Original: English

Atlantic Bluefin Tuna MSE – Preliminary Results & Next Steps

Executive Summary

This document presents updated results of the Atlantic bluefin tuna management strategy evaluation (MSE). The intention is to provide sufficient knowledge to facilitate discussion among scientists, fishery managers and other stakeholders at the 4 March 2022 meeting of Panel 2. This document summarizes some preliminary results and highlights key areas for Panel 2 input.

Candidate Management Procedures

There are currently 9 candidate management procedures (CMPs)[1] under development by 6 different international teams of scientists (**Table 1**). All currently assume a 2-year management cycle and calculate a separate total allowable catch (TAC) for the West and East management areas.

Key information

The SCRS proposes a two-step process for facilitating CMP selection.

Development tuning for CMP comparison (Step 1)

- CMPs are being tested on a common Br30[2] performance level (currently 1.0, 1.25 or 1.5, for each stock)
- SCRS will then rank CMPs across the remaining performance statistics corresponding to yield, status, safety and stability objectives
- Panel 2 will then be able to evaluate relative performance of the CMPs to select one or several top CMPs

Performance tuning of culled list of CMPs to determine the final CMP specifications (Step 2)

- All CMPs include at least one tuning parameter for each area that can be adjusted to determine how heavily or lightly it applies fishing pressure.
- These tuning parameters can be altered 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.
- Once top performing CMPs are selected in step 1 they will be *performance tuned* to best achieve Commission objectives. This dial setting will be fixed for the adopted MP.

Preliminary Results

We present preliminary results from anonymous CMPs selected to show key performance tradeoffs for competing management objectives. All CMPs will be refined and improved over the coming months. **Figures 1-6** depict preliminary results and key material. As requested by Panel 2 we have added a table of the percentage of biomass in each area that is of Eastern Stock origin by decade and by region, overall operating models in the reference grid (**Table 2**).

[1] While 9 CMPs are under development, not all will be deemed effective enough to be eligible candidates for MP adoption. Only 2 or 3 CMPs will be presented to the final Panel meeting before the Commission meeting for selection of one to present to the Commission.

[2] Br30 is the biomass ratio, or spawning stock biomass (SSB) relative to dynamic SSB_{MSY}, after 30 years.

Next Steps

Three Panel 2 meetings are scheduled in 2022 for the exchange of information among the SCRS, Panel 2, and stakeholders in advance of the 2022 Commission meeting. The Bluefin Species Group has also appointed ambassadors to help improve understanding of the MSE and answer questions and will continue with the Ambassador meetings. These experts include English, French and Spanish speakers.

At the 4 March 2022 Panel 2 meeting, feedback will be requested on:

- The % TAC change and retention of the default of no caps
- Performance statistics, noting that we currently have 17 but have elevated 8 to be the most useful for distinguishing performance differences across CMPs: **AvgBr, Br30, OFT, LD (5% and 15%iles), AvC10, AvC30, VarC** (See PA2_24 for descriptions) and still have a statistic for fishing mortality in development
- Initial operational management objectives
- The process of CMP selection and CMP performance tuning.
- What additional information PA-2 needs to facilitate the decision points (Noted below) for the 9 May Panel 2 meeting.

At the 9 May 2022 Panel 2 meeting, feedback will be requested on:

- Decisions on final operational management objectives (e.g., Blim) and associated performance statistics
- Decisions on the process for final CMP selection- culling the 9 down to 3 or fewer
    - Development tuning
    - Performance tuning
- Decisions on certain CMP specifications
    - Final agreement on TAC change interval
    - Final agreement regarding limitations on % TAC change up and down
- Feedback on the culled list of CMPs

Other Resources

Atlantic Bluefin Tuna MSE splash page, including interactive Shiny App (Eng only)
Harveststrategies.org MSE outreach materials (multiple languages)

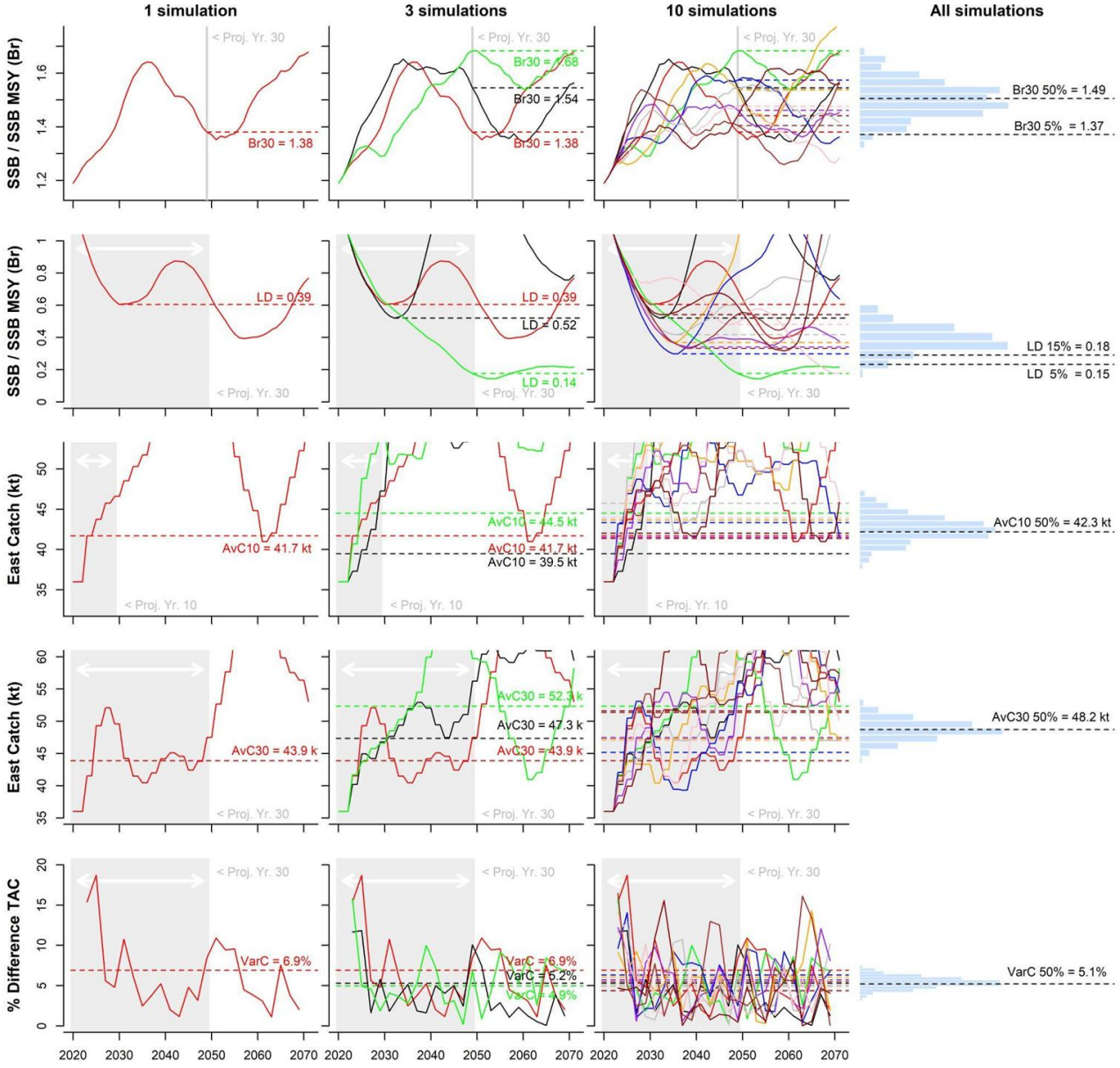

Figure 1. Visual descriptions of the calculation of five key performance statistics illustrating one simulation (first column), three simulations (second column) and ten simulations (third column) for one operating model (OM) and one CMP. The fourth column shows a histogram of values across all simulations (100 in this case) over the relevant time period (shaded area), providing an example of how the statistic is calculated (black text).

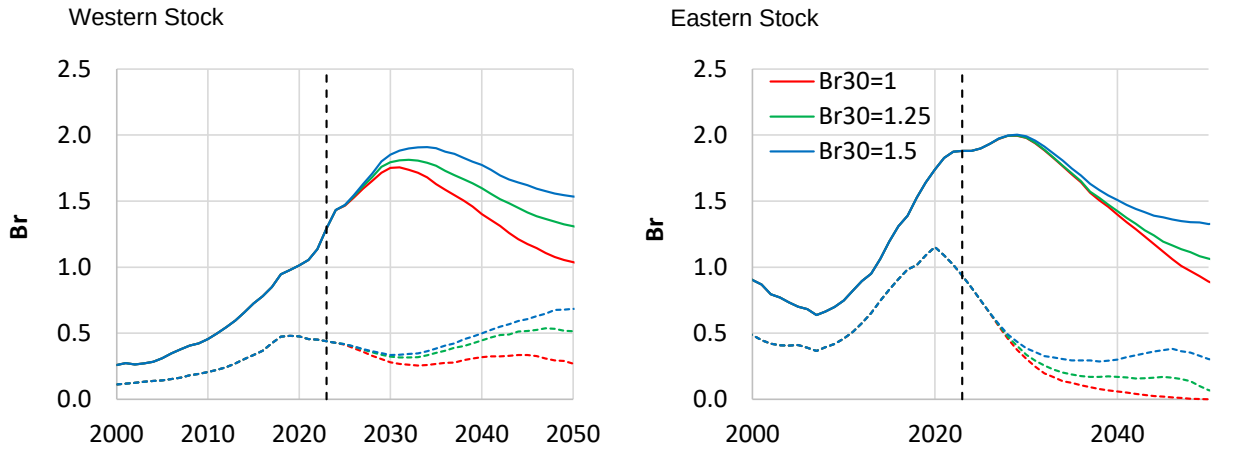

Figure 2. Western (left) and Eastern (right) stock time series of SSB/SSB_{MSY} (median and lower 5 percentile across all OMs) for three different Br30 tuning targets for the CMPs shown in previous Figure (CMP1-red, CMP2-green, CMP3-blue). These three CMPs are one actual CMP tuned to three different Br30 values. The solid lines show the median, and the dashed lines show the lower 5th percentile (i.e., meaning that 5% of biomass values across all OMs and all simulations fall below the dashed lines). The red dashed line in the right panel illustrates the risk of eastern stock collapse with a development tuning target of Br30=1.

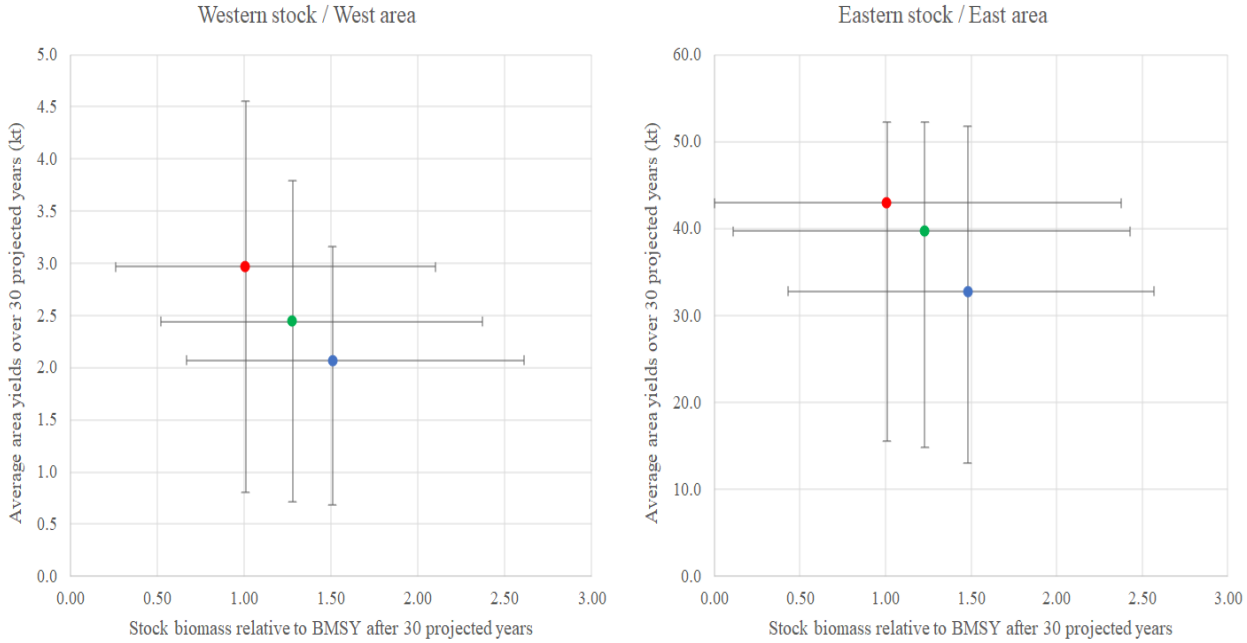

Figure 3. Western (left) and Eastern (right) Area Yields (what is taken by fishing over 30 years, expressed as annual average) vs spawning stock biomass (how much of the resource remains after those 30 years) for three CMPs (CMP1 – red, CMP2 – green, CMP3 – blue), with three different median Br30 tunings. The 90% probability intervals are also shown (by the error bars), again illustrating the danger of stock collapse with a development tuning target of Br30=1.

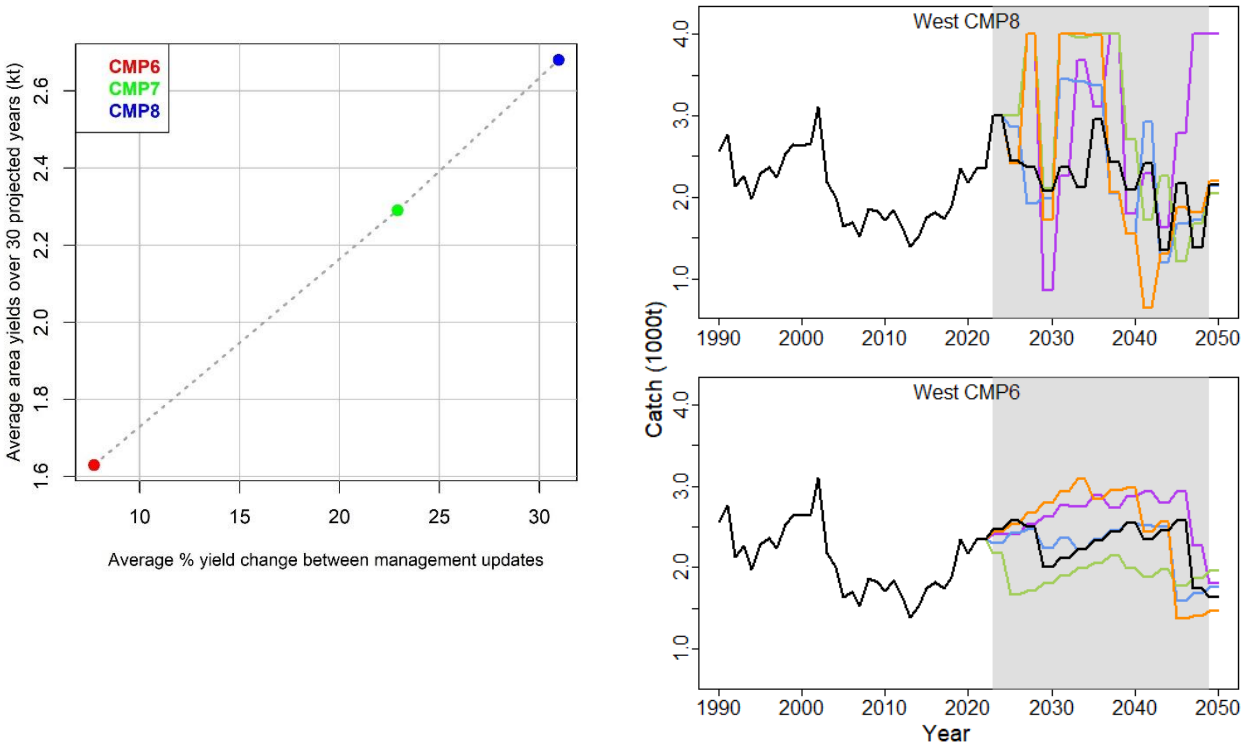

Figure 4. Performance trade-off between West area yields and yield variability. The left panel shows the tradeoff on average over the 30-year projection period across three CMPs (CMP6 – red, CMP7 – green, CMP8 – blue) with comparable biomass performance. Higher catches of CMP8 (upper right blue point) result in higher variability (>30%) of the extent of TAC changes whereas CMP6 (lower right red point) has lower but more stable catches (<10% average annual change in TAC). The right panel shows the time series of annual catches for CMP6 (bottom right) and CMP8 (top right) for the 30-year projection period (shaded), as well as the historical period. The four colored lines depict projections from four different possible future simulations (possible realities, arising mainly from differences in future recruitments) generated from one operating model to display the potential variability, with the median shown in black. The tighter cluster of catch trajectories for CMP6 illustrates the greater stability in catches compared to CMP8 with its higher average yield, demonstrating the trade-off between yield and yield variability.

West	Br30 target	VarC (median)	AvC10 (median)	AvC30 (median)	LD (5th percentile)	LD (15th percentile)
CMP1	1.25	13.79	3.09	2.87	0.22	0.43
CMP2	1.25	11.36	2.05	2.21	0.26	0.48
CMP3	1.25	15.97	2.96	2.53	0.02	0.25
East	**Br30 target**	**VarC (median)**	**AvC10 (median)**	**AvC30 (median)**	**LD (5th percentile)**	**LD (15th percentile)**
CMP1	1.50	16.72	39.06	37.65	0.30	0.55
CMP2	1.50	11.41	34.74	28.50	0.33	0.52
CMP3	1.50	13.95	41.48	30.29	0.07	0.29

Figure 5. Demonstration of the 'Quilt' plot, which illustrates an approach for summarizing the performance of candidate management procedures from development tuning. All CMPs are tuned to meet the same median Br30 value (in this case, 1.25 for the western stock and 1.5 for the eastern stock) to elucidate relative performance across other statistics. This 'levels' the field to facilitate evaluating choices amongst top performing CMPs. Six key performance statistics are shown, which are illustrated above. The absolute value of the statistic is shown, and the CMPs are ranked and color coded within a column. The colors are simply for visual representation of best (green), intermediate (yellow) and worst (red) within a column. Note that while red highlights the worst performing CMP for that statistic, it does not necessarily indicate unacceptable performance.

	VarC (50%)	AvC10 (50%)	AvC30 (50%)	AvgBr (5%)	LD (5%)
CMP1 +20 / - 20% on TAC change	11.3	35.9	31.1	0.40	0.07
CMP2 +20 / -30% on TAC change	12.3	36.6	30.9	0.61	0.11
% change in performance	9%	2%	-1%	51%	51%

Higher percentage TAC reduction allows for faster stock recovery with little loss in yield over time

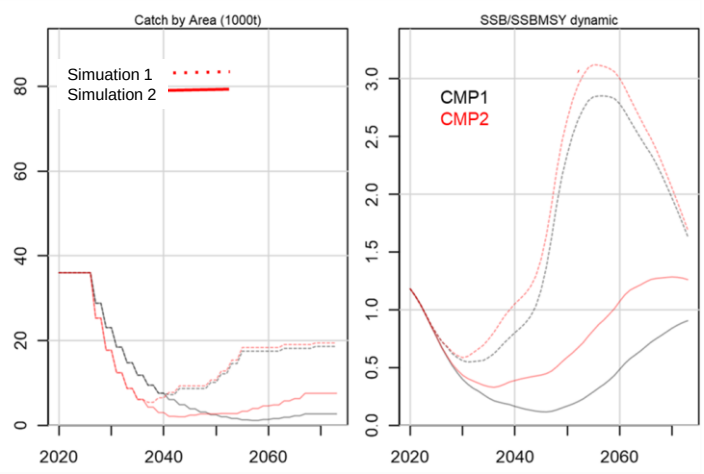

Figure 6. Rationale for allowing asymmetrical catch stability restrictions, using 20% for TAC increases but greater than 20% percent for TAC decreases. Allowing greater than 20% reductions in TAC leads to limited loss in total catch and substantial improvement in safety. The table on the left shows performance and percent change in performance for five performance statistics for two CMPs. CMP1 uses a maximum change of 20% for both TAC increases and decreases. CMP2 limits TAC increases to 20% but with up to a 30% limit on TAC decreases. Higher percentage TAC reduction allows for faster resource recovery with minimal loss in yield and minimal change in variability in catch. The Figures on the right show the catch (for the Eastern area, middle right) and SSB/SSB$_{MSY}$ (for the Eastern stock, far right) for two simulations of each CMP.

Table 1. Table of candidate management procedures (CMPs), indicating in red where changes have occurred since the November Panel 2 meeting.

CMP	Indices used		Formulae for calculating TACs	References
	EAST	WEST		
FZ	FR AER SUV2 JPN LL NEAtl2 W-MED LAR SUV	US RR 66-144, CAN SWNS RR US-MEX GOM PLL	TACs are product of stock-specific F0.1 estimates and estimate of US-MEX GOM PLL for the West and W-MED LAR SUV for the East.	SCRS/2020/144 SCRS/2021/122
AI	All	All	Artificial intelligence MP that fishes regional biomass at a fixed harvest rate.	SCRS/2021/028
BR	FR AER SUV2 W-MED LAR SUV MOR POR TRAP JPN LL NEAtl2	GOM LAR SUV US RR 66-144 US-MEX GOM PLL JPN LL West2 CAN SWNS RR	TACs set using a relative harvest rate for a reference year (2018) applied to the 2-year moving average of a combined master abundance index. In recent refinement, the weighting range across individual indices on the east area master index has been reduced, given, resulting in improved resource conservation performance.	SCRS/2021/121 SCRS/2021/152
EA	FR AER SUV2 W-MED LAR SUV MOR POR TRAP JPN LL NEAtl2	GOM LAR SUV JPN LL West2 US RR 66-144 US-MEX GOM PLL	Adjust TAC based on ratio of current and target abundance index.	SCRS/2021/032 SCRS/2021/P/046
LW	W-MED LAR SUV JPN LL NEAtl	GOM LAR SUV MEXUS_LL	TAC is adjusted based on comparing current relative harvest rate to reference period (2019) relative harvest rate.	SCRS/2021/127
NC	MOR POR TRAP	US-MEX GOM PLL	TAC is updated using an average of an index in recent years compared to and average in previous years. The scale of TAC increase/decrease is controlled based on the trend in catches and indices	SCRS/2021/122
PW	JPN LL NEAtl2 GOM LAR SUV	US-MEX GOM PLL GOM LAR SUV	TAC is adjusted based on comparing current relative harvest rate to reference period (2019) relative harvest rate.	SCRS/2021/155
TC	MOR POR TRAP JPN LL NEAtl2 W-MED LAR SUV GBYP AER SUV BAR	US RR 66-144	TAC is adjusted based on F/F_{MSY} and B/B_{MSY}.	SCRS/2020/150 SCRS/2020/165
TN	JPN LL NEAtl2	~~US RR 66-144~~ JPN LL West2	Both area TACs calculated based on their respective JPN LL moving averages.	SCRS/2020/151 SCRS/2021/041

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 South West 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. Percentage of biomass in each area that is of Eastern Stock origin by decade and by region, over all 24 operating models (noting that for recruitment level 3 the historical time period is the same as for recruitment level 1) in the reference grid. The six areas are WATL: Western Atlantic, GSL: Gulf of St Lawrence, SATL: South Atlantic, NATL: North Atlantic, EATL: East Atlantic are described in more detail in the Trials Specification Document. The 5th and 95th percentiles are shown to illustrate the range of variability across the 24 operating models.

Eastern Biomass %		Year					
Area	**Percentile**	**1970**	**1980**	**1990**	**2000**	**2010**	**2019**
	5%	29.3%	24.7%	28.8%	33.8%	32.6%	46.5%
WATL	**Median**	**40.8%**	**55.3%**	**68.6%**	**80.0%**	**75.6%**	**79.8%**
	95%	58.4%	63.3%	82.4%	87.7%	84.1%	84.7%
	5%	7.3%	15.8%	20.5%	17.5%	15.5%	24.5%
GSL	**Median**	**22.0%**	**36.4%**	**47.2%**	**60.1%**	**56.8%**	**59.7%**
	95%	45.3%	49.7%	78.4%	81.1%	86.4%	79.3%
	5%	99.9%	99.9%	99.9%	99.9%	99.9%	99.9%
SATL	**Median**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
	95%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	5%	96.6%	96.9%	98.9%	99.0%	98.7%	98.4%
NATL	**Median**	**98.6%**	**99.3%**	**99.7%**	**99.8%**	**99.8%**	**99.8%**
	95%	99.7%	99.8%	99.9%	99.9%	99.9%	99.9%
	5%	99.7%	99.8%	99.9%	99.9%	99.8%	99.9%
EATL	**Median**	**99.9%**	**99.9%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**
	95%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%