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PUTTING CANDIDATE MANAGEMENT PROCEDURES INTO PRACTICE

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SUMMARY

Currently ICCAT's SCRS Bluefin Tuna Species Group is working on finalizing their work on comparing the performance of different candidate management procedures. A topic overlooked to date is how the CMPs will work in practices and the TACs they will produce in the short-term using the actual index values as opposed to using the predicted values of the indices in the future. This paper reconstructs three of the currently active CMPs using the mathematical formulas submitted to the SCRS. We believe this will have four benefits: allow managers and harvesters to easily understand how changes to the indices will impact TACs in the various CMPs; help inform managers and stakeholders on the differences between the CMPs; confirm that the "mathematical re-creation" of the CMP is possible and that the mathematical descriptions of the CMPs are fulsome and accurate; and, confirm that the data available outside of the MSE-CMP testing environment is sufficient to run the CMP.

RÉSUMÉ

Actuellement, le Groupe d'espèces sur le thon rouge du SCRS de l'ICCAT s'efforce de finaliser ses travaux sur la comparaison des performances des différentes procédures de gestion potentielles. Un sujet négligé jusqu'à présent est la façon dont les CMP fonctionneront dans la pratique et les TAC qu'elles produiront à court terme en utilisant les valeurs réelles des indices par opposition aux valeurs prédites des indices dans le futur. Ce document reconstruit trois des CMP actuellement actives en utilisant les formules mathématiques soumises au SCRS. Nous pensons que cela aura quatre avantages : permettre aux gestionnaires et aux pêcheurs de comprendre facilement comment les changements d'indices auront un impact sur les TAC dans les diverses CMP ; aider à informer les gestionnaires et les parties prenantes sur les différences entre les CMP ; confirmer que la « recréation mathématique » de la CMP est possible et que les descriptions mathématiques des CMP sont complètes et précises et confirmer que les données disponibles en dehors de l'environnement de test MSE-CMP sont suffisantes pour exécuter la CMP.

RESUMEN

Actualmente, el Grupo de especies de atún rojo del SCRS está trabajando en la finalización de su trabajo sobre la comparación del desempeño de los diferentes procedimientos de ordenación candidatos. Un tema que se ha pasado por alto hasta la fecha es cómo funcionarán los CMP en la práctica y los TAC que producirán a corto plazo utilizando los valores reales de los índices en lugar de utilizar los valores previstos de dichos índices en el futuro. Este documento reconstruye tres de los CMP actualmente activos utilizando las fórmulas matemáticas presentadas al SCRS. Se considera que esto tendrá cuatro beneficios: permitir a los gestores y a los pescadores entender fácilmente cómo los cambios en los índices afectarán a los TAC en los distintos CMP; ayudar a informar a los gestores y a las partes interesadas sobre las diferencias entre los CMP; confirmar que la "recreación matemática" del CMP es posible y que las descripciones matemáticas de los CMP son completas y precisas; y, confirmar que los datos disponibles fuera del entorno de pruebas del MSE-CMP son suficientes para ejecutar el CMP

KEYWORDS

Risk, Management Strategy Evaluation, Performance Indicators

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1. Introduction

Currently ICCAT's SCRS Bluefin Tuna species group is working on finalizing their work on comparing the performance of different candidate management procedures (CMPs). These CMPs have been developed by CPC scientists who have free reign to develop and submit for review any CMP they believe may be successful in achieving the management objectives outlined by the commission for the eastern and western Bluefin tuna (BFT) stocks. The BFT species group has also been leading the communication of how the MSE process functions and how each CMP uses annual indices and catch data to set total allowable catches (TAC) in future years. Up until now, the focus has been on how the CMPs perform across a reference set of 48 OMs and corresponding performance indicators linked to interim objectives established for the MSE process. A topic overlooked to date is how the CMPs will work in practices and the TACs they will produce in the short-term using the actual index values as opposed to using the predicted values of the indices in the future.

This paper reconstructs three of the currently active CMPs using the mathematical formulas submitted to the SCRS. We believe this will have 4 benefits:

1. allow managers and harvesters to easily understand how changes to the indices will impact resulting TACs for the various CMPs;

2. help inform managers and stakeholders on the differences between the CMPs;

3. confirm that the "mathematical re-creation" of the CMP is possible and that the mathematical descriptions of the CMPs are fulsome and accurate (making sure that the CMPs are indeed reproducible is an important step); and,

4. confirm that the data available outside of the MSE-CMP testing environment is sufficient to run the CMP.

2. Format of tool and how to use it

2.1 Purpose and utility

Each CMP was recreated in excel (or in some cases in R if a sub-model was needed – see CMP FZ example) using the mathematical formulas submitted to the SCRS in order to provide a platform to automate calculations of TAC in the future as new or updated index values become available. This allows updates to individual indices to be entered into the tool for TAC calculations in future years. This will also allow users to determine the sensitivity of the TAC to alternative tuning values and changes in the TAC change constraints.

For example, if a CMP uses indices from the Atlantic northwest, managers or stakeholders can make predictions about what they think will happen to those indicators in the near future (perhaps abundances are high, and they believe CPUE will remain at the current level for the next 1-2 years). They simply need to enter in the next 1-2 years of indices values and the tool will produce a new TAC using the CMP's mathematical formula. This exercise can also be used to understand how the CMPs react to increases or decreases in indices or limits on percent changes in new TACs. In this way managers/harvesters can easily see the impact of their expectations of what is happening in their areas/waters.

2.2 Mathematical formulas

As a trial, three CMPs had their mathematical formulas represented in Excel to allow for future TACs to be calculated. The Butterworth and Rademeyer, F0.1, and Peterson and Walters CMPs were all re-created using the mathematical formula February MSE Technical Sub-group informal meeting report (Walter and Peterson, 2022), some CMP specific papers explaining the mathematics of the CMP, and some personal communications explaining any updates to the CMPs that had occurred since the February 2022 meeting.

3. Results & Discussion

3.1 Butterworth and Rademeyer (BR) (Butterworth and Rademeyer 2022)

As this CMP is only using the indices time series to adjust the 2020 TAC upwards or downwards it was relatively straight forward to develop in Excel using the published mathematical formulas. In the west the BR CMP uses: SWNS (Canada's southwest nova scotia index); JP_LL_west2 (Japan's western longline index later years); MEXUS (Mexico/USA longline index in the Gulf of Mexico); US_RR_66-144 (USA's rod and reel 66cm to 144cm index); and GOM_Lar (USA's Gulf of Mexico Larval survey index). The mathematical formula has been clarified that only the previous 5 are used in the CMP (Butterworth and Rademeyer 2022).

In the east the BR CMP uses: FR_aer_sur2 (French aerial survey index later years); MED_Lar (Mediterranean larval survey index); MOR_POR_traps (Morocco and Portuguese combined trap index); JP_LL_NEatl2 (Japan's eastern longline index later years); and, GBYP_lar (Grande Bluefin tuna Year Project larval survey index).

The CMP does use historical values of selected indices to create historical average values. As indices are updated many are re-standardized which can change the values in the historical time period. This does have an impact on future estimations of TAC as the value of future years of the index also come with changes to the historical period of the index values. This may be addressed through (yet to be determined) rules on how indices are updated in the future once an MP is in place. Due to the indices weighting conducted in the calculations it is it is important to include how to handle these lost years in the calculation of $J_y^{E/W}$. In cases of missing index values in year y, $J_y^{E/W}$ is computed by setting ω_i to zero.

The tool can quickly be used to show the impact of changing indices values when using the BR CMP. **Tables 1 and 2** show the stepwise calculations that exist in the excel tool and the associated values of intermediary variables needed to conduct the CMPs calculations.

Some aspects of the CMP are not yet finalized (percentage restrictions of TAC changes up or down, any parabolic changes in low abundances scenarios, number of years in a management cycle, etc.) but these will be easy to incorporate into the CMP when they become finalized.

Overall, the CMP was very easy to replicate and would be straightforward for the commission to incorporate into a management recommendation and implement. It is likely to be reassuring to mangers and stakeholders that the CMP can easily predict future outcomes, especially with a tool such as the one presented here.

As with all the CMPs they are continually being updated and improved, the tool describe here can also easily be updated to reflect any changes to the CMP.

Some items needing clarification:

Tuning in this CMP is incorporated using α and β values. These values would need to be provided by the developers for each of the tuning target levels in order to be able to complete the calculations. The authors have indicated that these would be available in later versions of their papers (Pers Comm. Doug Butterworth 2022).

3.2 Constant Harvest Rate Peterson/Walter (PW) (February MSE technical team meeting report)

This CMP uses indices and catch data to run relatively straight forward calculations to modify the previous TAC. The CMP sets a baseline U (calculated from catch and indices values) and compares this to a current U (using recent catches and indices values).

In the west the PW CMP uses: GOM_LAR_SUV; and, MEXUS. In the east the PW CMP uses: MED_Lar; and, JP_LL_NEatl2.

This CMP also uses historical values of selected indices to create historical average values, like what is done in BR. It therefore will have to address the same issue as BR in how indices are updated and if re-standarding will occur, this could change the values in the historical time period. This does have an impact on future estimations of TAC, especially as catch data in the historical time period is unlikely to change and the indices are measured relative to catch data. This may be addressed through (yet to be determined) rules on how indices are updated in the future once an MP is in place.

Again, like BR the tool can quickly be used to show the impact of changing indices values on the TAC. **Tables 7-10** show the stepwise calculations that exist in the excel tool and the associated values of intermediary variables needed to complete the CMPs calculations.

Like the other CMPs some aspects are not yet finalized (percentage restrictions of TAC changes up or down, any parabolic changes in low abundances scenarios, number of years in a management cycle, etc.) but these will be easy to incorporate into the CMP when they become finalized. The mathematical formula present to date includes a structure that appears to be setting the TAC for 3-year management periods.

The CMP authors were able to provide some updates to their CMPs from the mathematical formulations within Feb MSE technical team meeting report (2022; Per. Comm. Cassidy Peterson 2022). What is presented here includes these updates. The mathematical equations have been updated to include a target period of model years 53, 54, and 55 (these equate to 2017, 2018, and 2019). The FUN function used to calculate the Δratio produces a mean of the two indices values. The variable x used in the calculations of U_{target}, is the tuning factor.

Some of the updates to the PW formulas could not be updated in time for the submission of this paper, however the tool is still useful for illustrative purposes and the remaining changes can easily be made. As with all the CMPs they are continually being updated and improved, the tool describe here can also easily be updated to reflect any changes to the CMP.

Clarity is still needed on how the CMP handles missing data points as the CMP uses historical and running means which would have been impacted by missing data points during the CMP testing (MED: 2018 and 2021; GOM_Lar: 2020).

3.3 Is C1 going to be useful as a performance metric?

In reviewing the CMPs and the TACs the calculate for C1 we noticed issues with the range in C1 produced using our tool versus what the MSE produces. One issue with the C1 performance metric (PM) is that many of the indices do not currently have 2021 index values, therefore the OMs must predict those 2021 values. **Figure 1** shows the large range in these estimated values. With most of the indices providing such large ranges of 2021 estimated value we argue the C1 PM is not very informative for managers and should not be used in its current form.

Table 1. The BR CMP uses several calculations to create the western area TAC for future years. Within this table are the indices values for the western indices used as well as their calculations (as of 10 April 2022). Indices averages were calculated from year shaded in light green. Jw,2017 (yellow shaded) is used to compare to the 2020 TAC (2,350) as the first step in each TAC calculation. The GOM_lar survey was not conducted in 2020, therefore there is no value for that year. Light blue shaded cells are indices values that have not been updated yet but should be by September 2022; the dark blue shaded cells are future years of indices not yet collected. The blue cells values can be changed to any value and this will automatically update the TAC calculations. In this example all blue cells are copies of values from the most recent year to show calculation of the TAC for 2023 and 2025.

	GOM_lar	US_RR_66-144	MEXUS	JP_LL_west2	SWNS	Sum (ωi * Iy)	Jw,y	Jw,av,y
2006	0.703	0.707	0.798		1.436			
2007	0.580	0.694	0.495		1.286			
2008	0.426	0.680	0.818		1.362			
2009	0.764	0.557	0.697		2.300			
2010	0.402	0.871	0.515	0.179	2.136			
2011	1.353	0.757	0.929	0.643	1.786			
2012	0.362	0.835	1.504	0.820	1.740			
2013	1.227	1.308	0.737	0.652	1.309			
2014	0.344	0.805	1.303	0.692	1.484			
2015	0.506	0.376	1.918	0.446	1.484			
2016	3.037	0.576	1.605	1.042	1.909	15.48052549	1.156691	
2017	1.243	0.930	1.171	1.114	1.939	15.71252968	1.174026	
2018	2.528	0.677	1.484	2.145	1.658	15.30802126	1.143802	
2019	1.916	1.231	1.666	1.884	1.944	18.57262197	1.38773	1.235186
2020		1.695	1.262	1.382	2.281	20.1361764	1.557693	1.363075
2021	2.163	2.128	1.262	1.382	2.281	22.99199494	1.717941	1.554455
2022	2.163	2.128	1.262	1.382	2.281	22.99199494	1.717941	1.664525
2023	2.163	2.128	1.262	1.382	2.281	22.99199494	1.717941	1.717941

TACw 2023 =	(TACw,2020 / Jw,2017) * Beta * Jw,av,y-2
TACw 2023 =	(2,350/jw,2017) * Beta * Jw,av,2021
TACw 2023 =	XXX
TACw 2025 =	(TACw,2020 / Jw,2017) * Beta * Jw,av,y-2
TACw 2025 =	(2,350/jw,2017) * Beta * Jw,av,2023
TACw 2025 =	YYY

Table 2. The BR CMP uses several calculations to create the eastern area TAC for future years. Within this table are the indices values for the eastern indices used as well as their calculations (as of 10 April 2022). Indices averages were calculated from year shaded in light green. Je,2017 (yellow shaded) is used to compare to the 2020 TAC (36,000) as the first step in each TAC calculation. The MED_lar survey was not conducted in 2018, therefore there is no value for that year. Light blue shaded cells are indices values that have not been updated yet but should be by September 2022; the dark blue shaded cells are future years of indices not yet collected. The blue cells values can be changed to any value, and this will automatically update the TAC calculations. In this example all blue cells are copies of values from the most recent year to show calculation of the TAC for 2023 and 2025.

	FR_aer_suv2	MED_lar	MOR_POR_trap	JP_LL_NEatl2	GBYP_lar	Sum (ωi * Iy)	Je,y	Je,av,y
2008		2.001						
2009	0.018							
2010	0.014			2.343	1659			
2011	0.026	9.191		4.050	1392			
2012	0.018	24.984	95.370	8.624				
2013		39.828	126.727	7.253	2393			
2014	0.063	18.378	62.884	8.190				
2015	0.027	34.441	98.234	6.410	4766			
2016	0.107	30.764	94.287	5.724		4.932504456	1.190636	
2017	0.069	67.460	110.341	7.319	8001	7.257004748	1.409733	
2018	0.031		71.900	8.788		1.933549932	0.68609	
2019	0.063	44.888	99.881	8.374	13344	6.939567205	1.348068	1.147964
2020	0.136	44.888	104.125	8.374	11548	8.262199414	1.605	1.213053
2021	0.097	44.888	104.125	8.374	11548	7.44426456	1.44611	1.466393
2022	0.097	44.888	104.125	8.374	11548	7.44426456	1.44611	1.499073
2023	0.097	44.888	104.125	8.374	11548	7.44426456	1.44611	1.44611

TACe 2023 =	(TACe,2020 / Je,2017) * alpha * Je,av,y-2
TACe 2023 =	(2,350/je,2017) * 1.0 * Je,av,2021
TACe 2023 =	XXX
TACe 2025 =	(TACe,2020 / Je,2017) * alpha * Je,av,y-2
TACe 2025 =	(2,350/je,2017) * 1.0 * Je,av,2023
TACe 2025 =	YYY

Table 3. The $F_{0.1}$ CMP uses several calculations to create the western area TAC for future years, but also requires running a YPR (yield per recruit) in Fishmethods package in R. This table has the indices values for the western indices (as of 10 April 2022) used as well as their calculations to estimate partial F-at-age (PR_w) needed for the YPR calculation which will provide F0.1. Light blue shaded cells are indices values that have not been updated yet but should be by September 2022; the dark blue shaded cells are future years of indices not yet collected. The blue cells values can be changed to any value and this will automatically update the PR_w calculations. In this example all blue cells are showing results based on copying the most recently available indices value into future years as they are not currently available.

	US_RR_66-144	I'sm	Avg I'sm	I'sm/Itot	SWNS	I'md	Avg I'md	I'md/Itot	MEXUS	I'lg	Avg I'lg	I'lg/Itot	Itot	Ibm/q
2014	0.805	0.245	0.346		1.484	0.505	0.521		1.303	0.545	0.485		1.352	6,096,693
2015	0.376	0.000	0.259		1.484	0.505	0.469		1.918	0.854	0.554		1.282	8,979,625
2016	0.576	0.114	0.120		1.909	0.763	0.591		1.605	0.697	0.699		1.409	7,514,528
2017	0.930	0.316	0.143		1.939	0.781	0.683		1.171	0.480	0.677		1.503	5,482,297
2018	0.677	0.172	0.201	0.132	1.658	0.610	0.718	0.471	1.484	0.636	0.604	0.397	1.523	6,947,394
2019	1.231	0.488	0.325	0.195	1.944	0.784	0.725	0.436	1.666	0.727	0.614	0.369	1.665	7,798,095
2020	1.695	0.753	0.471	0.248	2.281	0.988	0.794	0.419	1.262	0.525	0.630	0.332	1.895	5,907,648
2021	2.128	1.000	0.747	0.331	2.281	0.988	0.920	0.407	1.262	0.525	0.593	0.262	2.260	5,907,012
2022	2.128	1.000	0.918	0.377	2.281	0.988	0.988	0.407	1.262	0.525	0.525	0.216	2.431	5,907,012
2023	2.128	1.000	1.000	0.398	2.281	0.988	0.988	0.393	1.262	0.525	0.525	0.209	2.514	5,907,012

Table 4. The PR_w (partial F-at-age) vectors needed to run the Fishmethods YPR which provides the $F_{0.1}$ value for the corresponding year. For the western calculations: ages 1-4 use the I'_{sm}/I_{tot} value from table 3; ages 5-6 use the I'_{md}/I_{tot} value from table 3; ages 7-16+ use the I'_{lg}/I_{tot} value from **Table 3**. In this example all blue cells are showing results based on copying the most recently available indices value into future years as they are not currently available.

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	F0.1
2019	0.195	0.195	0.195	0.195	0.436	0.436	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.20843
2020	0.248	0.248	0.248	0.248	0.419	0.419	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.332	0.21543
2021	0.331	0.331	0.331	0.331	0.407	0.407	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.262	0.21828
2022	0.377	0.377	0.377	0.377	0.407	0.407	0.216	0.216	0.216	0.216	0.216	0.216	0.216	0.216	0.216	0.216	
2023	0.398	0.398	0.398	0.398	0.393	0.393	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.20989

Table 5. The $F_{0.1}$ CMP uses several calculations to create the eastern area TAC for future years, but also requires running a YPR (yield per recruit) in Fishmethods package in R. This table has the indices values for the eastern indices (as of 10 April 2022) used as well as their calculations to estimate partial F-at-age (PR_e) needed for the YPR calculation which will provide F0.1. The MED_lar survey was not conducted in 2018, therefore there is no value for that year; however, MED_lar is not needed to complete TAC calculations for 2023 and future years. Light blue shaded cells are indices values that have not been updated yet but should be available by September 2022; the dark blue shaded cells are future years of indices not yet collected. The blue cells values can be changed to any value, and this will automatically update the PR_e calculations. In this example all blue cells are showing results based on copying the most recently available indices value into future years as they are not currently available.

	FR_aer_suv2	I'_{sm}	Avg I'_{sm}	I'_{sm}/I_{tot}	JPN_LL_NEatl2	I'_{md}	Avg I'_{md}	I'_{md}/I_{tot}	MED_LAR	I'_{lg}	Avg I'_{lg}	I'_{lg}/I_{tot}	I_{tot}	I_{bm}/q
2014	0.063	0.405	0.107		8.190	0.907	0.881		18.378	0.250	0.393			98,018,474
2015	0.027	0.109	0.132		6.410	0.631	0.767		34.441	0.496	0.441			183,685,634
2016	0.107	0.768	0.427		5.724	0.525	0.688		30.764	0.439	0.395			164,074,019
2017	0.069	0.448	0.442		7.319	0.772	0.643		67.460	1.000	0.645			359,787,254
2018	0.031	0.138	0.451	0.268	8.788	1.000	0.765	0.454		-0.030	0.470	0.279	1.686	0
2019	0.063	0.398	0.328	0.185	8.374	0.936	0.903	0.509	44.888	0.655	0.542	0.306	1.772	239,403,966
2020	0.136	1.000	0.512	0.270	8.374	0.936	0.957	0.505	44.888	0.655	0.427	0.225	1.896	239,403,966
2021	0.097	0.686	0.695	0.304	8.374	0.936	0.936	0.409	44.888	0.655	0.655	0.287	2.285	239,403,966
2022	0.097	0.686	0.790	0.332	8.374	0.936	0.936	0.393	44.888	0.655	0.655	0.275	2.381	239,403,966
2023	0.097	0.686	0.686	0.301	8.374	0.936	0.936	0.411	44.888	0.655	0.655	0.288	2.277	239,403,966

Table 6. The PR_e (partial F-at-age) vectors needed to run the Fishmethods YPR which provides the $F_{0.1}$ value for the corresponding year. For the eastern calculations: ages 1-4 use the I'_{sm}/I_{tot} value from table 5; ages 5-6 use the I'_{md}/I_{tot} value from table 5; ages 7-10+ use the I'_{lg}/I_{tot} value from table 5. In this example all blue cells are showing results based on copying the most recently available indices value into future years as they are not currently available.

	Age									
Year	1	2	3	4	5	6	7	8	9	10+	F0.1
2019	0.185	0.185	0.185	0.185	0.509	0.509	0.306	0.306	0.306	0.306	
2020	0.270	0.270	0.270	0.270	0.505	0.505	0.225	0.225	0.225	0.225	
2021	0.304	0.304	0.304	0.304	0.409	0.409	0.287	0.287	0.287	0.287	
2022	0.332	0.332	0.332	0.332	0.393	0.393	0.275	0.275	0.275	0.275	
2023	0.301	0.301	0.301	0.301	0.411	0.411	0.288	0.288	0.288	0.288	

Table 7. This table has the indices values and catches for the west (as of 10 April 2022). The PW CMP uses several calculations to create the western TAC including a 3-year index average ($I_{t-2:t-0}$)), 3-year catch average ($C_{t-:t-0}$), a ratio of average catch to average index value ($U_{current}$), the $U_{target}/U_{current}$ value is also calculated and the selection of Δratio (the smallest of the two $U_{target}/U_{current}$). The GOM_lar survey was not conducted in 2020, therefore there is no value for that year (orange cell), this impacts future average calculations that would have used that year. Yellow highlighted rows are the reference years used to calculate U_{target}. Light blue shaded cells are indices values that have not been updated yet, but should be available by September 2022; the dark blue shaded cells are future years of indices not yet collected. The blue cells values can be changed to any value and this will automatically update the TAC calculations. In this example all blue cells are showing results based on copying the most recently available indices value into future years as they are not currently available.

			West Catch	West Catch	GOM_Lar	GOM_Lar	GOM_Lar	GOM_Lar	MEXUS	MEXUS	MEXUS	MEXUS	
Model year	Real year	West TAC	C	$C_{t-3:t-1}$	index	$I_{t-3:t-1}$	$U_{current}$	$U_{target}/U_{current}$	index	$I_{t-3:t-1}$	$U_{current}$	$U_{target}/U_{current}$	Δ_{ratio} Min
49	2013				1.23				0.74				
50	2014	1,750	1,627		0.34				1.30				
51	2015	2,000	1,842		0.51				1.92				
52	2016	2,000	1,901		3.04				1.61				
53	2017	2,000	1,850	1,790	1.24	1.30	1,381.82	1.00	1.17	1.61	1,112.63	1.00	1.00
54	2018	2,350	2,027	1,864	2.53	1.60	1,168.84	1.18	1.48	1.57	1,191.23	0.93	0.93
55	2019	2,350	2,306	1,926	1.92	2.27	848.77	1.63	1.67	1.42	1,356.03	0.82	0.82
56	2020	2,350	2,179	2,061		1.90	1,087.22	1.27	1.26	1.44	1,430.74	0.78	0.78
57	2021	2,350	2,179	2,171	2.16	2.22	976.80	1.41	1.48	1.47	1,475.83	0.75	0.75
58	2022	2,726	2,726	2,221	2.16	2.04	1,089.12	1.27	1.48	1.47	1,510.28	0.74	0.74
59	2023	1,866	1,866	2,361	2.16	2.16	1,091.76	1.27	1.48	1.41	1,674.44	0.66	0.66
60	2024	1,866	1,866	2,257	2.16	2.16	1,043.54	1.32	1.48	1.48	1,520.65	0.73	0.73

Table 8. The west U_{target} values used in the PW CMP. The variable x is currently set at 1.0, but could be changed.

GOM_Lar U_{target}	
$C_{t52:t50}/I_{t52:t50}$	1,381.82
x	1.00
U_{target}	1,381.82

MEXUS U_{target}	
$C_{t52:t50}/I_{t52:t50}$	1,112.63
x	1.00
U_{target}	1,112.63

Table 9. This table has the indices values and catches for the east (as of 10 April 2022). The PW CMP uses several calculations to create the eastern TAC including a 3-year index average ($I_{t-2:t-0}$)), 3-year catch average ($C_{t-:t-0}$), a ratio of average catch to average index value ($U_{current}$), the $U_{target}/U_{current}$ value is also calculated and the selection of Δratio (the smallest of the two $U_{target}/U_{current}$ calculated for each index). The MED_lar survey was not conducted in 2018, therefore there is no value for that year (orange cells). Yellow highlighted rows are the reference years used to calculate U_{target}. Light blue shaded cells are indices values that have not been updated yet but should be available by September 2022; the dark blue shaded cells are future years of indices not yet collected. The blue cells values can be changed to any value and this will automatically update the TAC calculations. In this example all blue cells are showing results based on copying the most recently available indices value into future years as they are not currently available.

Model year	Real year	East TAC	East Catch C	East Catch $C_{t-3:t-1}$	MED_Lar index	MED_Lar $I_{t-3:t-1}$	MED_Lar $U_{current}$	MED_Lar $U_{target}/U_{current}$	JPN_LL	JPN_LL $I_{t-3:t-1}$	JPN_LL $U_{current}$	JPN_LL $U_{target}/U_{current}$	Δ_{ratio} Min
49	2013				39.83				7.25				
50	2014	13,400	13,261		18.38				8.19				
51	2015	15,821	16,201		34.44				6.41				
52	2016	18,911	19,132		30.76				5.72				
53	2017	22,705	23,616	16,198	67.46	27.86	581.38	1.00	7.32	6.77	2,390.91	1.00	1.00
54	2018	28,200	27,767	19,650		44.22	444.34	1.31	8.79	6.48	3,030.36	0.79	0.79
55	2019	32,240	31,211	23,505	44.89	49.11	478.60	1.21	8.37	7.28	3,230.08	0.74	0.74
56	2020	36,000	34,965	27,531	44.89	56.17	490.11	1.19	8.37	8.16	3,373.78	0.71	0.71
57	2021	36,000	36,000	31,314	44.89	44.89	697.61	0.83	8.37	8.51	3,678.72	0.65	0.65
58	2022	36,000	36,000	34,059	44.89	44.89	758.74	0.77	8.37	8.37	4,067.08	0.59	0.59
59	2023	23,397	23,397	35,655	44.89	44.89	794.31	0.73	8.37	8.37	4,257.70	0.56	0.56
60	2024	23,397	23,397	31,799	44.89	44.89	708.41	0.82	8.37	8.37	3,797.26	0.63	0.63

Table 10. The east U_{target} values used in the PW CMP. The variable x is currently set at 1.0, but could be changed.

MED_Lar		JPN_LL_NEatl2	
$C_{t52:t50}/I_{t-2:t-0}$	581.38	$C_{t52:t50}/I_{t52:t50}$	2,390.91
x	1.00	x	1.00
U_{target}	581.38	U_{target}	2,390.91

4. Conclusions

The tool should prove to be highly useful in testing the developed CMPs to confirm that the mathematical formulas being used in the MSE CMP testing phase can be clearly reproduced for implementation.

The tool's utility in fully explaining the CMPs to managers and stakeholders is likely to be high. It allows users to see how the CMPs react to varying indices values and therefore also allows managers and harvesters to see how their expectations of future indices values will play out in TAC results across the various CMPs.

Ideally the Bluefin tuna species group would continue developing this tool through the following steps:

- add the CMPs still being considered to the tool
- continually update the mathematical formulas within the tool to match changes made to the CMPs
- include the tuning parameter values in CMP mathematical formulas so the tool can fully incorporate these values
- clarify how missing years of indices values have been handled in the CMP testing so that can be replicated in the tool
- clarify how indices would be updated in the future and if they would be re-standardized during updates.

References

Butterworth, D.S. and R.A. Rademeyer. 2022. Refinements of the BR CMP as of April 2022. SCRS/2022/082.

Walter and Peterson. 2022. February MSE Technical Sub-group informal meeting report. SCRS/2022/076.

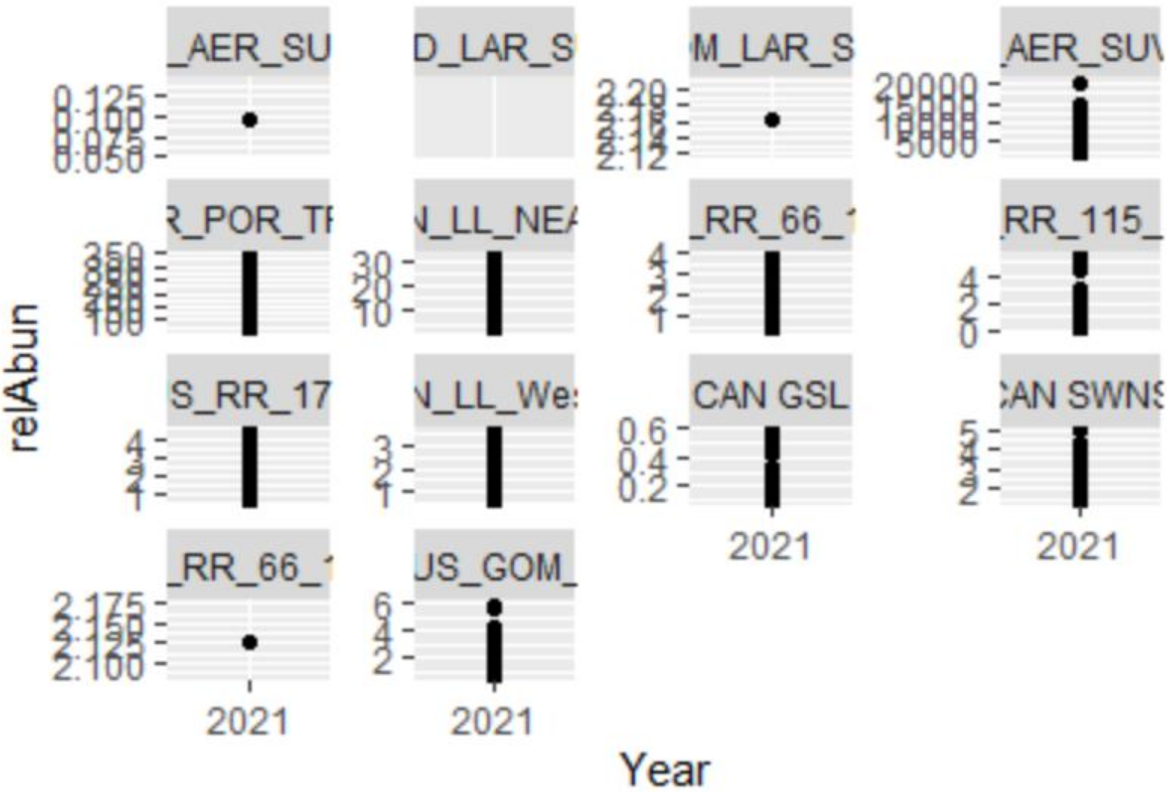

Figure 1. The 2021 values for all the indices across all 48 OMs. Indices with only 1 point are those that have been updated to 2021 and their value is known. The others have their 2021 value estimated by each OM and the range of values can be large.