REPORT OF THE 2020 INTERSESSIONAL MEETING OF THE ICCAT BLUEFIN TUNA MSE TECHNICAL GROUP

(*Madrid, Spain, 24-28 February 2020*)

1. Opening, adoption of agenda and meeting arrangements

The meeting was held at the ICCAT Secretariat in Madrid, 24-28 February 2020. The co-Chairs of the Bluefin Tuna MSE Technical Group ("the Group"), Drs Doug Butterworth (Professor Emeritus, University of Cape Town) and Gary Melvin (SCRS Chair, Canada), opened the meeting. The ICCAT Executive Secretary, Mr. Camille Jean Pierre Manel, welcomed the participants and highlighted the importance of the ICCAT's Atlantic bluefin tuna (BFT) Management Strategy Evaluation (MSE) process. He thanked the participants for their work so far and emphasized the importance of this work for the Commission. The SCRS Chair emphasised the need to adhere to the overall 2020 schedule for the bluefin tuna MSE work advised and accepted by the Commission in 2019. The co-Chairs proceeded to review the Agenda, which was adopted with minor changes (**Appendix 1**). Due to the time constraints, the Group focused on the main outputs from the meeting in this report and any technical aspects were expanded in Appendices. It was noted that this meeting does not have any authority to make final decisions, rather its purpose is to prepare the material required by the bluefin tuna intersessional meeting to be held in April 2020.

The List of Participants is included in **Appendix 2**. The List of Documents presented at the meeting is attached as **Appendix 3**. The abstracts of all SCRS documents and presentations provided at the meeting are included in **Appendix 4**. The following served as rapporteurs:

Sections	*Rapporteur*
Items 1, 10	A. Kimoto, N. Taylor
Items 2-9	C. Fernandez, D. Butterworth, G. Melvin, S. Cox

2. Summary of developments since the September Bluefin Tuna Species Group meeting and before this meeting

The bluefin tuna MSE Contractor gave a presentation explaining the progress made since the September 2019 meeting. Details, including relevant tables and figures, can be found in Carruthers (in press).

Intersessional work had explored many alternative weightings of the different datasets and priors, but it was not possible to find any Operating Model (OM) configurations that fitted reasonably well to **all** datasets and passed all acceptability standards set by the Group.

The basic problems were that the available data did not permit reliable estimation of the bluefin tuna abundance scales in the West and East areas, and that there are conflicts amongst the different data that inform on mixing. These issues were resolved shortly before the meeting by specifying mixing and scale values as different levels on further uncertainty axes added to the grid. The different choices for values along these axes were seen to reasonably span the range of spawning stock biomass (SSB) and mixing uncertainties concerned (see below).

Based on the findings of the intersessional work, the following possible uncertainty axes for the OM grid were presented (Table 2.2 of Carruthers (in press).

- *Recruitment*, with 3 levels, as previously: 1: Regime shift; 2: Single regime; 3: As for Level 1, but changing back to the 1st regime after 10 projection years; only levels 1 and 2 are considered for OM conditioning, because level 3 is identical to level 1 for the conditioning period.
- *Biology,* with 2 levels, as previously: a) Younger age of maturity and higher natural mortality (M); b) Older age of maturity and lower M.
- *Mixing* (proportion of western stock mature fish that would be in the East area under unfished equilibrium conditions), with 3 possible levels: I*: 1%; I: 5%; II: 20%.

– *Scale* (average SSB over the historical years, with the following average historical values: 15 and 50 kt for the West area and 200 and 400 kt for the East area; these values were based around results of the SS3 and VPA assessments in 2017 for the West area and the VPA assessment in 2017 for the East area). The combination of (West area SSB, East area SSB) resulted in 4 levels: -- (15 and 200 kt), -+ (15 and 400 kt), +- (50 and 200 kt), ++ (50 and 400 kt).

The choices above result in 48 potential OMs for the interim reference grid. Only two levels for Recruitment are taken into account in this calculation, because Recruitment level 3 differs from Recruitment level 1 only during the projection years.

Figures 3.1-3.4 of Carruthers (in press) show the resulting time series of SSB by area and by stock, as well as relative to dynamic SSB_{MSY}. This allowed consideration of the range of options, including stock status, covered by this potential grid of OMs. The range spanned situations with current stock status above and below SSB_{MSY} for both western and eastern stocks. This set of 48 OMs was considered to provide a rather stringent testing basis for any potential Candidate Management Procedure (CMP).

Acceptability standards for the conditioned OMs:

– Fits to the USA GOM (Gulf of Mexico) and Western MED (Mediterranean) larval survey indices were examined and were considered acceptable for all OMs.
– The fits to the quarterly distribution of biomass in the GOM and MED were also considered reasonable.
– Some of the OMs were not able to fit the historical catches in some years, but the misfits were for the early 2000s period, during which the actual total catches are highly uncertain because they include a high proportion of "guess-estimates" of illegal catches during that period. Hence, this relative lack of fit was not considered problematic.
– Showing comparisons to the Stock Synthesis (SS3) assessment for the East area in plots was considered inappropriate because this was of questionable reliability and the assessment had not been accepted by the bluefin tuna Species Group in 2017. In future plots, this will be replaced by a trajectory at 50% of the VPA assessment for the East area.

3. Review of results for conditioning of OMs for the interim grid and associated robustness tests

After the presentation (Agenda item 2), a Group discussion followed, focusing particularly on the scale and mixing options in the proposed interim OM grid and whether they covered reasonable ranges; in general, this was considered to be the case.

– For the mixing axis of the interim OM grid, the Group agreed to drop the 5% level, and to keep only the 1% and 20% levels. This reduced the number of OMs from 48 to 32.

It was further agreed to implement the 1% mixing option for all western stock fish and not just for the mature fish.

It was also agreed to consider a 0% western stock mixing option as a robustness test (see list of robustness tests, with priority order, later in this section).

The discussion also touched on whether it was sufficient to construct the OM grid by picking the extremes of the reasonable ranges (as is currently the case for many of the axes in the interim grid) or whether intermediate options, closer to a "central" OM, should be included. This discussion was revisited later under Agenda item 7.

The meeting decided to conduct various investigations, as detailed below.

Investigation of the approach for conditioning OMs on some fixed mixing level:

The Group's suggestion to consider the 1% mixing option on all western stock fish and not just on the mature fish was implemented. The OMs were reconditioned with the aim to achieve a certain proportion (1% or 20%) of western stock total biomass being in the East area on average during the 1965-2016 period.

Results of OMs with the new mixing specification were compared with those obtained with the previous OMs (where the mixing level had been specified for mature fish only and under unfished equilibrium conditions) for which results had been available at the start of the meeting.

The new configuration produced results for stock mixing that the Group found more plausible and more in line with what it aimed to achieve through the mixing uncertainty axis in the OMs (**Figures 1a** and **1b**). No other appreciable changes were detected in the results and, therefore, no obvious effects on other parameters were expected from implementing this change to the interim OM grid.

However, during examination of log-likelihood values for the 1% mixing option, some concern was expressed that the change of mixing method indicated a somewhat degraded fit to the genetics and otolith chemistry SOO datasets, suggesting that it could also be relevant to examine mixing levels between 1% and 20%. It was agreed that the bluefin tuna MSE Contractor would intersessionally repeat the profiling exercise on the mixing level (now using the new mixing specification), examining the resulting log-likelihood values for the different data components, that was previously conducted and presented in the 14 February Webinar.
In conclusion:

- The Group agreed to change to the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average over 1965-2016) for the OMs in the interim grid.

Investigation concerning the fits to length composition data:

The Group noted that the OM models presented at the start of the meeting often resulted in predicted length compositions that differed substantially from observed ones. This was raised as a concern on its own, but also because of its effects on selectivity estimates, which are used subsequently in various ways during the projection period considered in the MSE.

A preliminary investigation of the effect of increasing the weight for the log-likelihood of the length composition data by various amounts (by factors ranging from 20 to 100, relative to the weight used in the OMs available at the start of the meeting) was undertaken, which showed improved fits to length compositions and some indices but a degradation of the fits to some other data and in particular to the USA GOM and especially the Western MED larval indices. A degradation of the fits to abundance indices can have important consequences for deciding how the indices should be appropriately simulated in the MSE (Agenda item 5).

A more comprehensive investigation was undertaken for the case where the weight for the log-likelihood for the length composition data was increased by a factor 20 (from a LHw=0.05 weight, used in the OMs available at the start of the meeting, to LHw=1). The 32 OMs in the interim grid were reconditioned using this higher weight for the log-likelihood and results confirmed the improvement in the fits to the length composition data (**Figures 2a** and **2b**). Various effects of this change on the OM estimates were evident, the most noticeable being the substantial difference in the estimates of the proportion of the eastern stock biomass that are found in the West area (**Figures 1b** and **1c**). Changes in the fits to different indices also occurred, but these differences were generally not as pronounced as initially expected (**Figures 3a** and **3b**).

Substantial discussion followed as to whether the interim OM grid should be replaced with OMs conditioned using this higher weight for the log-likelihood for the length compositions. Finally, it was decided to move forward with OMs using each of the two log-likelihood weight values (i.e. LHw=0.05, used in the OMs available at the start of the meeting, and LHw=1). This essentially means adding a new uncertainty axis to the interim OM grid, expanding it from 32 to 64 OMs. Reasons for this included the importance of including this major uncertainty axis in the grid, and to be able to determine the impact this had on the performance of CMPs. It was acknowledged that a different decision in this respect might be reached after conducting further analyses over the coming months.

In conclusion:

- The Group agreed to include a new uncertainty axis in the interim OM grid, corresponding to the weight for the log-likelihood for the length composition data, with 2 levels: “Low LHw” (LHw=0.05) and “High LHw” (LHw=1). This increases the number of OMs in the grid from 32 to 64.

Investigation on senescence and growth:

The first aim here was to investigate if the current OMs estimate a disproportionate amount of fish in the age-35+ group (as had been found to be the case for southern bluefin tuna). Examining the estimated age structure of each stock in 2016, there was some evidence that this was the case for the western stock (particularly, when considering biomass, rather than numbers, at age) and less so for the eastern stock.

Previous meetings had agreed to explore two alternative OM specifications which can have an impact on age-35+ biomass: one was including senescence (higher M for older ages) and the other is to use the western stock growth curve also on the eastern stock. A preliminary investigation was conducted during this meeting, but there had been some misunderstanding concerning growth curves, and the analyses will be redone intersessionally with plots of pre-exploitation biomass at age being included as well. These investigations were included in the list of robustness tests agreed by the Group (see below).

Robustness tests (Table 9.3 of Trial Specifications Document (TSD)):

The Group reviewed the list of robustness tests (Table 9.3 of the TSD) agreed previously and updated this based on the work conducted since September 2019 and the discussions during this meeting. This resulted in the following table for inclusion in an updated TSD:

Revised TSD-Table 9.3. Robustness tests, including priority and OMs on which the test is to be conducted. In the column of “Updated Priority”, “NA”, ”1”, and “2” indicate “no longer applicable or superseded by other treatments”, ”to be ready for the April 2020 bluefin tuna intersessional meeting”, and ”to be conducted after the April 2020 bluefin tuna intersessional meeting”, respectively.

	Robustness test description	***Updated Priority***	***OMs****	***Notes***
1	**Western Contrast** Increased precision (CV of 15%) of the GOM_LAR_SUV index to create greater contrast in current western stock status	NA		No longer needed
2	**Gulf of Mexico SSB** Prior on higher GOM SSB in quarter 2 and lower GOM SSB in quarter 3	NA		Superseded by seasonal vector
3	**‘Brazilian catches’** Catches in the South Atlantic during the 1950s are reallocated from the West area to the East area.	1	4 OMs	Key questions of BFT SG participants
4	**Time varying mixing** Western mixing alternates between 10 and 30% every three years	2	2 OMs	Key question of BFT SG participants
5	**Persistent change in mixing** Western mixing increases from 20% to 30% after 10 years	2	2 OMs	Key question of BFT SG participants
6	**Western stock growth curve for eastern stock**	1	4 OMs	Important, may change OMs
7	**Senescence** An increase in natural mortality rate for older individuals as applied in CCSBT	1	4 OMs	Important, may change OMs
8	**Upweighting of CPUE indices**	NA		No longer needed

9	**Upweighting of 'fishery independent' indices**	NA		No longer needed
10	**Upweighting of genetic stock of origin data** 5x log-likelihood factor on genetics, ignore microchemistry SOO data by increasing imprecision to a logit CV of 500%	NA		No longer needed
11	**Greater influence of microchemistry stock of origin data** 5x log-likelihood factor on microchemistry data, and ignore genetics SOO data by increasing imprecision to a logit CV of 500%.	NA		No longer needed
12	**Greater influence of the Length composition data**	NA		Now in main grid
13	**Greater influence of the historical landings data**	NA		Now good fit to landings
14	**Catchability Increases** CPUE-based indices are subject to a 2% annual increase in catchability.	2		
15	**Decreasing catchability** 2% annual decline in the catchability of CPUE-based indices.	2		
16	**Non-linear indices** Hyperstability / hyper depletion in OM fits to data is simulated in projection years for all indices.	2		
17	**Unreported overages** Future catches in both the West and East areas are 20% larger than the TAC as a result of IUU fishing (not accounted for by the CMP).	2		
18	**Zero western stock mixing** No western stock in the East area	2		

* OMs: These exploratory robustness tests are implemented for more than one OM. The most stringent tests of CMPs are likely to occur for the smallest scale (--) and the highest mixing level (II), and for the highest weigh on length composition data. This leaves a grid over the recruitment (1, 2) and productivity axes (A, B), and hence four OMs for each robustness test (1AII-- , 2AII-- , 1BII-- , 2BII--); where only two OMs are involved, these are 1BII-- , 2BII--.

4. Recommendations, based on discussions under 3), regarding the acceptability of the conditioning and for possible changes to the interim grid specifications

Based on the intersessional work conducted since September 2019 and during this meeting, the Group recommended moving forward with the following updated interim reference OM grid. This should be included as Table 9.1 in an updated TSD.

The updated interim reference grid corresponds to 64 OMs for the conditioning period, and to 96 OMs once the projection period for the MSE is also taken into account. The reason for this difference is that Recruitment level 3 differs from Recruitment level 1 only for the projection years.

Revised TSD-Table 9.1. Factors and levels of key uncertainty axes in the reference grid of operating models

	Western stock	***Eastern stock***
Recruitment		
1	B-H with h=0.6 (“high R0”) switches to h = 0.9 (“low R0”) starting from 1975	50-87 B-H h=0.98 switches to 88+ B-H *h*=0.98, with a changed unfished recruitment level.
2	B-H with h=0.6 fixed, high R0	B-H with h=0.7 fixed, high R0
3	Historically as in Level 1. In projections, “low R0” switches back to “high R0” after 10 years	Historically as in Level 1. In projections, 88+ B-H with *h*=0.98 switches back to 50-87 B-H with *h*=0.98 after 10 years.
Spawning fraction both stocks		*Natural Mortality rate both stocks*
A	Younger (E+W same)	High
B	Older (E+W older but different for the 2 stocks)	Low
Western stock mixing into East area (average proportion of western stock biomass in the East area over 1965-2016)		
I	1%	
II	20%	
Scale (average SSB by area over 1975-2016 for the West area and 1968-2016 for the East area):		
	West area	East area
--	15kt	200kt
-+	15kt	400kt
+-	50kt	200kt
++	50kt	400kt
Weight for log likelihood for length composition data (Low or High):		
L	LHw=0.05	
H	LHw=1	

5. Re-selection of the indices to be projected into the future for use as inputs to CMPs, together with specification of their error structure for use in their generation in simulations

Under this agenda item, residuals for both abundance indices and Recruitment (i.e. Recruitment deviations from the Stock and Recruitment (SR) relationship fitted) for the years for which the OMs were being conditioned were examined in order to understand their properties and agree on consistent ways to generate them in simulations for future years for CMP testing.

5.1 Indices

There were 14 indices considered for potential use by CMPs, of which 9 indices were for the West area and 5 for the East area. They are standardised CPUE or survey indices that have been ongoing for several years and are expected to continue annually in the future.

The Group stressed that annual availability in all future years is an essential condition which any index should fulfil if it is to be considered for potential use in CMPs.

5.1.1 Examining properties of the indices' residuals:

For each of the 14 indices, time series of residuals for each of the 32 OMs [note: this subsequently became 64 OMs, after the addition of an extra uncertainty axis for the weight for the log-likelihood for length composition data] in the interim grid were initially displayed in graphs. It was difficult to draw conclusions from such a large set of graphs and, therefore, it was decided to summarise the information using relevant statistics.

Matrices (each with 14 columns, one per index, and 32 rows, one per OM) were presented, with each matrix corresponding to a particular statistic calculated from the residuals of the indices (actually, the residuals of the log(indices)).

The cells in each matrix were colour-coded, to provide a visual aid to identify "better / intermediate / worse" values, usually as identified by upper/middle/lower thirds of the range.

The matrices corresponded to the following statistics for the residuals (**Appendix 5**):

1. Standard Deviation (STD). These values are always > 0 and lower values are better.
2. Autocorrelation (AC). The values can be positive or negative; large positive values are disadvantageous because they result in poor precision of the estimated mean or trend in a series over time.
3. P-value for the runs test. The runs test evaluates departures from randomness, based on the proportion of times a plot of the residuals against year crosses the "0 axis" (i.e. changes sign). Higher P-values are better.
4. Length of longest run (where a run is a consecutive sequence of years on the same side of the "0 axis") in the last 10 years. Lower values are better.

For indices with gaps in the time series (western MED larval survey, GBYP aerial survey and French aerial survey), only the standard deviation and standard error statistics were calculated.

5.1.2 Selecting indices for potential use in CMPs

All 14 indices are expected to be available annually in future years. Therefore, in principle they could all be considered for use in CMPs.

The indices selected for potential use in CMPs will have to be generated in future year simulations in the bluefin tuna MSE package. The Group agreed that this generation would be achieved using the Standard Deviation (STD) and Autocorrelation (AC) properties of the series' historical residuals.

It was stressed that, in future MSE projections, index values corresponding to more recent years than those used in the OM conditioning, but which are already available at present (e.g. indices for the years 2017-2019) would not be simulated. Instead, if such indices were used in CMPs, their actual observed values for those years would be used (instead of simulated values).

It was also agreed that, for standardised CPUE series that were used to condition OMs and may also be used in CMPs, if the addition of new years of data resulted (through the standardisation method used) in changes to the earlier part of the series (i.e. the part of the series used for conditioning the OMs), then a multiplicative factor would be applied to the longer new series so as to achieve the same mean value for both series over the period of years used for OM conditioning. For the MSE testing process, the CMPs then input the original series, extended by the new data adjusted by this multiplicative factor.

In order to facilitate comparison across the 14 available indices and to aid in the selection of indices, for each index the average value across the 32 OMs was calculated for each of the 4 statistics (**Tables 1a** and **1b**). The resulting values were displayed in two new matrices, one for the West area (9x4 values) and one for the East area (5x4 values). Graphs for each index showing the observed time series of index values and the corresponding 32 OM fits to the time series were also displayed.

The Group considered all this information in order to make proposals for the indices to be selected, and for how each of the selected indices would be generated in the MSE projection years.

The Group started from the basis that all 14 indices would be retained unless there was a clear reason to exclude any of them.

In terms of index selection, the Group reached the following conclusions (proposals):

- Canadian Gulf of St. Lawrence (GSL) CPUE series: to be excluded, because it shows very poor behaviour across all 4 statistics.
- Canadian acoustic survey: although the past index behaviour is very good, the survey has recently undergone a vessel change, which is expected to have impacted its catchability. At this stage, it seems unlikely that this index could be used in future years as a continuous time series from the past. It was concluded that the index would still be simulated in the bluefin tuna MSE package, but that, unless further developments can be undertaken to appropriately calibrate for the effect of vessel change in the resulting index, it should not be used in CMPs.
- All the other indices were retained for potential use in CMPs.

Some concerns were expressed that some of the indices retained appeared to behave rather poorly for a substantial proportion of the OMs, and that it may be very difficult to find a way to simulate future indices with similarly poor properties. It was therefore agreed that the Workplan will need to include an item pertaining to developing a way of checking whether simulated indices have realistic behaviour (i.e. develop a statistic or plot to provide confidence that the data generated for future years is adequately reflecting the properties of those data series in the past. Decisions on this should be taken during the April BFT intersessional meeting).

5.1.3 Conclusions on method of future year simulation of selected indices

The STD and AC values used for each index will, by default, be OM-specific.

For indices with sufficiently long time series (i.e. all indices in the West area with the only exception of the JPN LL West2 index (the recent part of the Japanese longline index in the West Atlantic)), the STD and AC of their residuals from the OM fits will be used. Whenever the AC is < 0, it will be fixed at AC=0 for the projections, to avoid overly precise estimated trends as noted above.

The JPN LL West2 index was originally part of a long time series. However, the series has been split into two series (breakpoint in 2010) because of a change in regulations. It was agreed to keep the OM-specific STD values estimated from the recent-years series, which were rather high for all OMs (roughly of the order of 0.6), and to set AC=0 in all OMs, as the estimated AC values were < 0 for al lot of these. For comparison, the earlier-years series had even higher STD values for residuals (roughly of the order of 0.8).

All 5 indices in the East area correspond to short time series and, in some cases, there are gaps between years, creating considerable difficulties for reliable estimation of STD and AC values. Several options for selecting appropriate STD and AC values were considered by the Group.

Two main options were considered for selecting STD values:

In one of them, a random sample of STD values was generated under each OM, according to an inverse chi-square distribution with a spread consequently reflective of the uncertainty in the STD estimates (resulting in higher spread for shorter time series). The OM-specific STD values to be used in future index simulation would then be randomly selected from amongst those generated within the inter-quartile interval for the STD distribution for the corresponding OM. A primary reservation expressed about this option was that if the STD value was changed from its point estimate value, it was likely that the AC value would also change in a consistent manner, because the estimates of these two parameters are not independent. This makes it difficult to implement this approach reliably in a situation with limited information (such as for short time-series).

The second option for dealing with short series may be described as an "informal meta-analysis", and essentially handles the limitation in series-specific information by borrowing information from other series, with the idea of obtaining a reasonable compromise central STD value. Following an examination of STD values of residuals from various series in the East area, including also longer longline and trap index time series from earlier periods, as well as contrasting them with the ranges of STD values obtained under the previous option, the value STD=0.45 emerged as a reasonable compromise for all indices in the East area. The French aerial survey was the only exception to this; the series-specific average STD value for all the OMs estimated in this case was STD=0.8, considerably higher than 0.45, so that the Group decided to use STD=0.8 for this index.

The selections of AC values for the indices in the East area were made as follows:

For the JPN LL NEAtl2 CPUE series (the recent part of the Japanese longline index in the northeast Atlantic), AC was fixed to 0, using the same reasoning that had been applied for the JPN LL West2 CPUE series.

For the MOR-POR (Morocco-Portugal) Trap CPUE index, AC was fixed to 0.2, very similar to the average value across the 32 OMs (under both levels for the weight for the length composition log-likelihood), and also similar to the average STD value obtained for the earlier MOR-SPN (Morocco-Spain) trap index in the area.

For the three fishery-independent survey series in the MED which, in addition to being short, contained gaps in some years, the Group agreed to use AC=0.2 on the basis a similar “informal meta-analysis” approach as applied for the STD selection. This AC value choice is precautionary, based on the fact that, in general, smaller AC values were estimated for the indices for which such an estimation was possible. The only exception to the choice AC=0.2 was for the western MED larval survey index, for which some OM fits indicated that a larger value of AC would most likely be necessary in order to adequately characterise its behaviour; an appropriate AC value to be used for this index will be derived intersessionally.

The conclusions on index selection for potential inclusion in CMPs and method of future year simulation are summarised in the following table which should be newly included as Table 7.1 in an updated TSD.

TSD-Table 7.1. Index selection and simulation for potential inclusion in CMPs

Index	*Details*	*Selectivity*	*Selected for CMPs*	*STD value**	*AC**
Canada GSL RR	1984-2016, Q3, GSL	14: RRCAN	No	-	-
Canada SWNS RR	1988-2016, Q3, W Atl	14: RRCAN	Yes	OM-estim	OM-estim
US RR 66-114	1993-2016, Q3, W Atl	15: RRUSAFS (50 –125cm)	Yes	OM-estim	OM-estim
US RR 115-144	1993-2016, Q3, W Atl	15: RRUSAFS (100 – 150cm)	Yes	OM-estim	OM-estim
US RR 177+	1993-2016, Q3, W Atl	16: RRUSAFB (175cm+)	Yes	OM-estim	OM-estim
JPN LL West2	2010-2016, Q4, W Atl	18: LLJPNnew	Yes	OM-estim	0
US GOM PLL2	1992-2016, Q2, GOM	1: LLOTH	Yes	OM-estim	OM-estim
GOM LAR SUV	1977-2016 (gaps 1979-1980, 1985), Q2, GOM	SSB	Yes	OM-estim	OM-estim
CAN ACO SUV	1994-2016, Q3, GSL	14: RRCAN (150cm+)	No**	OM-estim	OM-estim
MOR POR TRAP	2012-2016, Q2, S Atl	13: TPnew	Yes	0.45	0.2
JPN LL NEAtl2	2010-2016, Q4, N Atl	18: LLJPNnew	Yes	0.45	0
FR AER SUV2	2009-2016 (gap 2013), Q3, Med	15: RRUSAFS	Yes	0.8	0.2
GBYP AER SUV BAR	2010-2015 (gaps 2012, 2014, 2016), Q2, Med	SSB	Yes	0.45	0.2
MED LAR SUV	2001-2015 (gaps 2006-2011), Q2, Med	SSB	Yes	0.45	to be derived intersessionally, >0.2

* OM-estim means OM-specific estimates from the index residuals of the corresponding OM fit. When the estimated AC is < 0, it will be fixed at AC=0 for the projections with that OM.
** The Canadian acoustic survey index will be simulated in the bluefin tuna MSE package, but should not be used in CMPs.

5.2 Recruitment deviations

Similar matrices (for the 4 statistics described in Section 5.1) as for the abundance index residuals were produced for the (log) recruitment deviations (**Appendix 6**):

Each matrix has one row per OM in the grid and 6 columns as follows:

- Western stock Single Recruitment Regime,
- Eastern stock Single Recruitment Regime,
- Western stock 2 Recruitment Regimes (1st regime),
- Western stock 2 Recruitment Regimes (2nd regime),
- Eastern stock 2 Recruitment Regimes (1st regime),
- Eastern stock 2 Recruitment Regimes (2nd regime)

Recruitment will have to be generated annually in future year simulations in the bluefin tuna MSE package.

- The Group agreed that the simulation of future recruitment values would be implemented using the Standard Deviation (STD) and Autocorrelation (AC) properties of their residuals (=recruitment deviations).
- The STD and AC values used for each index will, by default, be OM-specific.

– The STD and AC of their residuals (=recruitment deviations) from the OM fits will be used. Unlike was the case for indices, for Recruitment AC values < 0 are used as such (i.e. not reset to AC=0).

It should be kept in mind that, historically, recruitment deviations have been calculated in 2-year blocks when fitting the OMs.

For these matrices, each 2-year block was treated as if it was a single year (i.e. the time unit for the calculation of any statistic was the 2-year block rather than the individual year). For the generation of future index values, appropriate conversion to yearly units will be applied to the 2-year-block STD and AC values.

6. Review of codes and Trial Specifications document modifications required

The bluefin tuna MSE Contractor advised that a partial update of the Trial Specifications Document (TSD) had been prepared in advance of the meeting, focusing mainly on equations and the main changes in OM specifications. There was no time to complete the update during the meeting. The bluefin tuna MSE Contractor was encouraged to update the TSD after the meeting to incorporate the decisions taken during the meeting. The updated TSD will be made available as soon as possible.

7. Provide suggestions for approaches (e.g. a Delphi method) to plausibility-weight OMs for review at the April intersessional meeting of the Bluefin Tuna Species Group

An introduction to practices in other organizations (in particular the IWC (International Whaling Commission) and CCSBT (Commission for the Conservation of Southern Bluefin Tuna)) was provided.
The following four approaches were considered as possibilities for the bluefin tuna MSE.

7.1 "IWC-like approach"

In the IWC-like approach, trials of CMPs (each of which have a corresponding operating model (OM)) are divided into evaluation and robustness types. Evaluation OMs are considered to provide the most plausible and important CMP tests, whereas robustness OMs represent more extreme model and/or data scenarios. The latter also have the purpose of understanding the behaviour and properties of CMPs under more extreme (and even sometimes implausible) scenarios. The total set of OMs should not be too large (e.g., no more than about 50 trials) because CMP performance is evaluated for each individual OM, i.e., there is no integration over OMs to produce a single set of model-averaged performance statistics.

OMs within both types are assigned high, medium, low and "no agreement" (when consensus cannot be obtained on a high/medium/low designation) plausibility categories via consensus among participating experts, i.e. "expert judgement". High and medium plausibility OMs remain under consideration, while low plausibility OMs are not considered further. "No agreement" OMs are assigned medium plausibility.

Performance assessments of CMPs are focused mainly on conservation objectives with standard criteria specified separately for high and medium plausibility OMs. For high plausibility OMs, CMPs must satisfy more stringent conservation performance standards compared to medium plausibility OMs (i.e. the conservation criterion/bar is set lower for medium plausibility OMs).

Assignment of OM plausibility occurs after the set of OMs has been finalised. Revisiting the assignments to plausibility categories is not allowed later in the process (e.g. after seeing some results from CMPs), although in reality some latitude may need to be permitted.

The standard criteria (i.e., performance bars) used by IWC have been set in advance and are the same across all the MSEs which they conduct. However, slight flexibility to deviate from the established performance bars is admitted (i.e. "common sense" is applied for CMPs that "almost", but not completely, meet the required performance criterion for a few OMs).

7.2 "CCSBT-like approach"

The CCSBT approach involves a primary reference grid of OMs along with a set of robustness OMs. Reference grid OMs are derived from a full factor x level cross of key model and data uncertainties. Weighted-average CMP performance is computed over a reference grid which currently comprises over 400 individual OMs.

OM weights are determined either using likelihood components multiplied by prior weightings for key parameters (e.g., M) where this approach is considered reliable, or a Delphi approach for other components such as steepness, non-linearity of CPUE-abundance relationships and increasing gear efficiency over time.

The Delphi approach proceeds as follows:

Round 1 - a group of (e.g. 20) experts provide individual suggested weights for each OM. Experts providing the most extreme weights for particular OMs explain their rationale to the other experts.

Round 2 - individual experts re-weight the OMs in light of the rationales given for these extreme weightings.

Final weighting - mean or median weights for each OM are computed over the entire collection of expert weightings to provide a final set of OM weights.

CMP performance is then evaluated for each OM in the grid, and the weighted-averages of performance scores over the grid are used in the CMP selection process.

Robustness OMs in CCSBT are used to further distinguish amongst CMPs that have very similar performance for the reference grid. They are put forward for various reasons and are treated differently depending on their perceived relevance for CMP acceptance. For example, one robustness OM might reflect a scenario in which a low recruitment regime lasts several consecutive years. Another example might correspond to a specification considered too extreme for inclusion in the reference OM grid. Robustness OMs are not accorded explicit weightings; however, in practice, more attention may be paid to some robustness OMs compared to others in the final evaluation process.

7.3 "Simplified CCSBT-like approach"

A simplified CCSBT-like approach involves a reduced number of equally-weighted OMs. This approach has been used for South African hake, for example. For such approaches, the number of OMs in the final grid is typically small (e.g. less than 20), although it can be applied for larger numbers too.

7.4 "Hybrid approach":

A Hybrid approach involving selected elements of IWC-like and CCSBT-like approaches could be used to provide a flexible OM plausibility weighting and CMP evaluation method for bluefin tuna. For example, qualitative high/medium/low plausibility categories (i.e. IWC-like) could be assigned to uncertainty axes that are more "discrete" and/or where experts hold strongly different views (e.g., the form of SR relationship, the presence of a recruitment regime shift, high or low mixing between stocks). Quantitative OM weights (i.e. CCSBT-like) could next be applied within these categories to uncertainty axes that are "continuous" and/or lack strongly opposing views among experts. CMP evaluation could then be conducted using performance metrics within each of the discrete categories integrated over the continuous uncertainties. An example application of the hybrid-approach is as follows.

a) For each discrete OM factor level within the high and medium plausibility categories:
   i. Compute CMP performance for each continuous factor level OM while holding the discrete factor level constant.
   ii. Integrate over the continuous factor OMs via weighted model-averaging of CMP performance statistics.
b) Repeat a) for each discrete OM factor level.
c) Evaluate CMP performance for each discrete OM integrated over the continuous factors against the corresponding high or medium plausibility performance criteria.

Discussion and conclusions by the Group

IWC-like approach

In this case, CMPs have to pass the respective bar (at least for conservation objectives) for all OMs. If there are e.g. three CMPs that pass the required bars, and are therefore all acceptable, the final choice of MP is made on the basis of which of the three CMPs is predicted to provide the highest catches.

It was noted that in the IWC-like approach, results are reviewed for each single OM separately. For bluefin tuna, there are currently 64 OMs in the interim grid, and this may be too large a number to be able to properly review the results for each OM separately.

CCSBT-like approach, either with equal or differential weights

Given that the current OM interim grid is based on extremes (rather than on "central" OMs), it would probably be necessary to increase the number of levels in some of the uncertainty axes so as to include some "central" OMs in the grid in addition to the extremes.

For bluefin tuna, relying solely on a CCSBT-like approach would probably prove difficult because some of the uncertainty axes for bluefin tuna are not likely to readily result in a near-consensus view in the Group (e.g. mixing, regime shift for recruitment).

Hybrid approach

The Group considered that this approach could provide the greatest flexibility for dealing with the issues that arise for the bluefin tuna MSE and, therefore recommended its use in the bluefin tuna MSE process.

Applying a hybrid approach requires:

- Determining which factors (axes of uncertainty) in the OM will be assigned to a CCSBT-like approach (i.e. averaging results over all levels of such factors) and which will be treated in a IWC-like fashion (i.e. separately examining results for each of them).
- Determining the process for assigning plausibility weights to the OMs:

    - "IWC-like factors" to be classified according to high/medium/low/no agreement categories as determined by group consensus.

    - "CCSBT-like factors" to be weighted using the likelihood of fits when feasible/reasonable, or based on a Delphi-type approach otherwise.

The April bluefin tuna intersessional meeting will have to make final decisions on all the issues raised above.

The Group also agreed to produce an example of how a hybrid approach might look for the bluefin tuna MSE, with the aim of facilitating decisions at the April bluefin tuna intersessional meeting.

The following notes may assist in developing such an example.

- Candidate uncertainty axes for an IWC-like approach could be stock-recruitment (whether there are 1 or 2 regimes) and mixing level.
- Candidate uncertainty axes for a CCSBT-like approach could be biology (maturity and M) and assessment scale.
- A discussion about (likely conservation-related) performance bars will be needed for the axes for which a IWC-like approach is to be used.

The following additional general point was made during the Group's discussions.

– Setting performance targets based on percentiles different from the median (e.g. 30th percentile), may not be advisable because they can be very sensitive to changes, such as enlargement, of the set of trials considered. In contrast, median values tend to be much more robust in these circumstances, provided the set of OMs is kept balanced.

Timing and expectations going forward

It is essential that future meeting participants understand their role in and the sequential nature of the process. The next step needed is adoption of the operating model reference grid, for which the objective is to create a grid that covers the ranges of what is possible and to account for the key factors that are important for CMP performance testing. This is a separate process in time from plausibility weighting which is the task of assigning plausibility values to the models in the grid. The first process (Adoption) should happen in April 2020. If an OM grid is adopted, the second (Plausibility weighting) will occur at the September 17-19, 2020 intersessional meeting of the bluefin tuna MSE. In the interim, CMP developers will work on the reference grid to develop, tune and test CMPs.

8. Work plan leading up to the April bluefin tuna intersessional meeting, including consideration of provision of an updated package for CMP developers

For the bluefin tuna MSE Contractor:

1. Update ABT-MSE R framework to match conditioning model M3 v6.6
2. Update OM checking code including length composition and catch distribution among areas, seasons and fleets
3. Rebuild Package and help documentation (with at least reference set OMs) by Monday 9 March 2020
4. Update Trial Specifications document
5. Condition robustness OMs to the extent possible
6. Prepare for 13 March 2020 (Friday) webinar (new package, robustness OMs)
7. Repeat the profiling exercise on the mixing level (now using the new mixing specification
8. Develop an example CMP for demonstration purposes
9. Two weeks prior to April bluefin tuna intersessional meeting, compile the various CMPs submitted by developers
10. Run example MSEs
11. Time permitting, update Shiny App to summarize results (with demo CMPs)

9. Other matters

The Group reviewed Nøttestad (in press) that raises a concern as to whether the data available on mixing is comprehensive enough in space and time to proceed with both the eastern and western stocks in a unified MSE framework. While the extent and nature of mixing of bluefin tuna across the North Atlantic is uncertain, there is substantial mixing, and the scientific data available to develop plausible hypothesis about mixing rates has never been greater. For many years, mixing has remained one of the most substantive (and heretofore unaccounted) sources of uncertainty in the assessment and management of eastern and western bluefin tuna (ICCAT 2019); hence it has been identified as a critical axis of uncertainty in the MSE process. Furthermore, although uncertainties remain, it is precisely in these circumstances that MSE is the most appropriate approach to take to determine whether management is robust to different mixing scenarios. Keeping stock mixing in the MSE framework is directly in line with the requirements of the precautionary approach – as MSE was, in part, designed to address such uncertainties.

The Nøttestad (in press) also expressed concern that a single (and inappropriate) percentage agreed for mixing could lead to incorrect advice for management measures. It is for this reason the bluefin tuna MSE process explicitly incorporates a range of mixing scenarios to span plausible dynamics, and that range is informed by a large volume of otolith microchemistry, genetics and electronic tagging information. This is fundamental to the MSE approach in that it does not rely on a single "best" model. Instead, it requires the development of a number of models which cover the range of plausible possibilities associated with uncertain features (such as mixing in this case). Given these various models, the eventual management procedure (harvest control rule - HCR) adopted must be shown (by simulation) to exhibit robust performance across this range, so that application of the procedure will not put conservation of the resource at risk - a feature that is in line with the requirements of the precautionary approach. Pertinent in this instance is that science has clearly demonstrated that bluefin of eastern and western stocks are highly migratory and do mix across the Atlantic; the uncertainty is to what extent.

Nøttestad (in press) also recommends that Harvest Control Rules (HCR) should be developed separately for EBFT and WBFT; This is what is being done under the current MSE framework. All HCRs currently under consideration provide separate advice for the West and East Atlantic management areas, consistent with existing management advice conventions. Hence, while the Group agrees with Nøttestad (in press) statement that much remains to be learned regarding mixing, the bluefin tuna Technical Group considers that creating separate East and West (operating) models for the MSE would make it impossible to develop HCRs that are robust to a key source of uncertainty (i.e., the contribution of the eastern stock to the fish in the West area, and vice versa), as well as account for the effect on the other stock of implementing area-specific HCRs. In addition, it would leave the MSE process unable to achieve one of its key objectives of taking appropriate account of mixing towards which the bluefin tuna Species Group has been striving for over the past decade or more.

10. Adoption of the report

The report was adopted during this meeting. In closing, the meeting participants agreed that overall substantial positive progress had been made in addressing the major issues related to the operating models (OMs). The meeting was closed.

References

L. Nøttestad, R. Mjørlund, and P. Sandberg. (in press). Scientific reflections from Norway related to the MSE process on Atlantic bluefin tuna. Document SCRS/2020/015.

T. Carruthers. (in press). Reference set Operating Models (version 6.5) for Atlantic bluefin tuna assuming priors for area-specific scale and western stock mixing. Document SCRS/2020/018.

Table 1-a. Average values across the 32 OMs for each index (rows) for each of the 4 statistics for the time series of residuals of the fit to the data (Standard Deviation (STD), Autocorrelation (AC), P-value for the runs test (Runs p), and Length of longest run (where a run is a consecutive sequence of years on the same side of the "0 axis") in the last 10 years (Max run 10)), using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight of the length composition data (LHw=0.05).

	Strata	Area	n	St.Dev	A.C.	Runs p	Max run 10
GOM_LAR_SUV	1	GOM	37	0.59	-0.05	0.14	2
CAN_ACO_SUV	3	GSL	23	0.31	0.13	0.63	3.12
JPN_LL_West2	2	WATL	7	0.63	-0.12	0.82	3.12
US_RR_66_114	2	WATL	24	0.74	0.34	0.15	8
CAN SWNS	2	WATL	29	0.6	0.41	0.01	8.16
CAN GSL	3	GSL	33	0.86	0.58	0	10
US_GOM_PLL2	1	GOM	25	0.5	0.16	0.2	4.75
US_RR_177	2	WATL	24	0.67	0.26	0.15	4.34
US_RR_115_144	2	WATL	24	0.66	-0.04	0.8	2.75
GBYP_AER_SUV_BAR	7	MED	4	0.28			
MED_LAR_SUV	7	MED	10	0.35			
FR_AER_SUV2	7	MED	7	0.81			
JPN_LL_NEAtl2	5	NATL	7	0.4	-0.08	0.32	4.44
MOR_POR_TRAP	4	SATL	5	0.29	0.18	0.74	2.25

Table 1-b. Average values across the 32 OMs for each index (rows) for each of the 4 statistics for the time series of residuals of the fit to the data(Standard Deviation (STD), Autocorrelation (AC), P-value for the runs test (Runs p), and Length of longest run (where a run is a consecutive sequence of years on the same side of the "0 axis") in the last 10 years (Max run 10)), using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight of the length composition data (LHw=1).

	Strata	Area	n	St.Dev	A.C.	Runs p	Max run 10
GOM_LAR_SUV	1	GOM	37	0.64	0.02	0.55	2
CAN_ACO_SUV	3	GSL	23	0.35	0.25	0.48	4.12
JPN_LL_West2	2	WATL	7	0.53	-0.12	0.45	2.16
US_RR_66_114	2	WATL	24	0.73	0.33	0.14	8.88
CAN SWNS	2	WATL	29	0.56	0.38	0.01	8.31
CAN GSL	3	GSL	33	1	0.66	0	10
US_GOM_PLL2	1	GOM	25	0.56	0.35	0.07	6.84
US_RR_177	2	WATL	24	0.61	0.21	0.11	4.44
US_RR_115_144	2	WATL	24	0.65	-0.03	0.74	2.56
GBYP_AER_SUV_BAR	7	MED	4	0.23			
MED_LAR_SUV	7	MED	10	0.52			
FR_AER_SUV2	7	MED	7	0.88			
JPN_LL_NEAtl2	5	NATL	7	0.41	-0.13	0.33	4.5
MOR_POR_TRAP	4	SATL	5	0.3	0.2	0.82	2.47

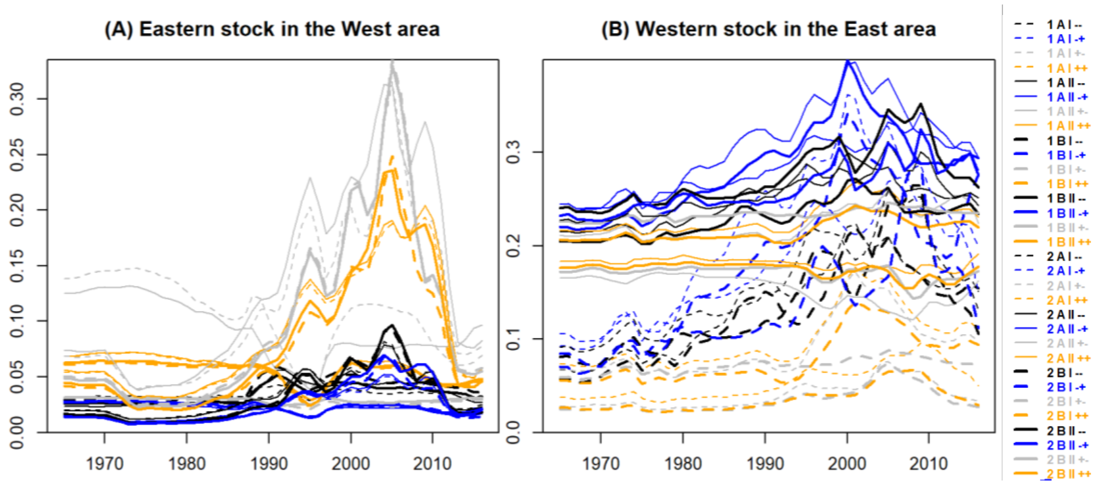

Figure 1-a. Proportions of (A) eastern stock biomass in the West area or (B) western stock biomass in the East area in 32 OMs, using the SCRS/2020/018 mixing method (corresponding to achieving a certain proportion of western stock SSB being in the East area, under unfished equilibrium conditions) with a low log-likelihood weight for the length composition data (LHw=0.05).

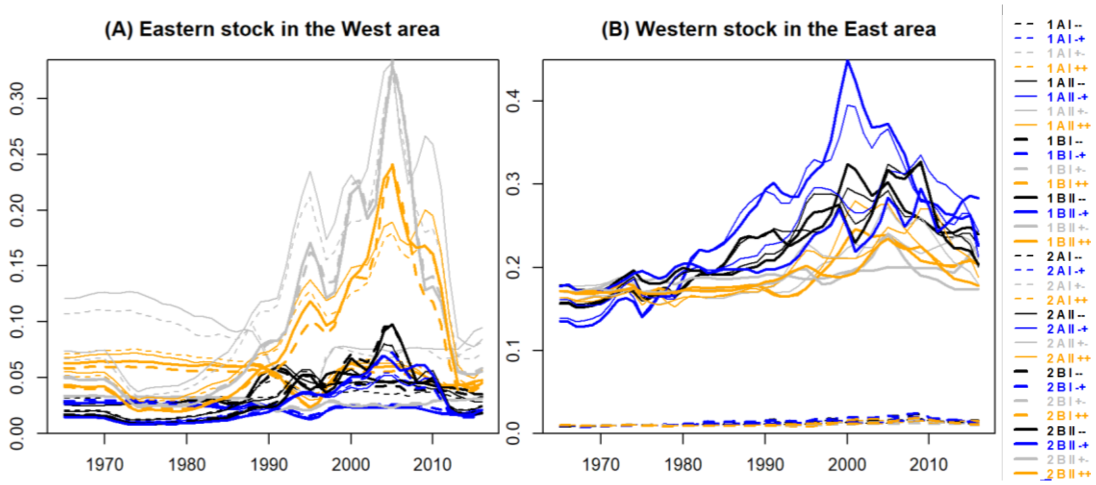

Figure 1-b. Proportions of (A) eastern stock biomass in the West area or (B) western stock biomass in the East area in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

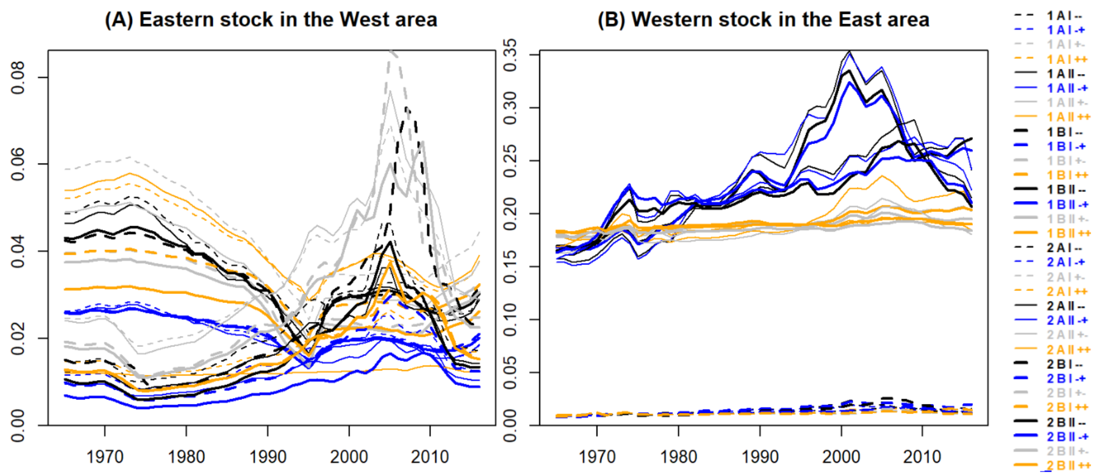

Figure 1-c. Proportions of (A) eastern stock biomass in the West area or (B) western stock biomass in the East area in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

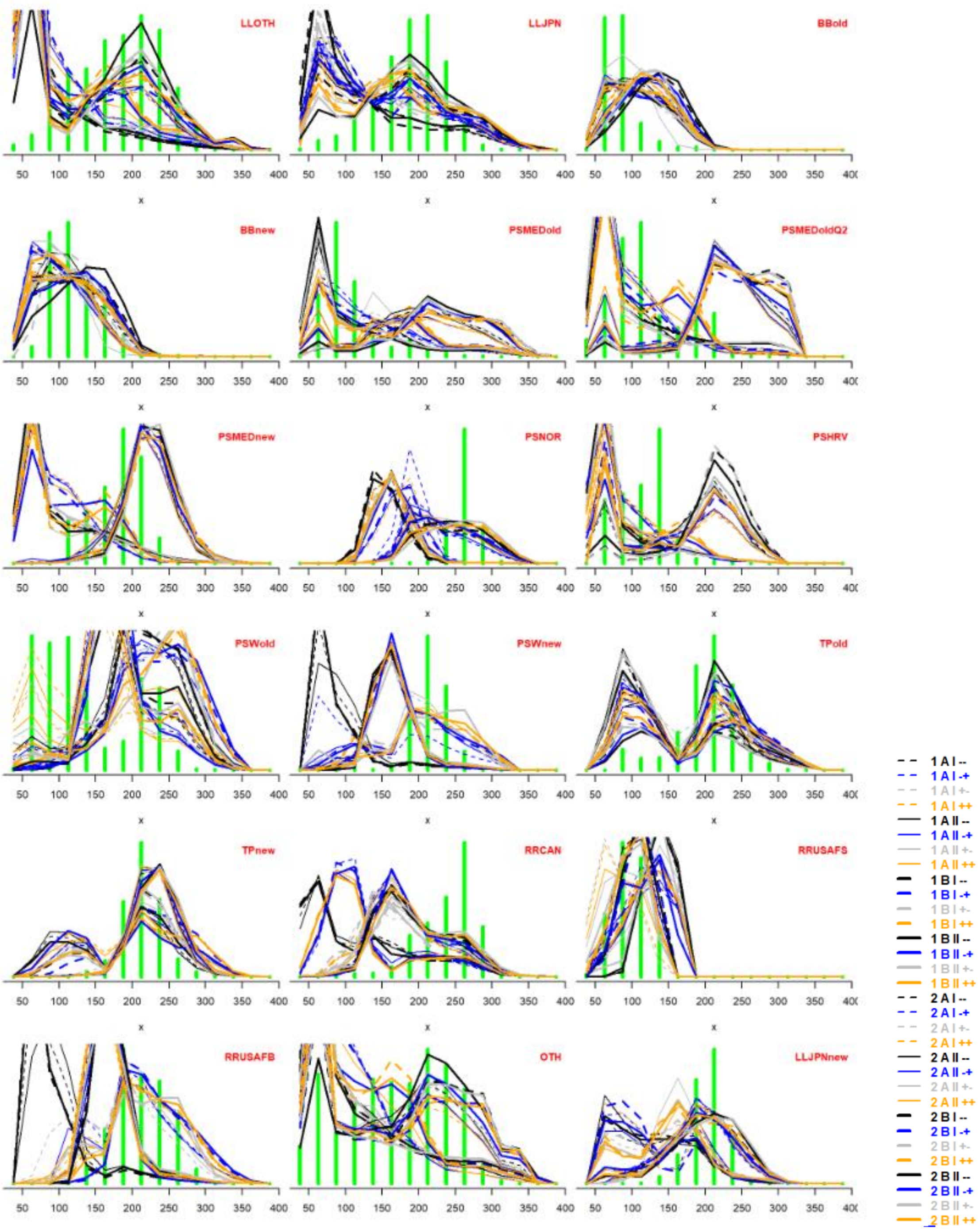

Figure 2-a. Fits to length composition data by fleet in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

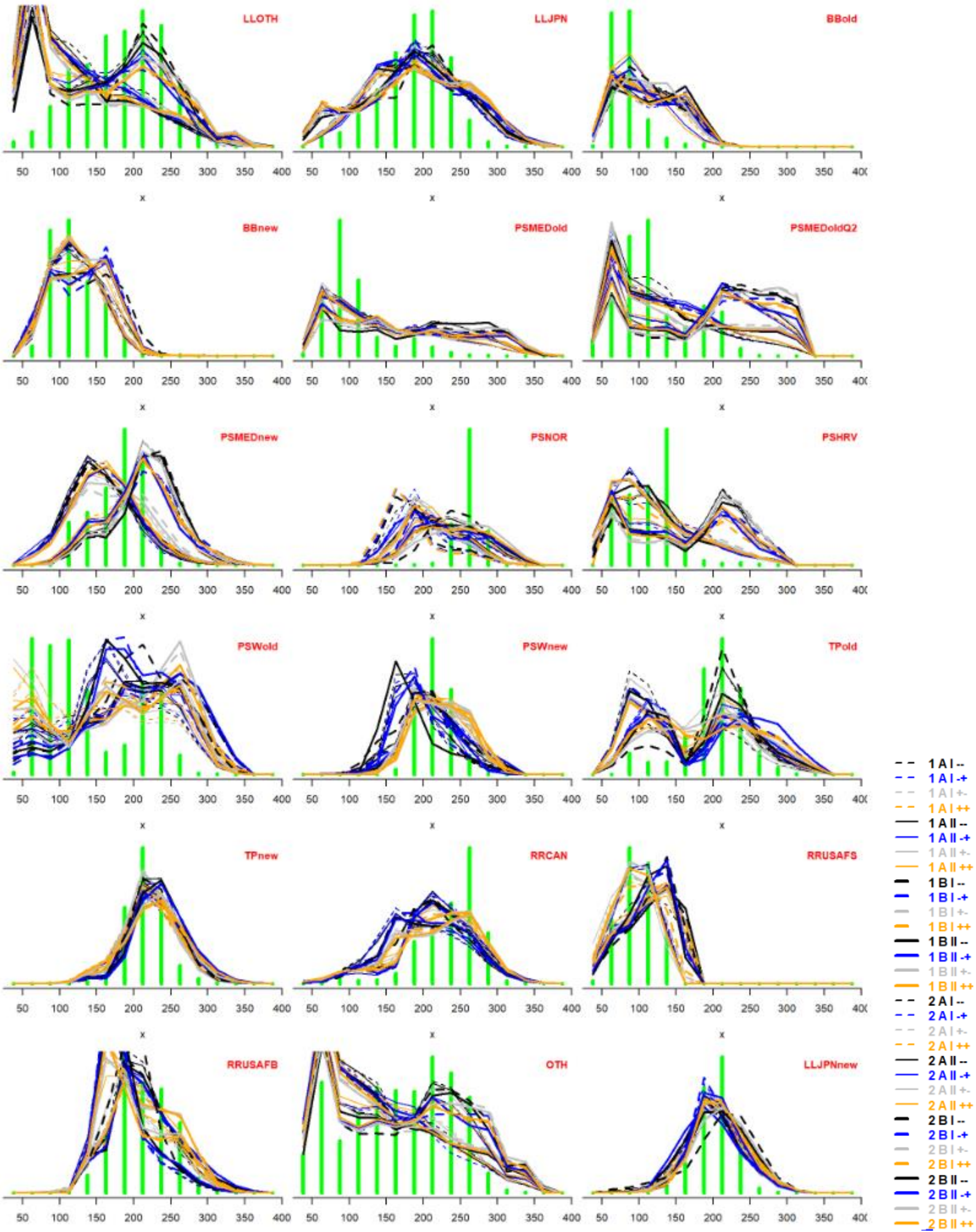

Figure 2-b. Fits to length composition data by fleet in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

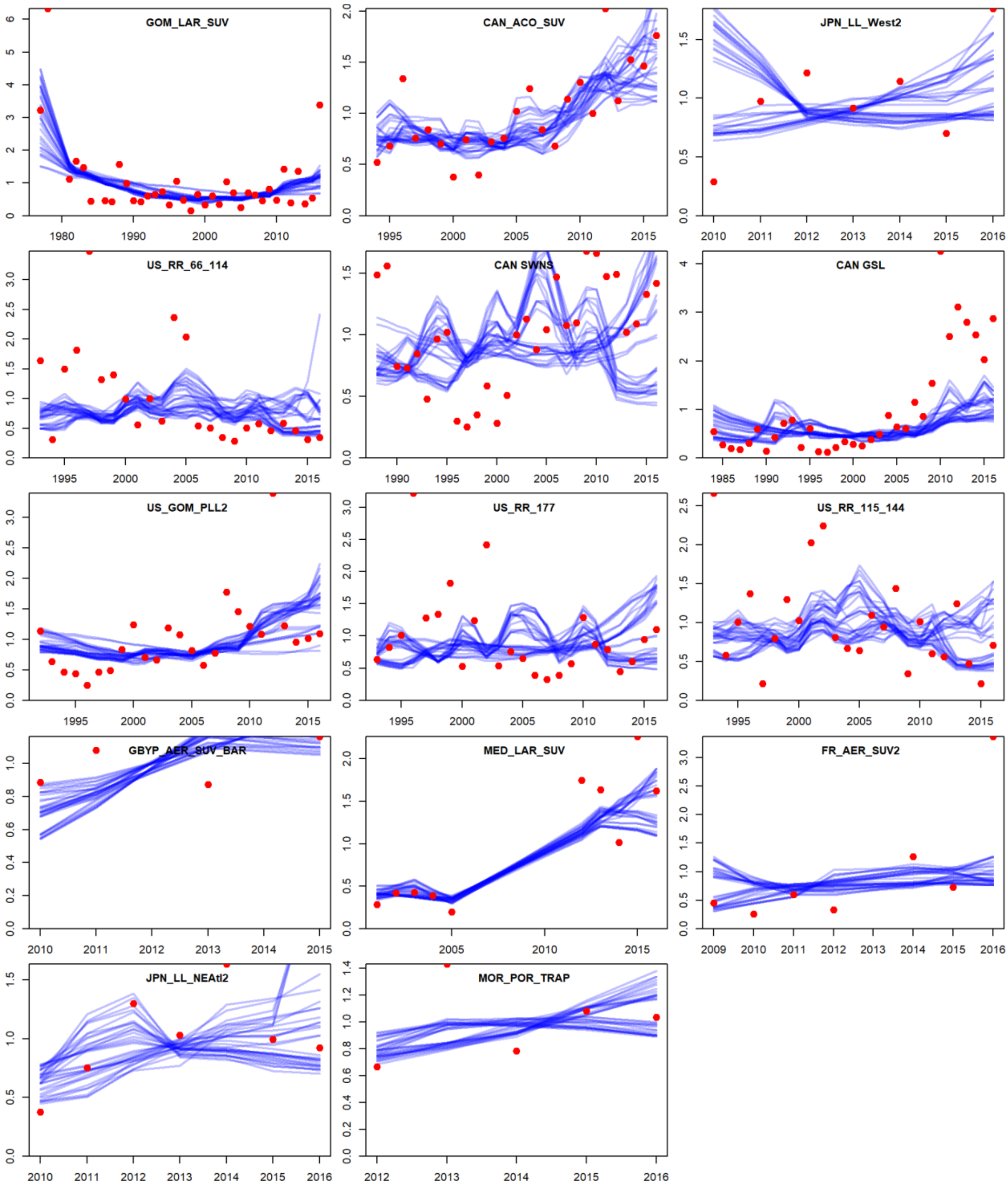

Figure 3-a. Fits to indices for CMPs in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

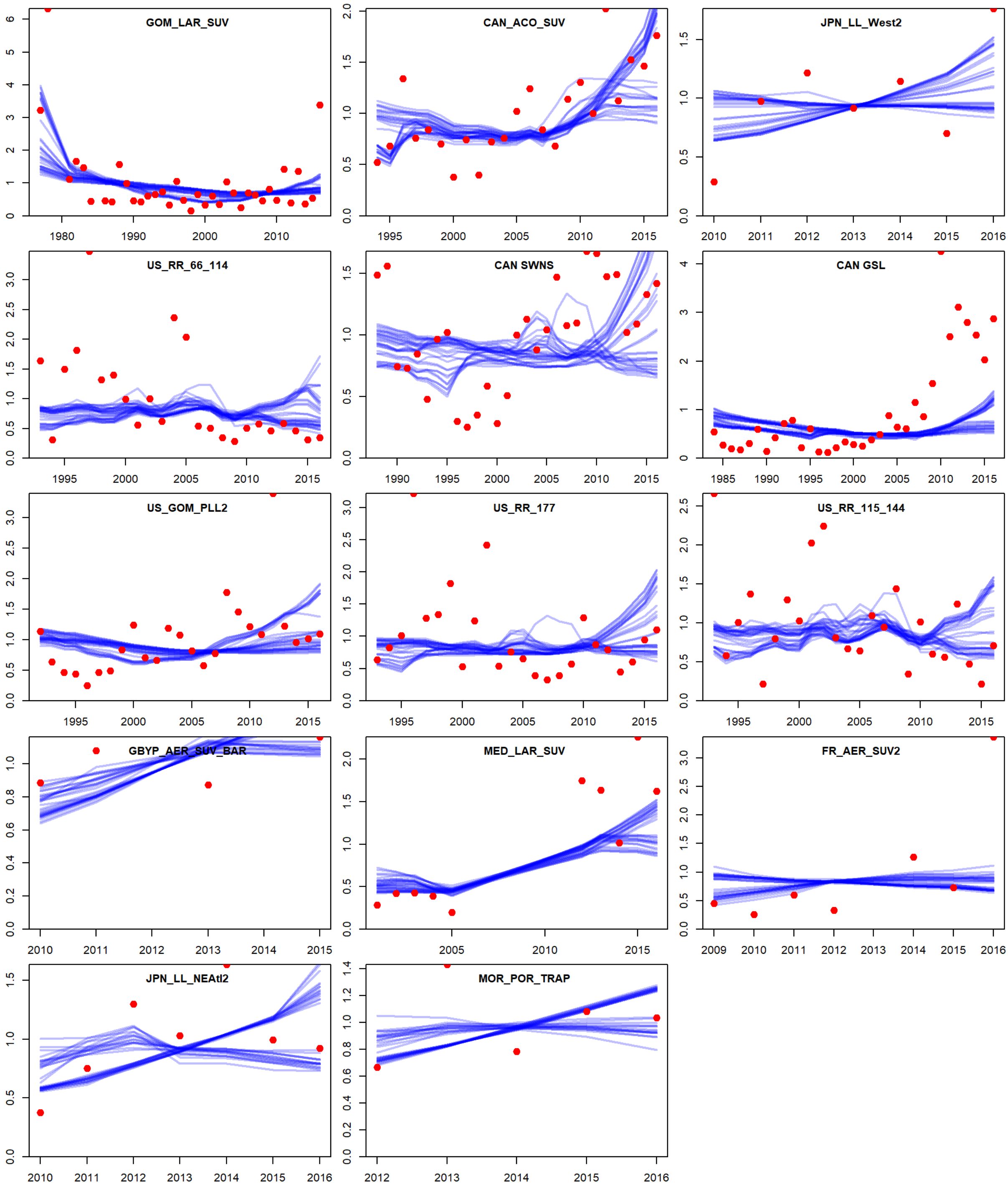

Figure 3-b. Fits to indices for CMPs in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

Appendix 1

Agenda

1. Opening, adoption of agenda and meeting arrangements
2. Summary of developments since the September Bluefin Tuna Species Group meeting and before this meeting
3. Review of results for conditioning of OMs for the interim grid and associated robustness tests
4. Recommendations, based on discussions under 3), regarding the acceptability of the conditioning and for possible changes to the interim grid specifications
5. Re-selection of the indices to be projected into the future for use as inputs to CMPs, together with specification of their error structure for use in their generation in simulations.
    - 5.1. Indices
        - 5.1.1. Examining properties of the indices' residuals
        - 5.1.2. Selecting indices for potential use in CMPs
        - 5.1.3. Conclusions on method of future year simulation of selected indices
    - 5.2. Recruitment deviations
6. Review of codes and Trial Specifications document modifications required
7. Provide suggestions for approaches (e.g. a Delphi method) to plausibility-weight OMs for review at the April intersessional meeting of the Bluefin Tuna Species Group
8. Work plan leading up to April BFT intersessional meeting, including consideration of provision of an updated package for CMP developers
9. Other matters
10. Adoption of the report

Appendix 2

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Appendix 3

List of Papers and Presentations

Number	Title	Authors
SCRS/2020/015	Scientific reflections from Norway related to the MSE process on Atlantic bluefin tuna	Nøttestad L., Mjørlund R., and Sandberg P.
SCRS/2020/018	Reference set Operating Models (version 6.5) for Atlantic bluefin tuna assuming priors for area-specific scale and western stock mixing	Carruthers T.

Appendix 4

SCRS Document and Presentations Abstracts as provided by the authors

SCRS/2020/015 - Merging the eastern and western stock of Atlantic bluefin tuna into one overall Trans-Atlantic Management Strategy Evaluation (MSE) is a huge step to take and involves a whole range of difficult and challenging scientific decisions to be made. We are concerned about whether the amount, quality and resolution of available data on ABFT in space and time are at the level which is needed to model EBFT and WBFT into one unified MSE framework. We question whether we have sufficient knowledge about the Trans-Atlantic mixing of ABFT to properly quantify this migration. We recommend that the Management Strategy Evaluation (MSE) with corresponding Harvest Control Rules (HCR) should be developed separately for EBFT and WBFT in ICCAT. The decision taken on this issue is highly relevant for the science, advice and management regime for both EBFT and WBFT in ICCAT in the future. Bearing in mind the consequences inadequate data on migration may have for stock assessment and management of each stock, we question whether building a joint model can be said to be in accordance with the Precautionary Approach.

SCRS/2020/018 - In this paper a relatively large reference set of operating models (version 6.5) are presented that have been conditioned on various data as well as informative "priors" for scale and western mixing. The derivation of these "priors" (actually sets of a few alternative values considered to span the plausible range) is described, and the results of the reference operating models fitted are presented. The purpose of this document is to provide sufficient information to begin a process of narrowing operating model specifications into a smaller (than the current 48 member), more manageable reference set for use in CMP development and testing. A central objective of these operating model runs is to facilitate the choice of a suitable lower bound for western mixing. Previously 5% was presented as a suitable lower bound, but a lower level still might be desirable to provide a more rigorous test of CMP performance.

Appendix 5

Matrices of 4 statistics for the abundance index residuals (columns) in 32 OMs (rows) using the new mixing methods with low or high log-likelihood weight of the length composition data

Table 1. Standard Deviation (STD) for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	0.29	0.36	0.78	0.68	0.72	0.5	0.48	0.83	0.52	0.82	0.31	0.3	0.56	0.24
2	1	A	I	-+	0.3	0.55	0.76	0.72	0.63	0.46	0.47	0.73	0.54	0.66	0.32	0.29	0.55	0.41
3	1	A	I	+-	0.3	0.34	0.83	0.76	0.66	0.53	0.47	0.86	0.52	0.73	0.33	0.34	0.63	0.28
4	1	A	I	++	0.3	0.53	0.79	0.72	0.66	0.5	0.49	0.75	0.52	0.65	0.32	0.29	0.61	0.42
5	1	A	II	--	0.3	0.37	0.75	0.67	0.71	0.52	0.5	0.83	0.53	0.81	0.31	0.3	0.57	0.24
6	1	A	II	-+	0.3	0.51	0.78	0.71	0.64	0.48	0.47	0.74	0.54	0.66	0.32	0.29	0.56	0.42
7	1	A	II	+-	0.3	0.33	0.84	0.76	0.67	0.54	0.47	0.86	0.53	0.77	0.32	0.34	0.63	0.26
8	1	A	II	++	0.31	0.36	0.8	0.72	0.66	0.52	0.48	0.75	0.52	0.66	0.32	0.29	0.62	0.38
9	1	B	I	--	0.3	0.38	0.77	0.66	0.74	0.51	0.45	0.82	0.55	0.8	0.33	0.3	0.56	0.24
10	1	B	I	-+	0.3	0.55	0.91	0.7	0.66	0.49	0.47	0.72	0.54	0.69	0.33	0.3	0.55	0.39
11	1	B	I	+-	0.33	0.34	0.69	0.62	0.54	0.61	0.53	0.82	0.58	0.76	0.3	0.31	0.7	0.26
12	1	B	I	++	0.32	0.32	0.81	0.73	0.64	0.53	0.48	0.77	0.55	0.67	0.32	0.32	0.63	0.37
13	1	B	II	--	0.3	0.36	0.76	0.67	0.74	0.52	0.46	0.82	0.53	0.8	0.32	0.3	0.57	0.25
14	1	B	II	-+	0.32	0.34	0.81	0.72	0.65	0.47	0.48	0.74	0.57	0.68	0.34	0.28	0.56	0.41
15	1	B	II	+-	0.34	0.33	0.71	0.6	0.54	0.63	0.52	0.82	0.6	0.76	0.29	0.32	0.7	0.26
16	1	B	II	++	0.32	0.3	0.79	0.72	0.64	0.54	0.48	0.77	0.55	0.68	0.32	0.31	0.64	0.37
17	2	A	I	--	0.26	0.42	0.65	0.61	0.67	0.46	0.76	0.92	0.69	0.9	0.32	0.31	0.57	0.22
18	2	A	I	-+	0.25	0.45	0.72	0.62	0.65	0.47	0.79	0.9	0.6	0.85	0.36	0.31	0.55	0.26
19	2	A	I	+-	0.27	0.39	0.67	0.62	0.65	0.47	0.74	0.91	0.65	0.89	0.31	0.32	0.57	0.22
20	2	A	I	++	0.25	0.43	0.76	0.64	0.67	0.48	0.78	0.85	0.56	0.88	0.34	0.29	0.56	0.24
21	2	A	II	--	0.25	0.36	0.66	0.61	0.65	0.46	0.79	0.93	0.69	0.92	0.32	0.31	0.56	0.25
22	2	A	II	-+	0.25	0.41	0.73	0.63	0.65	0.47	0.83	0.91	0.59	0.85	0.35	0.31	0.55	0.28
23	2	A	II	+-	0.25	0.32	0.68	0.61	0.63	0.47	0.81	0.86	0.68	0.93	0.31	0.29	0.57	0.29
24	2	A	II	++	0.25	0.36	0.77	0.64	0.66	0.48	0.83	0.83	0.58	0.9	0.34	0.27	0.56	0.28
25	2	B	I	--	0.28	0.43	0.63	0.62	0.72	0.46	0.76	0.98	0.78	0.9	0.44	0.32	0.57	0.18
26	2	B	I	-+	0.27	0.45	0.66	0.62	0.7	0.48	0.8	0.97	0.69	0.84	0.44	0.33	0.57	0.2
27	2	B	I	+-	0.28	0.41	0.66	0.62	0.68	0.48	0.71	0.94	0.72	0.91	0.42	0.3	0.59	0.17
28	2	B	I	++	0.28	0.41	0.71	0.63	0.71	0.49	0.73	0.93	0.64	0.85	0.4	0.3	0.59	0.18
29	2	B	II	--	0.28	0.39	0.63	0.62	0.72	0.45	0.77	0.99	0.77	0.9	0.42	0.32	0.57	0.2
30	2	B	II	-+	0.26	0.42	0.66	0.59	0.68	0.46	0.8	0.96	0.67	0.91	0.45	0.33	0.55	0.24
31	2	B	II	+-	0.28	0.42	0.66	0.61	0.68	0.48	0.72	0.96	0.71	0.91	0.43	0.31	0.6	0.17
32	2	B	II	++	0.26	0.4	0.72	0.63	0.68	0.48	0.82	0.91	0.62	0.86	0.4	0.31	0.58	0.22

Table 2. Autocorrelation (AC) for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	0.13	-0.23	0.39	0.08	0.44	0.18	-0.14	0.58	0.29	0.34	-0.27	0.15	-0.08	-0.46
2	1	A	I	-+	0.19	-0.16	0.39	0.03	0.28	0.09	-0.23	0.49	0.3	0.4	-0.22	0.11	-0.07	-0.5
3	1	A	I	+-	0.09	-0.25	0.5	0.13	0.34	0.33	-0.22	0.62	0.22	0.38	-0.2	0.25	-0.01	-0.49
4	1	A	I	++	0.17	-0.2	0.45	0.06	0.31	0.25	-0.19	0.51	0.28	0.41	-0.2	0.13	-0.05	-0.5
5	1	A	II	--	0.1	-0.23	0.39	0.06	0.43	0.23	-0.06	0.59	0.29	0.35	-0.27	0.14	-0.07	-0.46
6	1	A	II	-+	0.19	-0.14	0.37	0.04	0.27	0.13	-0.22	0.48	0.3	0.41	-0.2	0.09	-0.06	-0.5
7	1	A	II	+-	0.09	-0.2	0.49	0.16	0.35	0.34	-0.22	0.63	0.23	0.37	-0.23	0.21	0	-0.49
8	1	A	II	++	0.12	-0.15	0.44	0.07	0.3	0.27	-0.2	0.5	0.28	0.4	-0.22	0.13	-0.03	-0.5
9	1	B	I	--	0.1	-0.15	0.35	0.05	0.43	0.16	-0.12	0.57	0.36	0.34	-0.26	0.16	-0.07	-0.45
10	1	B	I	-+	0.19	-0.19	0.31	0.07	0.33	0.06	-0.24	0.47	0.27	0.4	-0.19	0.08	-0.08	-0.5
11	1	B	I	+-	0.03	-0.21	0.3	-0.05	0.07	0.47	-0.12	0.61	0.46	0.39	-0.21	0.1	0.09	-0.49
12	1	B	I	++	0.08	-0.21	0.47	0.07	0.28	0.31	-0.21	0.52	0.31	0.41	-0.26	0.2	-0.02	-0.5
13	1	B	II	--	0.11	-0.17	0.37	0.06	0.41	0.21	-0.15	0.61	0.33	0.35	-0.27	0.15	-0.06	-0.47
14	1	B	II	-+	0.09	-0.18	0.34	0.03	0.29	0.11	-0.24	0.48	0.31	0.37	-0.28	0.05	-0.06	-0.5
15	1	B	II	+-	0.02	-0.19	0.24	-0.08	0.04	0.48	-0.13	0.61	0.49	0.4	-0.2	0.1	0.1	-0.49
16	1	B	II	++	0.11	-0.2	0.44	0.06	0.28	0.34	-0.21	0.52	0.31	0.4	-0.26	0.2	-0.01	-0.5
17	2	A	I	--	0.26	0.08	0.24	-0.17	0.14	-0.01	-0.06	0.62	0.57	0.31	-0.05	0.14	-0.06	-0.04
18	2	A	I	-+	0.22	0.09	0.34	-0.15	0.28	0.05	-0.07	0.62	0.45	0.32	-0.12	0.1	-0.06	-0.29
19	2	A	I	+-	0.27	0.05	0.27	-0.14	0.19	0.06	-0.05	0.58	0.53	0.35	-0.08	0.13	-0.08	-0.09
20	2	A	I	++	0.26	0.04	0.39	-0.08	0.33	0.1	-0.05	0.55	0.4	0.36	-0.16	0.13	-0.08	-0.31
21	2	A	II	--	0.22	0.07	0.26	-0.19	0.13	-0.02	-0.07	0.63	0.56	0.31	-0.04	0.11	-0.06	-0.16
22	2	A	II	-+	0.17	0.08	0.36	-0.14	0.28	0.05	-0.07	0.63	0.43	0.32	-0.11	0.09	-0.06	-0.29
23	2	A	II	+-	0.18	0.01	0.28	-0.17	0.16	0.04	-0.05	0.54	0.56	0.33	-0.07	0.1	-0.07	-0.35
24	2	A	II	++	0.19	0.01	0.38	-0.09	0.32	0.07	-0.03	0.53	0.41	0.35	-0.17	0.07	-0.07	-0.38
25	2	B	I	--	0.28	0.05	0.15	-0.08	0.15	0.07	-0.05	0.65	0.61	0.33	0.08	0.17	-0.08	0.1
26	2	B	I	-+	0.29	0.06	0.25	-0.14	0.25	0.12	-0.06	0.66	0.54	0.34	0.01	0.18	-0.07	-0.06
27	2	B	I	+-	0.28	-0.02	0.26	-0.08	0.18	0.11	-0.05	0.63	0.55	0.34	0.08	0.08	-0.07	0.12
28	2	B	I	++	0.29	-0.02	0.36	-0.08	0.29	0.15	-0.06	0.62	0.49	0.35	-0.02	0.07	-0.07	-0.06
29	2	B	II	--	0.27	0.01	0.15	-0.11	0.14	0	-0.05	0.65	0.6	0.33	0.09	0.11	-0.08	0.05
30	2	B	II	-+	0.24	0.04	0.24	-0.16	0.27	-0.02	-0.07	0.66	0.51	0.33	0.02	0.09	-0.07	-0.31
31	2	B	II	+-	0.29	-0.03	0.25	-0.07	0.17	0.12	-0.04	0.64	0.55	0.34	0.09	0.1	-0.07	0.16
32	2	B	II	++	0.27	0	0.36	-0.11	0.3	0.13	-0.06	0.59	0.48	0.36	-0.03	0.19	-0.08	-0.22

Table 3. P-value for the runs test for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	0.8	0.4	0.07	0.94	0.15	0.24	0.4	0	0	0.93	0.83	0.67	0.04	1
2	1	A	I	-+	0	0.4	0.07	0.87	0.01	0.24	0.93	0	0.01	0.06	0.62	0.34	0.04	1
3	1	A	I	+-	0.8	0.4	0.07	0.94	0.06	0.01	0.4	0	0.01	0.91	0.71	0.67	0.26	1
4	1	A	I	++	0	0.4	0.07	0.87	0.01	0.04	0.93	0	0.01	0.06	0.62	0.93	0.08	1
5	1	A	II	--	0.8	0.4	0.07	0.94	0.17	0.24	0.4	0	0	0.93	0.62	0.16	0.09	1
6	1	A	II	-+	0	0.4	0.07	0.84	0.01	0.24	0.93	0	0.01	0.06	0.62	0.34	0.04	1
7	1	A	II	+-	0.8	0.4	0.07	0.44	0.06	0.01	0.93	0	0.01	0.91	0.62	0.99	0.26	1
8	1	A	II	++	0.8	0.4	0.07	0.87	0.01	0.04	0.93	0	0.06	0.91	0.62	0.99	0.2	1
9	1	B	I	--	0.8	0.4	0.07	0.87	0.17	0.04	0.4	0	0	0.93	0.83	0.67	0.04	1
10	1	B	I	-+	0	0.4	0.07	0.87	0.01	0.04	0.93	0	0.06	0.06	0.62	0.99	0.04	1
11	1	B	I	+-	0.8	0.4	0.07	0.84	0.31	0.01	0.4	0	0	0.93	0.62	0.67	0.83	1
12	1	B	I	++	0.8	0.4	0.07	0.87	0.01	0.04	0.93	0	0.06	0.91	0.62	0.93	0.2	1
13	1	B	II	--	0.8	0.4	0.07	0.87	0.06	0.24	0.4	0	0	0.93	0.83	0.67	0.04	1
14	1	B	II	-+	0.8	0.4	0.1	0.84	0.01	0.24	0.93	0	0.01	0.91	0.62	0.99	0.04	1
15	1	B	II	+-	0.8	0.4	0.07	0.84	0.31	0	0.93	0	0	0.93	0.62	0.67	0.83	1
16	1	B	II	++	0.8	0.4	0.07	0.84	0.01	0.01	0.93	0	0.06	0.91	0.62	0.67	0.2	1
17	2	A	I	--	0.89	0.27	0.3	0.87	0.36	0.29	0.91	0	0	0.93	0.38	0.09	0.04	1
18	2	A	I	-+	0.89	0.11	0.31	0.84	0.07	0.29	0.91	0	0.01	0.4	0.38	0.99	0.04	1
19	2	A	I	+-	0.89	0.27	0.3	0.84	0.31	0.29	0.91	0.01	0	0.93	0.71	0.51	0.09	1
20	2	A	I	++	0.89	0.27	0.31	0.55	0.31	0.29	0.91	0.01	0.03	0.93	0.71	0.51	0.09	1
21	2	A	II	--	0.89	0.27	0.3	0.87	0.36	0.29	0.91	0	0	0.93	0.71	0.44	0.04	1
22	2	A	II	-+	0.89	0.11	0.31	0.84	0.07	0.29	0.91	0	0.01	0.4	0.38	0.93	0.04	1
23	2	A	II	+-	0.89	0.27	0.3	0.84	0.31	0.29	0.91	0.01	0	0.93	0.38	0.93	0.09	1
24	2	A	II	++	0.89	0.27	0.31	0.55	0.07	0.29	0.91	0.01	0.04	0.93	0.71	0.51	0.09	1
25	2	B	I	--	0.89	0.27	0.07	0.5	0.06	0.29	0.91	0	0	0.93	0.38	0.09	0.04	1
26	2	B	I	-+	0.89	0.27	0.06	0.84	0.3	0.29	0.91	0	0	0.93	0.38	0.99	0.04	1
27	2	B	I	+-	0.89	0.27	0.07	0.5	0.06	0.29	0.91	0	0	0.93	0.38	0.51	0.09	1
28	2	B	I	++	0.89	0.27	0.3	0.87	0.3	0.29	0.91	0	0	0.93	0.38	0.51	0.09	1
29	2	B	II	--	0.89	0.27	0.07	0.5	0.06	0.29	0.91	0	0	0.93	0.38	0.44	0.04	1
30	2	B	II	-+	0.89	0.27	0.31	0.84	0.3	0.29	0.91	0	0	0.93	0.38	0.4	0.04	1
31	2	B	II	+-	0.89	0.27	0.06	0.87	0.06	0.29	0.91	0	0	0.93	0.38	0.44	0.09	1
32	2	B	II	++	0.89	0.27	0.3	0.87	0.31	0.24	0.91	0.01	0	0.93	0.38	0.51	0.09	1

Table 4. Length of longest run (where a run is a consecutive sequence of years on the same side of the "0 axis") in the last 10 years for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	3	4	10	3	6	4	2	10	6	4	3	3	2	2
2	1	A	I	-+	1	4	10	3	5	4	4	10	6	1	3	2	2	2
3	1	A	I	+-	3	4	10	3	6	6	2	10	6	3	2	4	2	2
4	1	A	I	++	1	4	10	3	6	6	4	10	6	1	3	2	2	2
5	1	A	II	--	3	4	10	3	6	4	2	10	6	4	3	2	2	2
6	1	A	II	-+	1	4	10	3	5	4	4	10	6	1	3	2	2	2
7	1	A	II	+-	3	4	10	3	6	6	4	10	6	3	3	4	2	2
8	1	A	II	++	3	4	10	3	5	6	4	10	6	3	3	2	2	2
9	1	B	I	--	3	4	10	3	6	5	2	10	10	4	3	3	2	2
10	1	B	I	-+	1	4	10	3	5	5	4	10	6	1	3	4	2	2
11	1	B	I	+-	3	4	10	3	4	9	2	10	10	4	3	3	2	2
12	1	B	I	++	3	4	10	3	5	6	4	10	6	3	3	3	2	2
13	1	B	II	--	3	4	10	3	6	4	2	10	10	4	3	3	2	2
14	1	B	II	-+	3	4	10	3	5	4	4	10	6	3	3	4	2	2
15	1	B	II	+-	3	4	10	3	4	9	4	10	10	4	3	3	2	2
16	1	B	II	++	3	4	10	3	5	6	4	10	6	3	3	2	2	2
17	2	A	I	--	2	5	6	2	3	4	3	10	10	4	5	4	2	2
18	2	A	I	-+	2	4	6	2	5	4	3	10	10	2	5	3	2	2
19	2	A	I	+-	2	5	6	2	3	4	3	10	10	4	3	5	2	2
20	2	A	I	++	2	5	6	4	3	4	3	10	8	4	3	3	2	2
21	2	A	II	--	2	5	6	2	3	4	3	10	10	4	3	3	2	2
22	2	A	II	-+	2	4	6	4	5	4	3	10	10	2	5	3	2	2
23	2	A	II	+-	2	5	6	2	3	4	3	10	10	4	5	3	2	2
24	2	A	II	++	2	5	6	4	5	4	3	10	8	4	3	3	2	2
25	2	B	I	--	2	5	6	3	3	4	3	10	10	4	5	4	2	2
26	2	B	I	-+	2	5	6	2	3	4	3	10	9	4	5	3	2	2
27	2	B	I	+-	2	5	6	2	3	4	3	10	9	4	5	3	2	2
28	2	B	I	++	2	5	6	2	3	4	3	10	9	4	5	3	2	2
29	2	B	II	--	2	5	6	3	3	4	3	10	10	4	5	3	2	2
30	2	B	II	-+	2	5	6	2	3	4	3	10	8	4	5	3	2	2
31	2	B	II	+-	2	5	6	2	3	4	3	10	9	4	5	3	2	2
32	2	B	II	++	2	5	6	2	3	4	3	10	9	4	5	5	2	2

Table 5. Standard Deviation (STD) for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	0.31	0.43	0.81	0.74	0.66	0.48	0.45	0.92	0.53	0.67	0.48	0.33	0.57	0.32
2	1	A	I	-+	0.31	0.42	0.86	0.73	0.66	0.48	0.46	0.9	0.51	0.78	0.44	0.33	0.56	0.29
3	1	A	I	+-	0.31	0.37	0.76	0.68	0.59	0.6	0.48	0.95	0.54	0.76	0.44	0.31	0.67	0.27
4	1	A	I	++	0.31	0.39	0.85	0.74	0.65	0.57	0.46	0.91	0.5	0.78	0.45	0.32	0.64	0.26
5	1	A	II	--	0.31	0.41	0.8	0.73	0.66	0.5	0.45	0.92	0.55	0.72	0.49	0.34	0.57	0.31
6	1	A	II	-+	0.31	0.4	0.84	0.75	0.67	0.51	0.46	0.88	0.52	0.77	0.48	0.32	0.57	0.28
7	1	A	II	+-	0.32	0.37	0.73	0.66	0.58	0.61	0.49	0.94	0.55	0.77	0.43	0.32	0.68	0.27
8	1	A	II	++	0.31	0.39	0.86	0.75	0.67	0.58	0.46	0.9	0.49	0.79	0.46	0.32	0.64	0.27
9	1	B	I	--	0.3	0.39	0.89	0.73	0.69	0.51	0.45	0.93	0.55	0.76	0.53	0.33	0.59	0.26
10	1	B	I	-+	0.3	0.39	0.92	0.74	0.71	0.51	0.46	0.88	0.52	0.8	0.49	0.32	0.57	0.25
11	1	B	I	+-	0.31	0.36	0.7	0.62	0.55	0.63	0.52	0.95	0.58	0.85	0.43	0.31	0.7	0.26
12	1	B	I	++	0.3	0.38	0.81	0.7	0.61	0.62	0.47	0.91	0.52	0.81	0.46	0.31	0.68	0.23
13	1	B	II	--	0.31	0.4	0.84	0.73	0.68	0.52	0.46	0.92	0.54	0.74	0.52	0.34	0.58	0.26
14	1	B	II	-+	0.3	0.39	0.87	0.75	0.71	0.53	0.45	0.88	0.52	0.79	0.49	0.32	0.58	0.25
15	1	B	II	+-	0.32	0.36	0.68	0.62	0.54	0.63	0.51	0.96	0.59	0.82	0.42	0.31	0.71	0.27
16	1	B	II	++	0.31	0.37	0.76	0.67	0.58	0.63	0.48	0.92	0.54	0.82	0.43	0.31	0.69	0.24
17	2	A	I	--	0.28	0.43	0.64	0.61	0.6	0.52	0.63	1.07	0.6	0.97	0.53	0.34	0.61	0.18
18	2	A	I	-+	0.27	0.45	0.68	0.62	0.58	0.55	0.61	1.05	0.56	0.95	0.55	0.32	0.62	0.17
19	2	A	I	+-	0.28	0.4	0.66	0.6	0.57	0.56	0.58	1.09	0.58	0.99	0.51	0.38	0.69	0.19
20	2	A	I	++	0.27	0.36	0.68	0.62	0.56	0.57	0.57	1.07	0.57	0.98	0.51	0.37	0.69	0.22
21	2	A	II	--	0.27	0.42	0.64	0.61	0.58	0.53	0.62	1.07	0.6	0.97	0.52	0.35	0.63	0.2
22	2	A	II	-+	0.26	0.42	0.67	0.62	0.57	0.56	0.61	1.06	0.56	0.94	0.54	0.34	0.64	0.2
23	2	A	II	+-	0.28	0.4	0.66	0.61	0.57	0.55	0.6	1.08	0.57	0.98	0.49	0.38	0.68	0.21
24	2	A	II	++	0.26	0.35	0.64	0.6	0.55	0.58	0.56	1.08	0.58	1.03	0.51	0.37	0.71	0.26
25	2	B	I	--	0.34	0.43	0.64	0.58	0.7	0.5	0.61	1.01	0.55	0.99	0.68	0.33	0.59	0.15
26	2	B	I	-+	0.28	0.55	0.65	0.59	0.58	0.56	0.6	1.11	0.61	0.93	0.66	0.39	0.64	0.15
27	2	B	I	+-	0.29	0.47	0.63	0.59	0.57	0.59	0.59	1.14	0.61	0.99	0.64	0.44	0.69	0.15
28	2	B	I	++	0.28	0.42	0.64	0.6	0.55	0.59	0.59	1.13	0.6	0.97	0.58	0.43	0.69	0.2
29	2	B	II	--	0.29	0.5	0.62	0.59	0.58	0.55	0.61	1.11	0.63	0.97	0.68	0.4	0.64	0.15
30	2	B	II	-+	0.27	0.44	0.63	0.59	0.56	0.57	0.6	1.1	0.59	0.94	0.57	0.41	0.66	0.2
31	2	B	II	+-	0.29	0.48	0.63	0.59	0.55	0.61	0.61	1.17	0.62	0.98	0.62	0.46	0.7	0.17
32	2	B	II	++	0.28	0.43	0.64	0.6	0.55	0.6	0.6	1.14	0.6	0.99	0.54	0.42	0.7	0.19

Table 6. Autocorrelation (AC) for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	0.12	-0.25	0.47	0.08	0.32	0.13	-0.22	0.62	0.25	0.42	-0.06	0.23	-0.07	-0.5
2	1	A	I	-+	0.14	-0.24	0.43	0.09	0.33	0.14	-0.21	0.61	0.26	0.37	-0.12	0.18	-0.09	-0.49
3	1	A	I	+-	0.1	-0.24	0.4	0.03	0.2	0.45	-0.16	0.64	0.38	0.4	-0.13	0.24	0.06	-0.49
4	1	A	I	++	0.11	-0.25	0.46	0.12	0.33	0.38	-0.19	0.62	0.26	0.38	-0.12	0.19	0.01	-0.48
5	1	A	II	--	0.11	-0.24	0.44	0.09	0.31	0.18	-0.22	0.62	0.26	0.4	-0.04	0.22	-0.06	-0.49
6	1	A	II	-+	0.13	-0.25	0.45	0.12	0.36	0.21	-0.22	0.6	0.25	0.37	-0.08	0.15	-0.07	-0.49
7	1	A	II	+-	0.08	-0.24	0.37	0	0.17	0.45	-0.15	0.64	0.41	0.38	-0.15	0.24	0.07	-0.49
8	1	A	II	++	0.12	-0.25	0.48	0.14	0.35	0.4	-0.2	0.61	0.24	0.37	-0.13	0.15	0.01	-0.48
9	1	B	I	--	0.14	-0.25	0.42	0.11	0.38	0.21	-0.21	0.61	0.21	0.37	-0.02	0.25	-0.03	-0.48
10	1	B	I	-+	0.15	-0.25	0.44	0.14	0.42	0.2	-0.22	0.59	0.2	0.35	-0.09	0.19	-0.06	-0.47
11	1	B	I	+-	0.12	-0.24	0.28	-0.05	0.08	0.49	-0.11	0.63	0.47	0.36	-0.16	0.24	0.1	-0.49
12	1	B	I	++	0.13	-0.25	0.42	0.08	0.26	0.47	-0.17	0.62	0.34	0.37	-0.13	0.18	0.07	-0.46
13	1	B	II	--	0.13	-0.25	0.43	0.11	0.36	0.23	-0.21	0.62	0.22	0.38	-0.03	0.24	-0.03	-0.48
14	1	B	II	-+	0.14	-0.25	0.46	0.15	0.41	0.25	-0.21	0.59	0.2	0.36	-0.08	0.19	-0.04	-0.48
15	1	B	II	+-	0.09	-0.24	0.27	-0.07	0.07	0.49	-0.12	0.64	0.48	0.36	-0.17	0.26	0.1	-0.49
16	1	B	II	++	0.11	-0.24	0.38	0.02	0.19	0.48	-0.16	0.62	0.39	0.36	-0.17	0.19	0.09	-0.47
17	2	A	I	--	0.28	-0.01	0.31	-0.16	0.17	0.3	-0.05	0.69	0.48	0.33	0.11	0.2	-0.04	-0.02
18	2	A	I	-+	0.29	0.02	0.33	-0.13	0.19	0.35	-0.07	0.69	0.43	0.33	0.07	0.13	-0.02	-0.01
19	2	A	I	+-	0.29	-0.03	0.29	-0.13	0.12	0.37	-0.06	0.7	0.45	0.33	0.11	0.31	0.06	-0.15
20	2	A	I	++	0.26	-0.03	0.3	-0.09	0.11	0.39	-0.06	0.69	0.44	0.33	0.05	0.27	0.07	-0.22
21	2	A	II	--	0.28	0	0.28	-0.17	0.14	0.32	-0.06	0.69	0.48	0.33	0.12	0.23	-0.01	-0.13
22	2	A	II	-+	0.28	0.02	0.31	-0.14	0.17	0.38	-0.08	0.69	0.44	0.33	0.07	0.18	0.01	-0.1
23	2	A	II	+-	0.29	-0.03	0.28	-0.13	0.14	0.37	-0.05	0.69	0.44	0.33	0.1	0.31	0.05	-0.23
24	2	A	II	++	0.24	-0.04	0.21	-0.12	0.08	0.42	-0.07	0.7	0.47	0.32	0.04	0.27	0.09	-0.27
25	2	B	I	--	0.23	-0.06	0.14	-0.12	0.26	0.23	0.02	0.66	0.36	0.33	0.18	0.02	-0.07	0.12
26	2	B	I	-+	0.3	0.02	0.2	-0.15	0.14	0.38	-0.05	0.71	0.48	0.34	0.15	0.35	0	0.11
27	2	B	I	+-	0.29	0.02	0.22	-0.15	0.1	0.43	-0.04	0.71	0.48	0.33	0.19	0.4	0.07	0.23
28	2	B	I	++	0.29	0.01	0.23	-0.13	0.07	0.43	-0.04	0.71	0.48	0.34	0.13	0.4	0.08	-0.18
29	2	B	II	--	0.29	0	0.16	-0.16	0.14	0.37	-0.04	0.7	0.5	0.33	0.18	0.32	0.01	0.05
30	2	B	II	-+	0.28	0.02	0.17	-0.16	0.1	0.4	-0.05	0.7	0.46	0.34	0.13	0.36	0.04	-0.17
31	2	B	II	+-	0.3	-0.03	0.2	-0.17	0.06	0.46	-0.05	0.72	0.51	0.33	0.19	0.43	0.08	-0.29
32	2	B	II	++	0.3	0	0.24	-0.15	0.07	0.45	-0.04	0.71	0.49	0.33	0.12	0.37	0.08	-0.17

Table 7. P-value for the runs test for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	0.8	0.4	0.07	0.94	0.03	0.24	0.4	0	0.01	0.91	0.38	0.83	0.04	1
2	1	A	I	-+	0.8	0.4	0.07	0.81	0.03	0.24	0.93	0	0.01	0.93	0.38	0.93	0.04	1
3	1	A	I	+-	0.8	0.4	0.07	0.87	0.17	0	0.4	0	0	0.93	0.38	0.72	0.83	1
4	1	A	I	++	0.8	0.4	0.07	0.81	0.17	0.1	0.4	0	0.01	0.93	0.38	0.93	0.83	1
5	1	A	II	--	0.8	0.4	0.07	0.87	0.01	0.04	0.4	0	0.01	0.93	0.38	0.22	0.04	1
6	1	A	II	-+	0.8	0.4	0.07	0.81	0.17	0.04	0.4	0	0	0.93	0.38	0.72	0.04	1
7	1	A	II	+-	0.8	0.4	0.07	0.87	0.22	0	0.4	0	0	0.93	0.38	0.72	0.83	1
8	1	A	II	++	0.8	0.4	0.07	0.81	0.17	0.02	0.4	0	0.01	0.93	0.38	0.83	0.26	1
9	1	B	I	--	0.8	0.4	0.07	0.87	0.01	0.24	0.4	0	0.01	0.93	0.38	0.83	0.04	1
10	1	B	I	-+	0.8	0.4	0.07	0.94	0.06	0.24	0.93	0	0	0.93	0.38	0.72	0.04	1
11	1	B	I	+-	0.8	0.4	0.07	0.81	0.31	0	0.4	0	0	0.93	0.38	0.72	0.83	1
12	1	B	I	++	0.8	0.4	0.07	0.81	0.17	0	0.4	0	0	0.93	0.38	0.72	0.98	1
13	1	B	II	--	0.8	0.4	0.07	0.87	0.01	0.04	0.4	0	0.01	0.93	0.38	0.83	0.04	1
14	1	B	II	-+	0.8	0.4	0.07	0.87	0.06	0.04	0.4	0	0	0.93	0.38	0.72	0.04	1
15	1	B	II	+-	0.8	0.4	0.07	0.84	0.31	0	0.4	0	0	0.93	0.38	0.27	0.83	1
16	1	B	II	++	0.8	0.4	0.07	0.94	0.22	0	0.4	0	0	0.93	0.38	0.72	0.83	1
17	2	A	I	--	0.89	0.27	0.31	0.87	0.06	0.04	0.4	0	0	0.93	0.38	0.4	0.98	1
18	2	A	I	-+	0.89	0.27	0.07	0.53	0.07	0.04	0.4	0	0	0.93	0.38	0.93	0.9	1
19	2	A	I	+-	0.89	0.27	0.07	0.53	0.06	0.01	0.4	0	0	0.11	0.38	0.09	0.39	1
20	2	A	I	++	0.89	0.27	0.07	0.81	0.06	0.01	0.4	0	0	0.93	0.38	0.44	0.39	1
21	2	A	II	--	0.89	0.27	0.31	0.53	0.31	0.04	0.4	0	0	0.93	0.38	0.4	0.98	1
22	2	A	II	-+	0.89	0.27	0.07	0.53	0.07	0.1	0.91	0	0	0.93	0.38	0.4	0.98	1
23	2	A	II	+-	0.89	0.27	0.07	0.53	0.06	0.01	0.4	0	0	0.11	0.38	0.09	0.64	1
24	2	A	II	++	0	0.27	0.07	0.81	0.06	0.01	0.4	0	0	0.11	0.38	0.09	0.39	1
25	2	B	I	--	0.89	0.27	0.36	0.87	0.06	0.29	0.4	0	0.16	0.11	0.02	0.99	0.09	1
26	2	B	I	-+	0.89	0.27	0.31	0.53	0.06	0.1	0.4	0	0	0.93	0.02	0.09	0.98	1
27	2	B	I	+-	0.89	0.27	0.31	0.53	0.06	0.01	0.4	0	0	0.11	0.02	0.01	0.39	0
28	2	B	I	++	0.89	0.27	0.07	0.53	0.06	0.01	0.4	0	0	0.93	0.02	0.01	0.39	1
29	2	B	II	--	0.89	0.27	0.31	0.87	0.06	0.1	0.4	0	0	0.93	0.02	0.09	0.98	1
30	2	B	II	-+	0.89	0.27	0.31	0.53	0.06	0.01	0.4	0	0	0.93	0.38	0.01	0.98	1
31	2	B	II	+-	0.89	0.27	0.31	0.53	0.06	0.01	0.4	0	0	0.93	0.02	0.01	0.65	1
32	2	B	II	++	0.89	0.27	0.31	0.53	0.06	0.01	0.4	0	0	0.93	0.38	0.01	0.91	1

Table 8. Length of longest run (where a run is a consecutive sequence of years on the same side of the "0 axis") in the last 10 years for 14 abundance indices residuals in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	MOR POR TRAP	JPN LL NEAtl2	US RR 66 114	US RR 115 144	US RR 177	US GOM PLL2	JPN LL West2	CAN GSL	CAN SWNS	FR AER SUV2	MED LAR SUV	CAN ACO SUV	GOM LAR SUV	GBYP AER SUV BAR
1	1	A	I	--	3	4	10	3	6	4	2	10	6	3	5	2	2	2
2	1	A	I	-+	3	4	10	3	6	4	4	10	6	4	5	2	2	2
3	1	A	I	+-	3	4	10	3	6	9	2	10	6	4	5	2	2	2
4	1	A	I	++	3	4	10	3	6	6	2	10	6	4	5	2	2	2
5	1	A	II	--	3	4	10	3	6	4	2	10	6	4	5	4	2	2
6	1	A	II	-+	3	4	10	3	6	4	2	10	6	4	5	4	2	2
7	1	A	II	+-	3	4	10	3	6	9	2	10	10	4	5	2	2	2
8	1	A	II	++	3	4	10	3	6	6	2	10	6	4	5	4	2	2
9	1	B	I	--	3	4	10	3	6	4	2	10	6	4	5	2	2	2
10	1	B	I	-+	3	4	10	3	6	4	4	10	6	4	5	4	2	2
11	1	B	I	+-	3	4	10	3	4	9	2	10	10	4	5	2	2	2
12	1	B	I	++	3	4	10	3	6	9	2	10	6	4	5	4	2	2
13	1	B	II	--	3	4	10	3	6	4	2	10	6	4	5	2	2	2
14	1	B	II	-+	3	4	10	3	6	4	2	10	6	4	5	4	2	2
15	1	B	II	+-	3	4	10	3	4	9	2	10	10	4	5	4	2	2
16	1	B	II	++	3	4	10	3	6	9	2	10	6	4	5	4	2	2
17	2	A	I	--	2	5	6	2	3	6	2	10	10	4	5	3	2	2
18	2	A	I	-+	2	5	10	2	4	6	2	10	10	4	5	3	2	2
19	2	A	I	+-	2	5	10	2	3	9	2	10	10	4	5	5	2	2
20	2	A	I	++	2	5	10	3	3	9	2	10	10	4	5	3	2	2
21	2	A	II	--	2	5	6	2	3	6	2	10	10	4	5	3	2	2
22	2	A	II	-+	2	5	10	2	4	6	3	10	10	4	5	3	2	2
23	2	A	II	+-	2	5	10	2	3	9	2	10	10	4	5	5	2	2
24	2	A	II	++	1	5	10	3	3	9	2	10	10	4	5	4	2	2
25	2	B	I	--	2	5	6	2	3	4	2	10	8	4	5	5	2	2
26	2	B	I	-+	2	5	6	2	3	6	2	10	10	4	5	5	2	2
27	2	B	I	+-	2	5	6	2	3	9	2	10	10	4	5	8	2	1
28	2	B	I	++	2	5	10	2	3	9	2	10	10	4	5	8	2	2
29	2	B	II	--	2	5	6	2	3	6	2	10	10	4	5	5	2	2
30	2	B	II	-+	2	5	6	2	3	9	2	10	10	4	5	8	2	2
31	2	B	II	+-	2	5	6	2	3	9	2	10	10	4	5	8	2	2
32	2	B	II	++	2	5	6	2	3	9	2	10	10	4	5	8	2	2

Appendix 6

Matrices of 4 statistics for the (log) Recruitment deviations (columns) in 32 OMs (rows) using the new mixing methods with low or high log-likelihood weight for the length composition data

Table 1. Standard Deviation (STD) for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			0.4	0.34	0.39	0.46
2	1	A	I	-+			0.52	0.32	0.34	0.37
3	1	A	I	+-			0.5	0.45	0.37	0.3
4	1	A	I	++			0.48	0.32	0.35	0.48
5	1	A	II	--			0.42	0.3	0.43	0.37
6	1	A	II	-+			0.49	0.47	0.37	0.41
7	1	A	II	+-			0.34	0.49	0.36	0.31
8	1	A	II	++			0.44	0.34	0.35	0.54
9	1	B	I	--			0.39	0.34	0.53	0.51
10	1	B	I	-+			0.47	0.57	0.52	0.44
11	1	B	I	+-			0.31	0.33	0.24	0.34
12	1	B	I	++			0.47	0.34	0.41	0.64
13	1	B	II	--			0.43	0.42	0.44	0.53
14	1	B	II	-+			0.45	0.57	0.46	0.52
15	1	B	II	+-			0.24	0.3	0.4	0.34
16	1	B	II	++			0.38	0.36	0.36	0.63
17	2	A	I	--	0.58	0.77				
18	2	A	I	-+	0.55	0.63				
19	2	A	I	+-	0.59	0.78				
20	2	A	I	++	0.55	0.66				
21	2	A	II	--	0.59	0.77				
22	2	A	II	-+	0.57	0.64				
23	2	A	II	+-	0.63	0.73				
24	2	A	II	++	0.6	0.63				
25	2	B	I	--	0.62	0.76				
26	2	B	I	-+	0.62	0.7				
27	2	B	I	+-	0.58	0.76				
28	2	B	I	++	0.55	0.7				
29	2	B	II	--	0.64	0.77				
30	2	B	II	-+	0.66	0.63				
31	2	B	II	+-	0.6	0.76				
32	2	B	II	++	0.6	0.71				

Table 2. Autocorrelation (AC) for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			0.09	0.05	0.02	0.05
2	1	A	I	-+			0.33	0.19	0.31	0.49
3	1	A	I	+-			0.39	0.19	0.23	-0.29
4	1	A	I	++			0.36	0.29	0.39	0.53
5	1	A	II	--			-0.14	-0.05	0.52	0.16
6	1	A	II	-+			0.27	0.06	0.41	0.5
7	1	A	II	+-			-0.07	-0.01	0.23	-0.01
8	1	A	II	++			0.3	0.07	0.32	0.39
9	1	B	I	--			-0.18	0.18	-0.16	0.33
10	1	B	I	-+			0.1	0.1	-0.2	0.42
11	1	B	I	+-			-0.07	0	0.43	0.25
12	1	B	I	++			0.27	0.02	0.25	0.2
13	1	B	II	--			-0.25	0.19	0.29	0.28
14	1	B	II	-+			-0.01	-0.02	0.3	0.17
15	1	B	II	+-			-0.34	-0.09	-0.27	0.22
16	1	B	II	++			0.17	0.03	0.28	0.19
17	2	A	I	--	0.38	0.49				
18	2	A	I	-+	0.39	0.45				
19	2	A	I	+-	0.27	0.52				
20	2	A	I	++	0.31	0.52				
21	2	A	II	--	0.38	0.48				
22	2	A	II	-+	0.37	0.44				
23	2	A	II	+-	0.32	0.53				
24	2	A	II	++	0.31	0.5				
25	2	B	I	--	0.38	0.56				
26	2	B	I	-+	0.38	0.55				
27	2	B	I	+-	0.39	0.55				
28	2	B	I	++	0.37	0.54				
29	2	B	II	--	0.39	0.54				
30	2	B	II	-+	0.29	0.5				
31	2	B	II	+-	0.4	0.54				
32	2	B	II	++	0.37	0.54				

Table 3. P-value for the runs test for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			0.89	0.78	0.11	0.35
2	1	A	I	-+			0.89	0.39	0.79	0.1
3	1	A	I	+-			0.89	0.78	0.49	0.59
4	1	A	I	++			0.89	0.39	0.82	0.1
5	1	A	II	--			0.44	0.78	0.85	0.02
6	1	A	II	-+			0.89	0.35	0.82	0.59
7	1	A	II	+-			0.89	0.78	0.85	0.97
8	1	A	II	++			0.89	0.03	0.7	0.59
9	1	B	I	--			0.44	0.85	0.13	0.01
10	1	B	I	-+			0.89	0.14	0.52	0.1
11	1	B	I	+-			0.89	0.11	0.52	0.68
12	1	B	I	++			0.89	0.11	0.85	0.01
13	1	B	II	--			0.44	0.85	0.82	0.02
14	1	B	II	-+			0.89	0.35	0.05	0.1
15	1	B	II	+-			0.89	0.11	0.02	0.59
16	1	B	II	++			0.89	0.11	0.85	0.1
17	2	A	I	--	0.27	0				
18	2	A	I	-+	0.02	0.02				
19	2	A	I	+-	0.19	0				
20	2	A	I	++	0.05	0				
21	2	A	II	--	0.27	0				
22	2	A	II	-+	0.03	0				
23	2	A	II	+-	0.03	0				
24	2	A	II	++	0.13	0				
25	2	B	I	--	0.03	0				
26	2	B	I	-+	0.05	0				
27	2	B	I	+-	0.39	0				
28	2	B	I	++	0.05	0				
29	2	B	II	--	0.03	0				
30	2	B	II	-+	0.27	0				
31	2	B	II	+-	0.05	0				
32	2	B	II	++	0.03	0				

Table 4. Length of longest run (where a run is a consecutive sequence of years on the same side of the "0 axis") in the last 10 years for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a low log-likelihood weight for the length composition data (LHw=0.05).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			2	3	2	6
2	1	A	I	-+			2	6	3	5
3	1	A	I	+-			2	3	3	3
4	1	A	I	++			2	6	3	5
5	1	A	II	--			3	3	3	5
6	1	A	II	-+			2	3	3	3
7	1	A	II	+-			2	4	3	3
8	1	A	II	++			2	6	3	3
9	1	B	I	--			3	3	3	5
10	1	B	I	-+			2	4	4	4
11	1	B	I	+-			2	8	7	5
12	1	B	I	++			2	8	3	7
13	1	B	II	--			3	4	3	5
14	1	B	II	-+			2	4	3	5
15	1	B	II	+-			2	8	7	3
16	1	B	II	++			2	8	3	5
17	2	A	I	--	6	6				
18	2	A	I	-+	6	3				
19	2	A	I	+-	6	6				
20	2	A	I	++	6	6				
21	2	A	II	--	6	6				
22	2	A	II	-+	6	3				
23	2	A	II	+-	6	6				
24	2	A	II	++	5	5				
25	2	B	I	--	6	6				
26	2	B	I	-+	6	6				
27	2	B	I	+-	6	6				
28	2	B	I	++	6	6				
29	2	B	II	--	6	6				
30	2	B	II	-+	6	3				
31	2	B	II	+-	6	6				
32	2	B	II	++	6	6				

Table 5. Standard Deviation (STD) for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			0.41	0.48	0.39	0.28
2	1	A	I	-+			0.35	0.42	0.37	0.35
3	1	A	I	+-			0.25	0.45	0.23	0.22
4	1	A	I	++			0.3	0.44	0.26	0.36
5	1	A	II	--			0.32	0.52	0.35	0.29
6	1	A	II	-+			0.31	0.5	0.32	0.35
7	1	A	II	+-			0.21	0.45	0.23	0.2
8	1	A	II	++			0.25	0.5	0.28	0.35
9	1	B	I	--			0.33	0.49	0.54	0.29
10	1	B	I	-+			0.33	0.43	0.53	0.3
11	1	B	I	+-			0.22	0.4	0.23	0.28
12	1	B	I	++			0.24	0.4	0.22	0.26
13	1	B	II	--			0.33	0.54	0.43	0.29
14	1	B	II	-+			0.32	0.44	0.39	0.33
15	1	B	II	+-			0.22	0.41	0.25	0.26
16	1	B	II	++			0.22	0.39	0.21	0.27
17	2	A	I	--	0.43	0.7				
18	2	A	I	-+	0.38	0.62				
19	2	A	I	+-	0.35	0.71				
20	2	A	I	++	0.31	0.63				
21	2	A	II	--	0.42	0.7				
22	2	A	II	-+	0.37	0.62				
23	2	A	II	+-	0.37	0.72				
24	2	A	II	++	0.35	0.64				
25	2	B	I	--	0.56	0.65				
26	2	B	I	-+	0.4	0.6				
27	2	B	I	+-	0.37	0.71				
28	2	B	I	++	0.33	0.63				
29	2	B	II	--	0.42	0.67				
30	2	B	II	-+	0.4	0.58				
31	2	B	II	+-	0.38	0.7				
32	2	B	II	++	0.35	0.65				

Table 6. Autocorrelation (AC) for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			0.14	0.14	0.27	0.38
2	1	A	I	-+			0.07	0.21	0.19	0.43
3	1	A	I	+-			0.03	0.17	0.06	0.34
4	1	A	I	++			0.18	0.18	0.08	0.56
5	1	A	II	--			-0.19	0.2	0.22	0.24
6	1	A	II	-+			-0.12	0.15	0.23	0.42
7	1	A	II	+-			-0.23	0.21	0.27	0.24
8	1	A	II	++			0.01	0.13	0.08	0.48
9	1	B	I	--			-0.23	0.17	0.06	-0.01
10	1	B	I	-+			-0.23	0.16	0.07	0.19
11	1	B	I	+-			-0.36	0.13	0.31	0.32
12	1	B	I	++			-0.19	0.16	0.03	0.29
13	1	B	II	--			-0.46	0.19	0.17	0.01
14	1	B	II	-+			-0.39	0.17	0.25	0.24
15	1	B	II	+-			-0.54	0.16	0.48	0.24
16	1	B	II	++			-0.38	0.15	0.16	0.29
17	2	A	I	--	0.32	0.57				
18	2	A	I	-+	0.31	0.56				
19	2	A	I	+-	0.15	0.51				
20	2	A	I	++	0.14	0.47				
21	2	A	II	--	0.33	0.57				
22	2	A	II	-+	0.3	0.56				
23	2	A	II	+-	0.27	0.55				
24	2	A	II	++	0.34	0.48				
25	2	B	I	--	0.44	0.6				
26	2	B	I	-+	0.41	0.57				
27	2	B	I	+-	0.25	0.49				
28	2	B	I	++	0.31	0.45				
29	2	B	II	--	0.42	0.64				
30	2	B	II	-+	0.44	0.52				
31	2	B	II	+-	0.37	0.57				
32	2	B	II	++	0.32	0.52				

Table 7. P-value for the runs test for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			0.89	0.03	0.12	0.19
2	1	A	I	-+			0.89	0.03	0.33	0.1
3	1	A	I	+-			0.89	0.03	0.52	0.02
4	1	A	I	++			0.89	0.03	0.13	0.1
5	1	A	II	--			0.89	0.03	0.94	0.97
6	1	A	II	-+			0.89	0.03	0.85	0.1
7	1	A	II	+-			0.89	0.39	0.61	0.27
8	1	A	II	++			0.89	0.03	0.52	0.1
9	1	B	I	--			0.89	0.03	0.08	0.59
10	1	B	I	-+			0.89	0.03	0.08	0.1
11	1	B	I	+-			0.8	0.39	0.13	0.06
12	1	B	I	++			0.89	0.39	0.52	0.1
13	1	B	II	--			0.8	0.03	0.33	0.3
14	1	B	II	-+			0.8	0.39	0.33	0.03
15	1	B	II	+-			0.89	0.39	0.13	0.91
16	1	B	II	++			0.8	0.39	0.61	0.03
17	2	A	I	--	0.02	0				
18	2	A	I	-+	0.02	0				
19	2	A	I	+-	0.08	0				
20	2	A	I	++	0.72	0				
21	2	A	II	--	0.02	0				
22	2	A	II	-+	0.02	0				
23	2	A	II	+-	0.02	0				
24	2	A	II	++	0.82	0				
25	2	B	I	--	0.12	0				
26	2	B	I	-+	0	0				
27	2	B	I	+-	0.19	0				
28	2	B	I	++	0.3	0				
29	2	B	II	--	0.02	0				
30	2	B	II	-+	0.02	0				
31	2	B	II	+-	0.12	0				
32	2	B	II	++	0.02	0				

Table 8. Length of longest run (where a run is a consecutive sequence of years on the same side of the "0 axis") in the last 10 years for 6 different Recruitment Regime scenarios in 32 OMs, using the new mixing method (corresponding to achieving a certain proportion of western stock total biomass being in the East area on average during 1965-2016) with a high log-likelihood weight for the length composition data (LHw=1).

OM	R	P	M	S	West all	East all	West 65-74	East 65-87	West 75-16	East 88-16
1	1	A	I	--			2	6	2	5
2	1	A	I	-+			2	5	3	5
3	1	A	I	+-			2	6	3	2
4	1	A	I	++			2	6	3	5
5	1	A	II	--			2	7	3	3
6	1	A	II	-+			2	6	3	5
7	1	A	II	+-			2	6	3	2
8	1	A	II	++			2	6	3	5
9	1	B	I	--			2	6	3	4
10	1	B	I	-+			2	6	3	5
11	1	B	I	+-			2	6	7	4
12	1	B	I	++			2	6	3	6
13	1	B	II	--			2	7	3	5
14	1	B	II	-+			2	6	3	5
15	1	B	II	+-			2	6	7	2
16	1	B	II	++			2	6	3	6
17	2	A	I	--	6	6				
18	2	A	I	-+	6	6				
19	2	A	I	+-	6	6				
20	2	A	I	++	6	5				
21	2	A	II	--	6	6				
22	2	A	II	-+	6	6				
23	2	A	II	+-	6	6				
24	2	A	II	++	8	5				
25	2	B	I	--	6	6				
26	2	B	I	-+	6	6				
27	2	B	I	+-	6	6				
28	2	B	I	++	6	5				
29	2	B	II	--	6	6				
30	2	B	II	-+	6	5				
31	2	B	II	+-	7	6				
32	2	B	II	++	6	5				