Collect. Vol. Sci. Pap. ICCAT, 81(2), SCRS/2024/163: 1-6 (2024)

2024 ATLANTIC YELLOWFIN TUNA STOCK ASSESSMENT STOCHASTIC STOCK PROJECTIONS APPLYING A MONTE CARLO APPROACH

M. Lauretta[1], A. Kimoto[2], K. Zipp[3], S. Sagarese[1], D. Courtney[4], A. Urtizberea[5], G. Merino[5], M. Ortiz[2], and S. Cass-Calay[1]

SUMMARY

The stock projection assumptions and settings for Atlantic yellowfin tuna were defined during the Stock Assessment Meeting in July 2024 (Anon., 2024). The Monte Carlo (MC) runs in Stock Synthesis (4,000 total trials) that were used for stock status estimates were projected across 14 different constant catch scenarios; including 0 t, and the range of values between 100,000 and 160,000 t in 5,000 t increments. The MC approach required long computation times; it was therefore necessary to finalize all projection runs intersessionally. This document provides the final projection results (2025-2034) for Atlantic yellowfin tuna, including estimated Kobe 2 strategy matrices.

RÉSUMÉ

Les paramètres et les postulats de projection du stock pour l'albacore de l'Atlantique ont été définis au cours de la réunion d'évaluation du stock en juillet 2024 (Anon., 2024). Les scénarios de Monte Carlo (MC) dans Stock Synthesis (4.000 essais au total) qui ont été utilisés pour les estimations de l'état du stock ont été projetés à travers 14 différents scénarios de prise constante ; y compris 0 t, et la gamme de valeurs entre 100.000 et 160.000 t, par incréments de 5.000 t. L'approche MC a nécessité de longs temps de calcul ; il a donc été nécessaire de finaliser toutes les projections pendant la période intersessions. Le présent document fournit les résultats des projections finales (2025-2034) pour l'albacore de l'Atlantique, y compris les matrices stratégiques estimées de Kobe II.

RESUMEN

Los supuestos y ajustes de proyección de stock para el rabil del Atlántico se definieron en la reunión de evaluación de stock de julio de 2024 (Anon., 2024). Las ejecuciones de Monte Carlo (MC) en Stock Synthesis (4.000 pruebas en total) que se utilizaron para las estimaciones del estado del stock se proyectaron a través de 14 escenarios diferentes de capturas constantes; incluyendo 0 t, y el rango de valores entre 100.000 y 160.000 t en incrementos de 5.000 t. El enfoque MC exigía periodos de cálculo largos, por lo que fue necesario finalizar todas las proyecciones entre sesiones. Este documento proporciona los resultados finales de la proyección (2025-2034) para el rabil del Atlántico, incluidas las matrices de estrategia Kobe 2 estimadas.

KEYWORDS

Atlantic yellowfin tuna; stock synthesis; Monte Carlo; projection

[1] NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division, 75 Virginia Beach Drive, Miami, FL, 33149-1099, USA
[2] ICCAT Secretariat. Calle Corazón de Maria 8, Madrid Spain 28002
[3] UNIVl Miami
[4] NOAA Fisheries, Southeast Fisheries Center, Sustainable Fisheries Division, 3500 Delwood Beach Road, Panama City Beach Florida 32408
[5] AZTI, Marine Research division; Herrera kaia portualdea z/g, 20100 Pasaia (Gipuzkoa), Spain

1. Introduction

During the 2024 Atlantic Yellowfin Tuna Stock Assessment Meeting in July 2024 (Anon., 2024), it was agreed to conduct projections using the same Monte Carlo approach (4,000 iterations in Stock Synthesis) used for estimation of stock status. This approach required a long computation time, therefore the preliminary deterministic projections were provided at the meeting (Anon., 2024) and it was recommended to finalize the projection work intersessionally before the Tropical Tuna Species Group (TTSG) meeting in September. This document provides the projection results based on 4,000 Monte Carlo iterations for Atlantic yellowfin tuna, Kobe 2 strategy matrices, and depletion probabilities (10% or 20% of spawning stock biomass (SSB) at maximum sustainable yield (MSY) or lower) for management advice.

2. Materials and methods

The TTSG provided the 2024 yellowfin tuna stock assessment results based on the Stock Synthesis model applying a Monte Carlo approach for the basis of management advice (Anon., 2024). The TTSG requested to run stock projections based on the 4,000 Monte Carlo iterations. The specifications for the projections were agreed upon during the stock assessment meeting:

- 2023 and 2024 catches set equal to the average of terminal 3 years (141,805 t);
- Projections with different constant catch (landings and dead discards) scenarios started in 2025 and were run for 10 years, ending in 2034;
- 14 different constant catch (landing + dead discards) scenarios, 0 catch and from 100,000 to 160,000 t with an interval of 5,000 t;
- These projected constant catch scenarios by fleet and season (2025-2034) were calculated using the average percentages between 2020 and 2022;
- Projected annual recruitment obtained from the Stock Synthesis reference case stock-recruitment curve (rec dev = 0); The projected relative proportion of annual recruitment between seasons obtained from the Stock Synthesis reference case model is constant.
- Fleet selectivity equivalent to the average of the terminal 3 years (2020-2022) from the Stock Synthesis reference case

3. Results

The Monte Carlo projections took several days to run, and the process was optimized over multiple iterations. The most efficient process involved parallel processing of SS runs at the fixed parameter estimates from the 4,000 trials, and varying only the future constant catch scenarios between 2025 and 2034. Furthermore, it was important to iteratively delete individual run files (after extracting the derived quantities using r4ss and saving as csv files of size ~20KB, compared to saving individual SS runs at ~100MB each). Otherwise, the total drive space required to run the 4,000 runs across 14 catch scenarios exceeded 2 TB of storage. Furthermore, reading and compiling 56,000 csv files took a couple of minutes, compared to compiling SS report files.

A small proportion of runs (~1%) showed divergent stock projections toward the end of the projected years, involving scenarios where biomass was heavily depleted (<1000 t), then increased sharply to implausibly high estimates the following year. These runs were corrected to assume that once heavily depleted, the stock would remain depleted under that catch scenario. The occurrence of these errored trials was non-systematic, albeit observed in a very small fraction of runs. The corrections had little effect on estimated Kobe matrix percentiles, given the large MC resample size, but the effect may be noted for future MC runs using lower sample sizes.

The estimated Kobe 2 strategy matrices and the trends of joint projected relative stock biomass and fishing mortality are presented in **Table 1** and **Figure 1**, respectively. Constant catch scenarios of 125,000 t and less resulted in greater than 54% probability of the stock remaining in the green quadrant (not overfishing and not overfished) between 2025 and 2034. Catches of 130,000 t and greater were projected to result in less than 50% probability of green quadrant at the end of 2034. The probability of stock depletion below 10% and 20% of the spawning biomass at MSY was predicted across constant catch scenarios (**Tables 2** and **3**). Constant catches of 125,000 t and lower resulted in less than 5% predicted probability of stock depletion below the defined thresholds. Risk of stock depletion increased notably (to greater than 10% depletion risk) for catch scenarios at 140,000 t and higher. It should be noted that the probability thresholds reported, 50% probability of being in the green quadrant and stock depletion at 10% and 20% of spawning biomass that supports MSY, were selected for informational purposes and have not been adopted formally by the SCRS for tropical tunas.

References

Anonymous. 2024. Report of the 2024 ICCAT Yellowfin tuna stock assessment meeting. Collect. Vol. Sci. Pap. ICCAT 81(2):1-137.

Table 1. Estimated probabilities of the Atlantic yellowfin tuna stock being below F_{MSY} (overfishing not occurring), above B_{MSY} (not overfished), and above B_{MSY} and below F_{MSY} (green zone) in a given year for a given catch level (0, 100,000 - 160,000 t), based upon the Monte Carlo projections of Stock Synthesis.

Probability $F < F_{MSY}$

Catch	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
0kt	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
100kt	92%	91%	90%	89%	89%	89%	88%	88%	88%	88%
105kt	90%	89%	87%	86%	85%	85%	84%	83%	83%	82%
110kt	88%	86%	84%	82%	81%	80%	79%	77%	76%	75%
115kt	86%	83%	81%	79%	76%	74%	72%	70%	68%	67%
120kt	83%	80%	77%	74%	71%	67%	65%	63%	62%	61%
125kt	81%	77%	73%	69%	65%	62%	60%	58%	56%	55%
130kt	78%	74%	68%	64%	60%	57%	55%	53%	51%	49%
135kt	75%	70%	64%	60%	56%	53%	50%	48%	46%	44%
140kt	71%	66%	61%	56%	51%	48%	45%	44%	42%	41%
145kt	68%	63%	57%	52%	48%	44%	42%	41%	39%	38%
150kt	65%	60%	54%	48%	44%	42%	39%	38%	36%	35%
155kt	62%	56%	51%	45%	42%	39%	37%	35%	34%	33%
160kt	60%	54%	47%	43%	39%	36%	34%	33%	31%	30%

Probability $B > B_{MSY}$

Catch	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
0kt	93%	94%	97%	99%	100%	100%	100%	100%	100%	100%
100kt	90%	87%	86%	85%	85%	85%	85%	85%	84%	84%
105kt	89%	87%	85%	84%	83%	82%	81%	81%	80%	80%
110kt	89%	86%	84%	82%	81%	79%	78%	76%	75%	74%
115kt	89%	86%	83%	81%	78%	76%	74%	72%	69%	67%
120kt	89%	85%	82%	78%	75%	72%	69%	66%	64%	62%
125kt	89%	85%	81%	76%	72%	68%	64%	61%	59%	57%
130kt	89%	84%	80%	74%	70%	64%	60%	57%	54%	52%
135kt	88%	84%	78%	72%	66%	60%	56%	53%	50%	48%
140kt	88%	84%	77%	70%	63%	57%	53%	49%	46%	44%
145kt	88%	83%	76%	68%	59%	54%	49%	45%	43%	41%
150kt	88%	82%	74%	66%	56%	50%	46%	43%	40%	38%
155kt	87%	82%	73%	63%	54%	47%	43%	40%	38%	36%
160kt	87%	81%	72%	61%	51%	44%	41%	37%	35%	34%

Probability $F < F_{MSY}$ and $B > B_{MSY}$

Catch	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
0kt	93%	94%	97%	99%	100%	100%	100%	100%	100%	100%
100kt	90%	87%	86%	85%	85%	85%	85%	85%	84%	84%
105kt	89%	87%	85%	84%	83%	82%	81%	81%	80%	80%
110kt	88%	86%	84%	82%	80%	79%	78%	76%	75%	74%
115kt	86%	83%	81%	79%	76%	74%	72%	70%	68%	66%
120kt	83%	80%	77%	74%	71%	67%	65%	63%	62%	61%
125kt	81%	77%	73%	69%	65%	62%	60%	58%	56%	55%
130kt	78%	74%	68%	64%	60%	57%	55%	53%	51%	49%
135kt	75%	70%	64%	60%	56%	53%	50%	48%	46%	44%
140kt	71%	66%	61%	56%	51%	48%	45%	44%	42%	41%
145kt	68%	63%	57%	52%	48%	44%	42%	41%	39%	38%
150kt	65%	60%	54%	48%	44%	42%	39%	38%	36%	35%
155kt	62%	56%	51%	45%	42%	39%	37%	35%	34%	33%
160kt	60%	54%	47%	43%	39%	36%	34%	33%	31%	30%

Table 2. Estimated probabilities of biomass < 10% of SSB at MSY for the Atlantic YFT stock, estimated across the 4,000 Stock Synthesis Monte Carlo runs in a given year for a given catch level (0, 100,000 – 160,000 t).

Probability of B < 10% of B_{MSY}

Catch	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
0kt	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100kt	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%
105kt	0%	0%	0%	0%	0%	0%	0%	1%	1%	1%
110kt	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%
115kt	0%	0%	0%	0%	0%	0%	1%	1%	1%	2%
120kt	0%	0%	0%	0%	0%	1%	1%	1%	2%	2%
125kt	0%	0%	0%	0%	0%	1%	1%	2%	2%	4%
130kt	0%	0%	0%	0%	0%	1%	1%	2%	4%	5%
135kt	0%	0%	0%	0%	1%	1%	2%	3%	5%	7%
140kt	0%	0%	0%	0%	1%	1%	2%	4%	7%	9%
145kt	0%	0%	0%	0%	1%	2%	3%	6%	9%	12%
150kt	0%	0%	0%	0%	1%	2%	4%	7%	11%	16%
155kt	0%	0%	0%	0%	1%	2%	5%	9%	14%	20%
160kt	0%	0%	0%	1%	1%	3%	7%	11%	18%	25%

Table 3. Estimated probabilities of biomass < 20% of SSB at MSY for the Atlantic YFT stock, estimated across the 4,000 Stock Synthesis Monte Carlo runs in a given year for a given catch level (0, 100,000 – 160,000 t).

Probability of B < 20% of B_{MSY}

Catch	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
0kt	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
100kt	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%
105kt	0%	0%	0%	0%	0%	1%	1%	1%	1%	1%
110kt	0%	0%	0%	0%	0%	1%	1%	1%	1%	2%
115kt	0%	0%	0%	0%	1%	1%	1%	1%	2%	3%
120kt	0%	0%	0%	0%	1%	1%	1%	2%	3%	4%
125kt	0%	0%	0%	0%	1%	1%	2%	3%	4%	5%
130kt	0%	0%	0%	0%	1%	1%	2%	4%	5%	7%
135kt	0%	0%	0%	1%	1%	2%	3%	5%	7%	10%
140kt	0%	0%	0%	1%	1%	2%	4%	6%	9%	13%
145kt	0%	0%	0%	1%	2%	3%	5%	8%	12%	17%
150kt	0%	0%	0%	1%	2%	4%	7%	10%	15%	21%
155kt	0%	0%	0%	1%	2%	5%	8%	13%	20%	26%
160kt	0%	0%	0%	1%	3%	6%	10%	16%	24%	32%

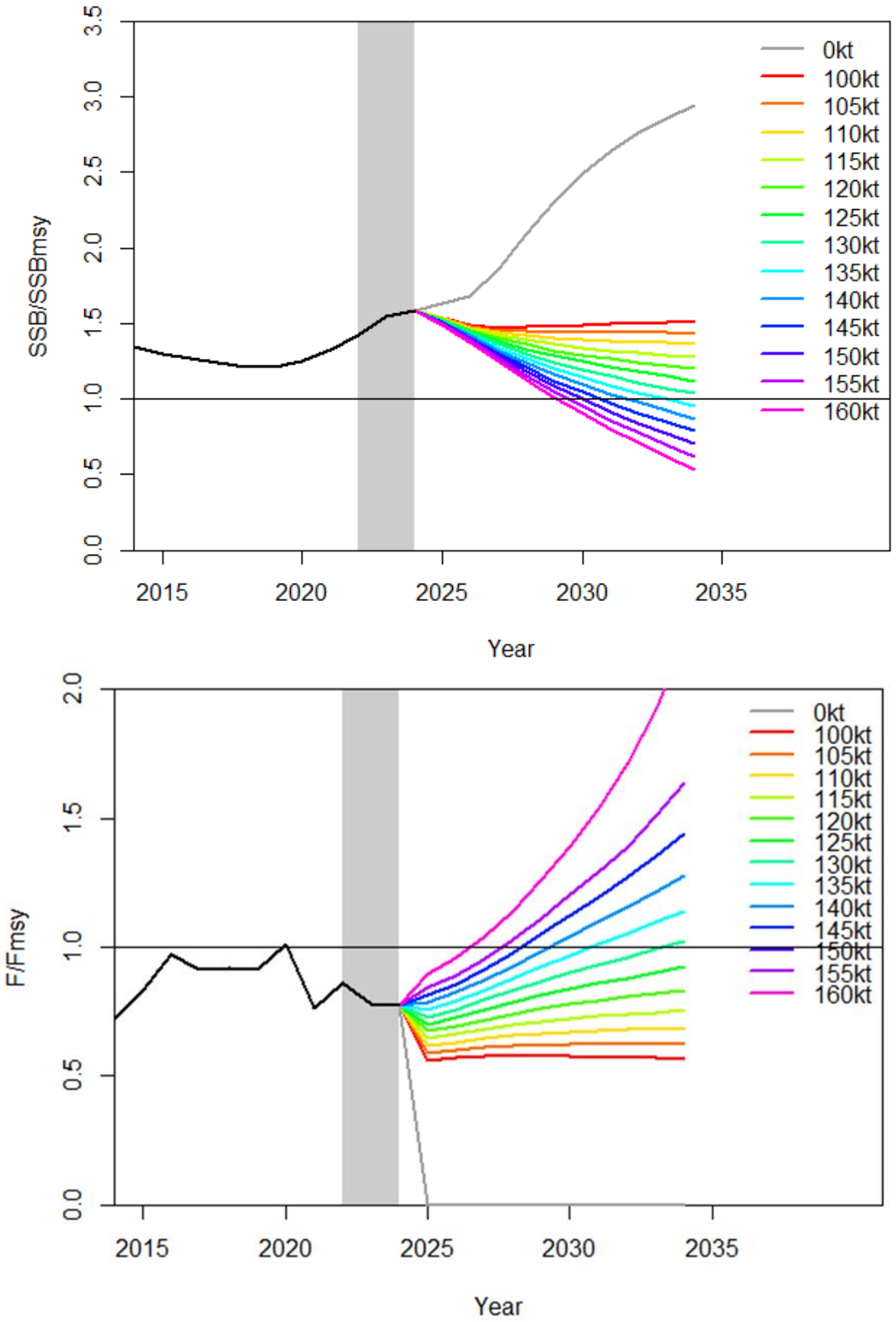

Figure 1. Trends of projected relative stock biomass (upper panel, B/B_{MSY}) and fishing mortality (bottom panel, F/F_{MSY}) for Atlantic yellowfin tuna under different fixed catch scenarios of 0 and 100,000–160,000 t, based upon the Monte Carlo projections of Stock Synthesis. Each line represents the median of the 4,000 Monte Carlo iterations by projected year.