Atlantic Bluefin Tuna MSE – Results, Decisions, & Next Steps

Executive Summary

This document presents updated results from the Atlantic bluefin tuna management strategy evaluation (MSE) process from new analyses conducted to address feedback received at the Second Intersessional Meeting of Panel 2 on Bluefin Tuna Management Strategy Evaluation (BFT MSE), held online from 9-10 May 2022. The intention is to provide sufficient information to facilitate discussion among scientists, fishery managers and stakeholders, as well as decision-makers, at the Third Intersessional Meeting of Panel 2 on Bluefin Tuna Management Strategy Evaluation, to be held online on 14 July 2022 meeting.

Candidate Management Procedures

There are currently 6 candidate management procedures (CMPs) under development by the SCRS (**Table 1**). All calculate separate total allowable catches (TACs) for the West and East management areas. The SCRS rigorously reviewed all available western and eastern indices, resulting in two indices being deemed unsuitable in their present condition to be used for CMP inputs. After this, the choice of indices used in each CMP has been at the discretion of developers with emphasis placed on whether the CMPs perform well when using these indices. We present recent results from 6 CMPs to show key performance tradeoffs for management objectives in a 'quilt plot' (**Figure 1**) that ranks the most recent results of these CMPs on 5 key performance statistics for both East and West. A second plot (**Figure 2**) includes 10 additional statistics for background. The performance statistics are described in **Table 2**.

The agenda of the Third Intersessional Meeting of Panel 2 on Bluefin Tuna Management Strategy Evaluation (online, 14 July 2022) specifies four main decision points:

- Decision point 1 (Item 6.a of PA2_BFT_MSE_JUL_01/i2022): 2-year vs. 3-year management cycle and symmetric stability

    - 3-year management cycles were tested for 2 CMPs: BR and TC. The results for the BR CMP variants tuned to a common LD*15 value are shown in **Table 3** and summarized below.
    - The 3-year cycle was slower to react to signals to decrease TAC and thus had lower 50%ile biomass status (Br30) and slightly reduced AvC30 coupled with slightly higher variability in TAC changes.
    - To compensate, the SCRS explored greater allowable TAC reductions (+20%/-35% stability) that improved Br30 status slightly for both eastern and western stocks.
    - Performance was only slightly inferior and practical considerations (stability, reduced administrative burden) may support a 3-year management cycle; *this decision should be made at this meeting to facilitate further CMP development and SCRS notes that this will be time consuming for all developers to implement.*
    - The Second Intersessional Meeting of Panel 2 on Bluefin Tuna Management Strategy Evaluation (BFT MSE), held online from 9-10 May 2022, requested the SCRS to evaluate a symmetrical stability provision of +/-20% compared to the default +20%/-30%. The +20/-20 option was slower to implement necessary TAC decreases and thus had lower yield and biomass performance (i.e., greater risk) (**Table 4**). The SCRS has not yet evaluated +20/-20 with a 3-year cycle but expects performance to be worse, since not even +20/-30 had satisfactory performance in terms of agreed to B_{LIM} requirements. Nonetheless, to facilitate further CMP development, *Panel 2 should decide at this meeting whether symmetrical stability provisions are required.*

- Decision point 2 (Item 6.b of PA2_BFT_MSE_JUL_01/i2022): Incorporation of 'phase-in' as default

    - Per PA2 guidance in May, all CMPs were tested with a phase-in (i.e., limiting any downward TAC change to 10% for the first two 2-year management cycles). The phase-in made little difference to long-term biomass (risk) or yield outcomes, and thus is confirmed as a viable approach; *this decision should be made at this meeting to facilitate further CMP development.*

- Decision point 3 (Agenda Item 6.c of PA2_BFT_MSE_JUL_01/i2022): Culling of CMPs that fail thresholds defined in the 2nd Intersessional Meeting of Panel 2 on BFT MSE (9-10 May 2022)

    - Lowest depletion, LD* (>15% probability of falling below B_{LIM}, i.e., 40% of dynamic SSB_{MSY})

        - Two CMPs (i.e., EA and TN) were withdrawn by their developers due to difficulties in meeting this LD* 15% threshold; *this decision to remove these CMPs has been made by their individual developers so no decision is necessary by Panel 2.*

    - 60% PGK (i.e., probability of being in the green quadrant of the Kobe matrix in year 30)

        - All 6 CMPs meet or nearly meet this (**Figure 1**) for the default tuning level (median Br30 of 1.25 for the western stock and 1.50 for the eastern).

- Decision point 4: Culling of lowest performing CMPs

    - Of the 6 presented CMPs, does Panel 2 want to cull any now? *The SCRS does not expect any culling to occur now.*

    - Examining the quilt plots in **Figures 1** and **2**, are there certain performance statistics or trends that are considered undesirable, concerning or unacceptable by PA2?

Feedback is also sought on the following points related to CMP structure and behavior and the path forward:

- Preferences on yield path

    - Recent high abundance is expected to result in increased catches (both in the East and the West) in the short term, followed by a decline. Should the possibility of reducing the size of the peak of this pulse in TACs to spread it over a longer period be investigated?

- Index selection for CMPs

    - Number of indices: Some CMPs use all 10 of the approved indices to set TACs, while others use as few as 2 per management area (**Figure 1**).

- Performance tuning

    - The SCRS will discuss the process of performance tuning to achieve higher yield performance while meeting minimum safety and status objectives.

- Process for obtaining feedback from CPCs of their stakeholder preferences relative to CMP decisions (see also Next steps below)

    - How may the SCRS assist in CPC-planned stakeholder outreach?

Next steps

After the Third Intersessional Meeting of Panel 2 on Bluefin Tuna Management Strategy Evaluation (14 July 2022), there is one remaining meeting of Panel 2 to take place before the Commission Plenary, scheduled for 14 October 2022. This will follow the September meetings of the SCRS Bluefin MSE Technical Subgroup, Bluefin Species Group, and SCRS Plenary meeting. The Bluefin Species Group also hopes to convene additional Ambassador meetings (tentatively, in late July and early October) in English, French and Spanish, and some summary materials are available in Arabic.

Other resources

Atlantic Bluefin Tuna MSE splash page, including interactive Shiny App (ENG only)

- CMP Results and Plotting
- CMP Performance Overview with Quilt Plots
- CMP Performance with Spider Plot

Harveststrategies.org MSE outreach materials (multiple languages, including Arabic)

Table 1. Table of Candidate Management Procedures (CMPs). All indices are referenced at the end of the table.

CMP	Indices used		Detailed description	Strengths/Weaknesses	References
	EAST	WEST			
FO	FR AER SUV2 JPN LL NEAtl2 W-MED LAR SUV	US RR 66-144, CAN SWNS RR US-MEX GOM PLL	Uses an estimated $F_{0.1}$ applied to an estimate of biomass to provide TAC advice. The $F_{0.1}$ estimate is based on the relative abundance of young, medium and old fish for each area (which is informed from the areas indices noted on the left). Estimated biomass for each area is derived from an index from that area and a period of reference years.	Strengths: - performs well across several indicators. - uses indices that represent various age class to calculate TAC.	SCRS/2020/144 SCRS/2021/122
AI	All	All	An artificial neural network is trained on simulated projected data for all indices (from both sides of the ocean) and a management value V, that is the true simulated vulnerable biomass in each area multiplied by a harvest control rule. Once trained, the neural network can predict V using new index data (simulated or real). Area-specific TAC is then calculated as a constant fraction of V.	Strengths: - performs well across several indicators. - Uses all indices. Weaknesses: - lacks a clear relationship between index values and TAC, due to machine learning component. - struggles to achieve LD and PGK.	SCRS/2021/028
BR	All	All	TACs are set based on relative harvest rates (with some slight initial time dependence) for a reference year (2018) applied to the 2-year moving average of a combined master abundance index for each of the West and East areas. These master indices are weighted averages across the indices available for the area based on their variances and to achieve smoother TAC trends over time.	Strengths: - strong performance, across most indicators. - Uses all indices.	SCRS/2021/121 SCRS/2021/152 SCRS/2022/082 SCRS/2022/126
LW	W-MED LAR SUV JPN LL NEAtl2	GOM LAR SUV MEXUS_LL	LW uses a 3-yr average of catch divided by relative SSB to estimate a constant harvest rate metric. All 4 indices on the left are used for the West area to account for stock mixing; Med larval and JPN East LL are used for the East area.	Strengths: - performs well across several indicators. Weaknesses: - has struggled to achieve some of PA2 identified thresholds for PGK.	SCRS/2021/127
PW	W-MED LAR SUV JPN LL NEAtl2	GOM LAR SUV MEXUS_LL	Similar to LW, PW uses indices in the East and the West (as specified on the left) to achieve a constant exploitation rate. It adjusts western TAC according to eastern indices under the assumption that western TACs are supported by eastern mixing.	Strengths: - performs well across several indicators. Weaknesses: - poor stability and yield.	SCRS/2021/155 SCRS/2022/078
TC	MOR POR TRAP JPN LL NEAtl2 W-MED LAR SUV GBYP AER SUV BAR	US RR 66-144 JPN_LL_West2 GOM_LAR_SUV	Two fishery indices for each area (West: JPN_LL_West2, US_RR_66_144. East: JPN_LL_NEAtl2, MOR_POR_TRAP) and three stock-specific fishery independent indices (West: GOM_LAR_SUV. East: MED_LAR_SUV, GBYP_AER_SUV_BAR) are used to predict area biomass assuming a fixed rate of stock mixing (e.g., a fixed fraction of the eastern stock enters the West area). The TAC is calculated for each area by multiplying the predicted area biomass by a constant harvest rate.	Strengths: - highest stability. Weaknesses: - increased stability causes somewhat lower biomass and yield performance.	SCRS/2020/150 SCRS/2020/165

East indices: FR AER SUV2 – French aerial survey in the Mediterranean; JPN LL NEAtl2 – Japanese longline index in the Northeast Atlantic; W-MED LAR SUV – Larval survey in the western Mediterranean; MOR POR Trap – Moroccan-Portuguese trap index; GBYP AER SUV BAR – GBYP aerial survey in the Balearics.

West indices: US RR 66-144 – U.S. recreational rod & reel index for fish 66-144 cm; CAN SWNS RR – Canadian Southwest Nova Scotia handline index; US-MEX GOM PLL – U.S. & Mexico combined longline index for the Gulf of Mexico; GOM LAR SUV – U.S. larval survey in the Gulf of Mexico; JPN LL West2 - Japanese longline index for the West Atlantic.

Table 2. Table of Operational Management Objectives and Performance Statistics.

Management Objectives (Res. 18-03) + May 2022 PA2 guidance	**Primary Performance Statistics (Tuning Objective & Quilt 1)**	**Secondary Performance Statistics (Quilt 2)**
Status The stock should have a greater than [60]% probability of occurring in the green quadrant of the Kobe matrix. (To be evaluated at intermediate points between zero and 30 years, and at the end of the 30-year period.)	**Br30** – Br [i.e., biomass ratio, or spawning stock biomass (SSB) relative to dynamic SSB_{MSY}[1]] after 30 years. **PGK**: Probability of being in the Kobe green quadrant (i.e., SSB>dSSB_{MSY} and U<U_{MSY}[2]) in year 30.	**AvgBr** – Average Br over projection years 11-30. **Br20** – Br after 20 years. **POF** – Probability of overfishing (U>U_{MSY}) after 30 projected years. **PNRK** – Probability of not being in the red Kobe quadrant (SSB > SSB_{MSY} or U < U_{MSY}) after 30 projected years. **OFT** – Overfished Trend, SSB trend if Br30<1. **PrpOF** – Proportion U > U_{MSY} (i.e., probability of overfishing in projection years 1-30). (*See presentation. Not currently in quilt plot.*) **AvUrel** – Mean U/U_{MSY} in projection years 1-30. (*See presentation. Not currently in quilt plot.*) **U/U_{MSY}** – Exploitation rate (U) in biomass divided by exploitation rate at MSY. (*Shown as a trajectory in the presentation rather than in a quilt plot.*)
Safety There should be no more than a [15]% probability of the stock falling below B_{LIM} at any point during the years 11-30 of the projection period.	**LD*** – Lowest depletion (i.e., SSB relative to dynamic SSB_{MSY}) over years 11-30 in the projection period. LD* value is evaluated relative to SCRS-proposed B_{LIM} (40% of dynamic SSB_{MSY}).[3] LD5%, LD10% and LD15% will all be evaluated, with the latter in Quilt 1 and the former 2 in Quilt 2.	
Yield Maximize overall catch levels.	**AvC10** – Median TAC (t) over years 1-10. **AvC30** – Median TAC (t) over years 1-30.	**C1** – TAC in first 2 years of MP (i.e., 2023-24). **AvC20** – Median TAC (t) over years 1-20.
Stability Any change in TAC between management periods should be no more than a 20% increase or a [20][30]% decrease, except during the application of the MP in the first two management periods, where any TAC change shall not exceed a 20% increase or a 10% decrease.	**VarC** – Variation in TAC (%) between 2-year management cycles.	

[1]Dynamic SSBMSY is a set fraction of dynamic SSB0, which is the spawning stock biomass that would occur in the absence of fishing, historically and in the future. Dynamic SSBMSY can change over time since it is based on current recruitment levels, which fluctuate due to time-varying dynamics in the models.
[2]The exploitation rate (U) is annual catch (in tonnes) divided by the total annual biomass in tonnes. UMSY is the fixed harvest rate (U) corresponding with SSB/SSBMSY=1 at year 50.
[3]SCRS proposed a BLIM of 40% of dynamic SSBMSY for the purposes of the MSE for CMP testing and performance tuning. Status relative to BLIM is calculated as the lowest depletion (spawning biomass relative to dynamic SSBMSY) over projection years 11-30 for which the CMP is applied across the plausibility weighted operating models. BLIM is proposed as a performance statistic, not as an 'active' or functional trigger for determining a management action.

Table 3. Performance for management cycle variations of the BR CMP tuned to a common LD*15 (0.4 of dynamic SSB_{MSY}) for comparative purposes. Performance statistics are described in **Table 2.** The 3-year cycle (BR5c) was slower to react to signals to decrease TAC and thus had slightly worse performance for status, yield and stability when compared to the 2-year cycle (BR5a). Improved status (Br30 5th and 50th percentiles) can be achieved with a 3-year management cycle by allowing for greater reductions in TAC as shown by BR5d.

			East						West					
Variant	**Mgmt Cycle**	**Stability**	**Br30 50% tile**	**Br30 5% tile**	**LD*15**	**LD*10**	**Difference in AvC30 (kt)**	**VarC**	**Br30 50% tile**	**Br30 5% tile**	**LD*15**	**LD*10**	**Difference in AvC30 (kt)**	**VarC**
BR5a	2-year	+20/-30	1.03	0.24	0.4	0.31	-	19.7	1.07	0.41	0.4	0.32	-	13.56
BR5c	3-year	+20/-30	1.1	0.20	0.4	0.28	-1.81	20.1	1.15	0.37	0.4	0.29	-0.11	15.12
BR5d	3-year	+20/-35	1.13	0.31	0.4	0.34	-2.37	20.9	1.17	0.42	0.4	0.31	-0.08	15.33

Table 4. Comparative performance for variations of the BR CMP with symmetric TAC change restrictions. Performance statistics are described in **Table 2**. Performance of BR2g (+20/-20 stability) has slightly lower yields (AvC30) compared to BR2a (+20/-30 stability), as well as poorer conservation (LD*) performance.

			East					West				
Variant	**Mgmt Cycle**	**Stability**	**Br30 50% tile**	**LD*15**	**LD*10**	**Difference in AvC30 (kt)**	**VarC**	**Br30 50% tile**	**LD*15**	**LD*10**	**Difference in AvC30 (kt)**	**VarC**
BR2a	2-year	+20/-30	1.5	0.66	0.58	-	16.56	1.25	0.49	0.38	-	12.61
BR2g	2-year	+20/-20	1.49	0.55	0.46	-0.27	14.53	1.24	0.46	0.32	-0.01	12.15

CMP	West					East					Tot	# indices
	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)		
BR2a	0.63	3.02	2.72	12.61	0.49	0.78	40.9	32.65	16.56	0.66	0.26	10
AI2a	0.58	3.03	2.77	16.43	0.53	0.71	41.16	37.62	16.17	0.65	0.27	10
TC2a	0.61	2.83	2.64	6.71	0.4	0.73	33.43	29.21	8.18	0.54	0.48	7
FO2a	0.62	2.84	2.77	14.29	0.48	0.64	37.37	30.46	13.93	0.47	0.53	6
LW2a	0.59	2.68	2.56	15.63	0.5	0.72	34.63	30.27	17.21	0.6	0.58	4
PW2a	0.67	2.37	2.29	17.11	0.45	0.74	35.36	29.93	13.27	0.6	0.71	4

Figure 1. Primary quilt plot for the West and East for tuning level 2 (i.e., Br30=1.25 for West and Br30=1.5 for East) using the default weighting scheme (i.e., 0 for PGK; 0.5 for AvC10 and AvC30; 1.0 for VarC and LD15) and ordered relative to the total column. Color scale represents relative performance from dark (best) to light (worst) within a column. This plot shows the top 5 performance statistics chosen on the basis of removing duplicative statistics and focusing on the four operational performance statistics of safety, status, stability and yield. The five statistics and associated percentiles are PGK: probability of being in the Kobe green quadrant (i.e., $SSB>SSB_{MSY}$ and $U<U_{MSY}$) in year 30; AvC10: average catch (kilotons, kt) over years 1-10 (50%tile); AvC30: average catch (kt) over years 1-30 (50%tile); VarC: Variation in catch (kt) between 2-year management cycles (50%tile); LD*(15%): 15%tile of lowest depletion over years 11-30. PGK is not weighted in the scoring as all CMPs are tuned to achieve similar biomass status. Ordering is achieved by scaling each column according to its minimum and maximum, within a column, giving a rank order from 0 (best) to 1 (worst), weighting columns according to the default weighting, obtaining an average for West and East and then taking the average across East and West (Tot). See **Table 2** for more detailed descriptions of performance statistics. The 'a' for each CMP refers to the +20/-30 stability tuning without phase in.

East

CMP	C1 (50%)	AvC20 (50%)	AvgBr (50%)	Br20 (50%)	Br30 (5%)	LD (5%)	LD (10%)	POF (Mean)	PNRK (Mean)	OFT (P>0)
BR2a	43.2	34.05	1.49	1.45	0.73	0.49	0.58	0.03	0.99	0.96
Al2a	32.27	40.51	1.53	1.51	0.47	0.42	0.55	0.11	0.9	0.86
TC2a	37.26	28.84	1.59	1.58	0.52	0.37	0.47	0.07	0.94	0.9
FO2a	43.2	29.83	1.52	1.5	0.3	0.25	0.37	0.21	0.81	0.84
LW2a	43.2	30.14	1.52	1.5	0.55	0.44	0.53	0.08	0.95	0.92
PW2a	41.14	30.2	1.53	1.5	0.57	0.43	0.52	0.06	0.97	0.93

West

CMP	C1 (50%)	AvC20 (50%)	AvgBr (50%)	Br20 (50%)	Br30 (5%)	LD (5%)	LD (10%)	POF (Mean)	PNRK (Mean)	OFT (P>0)
BR2a	2.71	2.73	1.34	1.31	0.54	0.28	0.38	0.22	0.83	0.86
Al2a	2.82	2.83	1.35	1.31	0.63	0.32	0.42	0.26	0.87	0.87
TC2a	2.68	2.59	1.42	1.41	0.35	0.18	0.27	0.28	0.78	0.86
FO2a	2.41	2.78	1.38	1.35	0.48	0.3	0.38	0.26	0.81	0.85
LW2a	2.53	2.56	1.34	1.3	0.49	0.28	0.38	0.26	0.81	0.84
PW2a	2.42	2.27	1.23	1.18	0.49	0.28	0.38	0.09	0.95	0.94

Figure 2. Secondary quilt plots, shown separately for East and West, which depict the following 10 performance statistics – C1: catch in the first year of CMP application (50%); AvC20: average catch (kilotons, kt) over years 11-20 (50%tile); AvgBr: spawning biomass relative to dynamic SSB_{MSY} over projection years 11-30 (50%); Br20: Depletion (spawning biomass relative to dynamic SSB_{MSY}) in projection year 20 (50%); Br30: Depletion (spawning biomass relative to dynamic SSB_{MSY}) in projection year 30 (5%); LD* (5%): 5%tile of lowest depletion over years 11-30; LD* (10%) 10%tile of lowest depletion over years 11-30; POF: Probability of Overfishing ($U > U_{MSY}$) after 30 projected years (mean); PNRK: Probability of not Red Kobe ($SSB > SSB_{MSY}$ or $U < U_{MSY}$) after 30 projected years (mean); OFT: Overfished trend, SSB trend over projection years 31 - 35 when Br30 < 1. See **Table 2** for more detailed descriptions of performance statistics. The 'a' for each CMP refers to the +20/- 30 stability tuning without phase in. Order of the CMPs is the same as in quilt plot 1.