplan for the review of the Tropical Tuna Research and Data Collection Program. The plan is to pursue a comprehensive multi-year research programme which will be reviewed annually.

The Group agreed to develop this plan in 2024 according to the following steps: 1) approving a template and re-initiating the Tropical Tunas Species Group; 2) populating the template with the Group and species leads; 3) presenting the plan and finalizing at the Tropical Tunas Species Group meeting in September 2024; and 4) approving of the funding request for the next two years of work by the SCRS plenary.

The template agreed by the Group is provided as **Table 9**, and a request was made for meeting participants to contact the Tropical Tunas Species Group Coordinator if they were willing to be part of the working group to develop this intersessionally.

7.2 *Contracts*

There were a number of discussions about contracts which are summarised below including an ongoing tagging contract in the North-West Atlantic.

During the AOTTP a contract was signed with the University of Maine to tag 5000 tropical tunas in the NW Atlantic. Due to the limited availability of tagging opportunities the contractor requested that the original target number be reduced from 5000 to 2000, and by the end of this contract 1025 fish were tagged. In 2021 there was a request from the SCRS to sign a contract to continue tagging off the NW Atlantic, aiming to reach the target for the region. A Call for Tenders was launched, and a new contract was therefore signed with the same contractor with a completion date of 31 December 2022. However, the Contractor was unable to reach the target (1400), and a change request was made linked to the limited availability of fish in specific areas. The change in the ToRs was accepted by the Group in February 2023, with the approval of new targets by geographical area and agreeing an extension which was sent to the Contractor in July 2023. However, this amendment was never signed since, although the Contractor contacted the Executive Secretary in mid-November 2023, due to an e-mail issue the message never reached the relevant Secretariat staff.

The Secretariat requested guidance from the Group on the way forward. The Group agreed that there is value in tagging in the Northwest Atlantic. However, based on the continued lack of communication, non-compliance with the Terms of Reference of the contract (e.g. non-attendance of SCRS meetings to provide an update on activities and achievements), and limited updates over the last few years, the Group requested that the contract be cancelled. Moreover, the Group agreed to review how to continue this work in the future as part of the Tropical Tuna Research and Data Collection Program.

7.3 *Data collection proposal*

The SCRS Chair presented the draft Terms of Reference (ToRs) of a proposal for the improvement of data collection and reporting in the Caribbean. This work will be fully supported through voluntary financial contributions from the United States, using funds secured through a financial settlement with the company responsible for the 2010 Deepwater Horizon oil spill in the Gulf of Mexico to support restoration projects to address damage to natural resources. This project would address the restoration of highly migratory species stocks through improvements in data collection and reporting to support the management of the fisheries, with the Caribbean region identified as the focus.

The Group acknowledged that this proposal addresses the need to improve data collection and reporting in the Caribbean which was previously identified as a priority by the SCRS. The Group also highlighted the need to engage other SCRS working groups in the discussions of the ToRs. Accordingly, it was agreed that further intersessional work is required to allow relevant parties to review and contribute to the ToRs.

It was agreed that the ToRs will be circulated to the relevant SCRS officers, before being circulated by the Secretariat to the CPCs in the Caribbean region for their input (in the three ICCAT languages), aiming to get an approved version at the Yellowfin Tuna Stock Assessment Meeting. In addition to developing and finalising the ToRs, the Group agreed that further information is required to clarify budgets available and timelines. There was also an acknowledgment by the Group that capacity building and improving data reporting remain an important priority for other CPCs.

7.4 Budget

The Secretariat presented a summary of the 2023 and 2024 spending to date including the remaining budget balance. After review, a number of areas were identified as ongoing or still requiring ToRs. The Secretariat agreed to summarise the outstanding ToRs which have not been drafted yet, with the tropical tuna rapporteurs agreeing to develop the ToRs as soon as possible.

8. Recommendations

a. Research and statistics

The Group recommended that CPCs consider the new iTUNNES research programme funded by the EU to identify opportunities for coordinating their respective sampling programme of biological studies on tropical tunas.

The Group recommended that a workshop be held for tropical tunas PS fisheries on the implementation and use of the updated TT3R version in 2025. The objective is to present the new features of TT3R and the updated AVDTH SQL database, aiming to promote the use and standardization of all tropical tunas for the estimation of catch composition and total catch by all fleets.

The Group recommended that CPCs with tropical fisheries targeting yellowfin, bigeye and skipjack tunas present a summary of current sampling methodologies used on the field, sampling coverage, and what statistical methods are used to estimate catch, catch composition, and size distribution of the catch.

The Group recommended to the Subcommittee of Statistics to consider:

- Eliminating the need to separate reports of task 1NC YFT catches between the East and West sampling areas.
- Whether it is possible to effectively report in Task 1 the lack of activity of a fleet that had catches in the past, recognizing that activity is best reported in Task 2 Catch and Effort.

The Group recommended to improve the research on incorporating spatio-temporal factors in the estimation of standardized CPUE indices of relative abundance. This will permit to better test, among other things, whether abundance and distribution of yellowfin tuna is changing through history and whether such changes may be related to climate change.

The Group recommended the activation of the Tropical Tunas Technical Sub-Group on MSE following the terms of reference, as indicated in **Appendix 5**.

The Group recommended that training materials from ICCAT capacity building workshops be made available to the SCRS through the website. As this has some associated costs, the Group recommends that a budget be prepared that reflects such costs for consideration by ICCAT.

The Group recommended that the TORs for the next capacity building workshop(s) for MSE be prepared in accordance with the recommendations of the Group (Section 6b) and SCRS/2024/017.

b. Management

The Group recommended to the SCRS to request specific input from the Commission on management objectives for the multi-stock MSE, including probabilities and timelines.

9. Responses to the Commission

The Group reviewed the spreadsheet of Active Responses maintained by the Secretariat and also considered a comprehensive list of questions prepared by Panel 1 (**Appendix 6**). The Group noted three active responses to the Commission.

9.1 A response pertaining to the completion of the SKJ-W MSE

The Group will prepare a response describing the progress of the SKJ-W MSE before the SCRS Annual Meeting.

9.2 An update of the MSE Roadmap

The Group will prepare an update of the MSE Roadmap before the SCRS annual meeting.

9.3 An update of the historical FAD set data

With regard to this response, the Secretariat noted that it has already received all the data that are likely to be available from CPCs, and that there may be no new information to improve upon our previous responses. The Group discussed various approaches to inform the Commission about the maximum number of FADs (or FAD sets) that could be deployed and determined that the data to make statistically rigorous evaluations are very limited. The Tropical Tuna Rapporteurs and the Secretariat will explore the available information prior to the Yellowfin Tuna Stock Assessment Meeting in July and will prepare a draft response if possible.

9.4 Panel 1 questions not included in official responses

With regard to the extensive list of requests developed by Panel 1 in 2023 (**Appendix 6**), the Group expressed concerns about the number and complexity of the questions. The SCRS Chair noted that there was little time to discuss, prioritize, or refine the questions before the 2023 SCRS meeting. Moreover, he agreed to bring this to the attention of Second Intersessional Meeting of Panel 1 in May 2024, to determine whether this list can be refined to develop a manageable list of requests. It was also noted the importance of including all these Commission requests under the annual Tropical Tunas Workplan and in coordination with the Secretariat.

10. Other matters

a. Update on SCRS Workshop recommendations

The SCRS Workshop was held from 18-20 March 2024 in Madrid, and included discussion of a broad range of topics relevant to how the SCRS conducts its work. The report of that workshop is being adopted by correspondence, but a list of recommendations that emerged from the discussion was adopted during the workshop. The SCRS Chair provided an overview of those recommendations, highlighting particular recommendations that had relevance to discussions that took place during this Yellowfin Tuna Data Preparatory Meeting or were relevant to this year's stock assessment process.

These highlighted recommendations related to discussions at this meeting included, for example, a call for materials from ICCAT training workshops to be maintained and made available for the use of the SCRS and the Commission. There was also a call for working groups to provide ToRs for research funding requests at the September Species Group meetings, or the latest by the annual Commission meeting so that calls for tender for funded projects can be disseminated early in the following calendar year. There were relevant recommendations that called for reactivating the Ad Hoc Working Group on Tagging and provided additional guidance on the use of electronic tags.

One recommendation emerging from the SCRS Workshop generated discussion during this (Yellowfin Tuna Data Preparatory) meeting. This recommendation called for Working Groups to structure their workplans to allow for modelers to meet online with the other scientists involved in the assessment meeting 2 or more weeks before scheduled assessment meetings. The intent would be to inform Working Groups of any preliminary results or any unplanned decisions that modelers made to improve model performance and to allow the other scientists to request alternative approaches as appropriate.

The Group expressed several concerns regarding this recommendation. There were also concerns that if the time between the online meeting and the assessment meeting was too short, there would be no time to address any requests for additional or modified analyses; therefore, the timing should be greater than two weeks in advance of the assessment meeting. There was also concern that the time available for analysis between the finalization of data for this assessment and any online meeting with the modelers may be too short to advance the analyses sufficiently.

The SCRS Chair clarified that this recommendation was provided for the Group's consideration as a possible approach this year, and has not been adopted by the SCRS as mandatory. In addition, the recommendation calls for this to be considered during the development of the workplan, so in the future perhaps more time between meetings could be considered to facilitate holding this online meeting.

b. Plan for intersessional work related to data improvements

A progress report of the update to the T3 (Tropical Tuna Treatment) process was presented as requested by the Group (SCRS/P/2024/025). This process aims to estimate the catch per species of tropical tuna PS fisheries, based on routine sampling programmes at landings. A summary of historical changes to the procedure can be found in the scientific document by Pianet *et al.* (2000). This document also explains and justifies the changes that have occurred throughout recent history to correctly obtain a specific composition of PS fleet catch. Due to the changing fishing strategy increasing sets on floating objects beginning in 1991, along with the later use of beacons and echosounders, it was necessary to review the sampling programmes at landings. Thus, in the years 1996-97 (Pallarés and Nordstrom, 1997 and Pallarés and Petit, 1998), the specific composition, statistics, size distributions, and conversion procedures from size measure of the 1st dorsal (LD1) to standard fork length (LF) were improved. The T3 programme was originally developed in the Fortran language associated with an ACCESS databases and has been used to correct major tuna catch since then. From 2020, the development of the T3 is performed by the Intersessional Subgroup (ISSG) Tropical Tuna of the EU Regional Coordination Group for Large Pelagics (RCG-LP). This group is composed of EU-Spain, EU-France, Senegal, and the Seychelles scientists who shared a common sampling design, databases, and treatment, including the T3 process.

The T3 process was recently coded in the form of an R package to facilitate its collaborative development and open access to the scientific community. The 2024 version of the package can handle various databases or files as inputs, aiming to be used by any PS fishery having the required data for catch estimation. In particular, a robust sampling of landings is a fundamental piece for the process to be successful. Outputs of the T3 process were formatted to give catch and size distribution data according to the tuna RFMOs standards (ICCAT and IOTC). Preliminary trials on the historical time series have demonstrated consistency in the estimations in comparison with time-series estimates using the previous versions of the T3 process. EU-Spain, EU-France, Senegal, and the Seychelles aim to submit the 2023 catch estimation using the new T3R version.

It was noted that some analyses needed for responses to the Commission rely on catch-at-size (CAS) for all three species and that therefore CPCs should provide CAS for all three tropical tuna species, not just for yellowfin tuna. The Secretariat confirmed that it will provide CAS before the stock assessment meeting. The Group also noted that if the Commission is interested in the effect of changes in selectivity, there are various approaches that could be used, some of which have been loaded into the background documents references (Correa *et al.*, 2023).

11. Adoption of the report and closure

The report was adopted during the meeting. The Chair of the Group thanked all the participants and the interpreters for their efforts. The meeting was adjourned.

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