Atlantic Bluefin Tuna MSE – Final Results & Decision Guide Package

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Introduction to the Decision Guide

This Decision Guide presents final results from the Atlantic bluefin tuna management strategy evaluation (MSE). It also provides a step-by-step approach to facilitate discussion and decision-making among scientists, fishery managers and stakeholders on selection of a final management procedure (MP) at the Fourth Intersessional Meeting of Panel 2 on Bluefin Tuna Management Strategy Evaluation, to be held on 14 October 2022, in advance of MP adoption at the ICCAT Annual Meeting in November.

The SCRS has made substantial progress in testing candidate management procedures (CMPs) and considers the MSE to be complete except for exceptional circumstances provisions to be drafted in 2023. There are now four CMPs remaining, each with multiple variants, for consideration for adoption. All meet Panel 2's guidance on minimum performance standards for stock status and safety; they also balance tradeoffs to maximize performance relative to the yield and stability objectives. They provide viable, robust options for setting total allowable catches (TACs) for Atlantic bluefin tuna in 2023 and beyond.

Candidate Management Procedures

Four types of candidate management procedures (**Table 1**) remain (TC, BR, LW and FO). Two CMPs (PW and AI) reported upon previously are no longer supported by their developers, as they did not exhibit improved performance relative to the remaining four. All CMP types have the following characteristics:

- Each CMP is a 'package-deal' in that one single CMP calculates separate TACs for the West and East management areas.
- They include a 'phase-in' period where TAC changes are limited to a 20% increase and 10% decrease for two cycles for a 2-yr setting or one cycle for a 3-yr setting.
- All results tested and presented here assume that the operational management objectives and other CMP specifications (e.g., management cycle length) are the same for both stocks/management areas.

Each of the four CMPs has multiple variants, performance tuned[1] to the probability of being in the green quadrant of a Kobe plot (PGK) performance statistic. All performance statistics are described in detail in **Table 2**. The variants are defined as follows:

CMP Variant	Management cycle length	PGK	TAC stability (after phase-in)
5a	2 years	60%	+20%/-30%
5b	3 years	60%	+20%/-30%
6a	2 years	70%	+20%/-30%
6b	3 years	70%	+20%/-30%
5c	3 years	60%	+20%/-35%

[1] Performance tuning is the process by which CMPs are adjusted to satisfy different minimum performance standards relative to PGK and LD* across the grid of operating models, while also achieving higher yield and stability objectives. All CMPs include at least one adjustable setting to determine how heavily or lightly it applies fishing pressure to achieve desired performance on the risk-reward tradeoff (i.e., catch vs. biomass) for each of the East area/eastern stock and West area/western stock, and this setting is adjusted during performance tuning.

Furthermore, one CMP (TC) was tuned to the lowest depletion (LD*$_{10\%}$ and LD*$_{15\%}$) performance statistics to provide additional comparisons.

CMP Variant	Management cycle length	LD*	TAC stability (after phase-in)
7a	2 years	15%	+20%/-30%
8a	2 years	10%	+20%/-30%

Decision Guide Outline

There are several key decisions required for adoption of a final management procedure. Because relative performance is largely maintained across these elements, the decisions can be made one at a time, in any order Panel 2 chooses or holistically. However, the SCRS recommends that these be taken in the following order:

1) Operational management objective for Safety: no more than **10%** or **15%** probability of the lowest depletion (LD) dropping below the limit reference point of 40% of dynamic SSB_{MSY} in years 11 through 30. LD* is the lowest value of spawning stock biomass (SSB) relative to dynamic SSB_{MSY} for each simulation during projection years 11 through 30.
2) Operational management objective for Stock Status: **60%** or **70%** probability of occurring in the green quadrant ($SSB \geqq SSB_{MSY}$ & $U < U_{MSY}$) of the Kobe plot in year 30 of the projection period (PGK).
3) Management cycle length: **2**- or **3**-yr TAC setting intervals.
4) Operational management objective for Stability: This is a subsidiary decision needed only for the 3-year TAC setting. Following the phase-in period, allowing greater possible reductions in TAC change between management cycles: moving the default of **+20/-30%** to **+20%/-35%**.
5) Management procedure: **BR**, **FO**, **LW** or **TC**.
6) Timeframe for review of Management Procedure.

Each decision point is addressed in individual sections of this package.

An additional consideration for Panel 2 may be a minimum threshold for TAC change to minimize the administrative burden related to adopting new TAC advice that represents a small change from the previous TAC. If such a minimum threshold were incorporated in an MP, for those instances where application of the MP would otherwise indicate a TAC change of less than the minimum threshold, there would be no change in TAC. A preliminary analysis based on a single CMP was performed, which has not yet been fully reviewed by the Committee, in order to evaluate the impacts on performance metrics of a minimum threshold. The minimum tested was 100 t in the West and 1000 t in the East for both 2 and 3-yr intervals and PGK 60% and 70%. This testing resulted in minimal differences in any of the key performance statistics. Alternatively, Panel 2 could likely implement such a TAC threshold up to the levels tested for both areas. If Panel 2 wishes to implement such a minimum change for the preferred CMP, it will be possible to provide such results prior to the 2022 Commission meeting.

Presenting results

This package presents multiple performance tables called "quilt plots" (e.g., **Table 4**). They present five key statistics and associated percentiles, including PGK: probability of being in the Kobe green quadrant (i.e., $SSB \geqq SSB_{MSY}$ and $U \leq U_{MSY}$) in year 30; AvC10: average catch (kilotons, kt) over years 1-10 (50%ile); AvC30: average catch (kt) over years 1-30 (50%ile); VarC: Variation in catch (% change from prior TAC) between management cycles (50%ile); LD*$_{15\%}$: 15%tile of lowest depletion over years 11-30. These 5 top performance statistics were chosen on the basis of removing duplicative statistics and focusing on the four operational performance statistics of safety, status, yield, and stability.

To aid decision making, the SCRS provides a total score as a tool to rank CMPs to evaluate whether the relative ordering is conserved across the variants. Quilt plots use the default weighting scheme (i.e., 0 for

PGK; 0.5 for AvC10 and AvC30; 1.0 for VarC and LD*$_{15\%}$); though different weighting of management objectives resulted in nearly similar ranking of CMPs (SCRS/2022/169). PGK is not weighted in the scoring as all CMPs are tuned to a pre-specified PGK value (either 60% or 70%). Color scale represents relative performance from dark (best) to light (worst) within a column. CMPs are ordered relative to the total column (*Tot*), like in golf a lower *Tot* score is better. *Tot* is calculated by scaling each column relative to the minimum to maximum range within that 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. Lower *Tot* values equal better performance. Actual *Tot* values should be considered as qualitative rather than quantitative as they account only for order and not the magnitude of the change in the value of the performance statistic amongst the CMPs.

Other resources

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

- CMP Results and Plotting
- CMP Performance Overview with Quilt Plots
- CMP Performance with Spider Plot
- SCRS/2022/169: Results, features, and interpretations of the four remaining BFT MSE candidate management procedures
- Harveststrategies.org MSE outreach materials (multiple languages, including Arabic)

Table 1. Candidate Management Procedures (CMPs). All indices are referenced at the end of the table. The AI (Artificial Intelligence) and PW (Peterson-Walter) CMPs have been discontinued by the developers due to improved performance by the remaining CMPs.

CMP	Indices used			Description
	EAST	WEST	Total	
BR Butterworth/ Rademeyer	All	All	10	Uses relative harvest rates compared to a reference year (2017), applied to the 3-year moving average of combined master abundance indices for East and for West.
FO Canada	FR_AER_SUV2 JPN_LL_NEAtl2 W_MED_LAR_SUV	US_RR_66_144 CAN_SWNS_RR MEXUS_LL	6	Uses a 3-year moving average of indices representative of young, medium and old fish to calculate an $F_{0.1}$ estimate which is applied to an estimate of biomass.
LW USA	W_MED_LAR_SUV JPN_LL_NEAtl2	GOM_LAR_SUV MEXUS_LL	4	Uses a 3-yr average of catch divided by relative SSB to estimate a constant harvest rate metric. Eastern indices are also used in the West to account for stock mixing (but not vice versa).
TC Carruthers	MOR_POR_TRAP JPN_LL_NEAtl2 W_MED_LAR_SUV GBYP_AER_SUV_BAR	US_RR_66_144 JPN_LL_West2 GOM_LAR_SUV	7	Indices are used to predict area biomass assuming a fixed rate of stock mixing, and that predicted biomass is then multiplied by a constant harvest rate.

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; MEXUS_LL – 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. Performance statistics are calculated based on 48 simulations/replicates for each of the 48 operating models of a 30-year projection under a CMP. Results reported are percentiles of the resultant distributions, e.g. median (50%-ile) or lower 5%-ile.

Management Objectives (Res. 18-03) + May 2022 PA2 guidance	**Primary Performance Statistics (Quilt plot 1)**	**Secondary Performance Statistics (Quilt plot 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.)	**PGK**: Probability of being in the Kobe green quadrant (i.e., SSB≧dynamic SSB_{MSY}[1] and U<U_{MSY}[2]) in year 30 of the management period (2052).	**Br30** – Br [i.e., biomass ratio, or spawning stock biomass (SSB) relative to dynamic SSB_{MSY}] after 30 years. **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} and/or U < U_{MSY}) after 30 projected years. **OFT** – Overfished Trend, SSB trend if Br30<1.
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., the lowest SSB relative to dynamic SSB_{MSY}) over years 11-30 in the projection period. LD* value is evaluated relative to B_{LIM} (40% of dynamic SSB_{MSY}).[3] $LD^*_{5\%}$, $LD^*_{10\%}$ and $LD^*_{15\%}$ are all 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 or 3 years of MP (i.e., 2023-24 or 2023-25), depending on management cycle length. **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 (for 3-year cycle) or two management periods (for 2-year cycle), where any TAC change shall not exceed a 20% increase or a 10% decrease.	**VarC** – Variation in TAC (%) between management cycles (2 or 3 year).	

[1]Dynamic SSB_{MSY} is a set fraction of dynamic SSB_0, which is the spawning stock biomass that would occur in the absence of fishing, historically and in the future. Dynamic SSB_{MSY} 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. U_{MSY} is the fixed harvest rate (U) corresponding with SSB/SSB_{MSY}=1 at year 50.
[3]SCRS proposed a B_{LIM} of 40% of dynamic SSB_{MSY} for the purposes of the MSE for CMP testing and performance tuning. Status relative to B_{LIM} is calculated as the lowest depletion (lowest spawning biomass relative to dynamic SSB_{MSY}) over projection years 11-30 across each simulation of the plausibility weighted operating models.

Decision Point #1: Operational management objective for Safety

Options: No more than **10%** or **15%** probability of the lowest depletion (LD) dropping below the limit reference point (B_{LIM} or LRP) of 40% of dynamic SSB_{MSY} in years 11 through 30 (i.e., $LD^*_{10\%}$ or $LD^*_{15\%}$ performance statistics). LD* is the lowest value of SSB relative to dynamic SSB_{MSY} for each simulation during projection years 11 through 30, so a single year gets the same score as multiple years below B_{LIM} in this scoring system. A stock that has recovered to well above the LRP may still have a low LD.

Strategic considerations:

- A 15% probability ("risk") of breaching the limit reference point (B_{LIM}) means higher risk to the stock than 10%.
- The limit reference point is used here solely in the context of the MSE to evaluate CMP performance and does not function as a hard 'trigger' that would require a management response, such as closing the fishery.
- Obtaining a $LD^*_{10\%}$ above the LRP is challenging to achieve for the western stock simply due to a fair number (5 of 48, or ~10%) of operating models starting close to B_{LIM}. This was the rationale for using years 11-30 to calculate LD*.
- Because obtaining $LD^*_{10\%}$ above the LRP results in a substantial reduction in fishing intensity, the SCRS recommends considering the decision point 2 related to PGK as a more straightforward means of addressing precautionary fishing intensity. PGK performance is linear between 60% and 70%, compared to the disproportionate decrease in fishing intensity required to achieve $LD^*_{10\%}$ when compared to $LD^*_{15\%}$.

Relevant results:

Only the TC CMP was tuned to $LD^*_{10\%}$ and $LD^*_{15\%}$, using a 2-yr management cycle, to give a comparison of the two tuning targets. Obtaining a $LD^*_{10\%}$ above the LRP would require substantial reductions in western TAC (**Table 3, Figure 1**).

Table 3. Performance results for the TC CMP for two separate tunings - TC7a tuned to $LD^*_{15\%}$ and TC8a tuned to $LD^*_{10\%}$. TC8a almost achieves $LD^*_{10\%}$. Both have a 2-yr management cycle. See **Table 2** for more detailed descriptions of performance statistics.

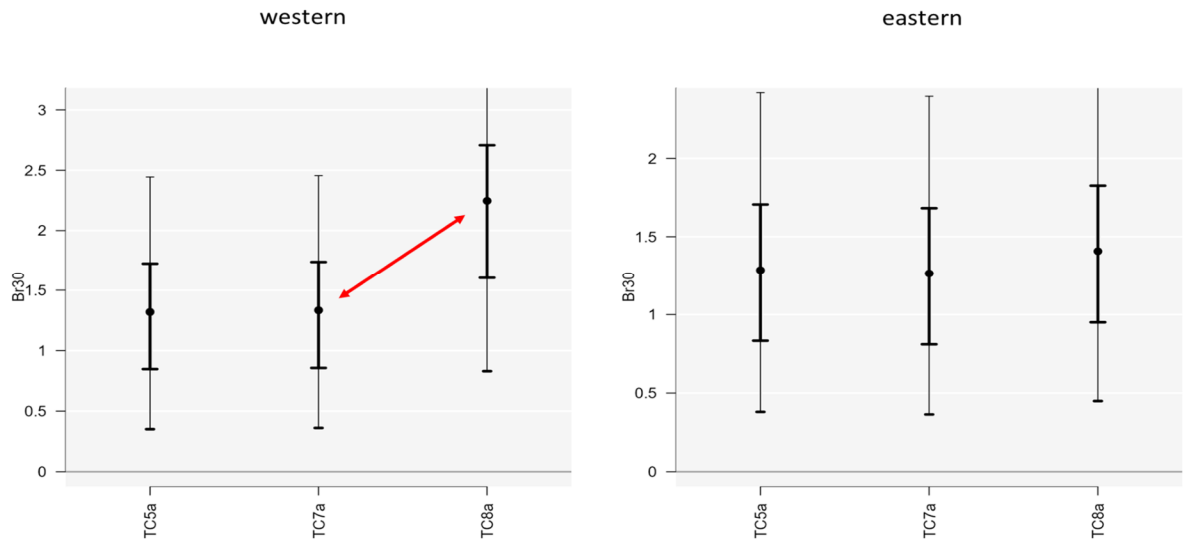
East

CMP	Tuning	Variant	$LD^*_{10\%}$	$LD^*_{15\%}$	PGK	AvC10 (t)	AvC30 (t)	VarC
TC7a	$LD^*_{15\%}$	2-yr, -30%	0.33	0.4	59%	41,780	36,790	10.1%
TC8a	$LD^*_{10\%}$	2-yr, -30%	0.4	0.47	67%	38,480	34,300	9.6%

West

CMP	Tuning	Variant	$LD^*_{10\%}$	$LD^*_{15\%}$	PGK	AvC10 (t)	AvC30 (t)	VarC
TC7a	$LD^*_{15\%}$	2-yr, -30%	0.26	0.4	61%	2,630	2,360	7.5%
TC8a	$LD^*_{10\%}$	2-yr, -30%	0.39	0.55	92%	1,240	710	12.8%

a)



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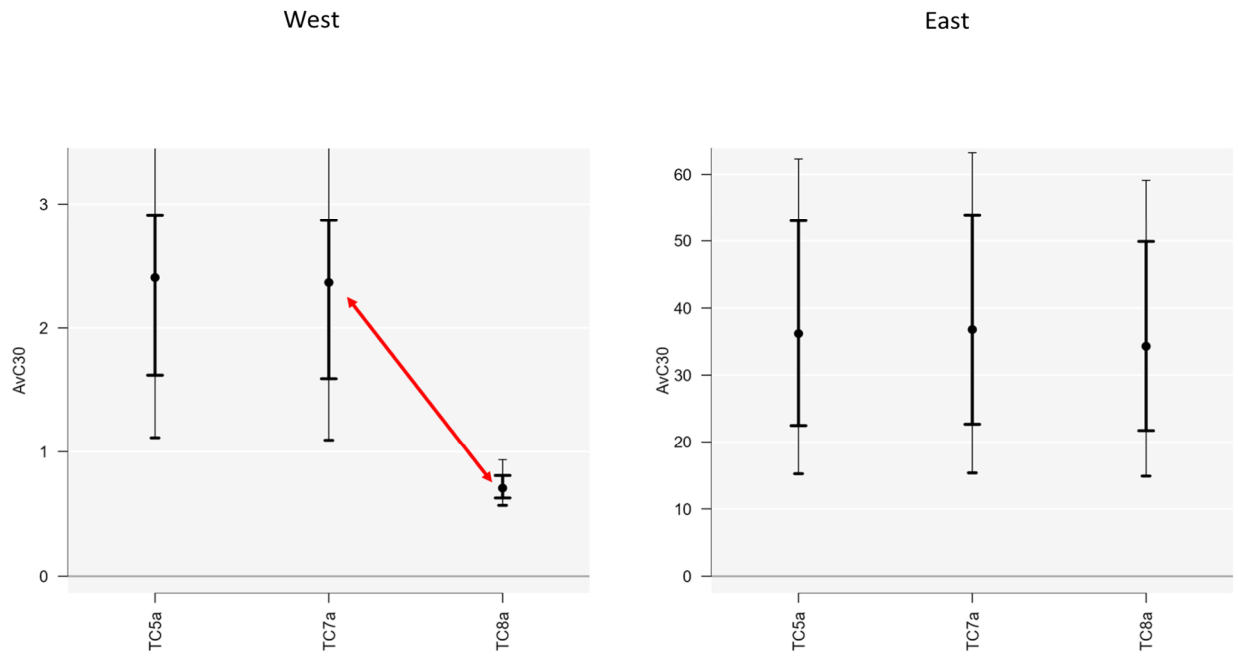


Figure 1. Performance results for a) Biomass - Br30 and b) Yield - AvC30 for the TC CMP for three separate tunings - TC5a tuned to PGK=60%, TC7a tuned to LD*$_{15\%}$, and TC8a tuned to LD*$_{10\%}$. All have a 2-yr management cycle. The western results are on the left, and the eastern results are on the right. The point indicates the median, the thick line indicates the 25/75%-iles, and the whiskers indicate the 5/95%-iles. Panel a) shows that stock status improves for LD*$_{10\%}$, with median Br30 values above dynamic SSB$_{MSY}$, while Panel b) shows the disproportionate reduction in yield. See **Table 2** for more detailed descriptions of performance statistics.

Decision Point #2: Operational management objective for Stock Status

Options: 60% or **70%** probability of PGK. PGK stands for Probability Green Kobe. It is the probability of being in the Kobe green quadrant (i.e., SSB≧dynamic SSB_{MSY} and U<U_{MSY}) in year 30 of the projection period (i.e., 2052).

Strategic considerations:

- PGK of 60% (heavier fishing pressure) entails a higher probability of overfishing and/or of being overfished, but delivers greater catches, relative to PGK 70% (lower fishing pressure).
- If a 3-yr management cycle is selected, in order to satisfy $LD^*_{15\%}$, PGK greater than 60% is required for CMPs TC and LW as these fail for PGK=60%. Only BR and FO can satisfy $LD^*_{15\%}$ for a 3-yr management cycle with PGK=60%, but then only if a +20%/-35% TAC stability provision is selected.

Relevant results:

All four CMPs were tuned to a minimum of both PGK=60% and PGK=70%, using 2 and 3-yr management cycles (**Tables 4, 5, 6, 7** and **Figure 2**).

Table 4. Primary quilt plot for the West and East for **tuning levels 5 (PGK=60%)** and **6 (PGK=70%).** The 'a' for each CMP refers to a **2-yr management cycle** with +20/-30 stability tuning following the phase-in. See "Presenting results" on page 3 for a description of quilt plots. CMPs are ordered within a 'Type' by the '*Tot*' column to indicate relative ranking within a CMP, note the reversal of rank of LW for PGK70%.

				West					East					
CMP	Type	Tuning	Variant	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	Tot
BR6a	BR	70%	2-yr, -30%	0.71	2.57	2.2	8.21	0.45	0.7	46.49	38.13	14.63	0.51	0.36
BR5a	BR	60%	2-yr, -30%	0.6	2.77	2.43	8.81	0.42	0.6	51.97	41.42	15.6	0.45	0.42
FO6a	FO	70%	2-yr, -30%	0.71	2.66	2.37	15.03	0.41	0.7	42.71	33.46	16.45	0.52	0.59
FO5a	FO	60%	2-yr, -30%	0.61	2.89	2.59	14.86	0.4	0.6	46.88	37.19	16.68	0.45	0.61
LW5a	LW	60%	2-yr, -30%	0.6	2.41	2.25	16.52	0.48	0.6	43.96	36.33	18.35	0.45	0.65
LW6a	LW	70%	2-yr, -30%	0.7	2.04	1.97	16.5	0.5	0.7	36.41	32.08	17.68	0.51	0.67
TC6a	TC	70%	2-yr, -30%	0.71	2.37	2.13	7.09	0.45	0.7	36.33	32.27	9.41	0.49	0.41
TC5a	TC	60%	2-yr, -30%	0.6	2.67	2.4	7.51	0.4	0.6	41.07	36.18	10.01	0.41	0.5

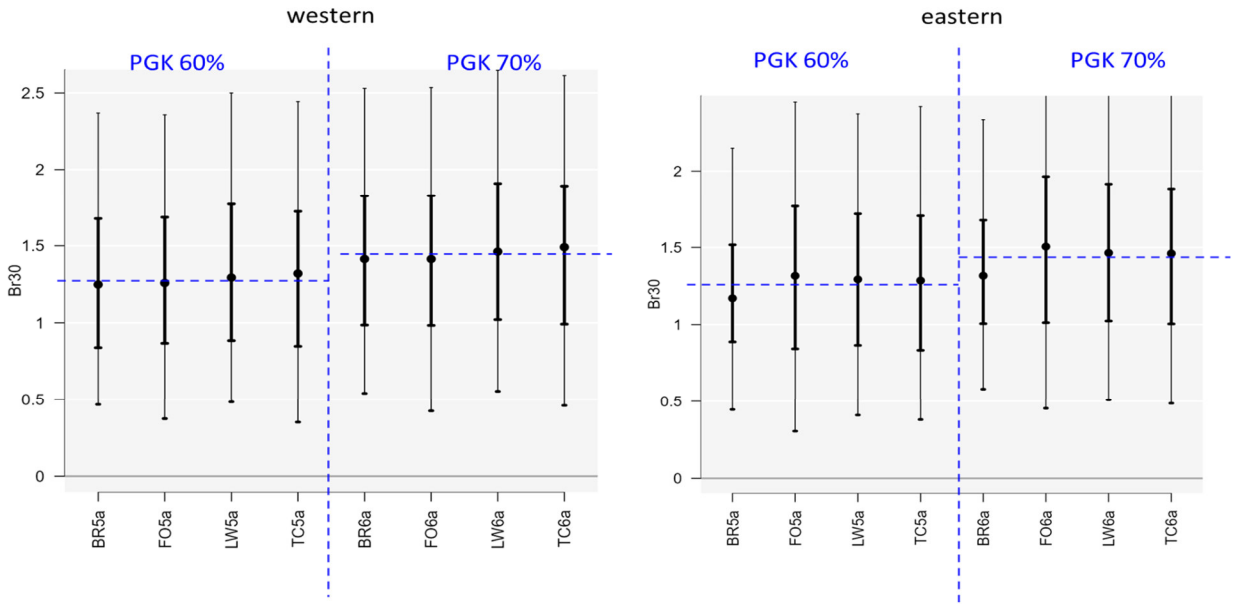
Table 5. Primary quilt plot for the West and East for **tuning levels 5 (PGK=60%)** and **6 (PGK=70%).** The 'b' for each CMP refers to a **3-yr management cycle** with +20/-30 stability tuning following the phase-in. The 'c' for each CMP refers to a **3-yr management cycle** with +20/-35 stability tuning following the phase-in. Results are not shown for 6c because the +20%/-35% stability allowance is required only if PGK=60%. See "Presenting results" on page 3 for a description of quilt plots. Values of $LD^*_{15\%}$ below the B_{LIM} (0.4) are denoted in red.

CMP	Type	Tuning	Variant	West					East					Tot
				PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	
BR5c	BR	60%	3-yr, -35%	0.6	2.74	2.46	10.49	0.4	0.6	48.37	41.28	18.65	0.41	0.37
BR6b	BR	70%	3-yr, -30%	0.7	2.55	2.18	9.75	0.43	0.7	43.27	37.2	17.14	0.44	0.37
TC6c	TC	70%	3-yr, -35%	0.71	2.33	2.1	8.24	0.43	0.71	36.25	32	11.11	0.44	0.37
TC6b	TC	70%	3-yr, -30%	0.71	2.33	2.1	8.22	0.43	0.71	35.89	31.69	11.05	0.43	0.39
BR5b	BR	60%	3-yr, -30%	0.6	2.7	2.4	10.37	0.4	0.6	47.75	41.17	17.96	0.38	0.42
TC5c	TC	60%	3-yr, -35%	0.6	2.6	2.39	8.53	0.37	0.6	40.4	36.01	11.9	0.35	0.47
TC5b	TC	60%	3-yr, -30%	0.61	2.59	2.38	8.49	0.37	0.6	40.12	35.76	11.84	0.34	0.49
FO5c	FO	60%	3-yr, -35%	0.62	2.59	2.51	17.41	0.42	0.62	47.15	37.75	19.85	0.41	0.53
FO6b	FO	70%	3-yr, -30%	0.71	2.43	2.3	17.27	0.42	0.7	43.08	34.46	19.13	0.46	0.55
LW5c	LW	60%	3-yr, -35%	0.6	2.22	2.22	17.74	0.47	0.6	47.09	37.88	20.25	0.39	0.57
FO5b	FO	60%	3-yr, -30%	0.61	2.59	2.51	17.12	0.4	0.6	47.15	38.29	19.35	0.37	0.6
LW5b	LW	60%	3-yr, -30%	0.6	2.21	2.22	17.34	0.46	0.6	45.02	37.04	19.72	0.37	0.62
LW6b	LW	70%	3-yr, -30%	0.7	2.02	1.97	17.42	0.47	0.7	37.94	32.22	19.08	0.44	0.65

Table 6. Performance statistics averaged across the four CMP types and the 2 and 3 yr management cycles for PGK 60% and PGK 70%, with the default stability of +20%/-30%. The percent difference row is shown relative to PGK=60% (i.e, the West AvC10 of -8.9% means that PGK 70% has 8.9% lower short-term catch than PGK 60%). By averaging across all CMP variants, this table isolates the key trade-offs for the PGK 60% vs. PGK 70% decision.

	West				**East**			
	AvC10 (50%)	**AvC30 (50%)**	**VarC (50%)**	**LD* (15%)**	**AvC10 (50%)**	**AvC30 (50%)**	**VarC (50%)**	**LD* (15%)**
PGK 60%	**2.60**	**2.40**	**12.63**	**0.42**	**45.49**	**37.92**	**16.19**	**0.40**
PGK 70%	**2.37**	**2.15**	**12.44**	**0.45**	**40.27**	**33.94**	**15.57**	**0.48**
% difference	**-8.9%**	**-10.2%**	**-1.5%**	**6.9%**	**-11.5%**	**-10.5%**	**-3.8%**	**18.0%**

a)



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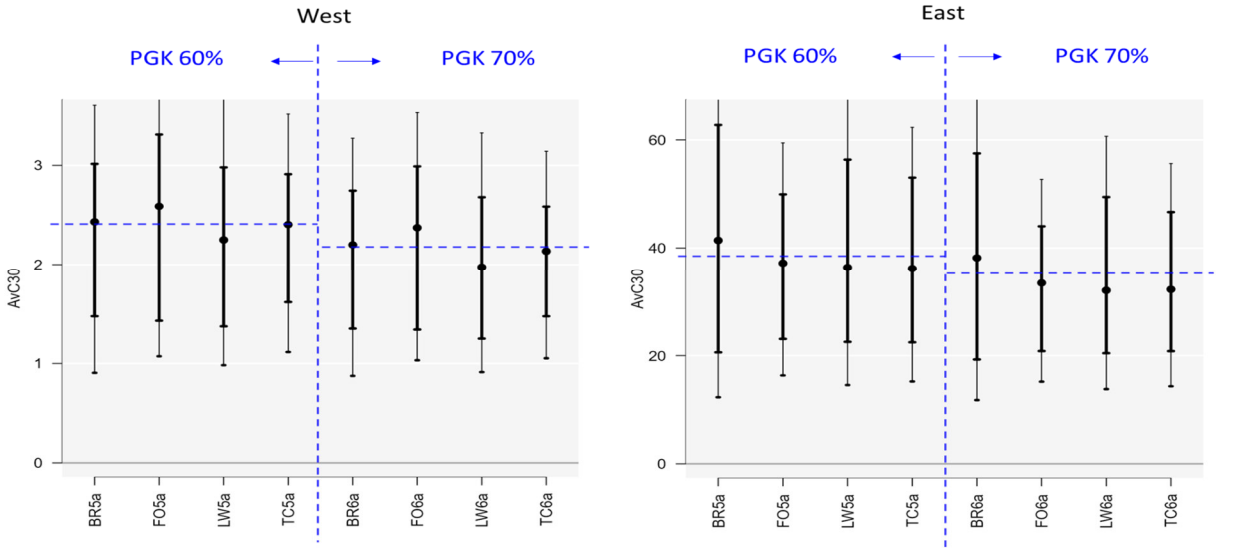

Figure 2. Performance results for a) Biomass - Br30 and b) Yield - AvC30 for four CMPs for the two separate PGK tunings - 5 for PGK=60% and 6 tuned to PGK=70%. All have a 2-yr management cycle. The point indicates the median, the thicker black line indicates the 25/75%-iles, and the whiskers indicate the 5/95%-iles. Panel a) shows that stock status improves for PGK=70%, while Panel b) shows the lower yield from PGK=70%. The blue horizontal dashed lines show the mean values.

Table 7. Relative performance results for the four CMPs for PGK60% vs. PGK70%. Ranking is based on the Tot column in the primary quilt plots. The first and last ranked CMPs are the same for PGK60% and PGK70%, but the second and third ranked switch places between the two PGK tunings. *TC did not meet minimum threshold for $LD^*_{15\%}$ for PGK60%.

Ranking	PGK=60%	PGK=70%
1	BR	BR
2	FO	TC
3	TC*	FO
4	LW	LW

Decision Point #3: Management cycle length

Options: 2-or **3**-yr TAC setting intervals. That is, the first TAC would apply for either 2023-2024 or 2023-2025.

Strategic considerations:

- The 3-yr cycle CMPs are slightly slower to react to signals to change the TAC. As a result, the changes in TAC need to be larger in the 3-yr cycle variants, and this is seen in larger VarC statistics.
- Yields are slightly lower when using a 3-yr management cycle, with more pronounced reductions in near-term TACs (AvC10) compared to long-term TACs (AvC30).
- If a 3-yr cycle is chosen with PGK=60%, +20%/-35% stability provisions are required to meet the $LD^*_{15\%}$ standard of 0.4 and only BR and FO CMPs meet this (see Decision Point #4).
- Managers will need to decide whether biomass and yield differences and CMP type restrictions are large enough to outweigh other considerations, such as administrative needs.

Relevant results:

Two- and 3-yr management cycles were tested for all four CMPs across PGK 60% and 70% (**Table 8, 9, 10, 11 and Figure 3**).

Table 8. Primary quilt plot for **tuning level 5 (PGK=60%).** Results are shown for **2-yr (variant a)** and **3-yr (variant b) management cycles**, each with +20/-30 stability following the phase-in. Values of LD*15 below the B_{LIM} (0.4) are denoted in red. Note that although 3-yr cycles with +20%/-30% fail LD*15% for all CMPs shown in this table, changing to +20%/-35% stability satisfies the LD*15% objective for some CMPs (see Decision Point #4).

				West					East				
CMP	Type	Tuning	Variant	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)
BR5a	BR	60%	2-yr, -30%	0.6	2.77	2.43	8.81	0.42	0.6	51.97	41.42	15.6	0.45
BR5b	BR	60%	3-yr, -30%	0.6	2.7	2.4	10.37	0.4	0.6	47.75	41.17	17.96	0.38
FO5a	FO	60%	2-yr, -30%	0.61	2.89	2.59	14.86	0.4	0.6	46.88	37.19	16.68	0.45
FO5b	FO	60%	3-yr, -30%	0.61	2.59	2.51	17.12	0.4	0.6	47.15	38.29	19.35	0.37
LW5a	LW	60%	2-yr, -30%	0.6	2.41	2.25	16.52	0.48	0.6	43.96	36.33	18.35	0.45
LW5b	LW	60%	3-yr, -30%	0.6	2.21	2.22	17.34	0.46	0.6	45.02	37.04	19.72	0.37
TC5a	TC	60%	2-yr, -30%	0.6	2.67	2.4	7.51	0.4	0.6	41.07	36.18	10.01	0.41
TC5b	TC	60%	3-yr, -30%	0.61	2.59	2.38	8.49	0.37	0.6	40.12	35.76	11.84	0.34

Table 9. Primary quilt plot for the West and East for **tuning level 6 (PGK=70%).** Results are shown for **2-year (variant a)** and **3-yr (variant b) management cycles**, each with +20/-30 stability following the phase-in. All combinations meet the B_{LIM} threshold.

				West					East				
CMP	Type	Tuning	Variant	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)
BR6a	BR	70%	2-yr, -30%	0.71	2.57	2.2	8.21	0.45	0.7	46.49	38.13	14.63	0.51
BR6b	BR	70%	3-yr, -30%	0.7	2.55	2.18	9.75	0.43	0.7	43.27	37.2	17.14	0.44
FO6a	FO	70%	2-yr, -30%	0.71	2.66	2.37	15.03	0.41	0.7	42.71	33.46	16.45	0.52
FO6b	FO	70%	3-yr, -30%	0.71	2.43	2.3	17.27	0.42	0.7	43.08	34.46	19.13	0.46
LW6a	LW	70%	2-yr, -30%	0.7	2.04	1.97	16.5	0.5	0.7	36.41	32.08	17.68	0.51
LW6b	LW	70%	3-yr, -30%	0.7	2.02	1.97	17.42	0.47	0.7	37.94	32.22	19.08	0.44
TC6a	TC	70%	2-yr, -30%	0.71	2.37	2.13	7.09	0.45	0.7	36.33	32.27	9.41	0.49
TC6b	TC	70%	3-yr, -30%	0.71	2.33	2.1	8.22	0.43	0.71	35.89	31.69	11.05	0.43

Table 10. Performance statistics averaged across 4 CMPs and PGK 60% and 70% for 2 and 3-yr management cycles, with the default stability of +20%/-30%. The percent difference row is shown relative to a 2-yr cycle (i.e., the West AvC10 of -4.7% means that a 3-yr has 4.7% lower short-term catch than a 2-yr cycle). By averaging across all CMP variants, this table isolates the 2 vs. 3-yr decision. The rank order of CMPs is retained across 2 versus 3 years. Note that this does not include the +20/-35% stability provision for 3-yr management cycles.

	West				**East**			
Mgmt cycle (yrs)	**AvC10 (50%)**	**AvC30 (50%)**	**VarC (50%)**	**LD* (15%)**	**AvC10 (50%)**	**AvC30 (50%)**	**VarC (50%)**	**LD* (15%)**
2	**2.55**	**2.29**	**11.82**	**0.44**	**43.23**	**35.88**	**14.85**	**0.47**
3	**2.43**	**2.26**	**13.25**	**0.42**	**42.53**	**35.98**	**16.91**	**0.40**
% difference	**-4.7%**	**-1.5%**	**12.1%**	**-3.7%**	**-1.6%**	**0.3%**	**13.9%**	**-14.8%**

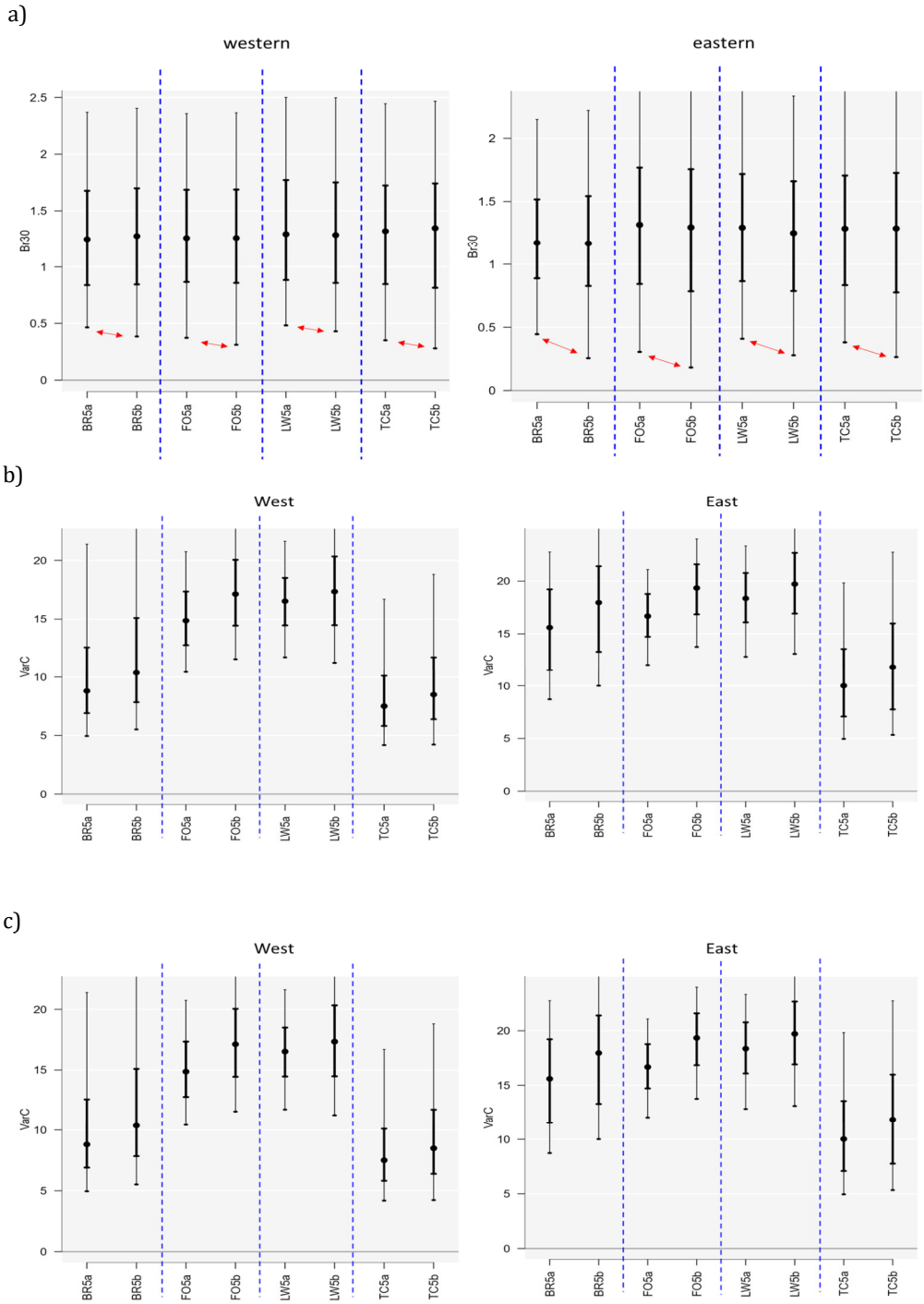

Figure 3. Performance results for a) Biomass - Br30, b) Yield - AvC30, and c) Stability - VarC for all CMPs for a 2-yr (a variant) vs. 3-yr (b variant) management cycle. All are tuned to PGK=60%. The western results are on the left, and the eastern results are on the right. The point indicates the median, the thick lines indicates the 25/75%-iles, and the whiskers indicate the 5/95%-iles. Panel a) shows that 2-yr cycles have better lower tail biomass performance than 3-yr cycles, especially for the eastern stock. Panel b) shows that cycle length has little impact on yield. Panel c) shows that 3-yr cycles have larger variability to compensate for fewer changes. See **Table 2** for more detailed descriptions of performance statistics.

Table 11. Relative performance results for the 4 CMPs for 2-yr vs. 3-yr management cycles. Ranking is based on the Tot column in the primary quilt plots. The relative ranking of CMPs (BR, FO, TC, LW) remains unchanged between the 2 and 3-yr management cycles. *Each of the 3-year variants use the default (+20/-30% stability provision and do not meet LD*$_{15\%}$.

Ranking	2-yr variants	3-yr variants
1	BR	BR*
2	FO	FO*
3	TC	TC*
4	LW	LW*

Decision Point #4: Operational management objective for Stability

Options: This is a subsidiary decision applicable only to the 3-yr TAC setting interval. If a 3-yr management cycle is chosen, then, following the phase-in period, allowing greater reductions in TAC change between management cycles, e.g. changing the default of **+20/-30%** to **+20%/-35%**, may need to be considered. All CMPs with a 2-yr management cycle use **+20%/-30%.**

Strategic considerations:

- All CMPs used a default stability provision to limit TAC changes to 20% increases and 30% decreases between management cycles, following the initial phase-in period.
- This asymmetry (as compared to +20%/-20%) has proven critical to enable CMPs to respond to stock declines.
- All CMPs were unable to achieve the minimum threshold $LD^*_{15\%}$=0.40 in variants using 3-yr management cycles and tuning to PGK60%.
- Should Panel 2 choose a 3-yr management cycle and 60% PGK, +20/-35% is required to meet the $LD^*_{15\%}$ threshold. Even then, this threshold can only be met only by CMPs BR and FO.

Relevant results:

Allowing greater asymmetry in stability (i.e., +20%/-35%) improves safety performance ($LD^*_{15\%}$) with little impact on (AvC30) and stability (VarC) when compared to the default (+20%/-30%) (**Table 12, Figure 4**).

Table 12. Primary quilt plot for **tuning level 5 (PGK=60%).** Results are shown for **3-yr cycles with +20%/-30% stability (variant b)** and **3-yr cycles with +20%/-35% stability (variant c)**, following the initial phase-in period. Note that not all CMPs were successful in meeting $LD^*_{15\%}$, even with +20/-35%. Values of $LD^*_{15\%}$ below the B_{LIM} (0.4) are denoted in red.

				West					East				
CMP	Type	Tuning	Variant	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)	PGK (Mean)	AvC10 (50%)	AvC30 (50%)	VarC (50%)	LD (15%)
BR5c	BR	60%	3-yr, -35%	0.6	2.74	2.46	10.49	0.4	0.6	48.37	41.28	18.65	0.41
BR5b	BR	60%	3-yr, -30%	0.6	2.7	2.4	10.37	0.4	0.6	47.75	41.17	17.96	0.38
FO5c	FO	60%	3-yr, -35%	0.62	2.59	2.51	17.41	0.42	0.62	47.15	37.75	19.85	0.41
FO5b	FO	60%	3-yr, -30%	0.61	2.59	2.51	17.12	0.4	0.6	47.15	38.29	19.35	0.37
LW5c	LW	60%	3-yr, -35%	0.6	2.22	2.22	17.74	0.47	0.6	47.09	37.88	20.25	0.39
LW5b	LW	60%	3-yr, -30%	0.6	2.21	2.22	17.34	0.46	0.6	45.02	37.04	19.72	0.37
TC5c	TC	60%	3-yr, -35%	0.6	2.6	2.39	8.53	0.37	0.6	40.4	36.01	11.9	0.35
TC5b	TC	60%	3-yr, -30%	0.61	2.59	2.38	8.49	0.37	0.6	40.12	35.76	11.84	0.34

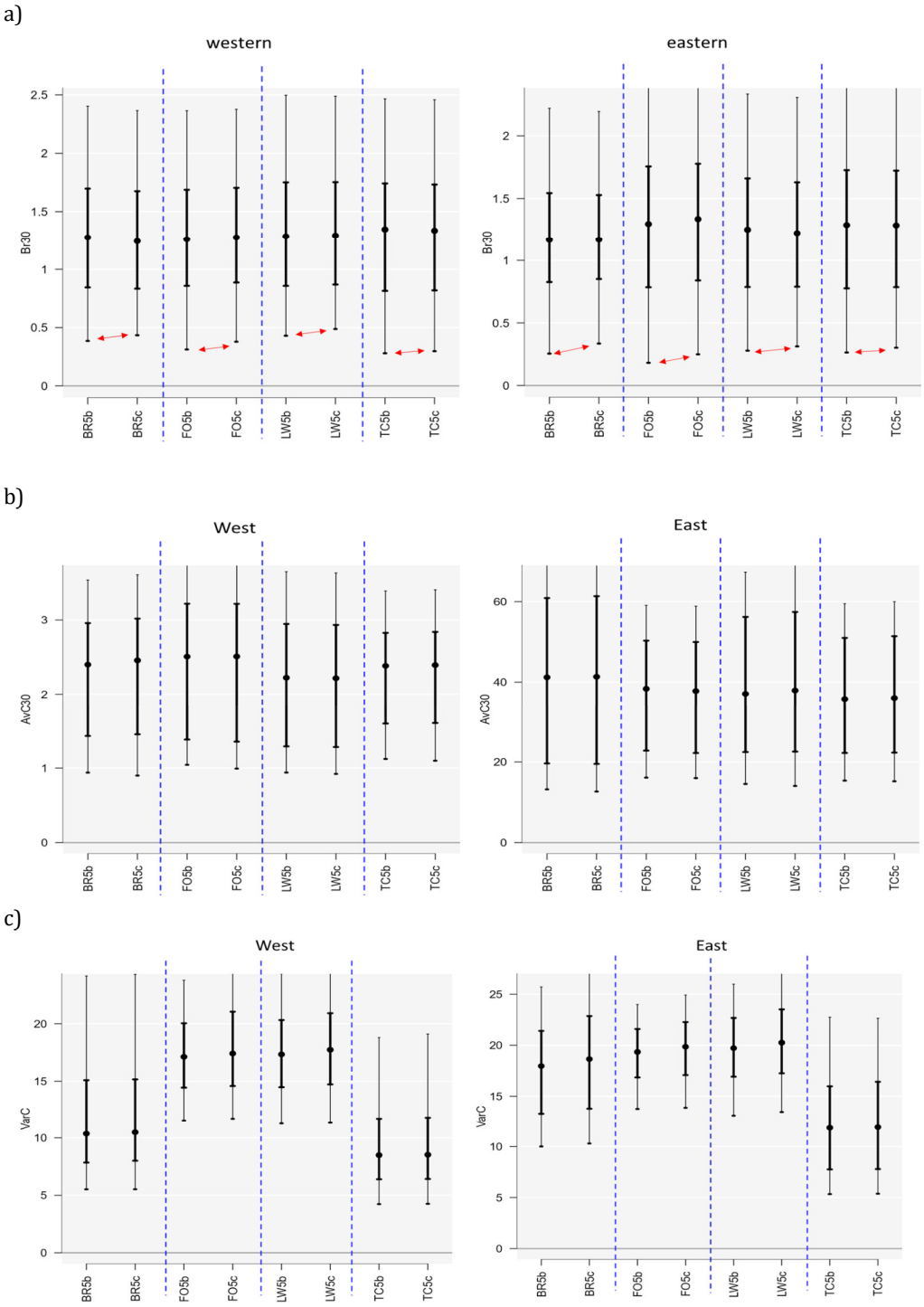

Figure 4. Performance results for a) Biomass - Br30, b) Yield - AvC30, and c) Stability - VarC for all CMPs for a 3-yr, +20%/-30% (a variant) vs. 3-yr, +20%/-35% (c variant) management cycle. All are tuned to PGK=60%. The point indicates the median, the thick line indicates the 25/75%-iles, and the whiskers indicate the 5/95%-iles. Panel a) shows that -35% allows a small improvement in tail biomass performance compared to -30%. Panel b) shows that these stability options have little impact on long-term yield. Panel c) shows that -30% and -35% have similar impacts on stability.

Decision Point #5: Management procedure type

Options: BR, FO, LW** or **TC

Strategic considerations:

- Assuming acceptance of the +20/-35% stability provision for PGK60% and 3-year cycles, this results in 4 CMPs x 4 variants (16 in total) tuned to 60% and 70% PGK, and using 2 and 3-yr management cycles (**Table 13**).
- Each CMP uses a different combination (or all) of the abundance indices.
- All CMPs meet or nearly meet minimum operational management objectives for Stock Status and Safety but with varying performance on the Yield and Stability tradeoffs.
- Relative CMP ranking is generally conserved across all the key decision points (e.g. 2-3 year cycles, PGK). The exception is that TC performs better than FO under PGK=70%, while FO outperforms TC under all other variants.
- TC results in the lowest TAC variation (VarC) between management cycles.

Relevant results:

Primary quilt plots are shown in the preceding sections to show relative performance of the four remaining CMPs (**BR**, **FO**, **LW** or **TC**), across the various PGK (**Tables 4, 5**) and management cycle length (**Tables 8, 9**) variants. These are ranked on 5 key performance statistics for both East and West (**Table 13**). A secondary quilt plot (**Table 14**) includes 10 additional statistics.

Relative ordering of the CMPs is similar across all variants as well as across each variant (e.g. 2 or 3-yr management cycle and PGK) (**Table 15**) except for TC and FO reversing order for PGK70%. This separates decision making on the variants from decisions on the CMPs, e.g. one could choose a variant first, or choose a CMP first, and the choices would be unaffected. Ordering of CMPs separately for the East and the West (**Table 16**) similarly indicates that the top ranked CMP remains the same across both, but there are some differences in order by East or West. The Committee also provides a summary table of the short and medium-term yields for all CMPs and their variants (**Table 17**).

Table 13. Primary quilt plot for **tuning level 5 (PGK=60%) and tuning level 6 (PGK=70%).** Results are shown for **2-yr cycles with +20%/-30% stability (variant a)** and **3-yr with +20%/-35% stability (variant c) cycles**, following the initial phase-in period. Note that not all CMPs were successful in meeting $LD^*_{15\%}$, even with +20/-35%. Values of $LD^*_{15\%}$ below the B_{LIM} (0.4) are denoted in red. In this table the CMPs are ordered by the '*Tot*' column.

				West					East					
order	CMP	Tuning	Variant	PGK	AvC10 (kt)	AvC30 (kt)	VarC	LD (15%)	PGK	AvC10 (kt)	AvC30 (kt)	VarC	LD (15%)	Tot
1	BR	PGK60%	2-yr	71%	2.57	2.2	8.21	0.45	70%	46.49	38.13	14.63	0.51	0.31
2	BR	PGK60%	2-yr	60%	2.77	2.43	8.81	0.42	60%	51.97	41.42	15.6	0.45	0.32
3	TC	PGK70%	2-yr	71%	2.37	2.13	7.09	0.45	70%	36.33	32.27	9.41	0.49	0.36
4	TC	PGK60%	2-yr	60%	2.67	2.4	7.51	0.4	60%	41.07	36.18	10.01	0.41	0.39
5	BR	PGK60%	3-yr, -35%	60%	2.74	2.46	10.49	0.4	60%	48.37	41.28	18.65	0.41	0.48
6	BR	PGK70%	3-yr	70%	2.55	2.18	9.75	0.43	70%	43.27	37.2	17.14	0.44	0.49
7	FO	PGK60%	2-yr	61%	2.89	2.59	14.86	0.4	60%	46.88	37.19	16.68	0.45	0.49
8	TC	PGK70%	3-yr	71%	2.33	2.1	8.22	0.43	71%	35.89	31.69	11.05	0.43	0.5
9	FO	PGK70%	2-yr	71%	2.66	2.37	15.03	0.41	70%	42.71	33.46	16.45	0.52	0.52
10	LW	PGK60%	2-yr	60%	2.41	2.25	16.52	0.48	60%	43.96	36.33	18.35	0.45	0.55
11	TC	PGK60%	3-yr, -35%	60%	2.6	2.39	8.53	0.37	60%	40.4	36.01	11.9	0.35	0.55
12	LW	PGK70%	2-yr	70%	2.04	1.97	16.5	0.5	70%	36.41	32.08	17.68	0.51	0.61
13	FO	PGK60%	3-yr, -35%	62%	2.59	2.51	17.41	0.42	62%	47.15	37.75	19.85	0.41	0.62
14	FO	PGK70%	3-yr	71%	2.43	2.3	17.27	0.42	70%	43.08	34.46	19.13	0.46	0.66
15	LW	PGK60%	3-yr, -35%	60%	2.22	2.22	17.74	0.47	60%	47.09	37.88	20.25	0.39	0.66
16	LW	PGK70%	3-yr	70%	2.02	1.97	17.42	0.47	70%	37.94	32.22	19.08	0.44	0.74

Table 14. Secondary quilt plots, shown separately for East (a) and West (b), which depict the following 10 performance statistics - C1: catch (kilotons, kt) in the first year of CMP application; AvC20: average catch (kt) over years 1-20 (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 ($SSB \geqq SSB_{MSY}$ or $U<U_{MSY}$) after 30 projected years (mean), OFT: Overfished trend, SSB trend over projection years 31 - 35 when Br30 < 1. CMPs are ordered by the '*Tot*' column from the primary quilt plot.

a)

	East												
order	CMP	Tuning	Variant	TAC_1 (kt) (or C1)	AvC20 (kt)	AvgBr	Br20	Br30 (5%)	LD (5%)	LD (10%)	POF	PNRK	OFT (P>0)
1	BR	PGK60%	2-yr	40.57	44.29	1.34	1.29	0.58	0.33	0.43	0.06	0.97	0.92
2	BR	PGK60%	2-yr	40.57	47.63	1.21	1.15	0.44	0.27	0.38	0.11	0.93	0.88
3	TC	PGK70%	2-yr	38.91	34.38	1.52	1.51	0.49	0.32	0.42	0.09	0.93	0.89
4	TC	PGK60%	2-yr	41.28	39.02	1.38	1.36	0.38	0.24	0.35	0.18	0.85	0.83
5	BR	PGK60%	3-yr, -35%	40.57	48.45	1.25	1.21	0.33	0.21	0.33	0.13	0.89	0.85
6	FO	PGK70%	3-yr	38.29	43.88	1.39	1.35	0.3	0.25	0.36	0.25	0.8	0.83
7	BR	PGK60%	2-yr	40.57	41.81	1.38	1.35	0.42	0.25	0.36	0.08	0.93	0.87
8	TC	PGK70%	3-yr	38.29	33.86	1.56	1.55	0.42	0.25	0.35	0.07	0.93	0.87
9	FO	PGK70%	2-yr	38.29	38.87	1.52	1.49	0.45	0.34	0.45	0.13	0.9	0.89
10	LW	PGK60%	2-yr	43.2	40.46	1.33	1.3	0.41	0.27	0.37	0.18	0.87	0.87
11	TC	PGK60%	3-yr, -35%	40.94	38.74	1.41	1.39	0.3	0.18	0.27	0.17	0.84	0.81
12	LW	PGK70%	2-yr	43.2	34.79	1.48	1.47	0.51	0.32	0.43	0.09	0.94	0.91
13	FO	PGK60%	3-yr, -35%	38.29	44.51	1.39	1.35	0.25	0.21	0.33	0.22	0.81	0.81
14	FO	PGK70%	3-yr	38.29	40.19	1.49	1.46	0.35	0.26	0.37	0.13	0.89	0.87
15	LW	PGK60%	3-yr, -35%	43.2	43.16	1.29	1.24	0.31	0.19	0.3	0.16	0.87	0.85
16	LW	PGK70%	3-yr	43.2	35.78	1.46	1.42	0.41	0.23	0.35	0.07	0.94	0.89

b)

	West												
order	CMP	Tuning	Variant	TAC_1 (kt) or C1	AvC20 (kt)	AvgBr	Br20	Br30 (5%)	LD (5%)	LD (10%)	POF	PNRK	OFT (P>0)
1	BR	PGK60%	2-yr	2.69	2.38	1.5	1.47	0.54	0.2	0.3	0.09	0.94	0.92
2	BR	PGK60%	2-yr	2.69	2.46	1.37	1.33	0.46	0.2	0.29	0.18	0.86	0.85
3	TC	PGK70%	2-yr	2.5	2.23	1.56	1.57	0.46	0.21	0.3	0.12	0.91	0.92
4	TC	PGK60%	2-yr	2.65	2.53	1.44	1.43	0.35	0.17	0.26	0.24	0.81	0.87
5	BR	PGK60%	3-yr, -35%	2.69	2.64	1.4	1.37	0.43	0.19	0.27	0.18	0.87	0.83
6	FO	PGK70%	3-yr	2.96	2.81	1.37	1.31	0.37	0.16	0.25	0.19	0.86	0.88
7	BR	PGK60%	2-yr	2.69	2.11	1.53	1.51	0.46	0.18	0.28	0.09	0.94	0.92
8	TC	PGK70%	3-yr	2.46	2.2	1.59	1.6	0.4	0.18	0.28	0.11	0.92	0.93
9	FO	PGK70%	2-yr	2.96	2.55	1.48	1.45	0.42	0.16	0.25	0.08	0.94	0.93
10	LW	PGK60%	2-yr	2.45	2.39	1.41	1.37	0.48	0.22	0.32	0.21	0.85	0.86
11	TC	PGK60%	3-yr, -35%	2.62	2.5	1.46	1.45	0.3	0.14	0.23	0.22	0.83	0.87
12	LW	PGK70%	2-yr	2.45	2.07	1.56	1.54	0.55	0.23	0.33	0.12	0.93	0.92
13	FO	PGK60%	3-yr, -35%	2.96	2.68	1.4	1.36	0.38	0.18	0.27	0.17	0.87	0.88
14	FO	PGK70%	3-yr	2.96	2.44	1.5	1.47	0.38	0.15	0.25	0.08	0.94	0.93
15	LW	PGK60%	3-yr, -35%	2.45	2.36	1.44	1.4	0.49	0.22	0.32	0.21	0.85	0.84
16	LW	PGK70%	3-yr	2.45	2.06	1.57	1.56	0.49	0.21	0.3	0.12	0.93	0.91

Table 15. Relative performance results for the 4 CMPs and their variants for the East and West combined. The relative ranking of CMPs (BR, FO, TC, LW) remains unchanged, except for PGK=70%, where the second and third ranked CMPs switch places. * Note that not all CMPs averaged here meet LD*$_{15\%}$.

Ranking	All variants	2-yr	3-yr	PGK=60%	PGK=70%
1	BR*	BR	BR*	BR	BR
2	FO*	FO	FO*	FO	TC
3	TC*	TC	TC*	TC*	FO
4	LW*	LW	LW*	LW	LW

Table 16. Relative performance results for the 4 CMPs and their variants, presented separately for the East and West. The top-ranked CMP is the same for all variants (i.e., BR), but the relative ranking of CMPs (FO, TC, LW) varies somewhat for East and West. *Note that some of the CMPs averaged here do not meet LD*$_{15\%}$.

Rank	East					West				
	All variants	2-yr	3-yr	PGK=60%	PGK=70%	All variants	2-yr	3-yr	PGK=60%	PGK=70%
1	BR	BR	BR	BR	BR	BR	BR	BR	BR	BR
2	FO	FO	FO	FO	FO	TC	TC	TC	TC	TC
3	TC	TC	TC	LW	TC	FO	FO	FO	FO	FO
4	LW	LW	LW	TC	LW	LW	LW	LW	LW	LW

Table 17. Table of all available CMPs and their variants and their short (C1) and medium (AvC10) yields and variability in yield (VarC). CMPs that do not satisfy LD*$_{15\%}$ are denoted in orange shading.

EAST									WEST								
CMP	LD	PGK	Cycle	Stability	C1	AvC10	VarC	Note	CMP	LD	PGK	Cycle	Stability	C1	AvC10	VarC	Note
BR	15	60	2	+20/-30	40,570	51,970	15.6		BR	15	60	2	+20/-30	2,690	2,770	8.81	
			3	+20/-30	40,570	47,750	17.96	LD=0.38				3	+20/-30	2,690	2,700	10.37	
				+20/-35	40,570	48,370	18.65						+20/-35	2,690	2,740	10.49	
		70	2	+20/-30	40,570	46,490	14.63				70	2	+20/-30	2,690	2,570	8.21	
			3	+20/-30	40,570	43,270	17.14					3	+20/-30	2,690	2,550	9.75	
TC	15	60	2	+20/-30	41,280	41,070	10.01		TC	15	60	2	+20/-30	2,650	2,670	7.51	
			3	+20/-30	40,780	40,120	11.84	LD=0.34				3	+20/-30	2,620	2,590	8.49	LD=0.37
				+20/-35	40,940	40,400	11.9	LD=0.35					+20/-35	2,620	2,600	8.53	LD=0.37
		70	2	+20/-30	38,910	36,330	9.41				70	2	+20/-30	2,500	2,370	7.09	
			3	+20/-30	38,290	35,890	11.05					3	+20/-30	2,460	2,330	8.22	
FO	15	60	2	+20/-30	38,290	46,880	16.68		FO	15	60	2	+20/-30	2,960	2,890	14.86	
			3	+20/-30	38,290	47,150	19.35	LD=0.37				3	+20/-30	2,960	2,590	17.12	
				+20/-35	38,290	47,150	19.85						+20/-35	2,960	2,590	17.41	
		70	2	+20/-30	38,290	42,710	16.45				70	2	+20/-30	2,960	2,660	15.03	
			3	+20/-30	38,290	43,080	19.13					3	+20/-30	2,960	2,430	17.27	
LW	15	60	2	+20/-30	43,200	43,960	18.35		LW	15	60	2	+20/-30	2,450	2,410	16.52	
			3	+20/-30	43,200	45,020	19.72	LD=0.37				3	+20/-30	2,450	2,210	17.34	
				+20/-35	43,200	47,090	20.25	LD=0.39					+20/-35	2,450	2,220	17.74	
		70	2	+20/-30	43,200	36,410	17.68				70	2	+20/-30	2,450	2,040	16.5	
			3	+20/-30	43,200	37,940	19.08					3	+20/-30	2,450	2,020	17.42	

Decision Point #6: Timeframe for review of Management Procedure

Options: The SCRS recommends that the MP be reviewed **every 6 years**, i.e. completed in 2028 for the first time.

A key element of the process of management procedure implementation is the process of its review. Such a review can occur at regularly, prescheduled intervals or following the declaration of exceptional circumstances. In most cases such a review would not constitute a wholesale revision to the operating model structure, full reconditioning of the OMs or substantial changes to the CMPs, though it offers that opportunity should the need arise. In most cases, such reviews could implement index revisions or relatively minor improvements to the operating models or MPs; indeed, the outcome may leave the MP unchanged.

The SCRS recommends that the period between regular MP reviews must be a multiple of the management (TAC-setting) cycle duration to ensure that the two processes remain in synchrony. Therefore, review should occur in a multiple of either 2 or 3 years since those are the two cycle periods which the Commission has under consideration. The SCRS notes that an inter-review period of 6 years, by the end of which a review must be completed, would be compatible with either of these two cycle durations, as well as with scientific considerations. It notes also that, subsequent to the Commission specifying this period, it might, in the light of experience gained, decide to change that period.

Table 18. Possible timeline of events for MP implementation and review.

Year	Run MP	Exceptional Circumstances	Stock Assessment/ Health Check	MP Review
2022	Adopt MP		East	
2023		Adopt EC protocol		
2024	If 2-yr cycle	Check		
2025	If 3-yr cycle	Check		
2026	If 2-yr cycle	Check		
2027		Check	TBD: As status check & to inform potential reconditioning	Start reconditioning of MSE & consider new data/methods
2028	If 2 or 3-yr cycle	Check		Finish reconditioning of MSE & consider new data/methods
2029		Check		

Atlantic Bluefin Tuna MSE – Background & Structure

Background

The SCRS's Bluefin Tuna Species Group has been developing a management strategy evaluation (MSE) framework for Atlantic bluefin tuna (BFT) since 2014 with support from the Atlantic-Wide Research Programme for Bluefin Tuna (GBYP). In 2015, the Commission called for adoption of a management procedure (MP) based on the MSE (Rec. 15-07), and preliminary work was first presented to the Commission in 2016. Since then, an MSE expert has been contracted to develop and coordinate the MSE. There have been multiple meetings in which the SCRS interacted with the Commission on MSE, and this included appraising the Commission on progress for the purpose of soliciting feedback. The Commission adopted conceptual management objectives for BFT in 2018 (Res. 18-03) to help guide MSE development. The MSE work is now complete, and ready as the basis for ICCAT to adopt an MP in 2022, in accordance with the Commission's MSE workplan.

MSE Overview

Mixing of East and West stocks

The Atlantic bluefin tuna MSE framework assumes that there are two genetically distinct stocks (western and eastern) that migrate and mix throughout the North Atlantic. The 45°W management boundary is used to divide the East and West management areas, but unlike the current stock assessments, the MSE takes account of the reality that bluefin from the eastern stock migrate into the West management area, and vice versa. Only western fish are assumed to be found in the Gulf of Mexico, and only eastern fish are assumed to be found in the Mediterranean Sea, but stock mixing takes place in the other 5 spatial strata, with stock composition varying by calendar quarter and age class (i.e., 1-4, 5-8, and 9+ year olds). Stock movements are projected based on data from electronic tagging, as well as genetic and otolith analyses (GBYP-supported research). Importantly, conservation targets are (appropriately) by stock, not by area.

Indices of abundance

Data from 26 different indices, both fishery dependent and independent, are used to condition the MSE. The MSE's historical period is from 1965 through to 2019 (with an additional data poor historical period of 1864-1965), and analysis of projections focuses on the next 30 years. The MSE computer code was independently reviewed in 2021, and no substantive problems were found.

Operating Models

Each operating model (OM) in the MSE represents a plausible scenario/a potential truth for the dynamics of the stocks and the fishery. The BFT MSE includes 48 main operating models (i.e., the "reference set or grid of OMs") based on four major sources of uncertainty:

1. Recruitment: the number of age 1 fish; reflects stock productivity over time (3 options)[2]
2. Spawning fraction/Natural mortality: the percent of individuals who reproduce/die of natural causes at a given age (2 options)
3. Scale: Rough abundances of fish in the West and East management areas (4 options)
4. Length composition weighting: a gauge of the confidence in the size data (2 options)

The 48 OMs allow for all combinations of these options (3x2x4x2=48). The relative plausibility of each assumption has been ranked by the SCRS according to a schema, referred to as "weighting," so that the results reflect more importance given to the more plausible OMs. The recruitment and scale options have been weighted based upon expert opinion, and the other two uncertainties are weighted equally. There are 44 additional "robustness" OMs to evaluate less likely but still possible scenarios, similar to more extreme "sensitivity runs" in a stock assessment.

[2] The first two recruitment scenarios in the OMs mimic the still unresolved debate between the low and high recruitment scenarios for the West Atlantic bluefin assessment. For the first of these two scenarios, the western stock switches from a high to a low productivity regime in the mid-1970s, while the eastern stock switches in the opposite direction in the mid-1980s. For the second recruitment scenario, there is no regime shift for either stock (this corresponds to the high recruitment scenario for the West Atlantic bluefin assessment). The third recruitment scenario in the OMs is identical to the first historically, but sees a reversal of the earlier regime shifts in 10 years. The three options are weighted 40/40/20%.

Glossary

AvC10: Average catch years 1-10, measures short term yield.

AvC30: Average catch years 1-30, measures long term yield.

Br30: Spawning biomass relative to dynamic SSB_{MSY} in projection year 30.

Limit reference point (LRP): A benchmark for an indicator that defines an undesirable biological state of the stock such as the B_{LIM} or the biomass limit which is undesirable to be below. To keep the stock safe, the probability of violating an LRP should be very low.

LD: Lowest depletion (spawning biomass relative to dynamic SSB_{MSY}).

Management objectives: Formally adopted social, economic, biological, ecosystem, and political (or other) goals for a stock and fishery. They include high-level or conceptual objectives often expressed in legislation, conventions or similar documents. They must also include operational objectives that are specific and measurable, with associated timelines. When management objectives are referenced in the context of management procedures, the latter, more specific definition applies, but sometimes conceptual objectives are adopted first (e.g., Rec. 18-03 for ABFT).

Management procedure (MP): Some combination of monitoring, assessment, harvest control rule and management action designed to meet the stated objectives of a fishery, and which has been simulation tested for performance and adequate robustness to uncertainties. Also known as a harvest strategy.

Management strategy evaluation (MSE): A simulation-based, analytical framework used to evaluate the performance of multiple management procedures relative to the pre-specified management objectives.

Operating model (OM): A model representing a plausible scenario for stock and fishery dynamics that is used to simulation test the management performance of CMPs. Multiple models will usually be considered to reflect the uncertainties about the dynamics of the resource and fishery, thereby testing the robustness of management procedures.

Performance statistic: A quantitative expression of a management objective used to evaluate how well an objective is being achieved by determining the proximity of the current value of the statistic to the objective. Also known as a performance metric or performance indicator.

Reference Grid: The operating models that represent the most important uncertainties in stock and fishing dynamics, which are used as the principal basis for evaluating CMP performance. The reference operating models are specified according to factors (e.g., natural mortality rate) that have multiple levels (possible scenarios for each factor, e.g., high).