WESTERN ATLANTIC BLUEFIN TUNA VIRTUAL POPULATION ANALYSIS STOCK PROJECTIONS[1]

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SUMMARY

This report documents the 2020 stock projections of West Atlantic bluefin tuna based on the results of the virtual population analysis. The SCRS Bluefin Tuna Species Group reviewed the projection model assumptions and settings via webinar during May 14-22, 2020. Analysts posted the projection files and results to the Bluefin Tuna Species Group meeting cloud-based drive on June 27, 2020. The current fishery status (2015-2017 status) is not overfishing (94% probability). However, stock projection at recent recruitments indicated a future decline in abundance and biomass. The projected yields at the target fishing mortality ($F_{0.1}$=0.13) were notably lower than current yields, with annual decreases predicted between 2020 and 2023. Yields at the current total allowable catch (2,350 metric tons) resulted in a high probability of overfishing in 2021 to 2023. We note that the final yield advice will integrate results from both the virtual population analysis and Stock Synthesis models. The Group will complete that task during the July 20-28, 2020 intersessional meeting.

RÉSUMÉ

Ce rapport documente les projections du stock de thon rouge de l'Atlantique Ouest pour 2020 sur la base des résultats de l'analyse de la population virtuelle. Le Groupe d'espèces sur le thon rouge du SCRS a examiné les hypothèses et les configurations du modèle de la projection via un webinaire du 14 au 22 mai 2020. Les analystes ont publié les fichiers et les résultats de la projection sur le dossier cloud de la réunion du Groupe d'espèces sur le thon rouge le 27 juin 2020. L'état actuel de la pêcherie (état de 2015-2017) n'est PAS de SURPÊCHE (94% de probabilité). Toutefois, les projections de stocks lors des récents recrutements ont indiqué une baisse future de l'abondance et de la biomasse. Les productions prévues avec la mortalité par pêche cible ($F_{0,1}$=0,13) étaient nettement inférieures aux productions actuelles, avec des diminutions annuelles prévues entre 2020 et 2023. Les productions avec le total des prises admissible actuelles (2.350 t) ont entraîné une forte probabilité de surpêche de 2021 à 2023. Nous notons que l'avis final sur la production intégrera les résultats des modèles d'analyse de la population virtuelle et de Stock Synthesis. Le Groupe s'acquittera de cette tâche lors de la réunion intersessions du 20 au 28 juillet 2020.

RESUMEN

En el presente informe se documentan las proyecciones de 2020 para el stock de atún rojo del Atlántico occidental basadas en los resultados del análisis de la población virtual. El Grupo de especies de atún rojo del SCRS revisó los supuestos y la configuración del modelo de proyección durante un seminario on line celebrado entre el 14 al 22 de mayo de 2020. Los analistas publicaron en ownCloud los archivos de la proyección y los resultados durante la reunión del Grupo de especies de atún rojo que se celebró el 27 de junio de 2020. El estado actual de la pesquería (estatus 2015-2017) es de NO SOBREPESCA (94 % de probabilidad). Sin embargo, la proyección del stock con los reclutamientos recientes indicaba una futura disminución de la abundancia y la biomasa. Los rendimientos proyectados con la mortalidad por pesca objetivo

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($F_{0,1}$=0,13) fueron notablemente inferiores a los actuales, con disminuciones anuales previstas entre 2020 y 2023. Los rendimientos con el total admisible de captura actual (2.350 t) dieron lugar a una alta probabilidad de sobrepesca de 2021 a 2023. Cabe señalar que el asesoramiento sobre el rendimiento final integrará los resultados de los modelos de análisis de población virtual y de stock synthesis. El Grupo completará esa tarea durante la reunión intersesiones que se celebrará del 20 al 28 de julio de 2020.

KEYWORDS

Stock assessment, projection, bluefin tuna, West Atlantic

1. Introduction

The SCRS Bluefin Tuna Species Group (Group) reviewed the results of the West Atlantic bluefin tuna (WBFT) virtual population analyses (VPA) via webinar during May 14-22, 2020. At that time, the Group determined the base VPA settings, and stock projection assumptions. During the period of intersession, the analytical team finalized the VPA and stock projection results, and posted the results to the cloud-based drive on June 27, 2020. The VPA covered the period 1974 to 2018, and the stock projections covered the period 2019 to 2025. This report serves as documentation of the methods and results of the stock projections of WBFT, for review by the SCRS during the July intersessional meeting.

2. Projection Methods

Stock projections integrated the VPA bootstrap iterations of fishing mortality-at-age and abundance-at-age using Pro-2Box software (Porch 2017). SCRS/2020/119 documented the methods applied in the VPA. Recent and future recruitments varied around a geometric mean, calculated separately by model iteration, based on 2010 to 2015 VPA bootstrap estimates (i.e. the 6-year recent average recruitment excluding the terminal three years of the VPA). We modeled recruitment deviations as a stochastic random deviate of the geometric mean recruitment, assuming first-order multiplicative (lognormal) auto-correlation. The standard deviation (sigmaR) varied by VPA bootstrap iteration, in addition to the mean. We replaced recruitment estimates for recent years, 2016 to 2018, with the mean recruitment. We evaluated short-term (three-year) yield projections at two reference fishing mortality rates: $F_{current}$ (geometric mean fishing mortality-at-age during 2015 to 2017) and $F_{0.1}$. We calculated the annual probability of not overfishing as the number of bootstrap iterations that resulted in an apical fishing mortality less than or equal to $F_{0.1}$ across the range of total allowable catches (0 to 3000 mt by 250 mt increments). The following list summarized the projection assumptions.

- Future recruitment assumption:
    - The 2017 benchmark used a geometric mean of the recent 6-yr period, excluding the terminal 3-yrs (2007-2012) and so for continuity purposes, the current update used the 2010 to 2015 mean recruitment for projections
    - The 3-year recent recruitments (2016-2018) were replaced with the mean
- Fleet selectivity: geometric mean of 2015 to 2017 selectivities
- Fishery status based on F current, the geometric mean apical F for years t-1 to t-3 (i.e. 2015 to 2017)
- Fixed yield scenarios ranged from 0 to 3000 mt by 250 mt increments
- Two constant exploitation scenarios, $F_{0.1}$ and $F_{current}$
- 2019 and 2020 catches assumed equal to 2,350 mt
- 5-year forecast (2021 to 2025) of fishing mortality, total stock biomass, and spawning biomass is estimated across constant catch and fishing mortality scenarios
- 3-year projected yields at F0.1
- 80% confidence intervals of F0.1, fishery status, and projected yields reported
- The Kobe strategy matrix for final SCRS advice will based on 1,000 combined model bootstraps including,
    - 500 bootstraps from the VPA (young spawn and older spawn scenarios produced equal estimates of abundance and yield).

- 250 from Stock Synthesis young spawn scenario
- 250 from Stock Synthesis older spawn scenario

3. Projection Results

Mean recent (2010 to 2015) recruitment estimates ranged between approximately 44,000 to 65,000 age-1 fish (80% confidence interval of bootstrap iterations); sigma R ranged 0.51 to 0.63. Recruitment (median = 53,300 age-1 fish) declined compared to the 2017 projections (median = 94,400 age 1-fish, **Figure 1**). Current fishing mortality ($F_{current}$) equaled 0.10 (80% confidence interval of 0.08 to 0.13, **Table 1**). The estimated fishing mortality reference point ($F_{0.1}$) equaled 0.13 (80% confidence interval of 0.11 to 0.15). Both fishing mortality metrics increased compared to the 2017 assessment (2017 $F_{current}$ = 0.08 and 2017 $F_{0.1}$ = 0.11). The median estimate of $F_{current}$ relative to $F_{0.1}$ equaled 0.80 (80% confidence interval of 0.68 to 0.96). The current fishery status is NOT OVERFISHING (94% probability, **Figure 2**). However, apical fishing mortality (F_{apical}, the maximum annual fishing mortality-at-age) increased between 2013 and 2018 with fishing mortality on select ages predicted to be higher than $F_{0.1}$ during the terminal two years of the VPA (**Figure 3**). Constant catch scenarios of 2,250 mt and higher resulted in increased F_{apical} in 2021 (**Figure 4**).

Estimates of recent low recruitments (**Figure 1**) signaled near-term decline in total stock (**Figure 5**), and spawning stock biomass (**Figure 6**). The decline occurred under all constant catch scenarios above 500 mt (**Figure 5**). The young spawning biomass scale and trend matched total biomass, indicating ages 4 and older comprised the majority of the stock biomass. The older spawner abundance and biomass decreased in all projection scenarios, due to eleven years of declining recruitment (i.e. between 2004 and 2015), and fewer individuals aging into that older spawner group.

Projected yields at $F_{0.1}$ were markedly lower than the current total allowable catch limit (2,350 mt), with annual decreases predicted between 2020 and 2023 (**Table 1**). Yields at the current total allowable catch resulted in a high probability of overfishing in 2021 to 2023 (95% or greater) (**Table 2**). We note that the final advice matrix will integrate results from both VPA and Stock Synthesis models. The Group will complete that task during the July 20-28, 2020 online meeting, after review and adoption of the projection models.

4. Acknowledgements

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Table 1. Current fishery status (2015-2017), projected recruitment (numbers of age-1 fish), and projected yields (2021-2023) of bluefin tuna in the West Atlantic at a constant fishing mortality rate ($F_{0.1}$=0.13) assuming recruitment varies around a 6-yr recent recruitment level (mean of 2010 to 2015 VPA estimates). Values in parentheses are the 80% confidence intervals across bootstraps.

F_current (2015-17)	0.10 (0.08-0.13)
F_0.1	0.13 (0.11-0.15)
F_current/F_0.1	0.80 (0.68-0.96)
Fishery Status	NOT OVERFISHING
Recruitment Period	6-yr_mean_2010-2015
Projected Recruits 2021	49,950 (25,460-109,600)
Projected Recruits 2022	53,130 (24,200-112,300)
Projected Recruits 2023	55,120 (26,160-110,700)
Projected_Yield_F0.1_2021	1,670 mt (1,317-2,102)
Projected_Yield_F0.1_2022	1,520 mt (1,196-1,918)
Projected_Yield_F0.1_2023	1,405 mt(1,099-1,775)

Table 2. Probability of not overfishing (F≤F0.1) bluefin tuna in the West Atlantic by constant total allowable catch (TAC) scenario, assuming recent 6-yr mean (2010 to 2015 VPA estimates) recruitment in stock projections.

TAC Scenario	2021	2022	2023	2024	2025
0 mt	100%	100%	100%	100%	100%
250 mt	100%	100%	100%	100%	100%
500 mt	100%	100%	100%	100%	100%
750 mt	100%	100%	100%	100%	100%
1000 mt	100%	98%	96%	93%	92%
1250 mt	93%	87%	76%	66%	61%
1500 mt	70%	54%	40%	31%	26%
1750 mt	42%	27%	14%	8%	7%
2000 mt	19%	7%	3%	2%	2%
2250 mt	5%	2%	1%	0%	0%
2350 mt	3%	1%	0%	0%	0%
2500 mt	2%	1%	0%	0%	0%
2750 mt	1%	0%	0%	0%	0%
3000 mt	0%	0%	0%	0%	0%

Recent Recruitment Levels

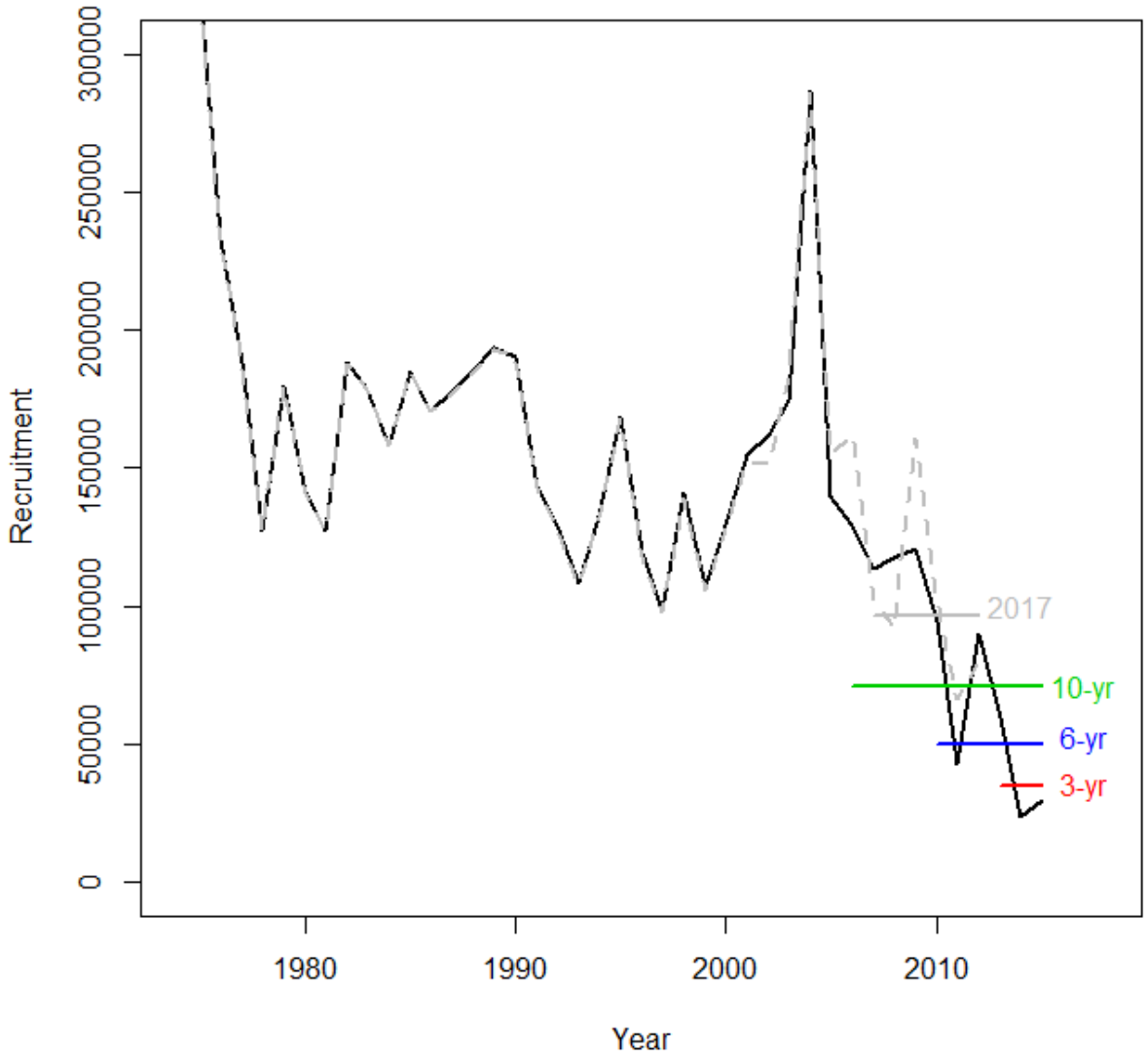

Figure 1. VPA recruitment estimates of bluefin tuna in the West Atlantic (black line). The colored lines denote the geometric mean of three periods: 3-yr (2013-2015, red line), 6-yr (2010-2015, blue line), and 10-yr (2006-2015, green line). Projections assumed the 6-yr recruitment mean (blue line) for 2016 to 2025 recruitments. The dashed gray line plots the estimated recruitments from the last assessment in 2017, and the horizontal solid gray line shows the mean recruitment used in the 2017 projections.

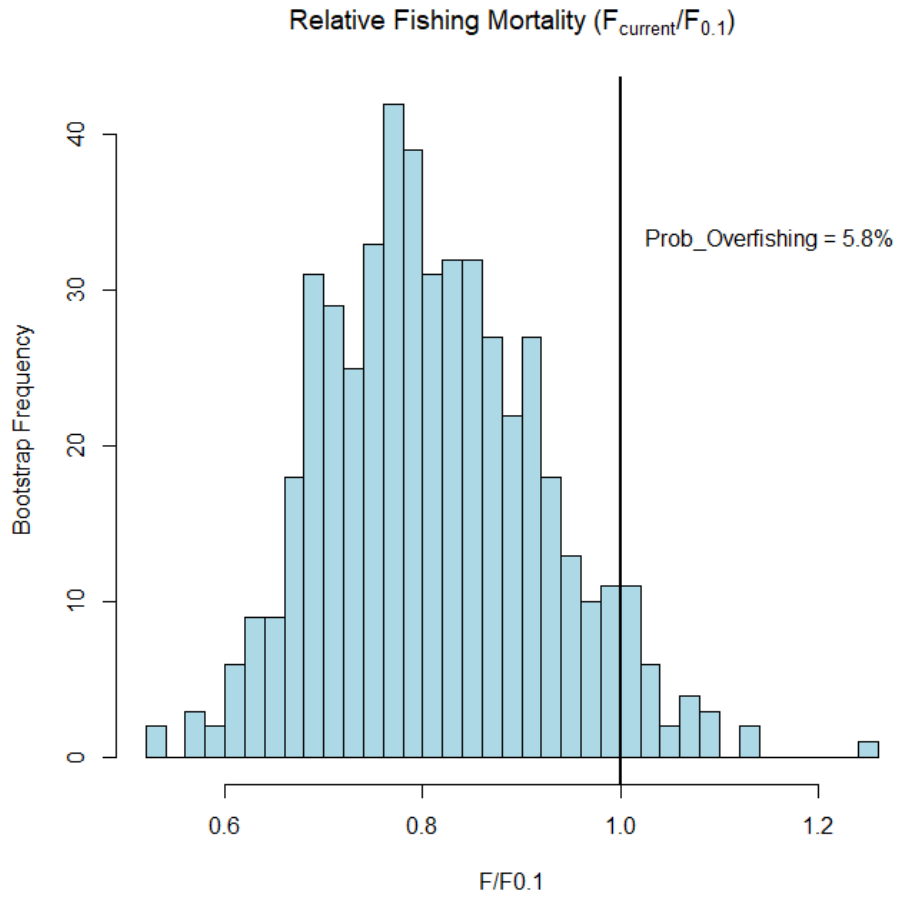

Figure 2. Frequency distribution of relative F ($F_{current}/F_{0.1}$) of bluefin tuna in the West Atlantic, estimated across VPA bootstraps. The vertical black line shows the overfishing threshold ($F_{current}=F_{0.1}$).

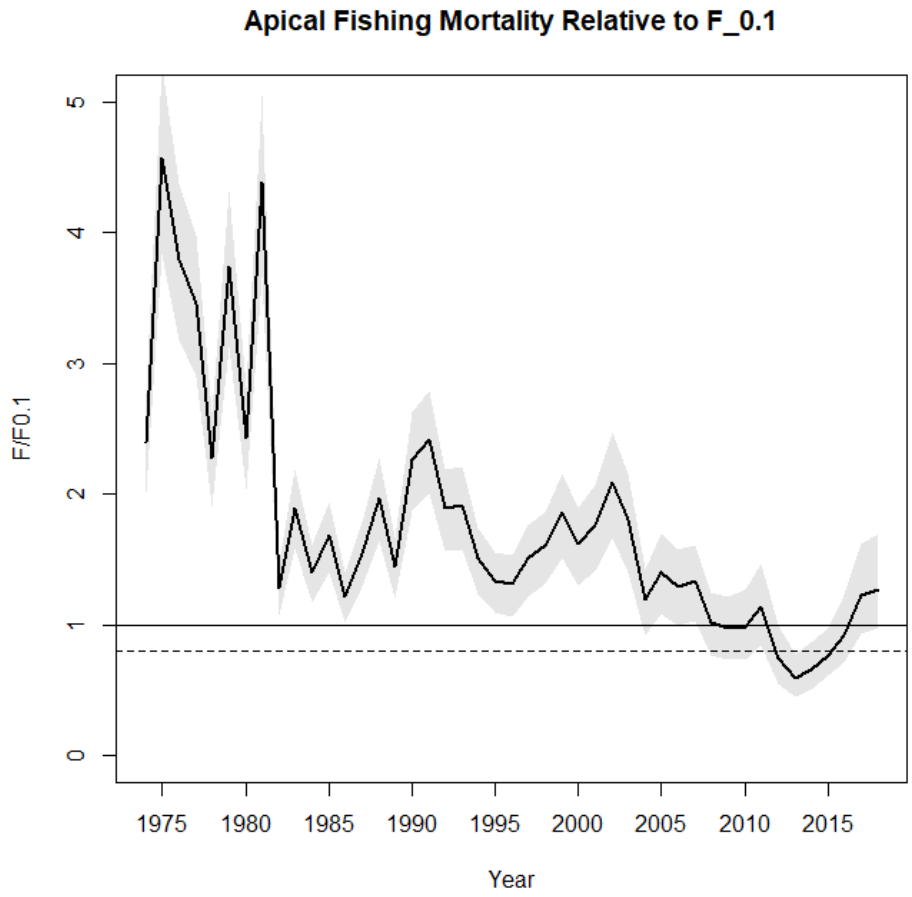

Figure 3. Apical fishing mortality estimates of bluefin tuna in the West Atlantic during 1974 to 2018. The black line indicates the median of the VPA bootstraps, the solid horizontal line represents the overfishing threshold ($F_{current}=F_{0.1}$), the dashed horizontal line denotes $F_{current}$, and the gray shaded region displays the 80% confidence intervals.

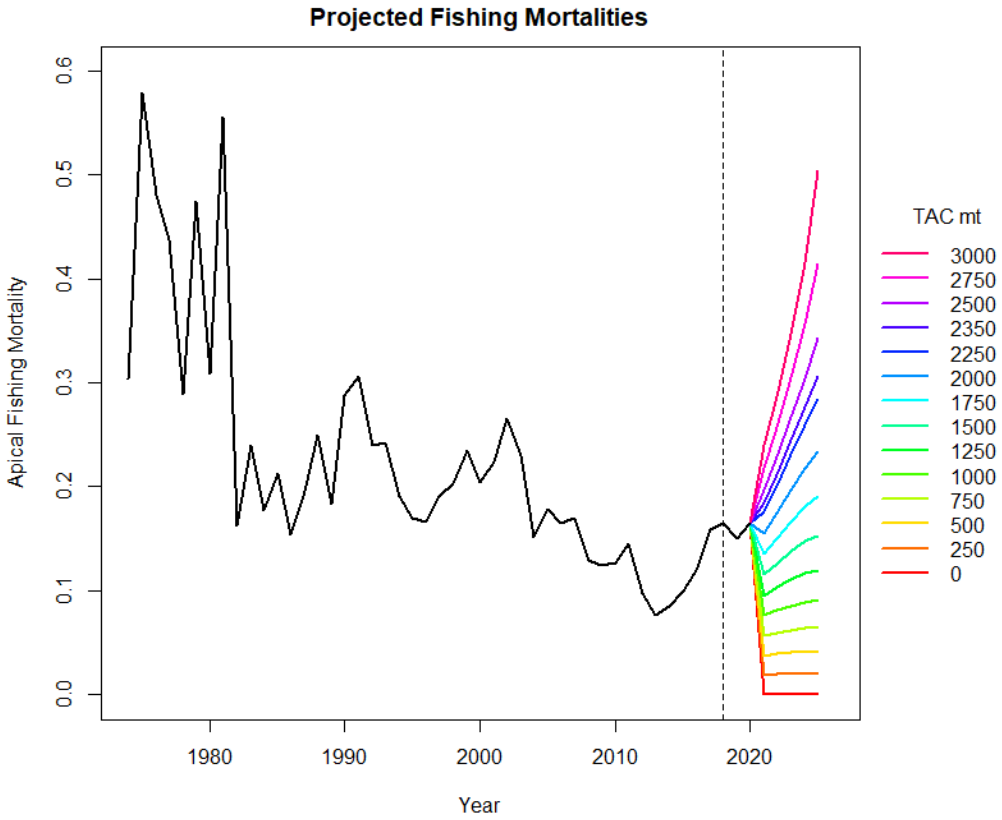

Figure 4. Predicted apical fishing mortality of bluefin tuna in the West Atlantic under alternative constant total allowable catch (TAC) scenarios. The dashed vertical line denotes the terminal year of the VPA (2018) and start of the projection period.

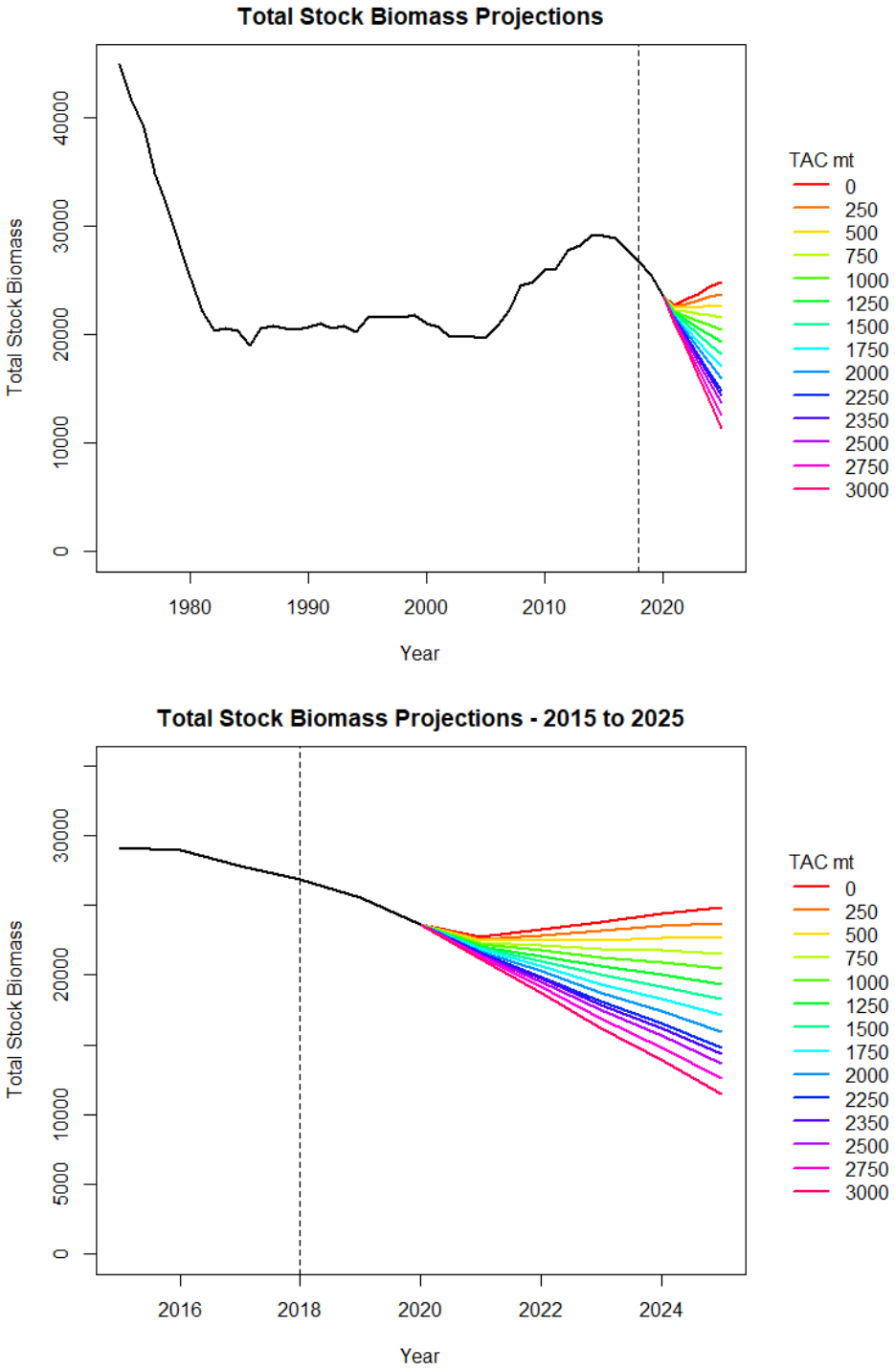

Figure 5. Projected total biomass of bluefin tuna in the West Atlantic under alternative constant total allowable catch (TAC) scenarios. The dashed vertical line indicates the terminal year of the VPA (2018) and start of the projection period. Upper panel: entire time series, lower panel: zoomed in to 2015 to 2025.

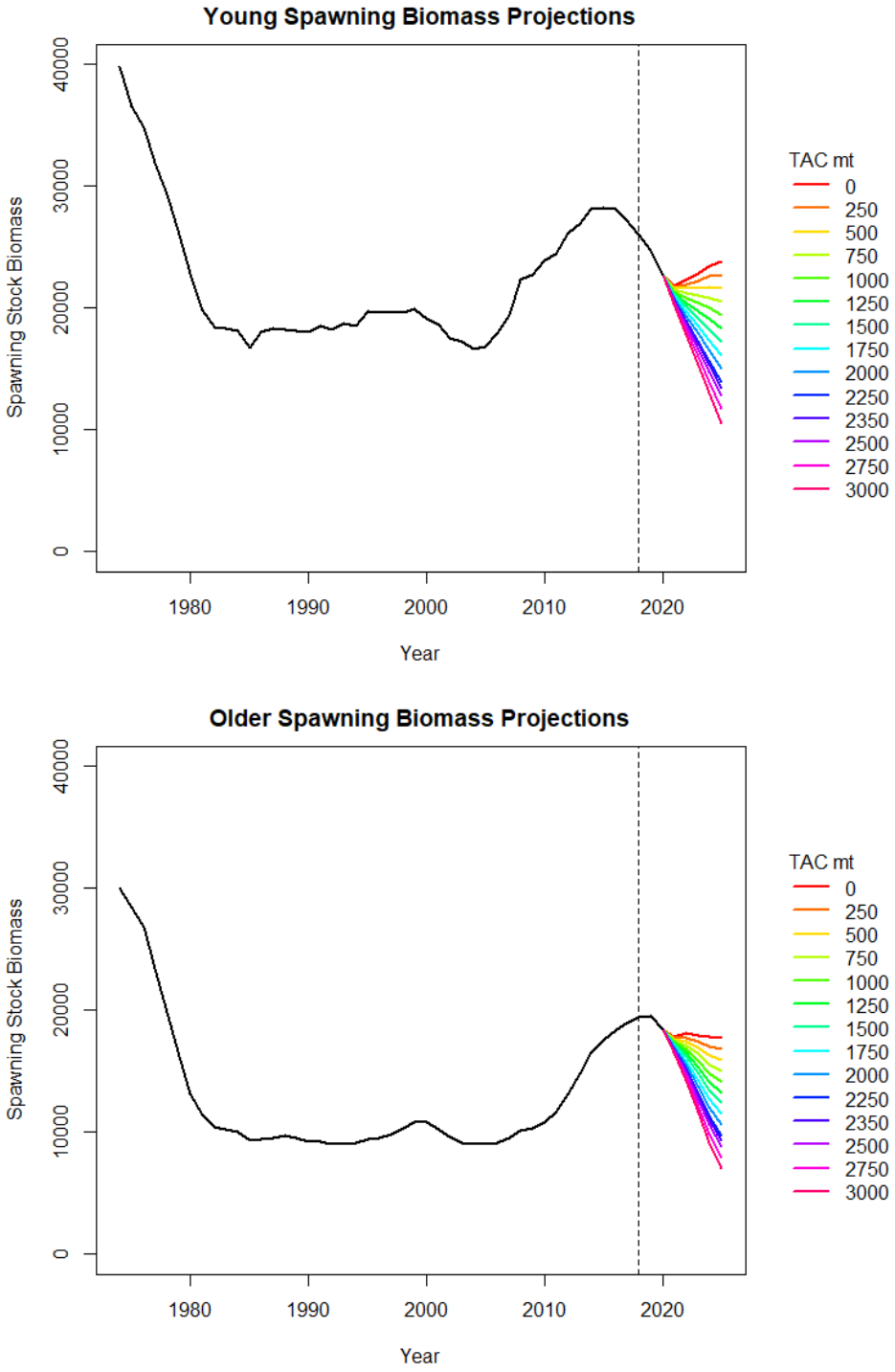

Figure 6. Projected spawning stock biomass of bluefin tuna in the West Atlantic under alternative constant total allowable catch (TAC) scenarios. Upper panel: young spawning scenario, lower panel: older spawning scenario.