REPORT OF THE FIRST 2021 INTERSESSIONAL MEETING OF THE BLUEFIN TUNA SPECIES GROUP (INCLUDING W-BFT DATA PREPARATORY)

(Online, 5-13 April 2021)

1. Opening, adoption of agenda and meeting arrangements and assignment of rapporteurs

The First 2021 Intersessional Meeting of the Bluefin Tuna Species Group ("the Group") was held online from 5 to 13 April 2021. Drs John Walter (USA) and Enrique Rodríguez-Marín (EU-Spain), the Rapporteurs for the western Atlantic and eastern Atlantic and Mediterranean bluefin tuna stocks (BFT), respectively, opened the meeting and served as Co-Chairs.

The Executive Secretary, Mr. Camille Manel, and the SCRS Chair, Dr Gary Melvin (Canada), welcomed the participants to the meeting. The Group Co-Chairs proceeded to review the Agenda which was adopted after some changes (**Appendix 1**).

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, 8	A. Kimoto
Item 2	S. Nakatsuka, A. Kimoto
Item 3	N. Taylor, H. Arrizabalaga
Item 4.1	P. Lino, Y. Tsukahara
Item 4.2	T. Rouyer
Item 4.3	E. Rodriguez-Marin, S. Deguara
Item 5	S. Tensek, F. Alemany, J. Walter
Item 6	K. Gillespie, A. Kimoto
Item 6.4	C. Palma, K. Gillespie, A. Kimoto
Item 6.5	J.-J. Maguire, Y. Tsukahara, A. Kimoto
Item 7	M. Ortiz

2. Summary of SCRS response to Panel 2 meeting

A summary of the SCRS's presentations and discussion to the Panel 2 meeting in March 2021 (Anon., 2021) was provided to the Group on the three key subjects identified by the SCRS Chair: i) a brief overview of BFT Management Strategy Evaluation (MSE) work and progress; ii) clarification of protocols for North Atlantic albacore Exceptional Circumstances; and iii) an update on growth rates for farmed bluefin tuna (BFT). A summary on catch rates was presented later in the Group meeting.

Panel 2 was informed that the BFT MSE process had been given a high priority by the SCRS for 2021 and 2022, and based on the workplan, is on track to provide TAC advice for 2023. A key challenge will be the characterization of future recruitment for projections.

The Group was informed that a number of CPCs expressed the need for more interactions and dialogue between managers and scientists. This will be addressed by additional and dedicated meetings in 2021/22 (e.g. September and November 2021). Inter stock mixing and its implications for management were also major concerns. For example, Panel 2 asked if there would continue to be separate East/West area management. Other CPCs wanted an option of no mixing in the MSE. Panel 2 was advised that there is no scenario for excluding mixing given the scientific evidence to the contrary, however, TAC advice will be provided for the East and West areas separately. Regular stock assessments will continue, but at greater spaced time intervals (about 5 years). Asked how the SCRS will rank the Candidate of Management Procedures (CMPs), the response was that a quantitative scoring based on the performance relative to the management objectives would be used.

For North Atlantic albacore, Panel 2 comments focused on the indicators of exceptional circumstances and how exceptional circumstances would be declared. It was noted that a Management Procedure (MP) could be adopted, even if the exceptional circumstances were not finalized. This could have implications for the BFT MSE.

For SCRS's ongoing BFT growth on farms work the Panel 2 Chair confirmed that the initial BFT weight for the fattening period will be the weight at caging, and that this can be the observed or estimated from lengths of wild fish. Concerns were raised about a potential bias in the survey design, stress, mortality and temperature on growth rates. Panel 2 was informed that given the data collected, it will be possible to provide some information on these issues. Maximum growth rates based on regions may lead to complex or confusing results. Notwithstanding this, the Commission specifically requested the SCRS to consider differences between geographical areas in the study. Regional data will be pooled when statistically justifiable.

The Group suggested that the specific provision of exceptional circumstances for the BFT MSE can be discussed after the choice of MP in 2022, as they may well need to be tailored for the particular MP adopted. Similarly, the Group also considered that the specific response when TAC is exceeded can be discussed in 2022 as part of the robustness test.

The possible timing of the suggested dialogue between managers and scientists on MSE was questioned, and the SCRS Chair clarified that it can be held in conjunction with both the Panel 2 meeting in September and the Commission meeting in November 2021.

The discussion on catch rates was deferred to Item 7.

3. MSE

3.1 Review of the data for OM reconditioning (catch and size data)

SCRS/2021/031 provided the updated Operating Model (OM) input dataset because it had been decided to recondition the OMs by incorporating updated datasets at the 2020 Third Intersessional Meeting of the ICCAT Bluefin Tuna Species Group in December 2020 (Anon., 2020a). The data put forward for reconditioning had been developed using the same methodology as had been used in the past. This study further reviewed catch data since 2019 and provides the summary of the input data (catch and size) until the 31 March 2021. All data to be used will be reviewed by the Bluefin Tuna Species Group in the reconditioning of the OMs. The authors reported that most of the quarter/OM area/Fleet catches are similar to the ones provided in 2019. One important exception is the PS inflated catch. After the review, the overall PS catch remained the same, but the distribution between quarters (and thus fleets) varied.

The Chairs confirmed that the reconditioning exercise would start the 16 April. Thus, catch data until 2019, together with other data needed for the reconditioning, will need to be provided to the developer by 15 April.

For the indices of abundance and catch, the Group decided to use data up to 2019 for the reconditioning (except for the Canadian Acoustic index that will only be updated to include 2017, see item 6.5). The Group decided not to update the size data (currently in the MSE these data extend to and include 2016). This decision was taken because adding 3 years of size data (2017 - 2019) was considered unlikely to substantively affect the results of reconditioning the OMs and would be very time consuming to prepare and evaluate.

In addition to other minor clarifications of the document, the Group noted that 25 cm coarse length bins used to model the length data might reduce precision, that French and Spanish purse seine (PS) catches were used for this review, but that the Italian size data were not used for Fleets 5-7 (but were used for Fleet 17). With regard to the length bins, this decision had been made in order to reduce the number of parameters estimated. With respect to the Italian size data, it was noted the reconditioning would be conducted using the same methods as had been applied historically, which at that time had not used the most recent Italian data for Fleets 5-7.

In addition, it was noted that original Figure 6 of SCRS/2021/031 seemed to illustrate very large interannual variability in catch in Fleets 5 (PSMEDold) and 6 (PSMEDoldQt2). The fundamental question was: is it considered reasonable that catches could fall by 50% and rise again by 50% within single year period? In response, it was pointed out that catches had been partitioned between quarters and that the difference between these two fleets is that Fleet 6 is specific to quarter 2 while Fleet 5 is the catches in the other 3 quarters in the year, so that together they equaled the total annual catch. The Group recommended that this issue to be checked, along with whether the Italian purse seine size data was used in the previous conditioning and for the Secretariat to make any changes necessary. During the meeting, the PS fleets (Fleets 5 and 6) for the inflated PS catches and French PS catches between 1998 and 2007 were corrected by CPC scientists and the Secretariat, and the dataset was provided including 2019.

3.2 Update from CMP developers on progress

SCRS/2021/030 reports on an informal BFT CMP developers' webinar held over 8-10 March 2021. The object of this webinar was primarily for developers to discuss further the results they had tabled at the 2020 Third Intersessional Meeting of the ICCAT Bluefin Tuna Species Group (Anon., 2020a) in December 2020 and at a subsequent informal webinar in January. The detailed views put forward at the webinar are discussed in the document.

SCRS/2021/046 provided an update of all the CMPs which had been tuned thus far. The associated presentation showed a top-level performance comparison, and detailed performance comparison of CMPs tuned to western Br30=1, intra- and inter-stock performance trade-offs, biomass level and trend performance, a detailed BR_10 and TC_10 CMPs comparison and a detailed look at the Artificial Intelligence (AI) CMP behaviour. Recent refinements to the BR and TC CMPs had provided substantial performance gains and insights, notably that: there are trade-offs evident both within area/stock and among stocks; it may be necessary to consider biomass trend diagnostics to further discriminate between CMPs that have comparable absolute biomass performance; and the new AI. CMPs which look promising but require further development to address some issues.

With regard to the general conclusions of the paper, two observations were noted: i) there would have to be tuning to both stocks – this would be most easily accomplished by tuning to the eastern stock first; and ii) that with the AI procedure (and other CMPs), the degree of omniscience (when the MPs 'knows' OM elements that then enables them to perform better) is an aspect that would need to be taken into consideration for all CMPs, to ensure that none have unwarranted superior performance linked to the specific set of OMs in the reference grid. This would be addressed through a set of additional robustness tests, particularly incorporating alternative future regime change scenarios.

The Group considered if it would be useful to expand on the existing table (Table 1 in SCRS/2021/046) to make the specifications of each CMP clear, since existing descriptions do not follow the same format. The Group agreed that this table should provide information about the assumptions, data sources and constraints used for each CMP. This table is found in **Appendix 5**.

Many developers commented that the summarization of the CMP results provided by the BFT MSE Contractor had been very informative for the Group. Several developers presented very brief summaries of their CMPs and many noted that their CMPs remained in the process of refinement.

Some participants noted while the AI CMP used all the available CPUE series, others (e.g. TN_X SCRS/2021/041) opted to omit certain indices due to potential non-availability in the future. The Co-Chairs reminded the Group that an important criterion for selection of indices for future projections was their anticipated availability in the future.

SCRS/2021/018 showed that placing a cap on the East area TAC and introducing a downward adjustment of West area TACs if abundance indices show a downward trend, lead to what are considered to be two trade-off improvements in the BR CMP performance. A concern that still needed to be addressed, are cases for the recruitment level R2, where the TACs for the East area can drop to approximately 10 kt even when the eastern stock status has climbed to generally well above B_{MSY} after 30 years, and hence catches would not seem to need to have been reduced so low.

SCRS/2021/028 presented two artificial neural networks (alluded to above) that estimate biomass in the West and East areas respectively, and that had been trained on simulated projected data from the reference grid of 96 stochastic operating models. The neural networks provided good to very good estimation accuracy using catch and index data only; the AI CMP was better than conventional CMPs at tailoring catch recommendations to available biomass, providing better yield performance in productive OMs, and better resource conservation performance in less productive OMs. The use of neural networks does however raise important issues of CMP overparameterization, omniscience and robustness, as discussed above and also further below.

The Group noted that for a complete evaluation the neural networks would need to be tested against OMs not used in the training set. Some such candidate scenarios to test would be different recruitment levels. While it seemed that the AI CMP could differentiate between recruitment levels R1 and R2 behaviour, the training set (and the whole interim grid) does not contain OMs with intermediate recruitment relative to these two extreme levels, so that an extension to consider two or three intermediate levels might be appropriate.

On the whole, the Group considered this work to be very interesting and noted that other CMP developers could consider AI approaches too, though it was noted that developers entertaining major structural modifications such as using AI should do this as soon as possible.

SCRS/2021/032 provides the mathematical definition of EA_X CMPs that had previously been put forward at Bluefin Tuna Species Group meetings commencing in 2019. While results showed that achieving these management objectives for the West area do not appreciably affect the East area in terms of average catches (AvC30), there were some important nuances: the variability of the metrics was still very high; moreover, when tuning one of the CMPs (EA_5), it was not possible to reach the management objective of Br30_West=1. The last exercise had focused on keeping both stocks at median Br30=1.

SCRS/2021/041 provides mathematical description of TN_X CMP developed with its results tuned for the western stock across the 96 OMs of the interim grid. This CMP uses the Japanese longline indices and the authors raised a particularly relevant point for the Bluefin Tuna Species Group to consider. Either when building CMPs and certainly when choosing final CMPs, it is important to consider the likely continuity of an index into the future when designing an MP. In this CMP, the choice of an index derived from the fishery provides a degree of stability and reassurance that the index and hence the CMP would continue to be available in the future.

SCRS/2021/042 seeks improved performance of the BR_6 CMP, described in SCRS/2021/018 to avoid very low TACs for the East area. This can be achieved by placing an upper cap on the East area TAC for the next 10 years at 36 kt, a value equal to the 2021 TAC. Stochastic results for the resultant BR10 CMP show a few instances of extirpation of the eastern stock for some recruitment level 2 (R2) OMs, indicating a need for further possible refinement of this CMP. Given strong differences in especially the eastern stock trajectory projections for the different recruitment levels (R), presenting CMP results separately for each of these levels, rather than as some weighted average across the three, may provide a more informative basis to compare performances across different CMPs.

Due to time limitations, the Group only reviewed presentations from a subset of CMPs but all CMPs are described in **Appendix 5**, documents describing their mathematical presentations are provided and all CMPs are included in the summary of CMP performance in **Appendix 6.**

3.3 Discussion on poll results and plausibility weighting of OMs

SCRS/2021/029 related the results of a poll for plausibility weighting of the levels within each OM uncertainty axes conducted by the Group after the 2020 Third Intersessional Meeting of the ICCAT Bluefin Tuna Species Group in December 2020 (Anon., 2020a). The initial results of the poll received from 27 respondents were discussed at an informal BFT CMP developers' webinar in March (SCRS/2021/030) and the second poll with the 27 respondents was suggested for any possible re-weighting after hearing/reading the different rationales for responses received. This document provided a summary of that poll which also included updated results from a second poll.

SCRS/2021/022 showed medians and lower percentiles for the East and West Br30 and AvC30 performance statistics over the interim grid of OMs which were compared for the most recent versions of BR_X and TC_X CMPs. The differences between their performance were generally independent of the development tuning value selected for the western stock (for the one exception to this result, such dependence is only slight); this suggested that CMP performance comparisons can proceed without first having to wait for agreement on OM weightings; such weightings would primarily be of consequence for the finalization tuning exercise that will need to be undertaken in 2022 when the Commission is scheduled to make its final choice of an MP.

The Group discussed whether these polling results provided a reliable basis for allocation of plausibility weights. Clarification was provided that their role in development tuning is simply to provide an overall scale; what is important at this stage of the process is to obtain a relative ranking of the CMPs' performances, and this appears to be largely independent of the tuning values.

The Group noted that the weights should be independent of performance for an OM in CMP testing and be based on first principles related to the biology and fisheries, i.e. not the particular trajectories fitted within each of the OMs. Because of this, the weights obtained by the poll should be valid after the reconditioning. However, some participants considered that it is worth going OM by OM to try to weight them individually. Some arguments were advanced that given the complexity of the system, many OMs might show characteristics that might look strange to some, but the important aspect was to determine whether or not that matters for CMP performance. Finally, it was agreed that weighting is more relevant for finalization tuning, and hence less relevant at this development tuning stage in the BFT MSE process. Consequently, the Group decided to retain the poll results for the present, and to have a closer look at individual OMs in the future when potentially some of them might be discarded.

The poll clearly indicated that the recruitment level R3 was considered less plausible than the other two recruitment levels. This is partly because it prescribes that there be a future regime shift in rather specific terms: when this will happen and what the exact magnitude will be. There was a suggestion that R3 be moved to the Robustness set, but the Group decided to keep it in the reference grid because this would ensure that the ability to test CMP's ability respond to potential regime shifts is retained.

3.4 Reference Grid finalization and adoption

There are five major uncertainty axes in conditioning and projections in the interim reference grid: recruitment; natural mortality/maturity (in combination); western stock mixing; scale of the spawning biomass in the East and West areas; and likelihood weight for the length composition data for OM conditioning. These axes assume that the options for the East and West areas (or western and eastern stocks) are linked across the rows of the table below. Several axes are designed to span extremes rather than to represent a single central tendency.

The Group first agreed at the 2020 Third Intersessional Meeting of the ICCAT Bluefin Tuna Species Group in December 2020 (Anon., 2020a) that the western stock mixing axis could be dropped from the grid because the performance of CMPs showed little change across that axis. The Group consequently enquired what level of western stock mixing (i.e. the proportion of the western stock in the East area) was to be specified for the grid OMs, i.e. 20% or 1% mixing. The Group agreed that going forward it would be 1%.

The task for this meeting was to come to an agreement on the OM grid, initial plausibility weighting and the key robustness tests. Final plausibility weighting for each OM would be considered further and will be most critical for finalization tuning of the top performing CMPs. The Co-Chairs acknowledged that the Group had not yet gone through the details of every OM to determine if there was either strange behaviour or if that behaviour mattered for CMP performance; but that doing so may not substantively alter the relative ranking of CMPs in either development tuning or finalization tuning. For finalizing the OM grid, the Co-Chairs reiterated that the focus will be on whether different OMs affect the relative ranking of the CMPs. The final reference grid that the Group agreed to adopt as follows:

Factors and levels of key uncertainty factors the reference set OMs.

Factor: **Recruitment**		
	Western stock	Eastern stock
level **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
level **2**	B-H with h=0.6 fixed, high R0	B-H with h=0.7 fixed, high R0

level **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
Factor: **Spawning fraction/Natural mortality rate for both stocks**		
level **A**	Younger spawning (E+W same)/High natural mortality	
level **B**	Older spawning (different for the 2 stocks)/Low natural mortality (with senescence)	
Factor: **Scale***		
	West area	East area
level **--**	15kt	200kt
level **-+**	15kt	400kt
level **+-**	50kt	200kt
level **++**	50kt	400kt
Factor: **Length composition weighting in likelihood**		
level **L**	0.05	
level **H**	1	

* The scale factor is intended to reflect extremes of area-specific spawning stock biomass based very approximately on the 2017 stock assessment values (Anon., 2017a). The numbers correspond with mean SSB values over the years 1968-2015 in the West area and 1974-2015 in the East areas. The fitting criterion in the conditioning of any OM includes penalty terms to ensure that the output SSB trajectories for the East and West areas for that OM have means over the periods indicated that match the two values applying to that OM as given in the table.

With respect to the overall process, final plausibility weighting and finalization tuning will take place once CMP developers have moved from the current stage of development tuning to the later stage of the MSE process. The Group agreed to an initial weighting scheme based on the plausibility scores in the poll, with the understanding that once OMs are reconditioned and the Group reached the finalization tuning stage of the process later in 2022, these weightings could be reconsidered. It was noted that even though the polling indicated that the Group considered an R3 scenario less likely (this scenario includes a shift in recruitment potential after 10 years), they still considered it necessary to capture some type of time-varying productivity to ensure that MPs are robust such scenarios.
Rounding the results of the polling exercise to the nearest 5 percent, the Group converged in the interim on the initial plausibility weights for the OMs as follows:

Plausibility weights for OMs by factors (rows) and levels (columns)

Factor/Level	**1**	**2**	**3**	**4**
Recruitment	40	40	20	
Spawn/M	50	50		
Scale	30	30	15	25
Length comp	50	50		

The Group plans to reconsider these weighting further in the future. When and how this will occur remains to be determined.

3.5 Finalization of input data for reconditioning

The Group reviewed SCRS/2021/047 which outlined key decisions and output that would need to be achieved at this meeting for the MSE process to continue on schedule. This document, as modified by the Group, became the basis for the MSE work-planning moving forward. The Group made a number of changes to the proposals in this document to reflect decisions made during the meeting, as summarized below.

Catch and size data for reconditioning

With respect to the overall needs for re-conditioning OMs for the MSE process, the Group discussed the data needs and timing. Catch inputs would need to be finalized categorically so that the Group is 100% confident that these will not be changed. The 2018 and 2019 data were considered final. The Secretariat agreed the 2019 CPUE data or abundance data would be available by 15 April 2021. Catch up to 2019 and size data to 2016 are currently available and indices will be posted at the end of this meeting.

The original proposal for reconditioning had been to use data up to 2018 if possible by the deadline (31 March 2021, Anon., 2020a), however the Group decided not to update any of the catch at size (i.e. for 2017 and later) for the purpose for reconditioning the OMs as it would be unlikely to substantively impact the OMs and it would be time consuming to compile and check data. Given this, the Group agreed to update purse seine data for catches between 1998 and 2007 and some minor revisions according to the Trial Specification Document (TSD, **Appendix 7**), but otherwise not to update any of the other size composition information to include 2017, 2018 and 2019. The Group was informed that the size data in 2008 by Canada will be revised, and agreed to incorporate this revision if the Secretariat receives it by 16 April.

Recalling that in broad terms, the purpose of the exercise was to update OMs with the most recent catches, the Group agreed to make small changes to historical data where they had been modified by CPCs, but that they would not add additional years except where indicated below. The Group sought to be consistent with its previous decisions on which new data to include in OM reconditioning, and agreed on updates to various data sources as follows.

	Terminal Year	Rationale	Comments
Indices	2019 (updated, 3 years added)		Canadian Acoustic index: terminal year 2017 (retained from previous conditioning) Follow section 6.4 (W-BFT assessment treatment)
Catch data	2019 (updated, 3 years added)		Update of the inflated PS and French PS catch data between 1998 and 2007. Some minor revisions as per SCRS/2021/031.
Size data	2016 (retained from previous conditioning)	Data will be too time consuming to include and unlikely to alter previous results	Some minor revisions as per SCRS/2021/031, and revised Canada data for 2008, if received by 15 April.
Stock of origin	2016 (retain from previous conditioning)	Data will be too time consuming to include and unlikely to alter previous results	
Electronic tagging	2016 (retain from previous conditioning)	Data will be too time consuming to include and unlikely to alter previous results	

Indices for OM reconditioning and projection

The procedure specified in the TSD, Section 7vi, will be applied to provide these values. See detail discussions on indices in items 4.1 and 6.5.

		Indices	Updated method?	Years	OM Fleet	OMarea/ /Season	Re-conditioning	In projections
RECENT	WEST	CAN_ACO_SUV1	No	1994 - 2017		3/3	yes	not used by CMPs
		CAN_ACO_SUV2	No	2018 - 2019		3/3	no	no
		CAN_GSL	Yes	1988 - 2020	14	3/3	yes	yes
		CAN SWNS	Yes	1996 - 2020	14	2/3	yes	yes

		Indices	Updated method?	Years	OM Fleet	OMarea/ /Season	Re-conditioning	In projections
		GOM_LAR_SUV	No	1977 - 2019		1/2	yes	yes
		US_RR_66_144	Yes	1995 - 2020	15	2/3	yes	yes
		US_RR_66_114	No	1995 - 2020	15	2/3	yes zero weight	yes*
		US_RR_115_144	No	1995 - 2020	15	2/3	yes zero weight	yes*
		US_RR_177	Yes	1993 - 2020	16	2/3	yes	yes
		US_GOM_PLL2	No	1992 - 2018	1	1/2	no	no
		JPN_LL_West2	No	2010 - 2020	18	2/4	yes	yes
		MEXUSA	Yes	1994 - 2019	1	1/2	yes	yes
	EAST	FR_AER_SUV2	No	2009 - 2020		7/3	yes	yes
	EAST	MED_LAR_SUV	Yes	2001 - 2019		7/2	yes	yes
	EAST	GBYP_AER_SUV_BAR	No	2010 - 2018		7/2	yes zero weight	yes
	EAST	MOR_POR_TRAP	No	2012 - 2020	13	4/2	yes	yes
	EAST	JPN_LL_NEAtl2	No	2010 - 2019	18	5/4	yes	yes
HISTORICAL	WEST	JPLL_GOM	No	1974 - 1980	2	1/2	yes	no
HISTORICAL	WEST	JP_LL_West1	Yes	1975 - 2009	2	2/4	yes	no
HISTORICAL	WEST	US_RR_145	No	1980 - 1992	15	2/3	yes	no
HISTORICAL	WEST	US_RR_195	No	1983 - 1992	16	2/3	yes	no
HISTORICAL	WEST	US_GOM_PLL1	No	1987 - 1991	1	1/2	yes	no
HISTORICAL	EAST	FR_AER_SUV1	No	2000 - 2008		7/3	yes	no
HISTORICAL	EAST	JPN_LL_NEAtl1	No	1990 - 2009	2	5/4	yes	no
HISTORICAL	EAST	SPN_BB	No	1952 - 2006	3	6/3	yes	no
HISTORICAL	EAST	SPN_FR_BB	No	2007 - 2014	4	6/3	yes	no
HISTORICAL	EAST	MOR_SPN_TRAP	No	1981 - 2011	12	4/2	yes	no
HISTORICAL	EAST	JPN_LL_Eatl_Med	No	1976 - 2010	2	4/2	yes	no

* US_RR_66_114 and US_RR_115_144 are used for only sensitivity analysis.

Removals between 2020 and 2022

The plan for how to capture near term removals in the OM was agreed to as follows.

Year	2020	2021	2022
Origin of catch removals	TAC (East) or Reported catches (West)	TAC	TAC
Value of East area removals	36000	36000	36000
Values of West area removals	2178	2350	2350*

*The initial suggestion for 2022 is to use the 2021 TACs; that value is known for the East area but yet to be finalized for the West area. The 2022 W-BFT TAC is a placeholder and will be updated with TAC decision made at the 2021 Commission meeting.

For details on how the overall TAC is proportioned by fleet, refer to the TSD.

Other major recent changes

The Group noted that as described in the new formulation of the OMs, whereas previously senescence (natural mortality M=0.47 for all ages *a>25*) was a robustness test, it is now to be used broadly in the grid OMs. The MSE Contractor commented that in most high M cases, the effects of senescence were mostly impossible to observe because fish in many of these OMs did not survive to ages >25 (due to natural and fishing mortality) and therefore would not be impacted by the modified M. The Group agreed to senescence (M=0.47 for all ages *a>25*) being used for all the low M OMs.

Robustness tests

The Group clarified the technical issues related to the Brazilian catches. Broadly the issue was that when the Brazilian data were used, the OM fit produced apparently spurious patterns; there has not been time to solve the model fitting problems associated with these patterns. Resolving these fitting problems would be future work for during the OM fitting process.

These robustness tests were added to the table of robustness tests, described below. The OMs used to test the robustness tests were also updated to use OMs with the low length comp weighting ('L'), previously the high length comp weighting was being used. This change in which OMs recommended for use in the robustness tests was based off the OMs that appear to be showing the biggest challenges in achieving MSE objectives in early runs of the CMPs; the OMs being used for robustness tests should be reviewed post-reconditioning in case different OMs are observed to be more challenging for CMPs.

The Group agreed that the priority ranking for tasks would be for the MSE Contractor and CMP developers to complete the reference grid and tests of CMPs against it. While desirable to have the robustness tests done in advance, robustness testing could be considered after the July meeting, if necessary.

But for one dissenting opinion, the Group adopted the revised list of priority robustness tests as follows. At the next meeting, the Group will discuss how best to interpret robustness test results.

Robustness trials - All are applied to four reference grid OMs: 1AII--L, 2AII--L, 1BII--L, 2BII--L. Order of prioritization often reflects practical considerations and not necessarily the plausibility of any robustness trial.

Priority	**Robustness test description**	**Notes**
1	**Western stock growth curve for eastern stock.**	West: 55% vs East: Growth 45% in plausibility weighting poll.
2	**Catchability Increases**. CPUE-based indices are subject to a 2% annual increase in catchability in the future.	Simple to do and a fundamental concern.
3	**Unreported overages.** Future catches in both the West and East areas are 20% larger than the TAC as a result of IUU fishing (not known and hence not accounted for by the CMP).	Important implications and simple to do.
4	**High western mixing.** The old mixing axis factor level 2: 20% western stock biomass in East area on average from 1965-2016.	Demoted from the reference grid, this provides a yardstick for evaluating whether robustness trials are 'consequential'. Important for setting scale, but not necessarily important for 'does it matter'.

5	**'Brazilian catches'.** Catches in the South Atlantic, including relatively high takes during the 1950s and 60s, are reallocated from the western stock to the eastern stock.	Important, but for practical purposes this should be developed after OMs priority 1-4 in order to prevent it absorbing disproportionate resources to get it working. If it proves to take inordinate amount of time, then suspend work on this to then move on to others in the list.
6	**Time varying mixing**. Eastern stock mixing alternates between 2.5%and 7.5% every three years.	Time consuming. Previously involved fitting two new operating models with 10% and 30% western mixing priors, but that dates back to before the 20% western mixing scenario was demonstrated to be inconsequential to CMP performance. Hence this has been changed to eastern time-varying mixing scenarios.
7	**Non-linear indices.** Hyperstability in OM fits to data is simulated in projection years for all indices.	Recondition the four operating models imposing a β parameter of 0.5 in the OM conditioning and maintain this in projections: $I = qB^{\beta}$ (needs change to M3 and M3 input files).
8	**Persistent change in mixing.** Eastern mixing increases from 2.5% to 7.5% after 10 years.	Was previously a change in western stock mixing before this was shown to be inconsequential to CMP performance. Hence this has been altered to a change in the eastern stock mixing as this will be influential (see **Figure 1**).
9	Varying time of regime change in R3.	Currently this changes 10 years after management under the MP commences.
10	Intermediate parameter levels for M, growth, maturity, scale, regime shifts.	The mean of existing high and low scenarios.
11	Zero eastern stock mixing. No Eastern stock in the West area.	Zero eastern mixing will require substantial further discussion regarding the interpretation. Apply only to the projections.

It was noted that there is also a second set of tests for the so-called "*Second round*" to be considered approximately five years into the application of the CMP adopted in the existing MSE process when this is reviewed and possibly revised for the first time. This second cycle produced some discussion. As the Group communicates with managers they may gain some insights into scenarios postponed to the second cycle that might be of immediate interest (notably more than two stocks in some OMs, TACs allocated on a more complex spatial basis).

It was emphasized that this second cycle would be considered only after the first cycle has been completed. A single criterion separates the first round of MSE from the second: items postponed to the second cycle are those that are too much work to complete in the first cycle. Items this category includes are re-writing computer code or restructuring the existing code architecture to accommodate novel OMs or MPs: such matters require several months of highly technical work, in addition to the attendant consultation with and approval from the Group. Other spatial or temporal resolutions could be considered at this juncture as is noted in the TSD.

Western and Eastern Development Tuning Targets

The Group received an overview of a section of the document (SCRS/2021/022) that noted that the West area did not have a strong influence on the East area so it follows that CMPs could most easily be tuned first to be comparable in the eastern Br30 outcomes before tuning to western Br30. However, while some MPs can be modified (with caps etc.) to protect the West from extirpation, it is very difficult to find any CMPs that bring the eastern Br30 to a median level of below 1.25 while also preventing the western stock Br30 median from falling far below 1.

It was emphasized that the point of *development tuning* was to compare different MPs on the same set of standards. The selection of tuning parameters does not preclude the inclusion of any other MP for the purpose of decision making at a point later in the process.

SCRS/2020/047 outlines the experimental design matrix for CMP testing. This document provided a parsimonious place to start organizing the simulations to provide useful advice. In spite of the difficulties in tuning to Br30=1 for each stock, some in the Group expressed the perspectives that ICCAT Convention management objectives are that each stock be at B_{MSY}, i.e. that Br30=1, and further that high Br30 values (1.75) are hardly compatible with such an objective. In response to advocating tuning to Br30=1 for both stocks, it was noted that a considerable amount of work had already demonstrated that this was very difficult, if not impossible to achieve for Br30=1 for both stocks without extirpating the western stock for some OMs. It was a considered to be a reasonable assumption that extirpating a stock will not be an acceptable outcome.

The Group noted that explaining why fisheries interactions for the two stocks was necessary in the MSE is something that will require clear explanation to the Commission; they will likely enquire: why can't the two stocks be treated separately in MP selection? The response to this question was that higher catches in the East area lead to a lower abundance of the eastern stock, and hence to fewer eastern origin bluefin in the Western area. This in turn means a greater proportion of western origin bluefin in an otherwise unchanged catch from the West area so that those increased removals from the western stock are not sustainable, and this then necessitates a reduction in the catches in the West area. This is the reason that while the advice framework will provide separate east and west area TACs, this TAC advice is not developed independently between areas.

It was further noted that the ICCAT management target is explicitly to be in the green quadrant of the Kobe matrix with high probability. The Br30 statistic may not capture entirely the notion of relevant temporal dimensions, nor the joint probability aspects of being above B/B_{MSY} and F/F_{MSY} that defines being in the green zone. With respect to temporal dimensions, the Group noted that longer time frames, i.e. 30 years are required to remove transient effects, i.e. when the stock is coming to an equilibrium under the feedback control mechanisms of an MP. It was expected that in respect of considering the probability of being in the green zone, plausibility weightings will become very important.

The Group noted that these tuning levels are mandatory for inclusion in the MSE process at this stage because it provides for a consistent basis for comparing performance metrics. While these are mandatory for inclusion in the reporting MSE results now, exploring other options as well is not excluded and might be very informative.

The selection of tuning parameters would need to be a combination of practical and palatable. Many CMP developers advised that exploring a large number of performance metrics and additional tuning parameters would prove to be an enormous amount of work. For the same reason, any consideration of tuning to additional targets creates a prohibitive amount of work. While many tuning levels cannot be considered for practical reasons, very few levels, e.g. one only, cannot sensibly be considered either. The Group selected the design matrix as follows.

Br30 levels		**CMP tuning options** (values are given in the order of western-eastern stocks)
western	**eastern**	**Paired plus (n=4)**
1.00	**1.00**	1.00 – 1.00, 1.25 – 1.25, 1.25 – 1.50, 1.50 – 1.50
1.25	**1.25**	
1.50	**1.50**	

It was noted that even if tuning to Br30=1 (or close approximations thereof) for both stocks will cause the stocks to be extirpated for some OMs, it was considered likely that the Commission would insist on seeing such results, even if only to demonstrate that it causes stocks (likely more frequently the western stock) to be extirpated.

Procedure for agreeing reconditioning outcomes

Although the ultimate adoption of the reconditioned OMs remains subject to the approval of the Bluefin Tuna Species Group, in order for the MSE work to continue to advance the BFT MSE Technical Sub-group will need to conduct a review of performance of the reconditioned OMs and make recommendations on their suitability for use in the MSE process. Based on those recommendations, the MSE work will continue based on those reconditioned OMs which are considered by the Sub-group to meet acceptability criteria. The Bluefin Tuna Species Group will retain its authority for formal approval of the use of the reconditioned OMs within the MSE, based on the recommendations of the Sub-group, but this approach will allow the MSE to continue until the Bluefin Tuna Species Group can meet (the next bluefin tuna intersessional meeting is scheduled on 2-9 September 2021).

The BFT MSE Technical Sub-group will carry out its review and recommendations regarding the reconditioned OMs according to the following process:

- The reconditioning results are anticipated to be available by early June 2021.
- An informal MSE Technical Sub-group meeting (i.e. not appearing on the official ICCAT schedule nor requiring a formal, adopted report that would be published by ICCAT) should take place (online, 2 days) as soon as possible after the results are made available, while allowing sufficient time for participants to review the results before the meeting.
- This meeting will allow CMP developers and other Bluefin Tuna Species Group members attending the opportunity to provide initial comments on the reconditioned OMs, thus allowing the MSE Contractor to make initial improvements based on recommendations developed during the meeting. This provides an important opportunity to determine if the reconditioned OMs exhibit any major violations of the "red-face tests", allowing the contractor to make any indicated modifications to address those violations.

To facilitate this process –

a) For all OMs in the grid, the MSE Contractor will prepare plots comparing the biomass trajectories on the same graph and provide those to the Bluefin Tuna Species Group by email. These will allow participants to evaluate the trajectories for the previous conditioning and the reconditioning. Only those cases for which marked differences are evident will require closer examination.
b) Where updated indices are simply methodologically identical extensions of their predecessors, only glances at fit diagnostics should likely be necessary. In contrast, if an index is new or considerably revised, fit diagnostics will need more thorough examination.

A formal meeting of the BFT MSE Technical Sub-group is scheduled to take place 5-10 July 2021. The MSE Contractor will provide results from the reconditioned OMs in advance of that meeting, incorporating the modifications recommended during the informal June meeting. During the July meeting, the MSE Technical Sub-group will carry out the review of the acceptability of the reconditioned OMs, and make recommendations on which OMs will be used as the MSE process continues.

Procedure for finalizing sigma and AC values for projections of abundance indices

The default is that these are left unchanged. For most of the indices, three more data points will make very little difference to these estimates, as agreed at the BFT MSE Technical Group meeting in February 2020 (Anon., 2020b). There are a few cases where the previous series were very short, so that three more points might indicate a more substantive difference to estimates. The Group agreed that the MSE Contractor use his discretion in such circumstances, so that if he considers the extra data to warrant a change, he report accordingly to the July 2021 meeting for consideration and then adoption.

If any new index series are agreed for inclusion in the reconditioning, or underwent considerable revisions, associated sigma and autocorrelation (AC) values will require estimation and re-evaluation. In such possible cases, the Group agreed that the MSE Contractor apply the same methodology as used at the BFT MSE Technical Group meeting in February 2020 (Anon., 2020b), and report the results to the July 2021 meeting for consideration.

Key performance statistics

The focus of this agenda item was to see if there could be a cautious expansion beyond the five key performance statistics (AvC30, AAVC, Br30, PGT, AvC10) that are currently being considered. The timeframe over which PGT statistic is calculated was discussed, leading to agreement that this statistic would be calculated for the five years after year 30. To capture performance earlier in the projection period, the Group agreed to add AvgBr to the table of additional performance statistics.

The revised performance statistics to be generated by the ABTMSE R package are listed in **Table 1**. What are, at this stage, considered more important ("key") performance statistics are listed below.

Key performance metrics (note that in each instance listed, there are two statistics: one east and one west, for area or stock as pertinent)

	Description
AAVC	Average annual variation in catches (AAV) among CMP updates
AvC10 (new)	Mean catches over first 10 projected years. Required to provide short-term vs long-term (AvC30) yield trade-offs
AvC30	Mean catches over first 30 projected years
AvgBr (new)	Average Br (spawning biomass relative to dynamic SSB_{MSY}) over projection years 11-30
Br30	Depletion (spawning biomass relative to dynamic SSB_{MSY}) after projection year 30
PGT (new)	'Probability Good Trend', 1 minus probability of negative trend (Br31 – Br35) and Br30 is less than 1. Probability of 1 is biologically better. In cases where all simulations are above Br30, PGT = 1 regardless of trend. This allows further discrimination between CMPs that have comparable fraction of simulations below Br30.

It was noted that while some performance statistics were calculated for projection year 30 only, there will be plots to display the status of the stock relative to B_{MSY} for the whole projection time period. These plots can be examined to see if any given MP gets to Br30, or if it subsequently diverges away from B_{MSY}.

The Group noted that it would be useful for managers to have some performance statistic that would indicate the maximum yield that could be supported by each stock i.e. MSY. In response it was noted that it was not immediately clear how to calculate this. This discussion was deferred to a small group to consider the technical and practical elements of this task.

Process for trimming performance statistics

The Group reviewed SCRS/2021/047 for the method proposed for removing performance statistics. The approach was proposed to examine the correlation of individual performance statistics. Performance statistics that are other highly correlated do not provide additional information and could be culled from reporting to reduce duplicative information.

Plots

The Group reviewed some of the plots in SCRS/2021/047. The Group agreed that statistical distributions should be represented by Zeh violin plots (Punt, 2015). To examine the performance of each CMP further, time-series plot of biomass and catch should be presented and examined.

Procedure for later including updated the GBYP aerial survey index

The Group reviewed a proposal for later updating the GBYP aerial survey index laid out in SCRS/2021/047. The proposal was as follows:

1. This series (i.e. the existing values) is not included in the re-conditioning of the OMs.
2. The existing series is fitted to each resultant re-conditioned OM to estimate catchability q together with sigma and AC values for the residuals (note that this can be done in 1. above simply

by giving that index minimal weight in the re-conditioning). Note that for this GBYP aerial survey, selectivity is pre-specified so does not have to be re-estimated.

3. Projections will include this index in case developers want to use it during 2021 (or perhaps to see whether it makes much difference whether they include or exclude it in their CMPs).
4. However, any CMPs for which results are presented to the Commission in October 2021 will exclude that index.
5. The revised and updated index will probably become available after November 2021.
6. The re-conditioning is not then redone to include that updated index.
7. The new updated data are fitted to each re-conditioned OM to estimate revised values for *q* together with sigma and AC values for the residuals, and projections then include this index as redefined by these new data.
8. The Bluefin Tuna Species Group will need to review the aerial survey index at some point in late 2021 or 2022.
9. CMP developers may use this index in their CMPs as developed further in 2022, and the MP finally adopted in late 2022 may include it.

The Group agreed that the Bluefin Tuna Species Group will need to review the results of numerical calculation of the index provided by the experts contracted for this work. The issue of the sampling survey design was set aside for now.

Some in the Group expressed their concern that this process was irregular, not ideal, and they had reservations as to whether this was an appropriate way of handling indices not ready for inclusion in the MSE. Arising from this discussion, the Group noted that they may want to consider a similar mechanism for other indices where circumstances clearly mandate substantive changes. This could potentially avoid the invocation of exceptional circumstances if an index was unavailable in the form used in conditioning.

3.6 TORs for MSE code review

The TORs for the MSE code review are identified in **Appendix 8**.

4. Progress of Technical Sub-groups

4.1 Technical Sub-group on Abundance Indices

4.1.1 E-BFT overview

The Co-Chair started with a brief presentation of the abundance indices that had been updated as requested for BFT in the East Atlantic and Mediterranean (E-BFT) for OM reconditioning. He presented a table with the indices showing the strict update of the Morocco-Portugal trap index provided up to 2020, although without an associated document. The Group received a strict update and revised index for French aerial survey, as well a strict update and revised index for western Mediterranean larval survey. A new potential egg-larval survival index was also provided to the Group. It was noted that the Japanese longline index was available up to 2019 (Tsukahara and Nakatsuka, 2019), but the 2020 data point was not yet available. Figures and tables showing the strict update and revised indices are provided for E-BFT (**Figure 1** and **Table 2**).

SCRS/2021/020 presented both a strict update to the French aerial survey over the Gulf of Lions and a Bayesian model accounting for the effects of wind. The revised index uses the wind intensity in July to capture some of the effect of the wind on the availability of bluefin tuna in the Gulf of Lions.

The Group was concerned that the index remained highly correlated with the environmental factor. A recommendation for the modeling would be to exclude the environmental factor from the model to be able to estimate the year effect independent of the environmental correlate that affects both availability and detection. The Group recommended that the authors should continue to explore the most appropriate means of incorporating the environmental effect in the CPUE standardization, but at this point the revised methodology for this aerial survey was not accepted and the strict update would be used continuously for OM reconditioning.

SCRS/2021/033 presented the results of a strict update and the revised version of the bluefin tuna larval index in the Balearic Sea with data up to 2019. Data from 2018 was not included because that survey took place outside the standard date range, and analyses of the data have not yet been possible. Both indices have been calculated applying different methods for the computation of the estimated marginal means (Searle *et al*., 1980; Length, 2020) and for the back transformation of the errors.

The Group noted that the CVs were higher for the revised version. The author explained that this is an effect of switching from the statistical assumptions during the back transformation of the errors from the logarithmic scales; the new marginal means approach provides higher CVs, but is more robust from a statistical perspective. The revised version of the index also included 2 additional years of data, 2008 and 2011. These new additions are from years with fewer sample stations completed but, based on analyses conducted by the authors the years had sufficient sample sizes (Alvarez-Berastegui *et al.*, 2020) to be included, whereas these years had been excluded in the past. The Group accepted that the revised version should replace the previous larval index for OM reconditioning.

SCRS/2021/045 presented a new fisheries independent recruitment index based on the potential egg-larval survival combining empirical data from rearing experiments of eggs and larvae, and environmental data from hydrodynamic models. This model estimates an annual recruitment index between 1990 and 2020 calculated as the cumulative sum of daily survival estimates for the daily average temperature in the Balearic Islands.

The Group considered this index to be promising and encouraged the authors to develop the model further; however, this index would not be included in the MSE at this time.

4.1.2 W-BFT overview

SCRS/2021/044 presented the revisions and recommendations on abundance indices mainly for BFT in the West Atlantic (W-BFT) by the lead rapporteur of the BFT Technical Sub-group on Abundance Indices. The detailed explanation, justification for the revisions, and the decisions for the use of indices for the West BFT stock assessment and the OM reconditioning were discussed under Item 6.5.

4.2 Technical Sub-group on Assessment models

The terms of reference (TORs) on the BFT Technical Sub-group on Assessment models, related to the E-BFT assessment, and the Sub-group members list were presented to the Group (**Appendix 9**). General aspects of the tasks were then discussed. It was noted that given the workload and the workplan ahead it would be difficult for the Group to be able to review too many assessment models in detail, but it was also realized that the potential list of models presented would probably decrease as the work of the Sub-group continued.

The Group also discussed the consideration of both traditional assessment approaches and the M3 model (used in the MSE) for providing TAC advice in 2022 for the 2023 fishing year. The fundamental difference between the modelling undertaken for the MSE, which includes mixing and multiple data sources, and most traditional assessment approaches is that the latter are area specific and mostly do not consider mixing. This will make the comparison of both approaches complex to reconcile for TAC advice. It was emphasized that traditional assessment methods were going to be part of the general TAC advice discussion in 2022, as a stock assessment has been requested by the Commission. It was noted that these more traditional approaches for E-BFT will therefore need to be placed on a similar time schedule as the MSE. Regarding the data to be used, it was generally agreed that the data currently available were to be used for model investigation until next year's scheduled assessment and data preparatory meetings, so that the workload does not increase for the Secretariat. Also discussed was that the depth of the model investigation to be undertaken by the Sub-group, which did not currently need to be specified.

4.3 Technical Sub-group on Growth in Farms

The Co-Chair presented SCRS/2021/043, which summarizes the conclusions of two meetings, attended by some members of the BFT Technical Sub-group on Growth in Farms, held to prepare the responses to Panel 2 regarding the activities of this Sub-group and especially in relation to the updating of the table of growth rates of farmed BFT. The authors describe the differences between the two length-weight (L-W) equations accepted by the SCRS for wild BFT to obtain weights from sizes. The equation used in the stereo cameras at the time of caging to obtain the catch from purse seiners (Deguara *et al*., 2017) shows lower weights with respect to the equation used for making projections and TAC recommendations (Rodriguez-Marin *et al*., 2015). In addition, the L-W equation used in the stereo cameras also showed a slightly lower weight for juvenile fish caught in the Adriatic and for adult fish from Moroccan traps when compared with *in situ* observations, and both equations seem to overestimate the real weight of the individuals captured in Portuguese traps when leaving the Mediterranean after spawning.

The Group considered that the differences between the two L-W equations should be further discussed within the Sub-group with full participation from the Sub-group members, in order to decide what equations should be used within the framework of growth in farms studies. The research line to determine growth rates by farm based on comparison between estimated weights at caging, considering both available official L-W relationships, from official stereo camera measurements and weights at harvesting from eBCD was also evaluated in more detail. It was proposed to estimate the maximum growth in farms as an expected percent increase in weight of farmed BFT as a function of the size at caging and the length of time in the farms. This line of research by the Sub-group will make it possible to update the table of farmed bluefin tuna growth rates so that the response to the Commission can be drafted in September 2021. These results will be complemented/validated by those from other ongoing lines of research on this issue as a part of the GBYP program, based on the analyses of individual growth trajectories of tagged specimens (as requested by the Commission) and on the intensive monitoring of the growth of modal groups, in selected representative cages from several regions, using image analysis systems.

The technical characteristics of two artificial intelligence (AI) technologies (SCRS/P/2021/007 and SCRS/P/2021/008) to obtain size measurements were presented. These technologies come from two Japanese companies that propose this system for use in BFT farming.

The Group was pleased to see the presentations on AI approaches to estimating size of fish in farms. The Group is aware of a number of other endeavors in this regard and encourages interested parties to conduct the necessary pilot studies to test the methodology, following guidelines outlined in Appendices 8 and 9 of Rec. 19-04.

5. GBYP matters

5.1 Aerial survey review

The GBYP Coordinator provided a brief overview of the GBYP aerial survey on BFT spawning aggregations (AS), focusing on the recurrent issues that motivated the AS review (SCRS/P/2021/009). He also reminded the Group of the recommendations provided by the external reviewers (Buckland, 2020; Vølstad, 2020) and the decisions of the Group made during the 2020 Third Intersessional Meeting of the ICCAT Bluefin Tuna Species Group in December 2020 (Anon., 2020a) and then proceeded to inform the Group of the progress made since. The CREEM team at the University of St Andrews-UK, the original developers of the DISTANCE methodology applied for the aerial surveys data analysis, has been selected for the re-analysis of AS datasets already available and to produce the new model-based survey time series. According to their work schedule, these activities will be completed by the end of July 2021. Further GBYP activities include launching a Call for Tenders for developing a pilot survey over the Balearic Sea, which would cover the usual area and an extended buffer zone around it and would combine human observers and a digital system.

The Group was concerned that focusing the activities on the Balearic Sea only might bias overall perceptions, given the specific oceanographic condition in the area. In response it was explained that all the datasets covering all four areas will be reanalyzed, providing the opportunity to obtain a reliable index for the other areas as well, given that only the Balearic Sea AS index has been used in the BFT MSE to date.

The Group recognized that the pilot study in the Balearic Sea would be convenient from a logistic perspective. It would provide a good opportunity for improving the index and comparing the usual with the new proposed methodology which will include digital systems. Therefore, the Group agreed to proceed with the plan for the pilot study. The Group also recommended that GBYP and the IFREMER group conducting the aerial survey in the Gulf of Lion coordinate efforts in relation to the use of extra high resolution image acquisition systems.

5.2 Intersessional workshops

5.2.1 Report from Close-Kin Workshop

The Group Co-Chair provided a short overview of the ICCAT GBYP Workshop on Close-Kin Mark Recapture for E-BFT, which was held on 8-9 February 2021 (SCRS/2021/023). He commented that the Workshop was well attended, indicating strong interest for pursuing the method for E-BFT. An introductory talk was given by Dr Bravington from CSIRO, who focused on the obstacles identified previously, which have now possibly been solved making the methodology more feasible; these possible solutions include epigenetic ageing and genetic stock assignment using larval samples. Potential stock structure in the Mediterranean resulting in incomplete mixing was noted as a major challenge, because the extent of this is still unknown. Therefore, sampling will have to be carefully planned in order to ensure well mixed samples to be representative of the entire pool of adults. The progress of methodology applied to W-BFT was also presented, as well as recommendations for future steps.

Some members of the Group expressed several concerns about the use of Close-Kin for E-BFT, most of which had already received attention during the workshop. The main issues remaining are the difficulty in dealing with mixed stock components and the elevated cost of the survey. Other concerns include the relationship of this method with the stock assessment; in response it was explained that the method would not replace the assessment but would bring key additional information to improve the assessment. Moreover, the Group was informed that application of the method to the W-BFT stock had provided several new insights into old uncertainties that earlier research had been unable to address, such as improving the description of the abundance indices, age structure, size structure and the spawning fraction in the Gulf of Mexico. Nevertheless, the Group reiterated that the project should not commence before confirming realistic and feasible sampling options, as was recommended during the workshop. The Group also recommended not to focus all future sampling efforts in the Balearic Sea if it proves possible to get enough larval samples elsewhere.

The Group put forward several additional ideas which may be advantageous, such as sampling at the Japanese market or on the Maltese farms, given that these may provide well mixed samples. The Group was also informed about the new sampling opportunity in the Balearic Sea, given that preliminary contacts have already been established with the artisanal fishermen who target young BFT adults. Comments were also made that the Close-Kin research may provide some interesting inputs on possible structure within the Mediterranean population, which genetic methods have been unable to determine thus far.

The Group endorsed the recommendations which were provided by the workshop, giving priority to development of the sampling design and protocol, conducting pilot study for sampling and analysis of larvae from Balearic Sea and elsewhere (if possible), and performing an epigenetic ageing pilot study. In order to develop the sampling design, a technical group meeting should be held. The pilot studies will be funded through GBYP, possibly within Phase 11 (2021), after redistributing a part of the budget initially dedicated to other activities which had to be cancelled due to the pandemic.

5.2.2 Report on the Workshop on Electronic Tagging for BFT

The GBYP Coordinator provided a short overview of the ICCAT GBYP Workshop on Electronic Tagging for BFT, which was held on 15-16 March 2021 (SCRS/2021/024). The workshop's objectives were as follows:

- to identify the main knowledge gaps regarding BFT spatial patterns,
- to update the status of ongoing BFT electronic tagging programs,
- to aim at finding potential synergies among national and ICCAT programs,
- to elaborate a list defining the priorities of research needs related to BFT spatial patterns,
- to improve the stock assessments and the MSE related modelling, and
- to agree on the best electronic tagging methodologies to fulfill objectives derived from the SCRS research needs.

Introductory sections included giving 13 presentations on current tagging programs from different groups, and a presentation on the use of these data in the MSE modelling. Some SCRS research needs in the field were identified, the main problems affecting the tagging programs and as well as some possible ways to solve them. Finally, several specific recommendations were provided. It was reiterated that the next workshop, which would focus on the data sharing policy and quality standards, will be organized when the pandemic allows in-person meetings.

The Group commented that the next tagging workshop should also focus on planning. It also recommended involving the fishing industry and stakeholders in the discussions.

The Group acknowledged that, since the inputs from the tagging and Close-Kin will eventually provide inputs for the MSE, the MSE developers should be consulted when identifying priorities and that stakeholders should also be involved. Therefore, it was decided to hold a special meeting for planning future Close-Kin sampling and tagging activities, in order to combine the two sets of objectives and to address MSE gaps.

6. Preparation for the W-BFT assessment

6.1 TOR for W-BFT stock assessment

The Co-Chair presented the tentative terms of reference (TORs) for the western BFT stock assessment in 2021. The Group discussed some treatments on the methods, other possible stock assessment methods, and the number of projection years. The SCRS Chair reminded the Group that the Commission recognizes the flexibility of the stock assessment regarding methodology and data, but this assessment should not interfere with the MSE process. There was brief discussion on use of M3 to provide advice. It was noted that while use of M3 for assessment advice would be relatively simple, review of the additional modeling and its diagnostics would be challenging given assessment timelines. The Group was also reminded that the stock assessment meeting will be held for 3 days only (30 August to 1 September 2021) including finalization of the report and will focus primarily on output from the Stock Synthesis and VPA models. The Co-Chair suggested that there would be opportunities through June and July for webinars to allow for review of the ongoing assessment work. The Group agreed that model specifications should diverge from previously accepted model specifications only if there was a very strong associated rationale. The Co-Chair suggested that there was leeway, however, to consider methods that allow for interannual variation in CPUE CVs to better capture uncertainty (e.g. iterative reweighting). The assessment TORs were modified to reflect these decisions and agreed upon during the meeting (**Appendix 10**).

The Group also reviewed the TORs drafted by a small group for the stock assessment external reviewers (**Appendix 11**). The TORs will be finalized by the Co-Chairs and the SCRS Chair.

6.2 Biology and age data

SCRS/P/2021/005 presented growth models fit to back-calculated length-at-age data generated from annuli measurements collected from BFT otolith sections. The results demonstrate that growth parameters differed when the repeated measures of back-calculated growth trajectories were treated either as independent or non-independent values at the individual level. The results of a mixed-model (VBNLME) estimated greater asymptotic length than that from the growth model currently used in the W-BFT stock assessment. Further analysis demonstrated a lack of difference in growth parameters between individuals of eastern and western spawning stocks. However, statistically significant differences were observed between males and females with males having a higher L_{INF}.

SCRS/P/2021/006 presented bi-phasic growth models fit to back-calculated growth trajectories for BFT used to estimate age-at-maturity for individuals. The results demonstrated a lack of difference in age-at-maturity estimates for individuals genetically assigned to the eastern and western spawning stocks. Further analysis is recommended to determine the robustness of these results.

The Group thanked the authors for their presentations of the new growth and maturity models. It was noted, however, that additional time would be needed to review these new biological parameters thoroughly before consideration of whether to include them in the stock assessment and MSE. The strong trend in the residuals for the NLME Von Bertalanffy fit called into question the reliability of its estimate of L_{INF}, and the overall modeling requires further consideration of the biases imparted by size selectivity on growth estimates (Goodyear, 2019). It was noted that the stock assessment analysts may explore some of these growth assumptions as sensitivity analyses. There were brief discussions on model parameterization, validation against physical samples, and the methods used to extrapolate growth curves to size classes not included in the sample set.

6.3 Size and age composition

The Secretariat has received the 2020 W-BFT size data from most CPCs, and these will be updated and provided to the analysts by 21 April 2021. Since the 2020 stock assessment, there have been no major updates of the size and the age composition data; however, it was noted that the Canadian Task 2 size data for 2008 are incorrect and need to be re-submitted. The details can be found in the TORs (**Appendix 10**).

6.4 Catch estimates

The Secretariat presented to the Group the most up-to-date statistical and biological information available to ICCAT on BFT for the East (E-BFT: Atlantic and Mediterranean) and West (W-BFT) areas, covering the period 1950 to 2020. This includes the Task 1 nominal catches (T1NC), the Task 2 catch and effort (T2CE), the Task 2 size frequencies (T2SZ), the Task 2 catch at size (T2CS) estimated by the ICCAT CPCs, and the conventional tagging.

In addition, a status update of BFT derived estimations made by the Secretariat was presented, specifically the CATDIS (overall catch distribution of T1NC by trimester and in a 5x5 spatial square grid) and the CAS (overall catch-at-size matrix).

6.4.1 Task I Nominal catches

The best and most complete SCRS estimates of the yearly BFT catches (T1NC) for both stocks between 1950 and 2020 are presented in **Table 3** and **Figure 2**. Information for 2020 is available for W-BFT only. The SCRS catalogues for BFT, showing the T1NC catch series and the corresponding availability of Task 2 datasets (T2CE: “a”; T2SZ: “b”; T2CS: “c”) are presented in **Tables 4** (W-BFT) and **5** (E-BFT).
The set of derived estimates of overall catches (CATDIS: catch estimation in biomass; CAS: catch-at-size in number; CAA: catch-at-age in number) will also be updated to reflect the new T1NC. The update status is:

- CATDIS: updated for 2018 and 2019 (both stocks) and 2020 (BFT-W only). No major changes were made to the years prior to 2018. The BFT Mediterranean PS catches for 2018 and 2019 without T2CE/T2SZ information already include a new estimation rule: “the allocation of the total catch to the 2nd trimester”, which replaces the equipartition by trimester.
- CAS: only updated for BFT-W and covers the years 1950-2020. With the updates expected for Canada (2008) and Mexico (2020), these estimates should be completed one day after the deadline for submitting data (April/16) given that only a few datasets remain outstanding.
- CAA: depends on CAS completion (three days after CAS is finished).

Some inconsistency was identified on the catch series of the Italian Ligurian Sea PS catches of the 90s. The Italian scientists informed the Group that they will try to revise the BFT Italian catch series with the Italian authorities and DG MARE and present the revision in time to be incorporated in the next E-BFT stock assessment planned for 2022.

6.4.2 Assumptions for projections

There was discussion on options for projections and benchmarks for the W-BFT assessment, and the Group agreed that the same specifications (but not absolute values) used in the 2020 assessment would be used again in 2021. The Group decided to project forward for three years (2021-2023) using the actual catches in 2020, and the TAC value for 2021 (2350 t). A more thorough analysis of projection specifications will be considered in an SCRS paper, to be developed by the Co-Chair.

6.5 Indices of abundance

The BFT Technical Sub-group on Abundance Indices for each stock area have been very active in 2021 prior to this meeting. A stock assessment for E-BFT is planned for 2022, and it is expected that the relevant stock size indices will be discussed further in a yet to be scheduled data preparatory meeting. This meeting includes a data preparatory component for the 2021 W-BFT stock assessment. This section covers only abundance indices for the West Atlantic, and the summaries of the Group decisions are provided in **Figures 3** and **4**, and **Tables 6** and **7**.

New treatments were agreed for several relative abundance indices. The Group agreed that the effects of the new treatments would be illustrated by making continuity runs in the VPA with the old and new indices as is common practice or running the 2020 stock assessment with the new indices. Hence in the assessments results with the new indices would be compared to those that would have been obtained had the previous time series been updated to the same final year.

SCRS/2021/025 provides updates for two Canadian handline (HL) indices of abundance i) in the Gulf of St. Lawrence (GSL) and ii) in South West Nova Scotia (SWNS), following a revised treatment of the existing data. For SWNS where trips can be of 5-6 days duration, the new treatment of the data is based on the same aggregation approach as used previously but with trips catching other tunas omitted and ex-sector fleets included. In the GSL, trips usually last one day and in previous analyses, day trips from a single fishing port were aggregated to calculate catch per day. In the revised analysis, individual fishing trips were not aggregated, and the new model included a fleet*year interaction term to account for management changes by fleet that influenced the effectiveness of fishermen, e.g. the change in the maximum fish per day allowed that occurred for the New Brunswick (NB) fleet in 2009, the introduction of individual tags for the Prince Edward Island (PEI) and Gulf Nova Scotia (NS) fleets in 2011, and the introduction of individual tags for the NB and Quebec (Qc) fleets in 2013.

The revised index in SWNS differed only slightly from the index used in previous assessments; the Group considered that it was an improvement, and consequently accepted the revised index. In the original presentation to the Group, differences between the new and the old treatment of the GSL index appeared large. However, when the old and new indices were placed on the same scale by dividing yearly values by each series' average, it became clear that it was the form of the original presentation that had led to a false impression of a larger difference between the two series. The Group considered that the new treatment was preferable because it represented an improvement to account for changes in regulatory or fishery practices. The difference in the old and new treatments from 2010 forward is due to the new characterisation of trip that accounts for the biggest difference between the current and previous model. The contribution of the predictors in the final model to the predicted trend in relative abundance indicates that the new definition of trip is largely responsible for the changes in the current index compared with the 2019 version. The new definition for a trip changes the catch-effort relationship and it is the effort effect fit to the new data that accounts for most of the deviation of the new index from the index based on aggregated catch/effort data. The Group accepted this revised treatment and the resultant GSL index series. Since the new treatment removed the indication of a large discontinuity which had been evident from the old treatment, the Group agreed not to split the series at this time.

The fishery characteristics in the GSL and SWNS fisheries are different. As indicated above, in the GSL, trips last a single day while trips may last 5-6 days in SWNS. In the GSL there are considerably more fishing vessels each with relatively small quotas, while in SWNS there are much fewer vessels with larger quotas. The size compositions in the GSL and SWNS are also different. The Group agreed to maintain these as separate indices for both MSE re-conditioning and 2021 stock assessment. In addition, considering that the Group decided to not use the 2018 and 2019 GSL Acoustic index values (SCRS/2021/036), the absence of a separate index for HL in the GSL would imply no indexing of the GLS size/age categories for those years.

Previously the Atlantic Multidecadal Oscillation (AMO) has been taken into account in the Stock Synthesis assessment to reconcile the diverging Canadian handline, Acoustic index and US RR >177 indices. No proposals were put forward to change this approach. The Group therefore agreed to continue to use the AMO as in the 2017 and 2020 assessments.

SCRS/2021/026 presents two indices of BFT relative abundance created from logbooks from U.S. pelagic longline (LL) fishery in the Gulf of Mexico during 1987 - 2020. The first index was a strict update following methods used in the 2020 assessment, and the second was a revision that accounts for spatial closures and changes in targeting. Several natural events (hurricanes) and management interventions (closed areas, changes in hooks, Deep Water Horizon restoration) resulted in a large reduction in recorded longline effort from an average of 42 vessels per year (~1360 sets) prior to 2015 to only 8 vessels (170 sets) in 2020. Given the reduction in fleet size during these terminal years, and the difficulty in modeling dynamic fleet regulations aimed at reducing bluefin tuna interactions, the Group does not recommend using this index in the 2021 stock assessment nor in the MSE. Instead, the U.S. LL data from the Gulf of Mexico should be used in combination with Mexican LL data to calculate a new index (SCRS/2021/035).

SCRS/2021/027 notes that the Canadian combined HL and U.S. rod and reel (RR) large fish (> 177 cm) CPUE for W-BFT were excluded from the 2017 and 2020 VPA assessment because they indicated conflicting trends. Discussions and analyses are underway to evaluate the possibility of combining RR indices in the northwest Atlantic (Canada SWNS and U.S. RR > 177). This paper discusses the characteristics of the two data sources and the catch at size in each country for the gears under discussion. When all sizes are considered, the Canadian SWNS fishery catches predominantly BFT larger than 150 cm, while fish smaller than 150 cm are more abundant in the USA fisheries. There appears to be a gradual shift toward larger fish after 2009 in the U.S. RR fisheries.

The Group pointed out that the proportional catch at length for the USA could be misleading as the USA had not caught larger fish above 177cm. Clarification was provided that small fish are dominant in the U.S. RR catch by the recreational fishery, but large fish also are targeted by the commercial fishery. A U.S. scientist also clarified that the CAS are estimated using survey data for small fish and commercial dealer reports for large fish (a census). The CAS shows the gap of fish for 150-177 cm in the catch, but it was explained that this could be due to the combination of the fish availability, targeting interest, and gear configuration etc.

The Group noted that size compositions should be carefully reviewed when the joint index is explored for fish larger than 177cm, because the Canadian SWNS catch size is remarkably stable from year to year, while the USA catch at size is considerably more variable inter-annually.

SCRS/2021/034 documents the review and revisions of the U.S. Large Pelagic Survey (recreational and commercial RR fisheries) indices of relative abundance of juvenile and sub-adult BFT, and recommends 1) modeling of a single size class (66 to144 cm straight fork length fish selected), 2) expanding the spatial coverage of the samples, 3) removing state as a fixed factor in the standardization model, 4) integrating sea surface temperature as a covariate to better model dynamic annual spatial distributions of the fish, and 5) adding vessel type (private versus charter, with headboats excluded) as a fixed factor to account for differences in the fishery related to shifts in angler composition over time. The revised index showed a lower inter-annual variability and greater precision than the previous two separate indices and is recommended to replace the two in the stock assessment and other population modeling applications.

The Group noted that while Sea Surface Temperature (SST) does not appear to have a large influence currently, this may change in the future. Several further analyses were discussed in a small group to ascertain if SST was acting on catchability or on density and the Group considered that using SST was acceptable because there was hardly any correlation between annual SST and the year effect from a GLM excluding SST. This indicated that SST was acting primarily on catchability, so that its inclusion could improve precision without possibly biasing trends.

SCRS/2021/035 summarizes the combined Mexico-U.S. pelagic longline data analysis and standardized index of bluefin tuna in the Gulf of Mexico. A main recommendation from previous workshops on this topic was to evaluate the Gulf of Mexico data at a finer scale than 5x5 degree latitude-longitude, to better assess fleet spatial coverage and BFT availability by month-area. The current analysis examined models at a 1x1 spatial scale. Several findings supported a combined index, mainly 1) estimation of month-region effects that corroborate observed migration patterns, 2) a non-significant Flag effect in the standardization model comparing fixed factors, 3) random residuals of Flag-year standardized indices relative to a combined index, and 4) correlation between indices that included flag-year effects versus excluding it. A multinational longline index is proposed for consideration in the next W-BFT stock assessment and is recommended by the authors to replace the U.S. pelagic longline index (SCRS/2021/026).

The Group noted that there were now sufficient data to calculate a separate Mexican LL index. It was noted that keeping the U.S. data in the analysis currently has little influence for the most recent years when the

U.S. fleet decreased notably in size, but this does inform for the long-term trend and could provide important information in the future. The Group agreed to use the combined MEX-USA index in the 2021 stock assessment and the MSE.

SCRS/2021/036 provided an overview of work on the GSL BFT stock size index derived from information collected during an acoustic survey for herring. Recent updates to the index (2018-2019) suggest a significant decline in BFT that does not appear to be consistent with the GSL Canadian HL index. The report investigated the effects of survey methodology, spatial distribution of BFT, prey species abundance and environmental co-variates as factors that may be contributing to the lower index values. Results suggest that the recent low index values do not appear to be related to survey methodology, vessel effects or halocline/thermocline depth. Tagging data for BFT in the survey area suggests that BFT may be entering the Baie-des-Chaleurs in months prior to the survey. Factors such as a decline in primary prey species (herring and mackerel) and anomalies in sea-surface temperature and volume of the cold intermediate layer may be related to recent low index values.

It was suggested that the acoustic survey correlation with other stock size indices in the GSL may have been spurious, given the short duration of the survey each year (2 weeks) and the small geographical area covered and that prey availability may have always had an influence on how many BFT were detected. It was clarified that for the all but the two most recent time series data points (24 of 26 years), the index was reasonably consistent with broader stock trends despite the small footprint of the survey.

The Group agreed, for the short-term, to split the index after 2017 with a new series starting in 2018, with a caveat that historical use of the index will be re-visited after the 2021 assessment when further examination of the index can be completed. The Group acknowledges that a new series with two observations (2018 and 2019) is unlikely to have much influence in the assessment and will not be included in the assessment or the MSE. The Group also agreed to continue to use the index up to 2017 in the OM reconditioning, but not for projections in CMPs.

SCRS/2021/038 provided standardized catch rates from the U.S. Large Pelagic Survey that have been used as an index of relative abundance for large BFT (>177 cm) in the west Atlantic for decades, but not in the 2017 and 2020 VPA stock assessments because of conflicting trends with a combined Canadian HL index for the same size group. A series of online stakeholder meetings produced several recommendations to improve the abundance index, including: 1) investigate changing participation and targeting in the fishery (related to a TV show "wicked tuna effect"); 2) explore models that capture the core spatial footprint of the fishery; 3) examine different effort statistics; and 4) incorporate ocean conditions into relative abundance models. Twelve exploratory standardization models using several different frameworks were developed to address issues highlighted by the workshop participants. Exploratory models were then compared to the index agreed previously. Results showed very similar trends across all alternative standardization models. Although the Group noted that further discussion was needed on the effect of SST, the Group agreed to use the exploratory model using SST in the 2021 W-BFT stock assessment. The Group also noted that U.S. RR (>177 cm) and Canadian HL indices were generally increasing which suggested that the conflict may be less problematic.

SCRS/2021/039 explains that U.S. and Canadian indices of abundance for large fish were not used in the 2017 and 2020 W-BFT VPA stock assessment because of conflicting trends. It is hypothesized that these conflicting trends result from spatial shifts rather than changes in stock abundance. Consolidating data between SWNS in Canada with the U.S. Large Pelagic Survey could produce an annual signal that is proportional to stock abundance while less sensitive to changes in stock distribution over time. Two separate statistical frameworks were used to combine U.S. and Canadian SWNS data into a single index of abundance. Both model frameworks converge, agree with fishermen's perceptions and indicate that abundance in the northwest Atlantic is increasing. Results are expected to help reconcile conflicting CPUE trends, provide a framework for reincorporating U.S. and Canadian catch rates into the W-BFT VPA, and potentially provide a reliable index of abundance for a candidate management procedure. The Group agreed to use separate indices for Canada GSL, Canada SWNS, and the U.S. RR greater than 177 for the 2021 stock assessment and the MSE.

The effort was considered a proof-of-concept application of a novel method, a vector-autoregressive spatiotemporal delta-generalized linear mixed model (VAST, Thorson 2015). The Group noted that stakeholders for both countries expressed concern and recommended caution in developing a combined index because the fishery management as well as monitoring, control and surveillance systems, and trip duration varied greatly between the two countries. Also, the number of fishermen is smaller, more stable and operates under an Individual Transferable Quota (ITQ) system in the SWNS fishery. The Group concluded that the combined index should not be recommended for use in the 2021 assessment or the MSE at this time.

SCRS/2021/040 presents updates to the abundance indices of BFT from the Japanese longline fishery in the West Atlantic up to 2021 fishing year (FY), adding data for one more year and using exactly the same method in a strict update from the previous update (Tsukahara and Nakatsuka, 2019). The index was standardized with a delta-lognormal model with random effects. The standardized CPUE in the West Atlantic since 2011 fishing year remained relatively high compared to the 1990s and early 2000s. Additionally, the spatial and temporal patterns of operation over time were investigated based on the TORs agreed by the Group at the 2020 Third Intersessional Meeting of the ICCAT Bluefin Tuna Species Group in December 2020 (Anon., 2020a). Those indicated that the operation area and periods become narrower and shorter recently because of the greater availability of BFT and the introduction of an individual quota system. It was also noted that the catch of small fish less than 100 kg has decreased to near zero since 2014 FY.

The Group noted that the index is split into two time periods after being standardized as a single series. This approach has been continued since 2010 when the split was recommended and the years after the split were too few to justify a separate standardization. Now that there are sufficient years in the second period, the Group considered whether one should standardize each time period separately and explore including more fishing areas in the early period. There was also discussion that the model, as it has in the past, included SST as a predictor in both the presence/absence and positive catch sub-models of the delta-lognormal model, and the Group recommended to fit the model without SST in the positive catch sub-model given concerns that SST changes may be confounded with changes in BFT density. The Group also recommended further developing the VAST modeling approach given the changes in the area fished by the fleet over time. Given the short timelines for implementing a correction and the perceived negligible effect of SST on the outcome, the Group agreed to continue to use the index presented in this document in the 2021 stock assessment and in the MSE.

6.6 Stock assessment models and its specification

The Group had detailed discussions on the assessment plan and model specifications for the analysts: see Item 6.1 and **Appendix 10**.

7. Other matters

Response to the Commission on Catch rates updates

The Co-Chair introduced the discussion with a presentation provided during the Panel 2 meeting in March 2021. It highlighted a new approach to update catch rates for E-BFT vessels by size category and main gear type based on by-vessel catch and effort information rather than the aggregated catch as done in the 2008 analysis (Anon., 2008), mainly due to the recent changes in the fisheries. It was also noted that Panel 2 requested an update by using similar analyses as in 2008, to evaluate potential differences in the results.

The Group reviewed the preliminary report on updated CPUE for E-BFT as presented in document SCRS/2021/037. There have been several important changes in the fisheries for E-BFT since 2008 (Anon., 2008). Most of the changes were in response to ICCAT management regulations including annual quotas, time restrictions, vessel authorizations, etc. During this time, Joint Fishing Operations (JFOs) have become the main fishing activity that accounts for most of the catches of E-BFT in recent years. Within a JFO, several vessels are registered and can share their added quota allocations. This allows that, for example, a single vessel catches the fish, but for monitoring and reporting each vessel is deducted a prescribed catch tonnage according to a predefined allocation key. Because of these JFOs, the approach used in the 2008 SCRS analysis of catch rates is not valid currently, because it considered aggregated catches by active vessel categories and area. The present analysis used instead by-vessel nominal catch and effort, considering only vessels that have actually performed the fishing activity in the case of JFOs. For this purpose, data on the catch by vessel were obtained from the BFT-weekly database, the eBCD, and ROP, while proxies of fishing effort were estimated from the BFT-VMS ICCAT data.

Analyses showed that from the registered active vessels, it is possible to identify a "core" fleet that has operated more consistently in the fishery, and that accounts for a large proportion of the total annual catch. Preliminary results indicated that the PS fleet has overall higher nominal CPUEs compared to LL or BB fleets. And, that PS vessels in the "core" fleet and JFOs have overall higher nominal CPUE for both large (LOA ≥ 40 m) and medium (24≤ LOA< 40 m) size categories compared to the non-core fleet. Similar results were observed for the LL core fleet versus the non-core fleet.

The Group acknowledged the work done by the Secretariat, indicating that interested scientists should review and work with the Secretariat to finalize the analysis for having an agreeable response to the Commission that can be reviewed during the September meeting. It was suggested to refer to these results as nominal CPUE rather than catch rates, in agreement with the SCRS response in 2020 (Anon., 2020c). The Group noted that for Mediterranean PS fleet(s) the proxy for fishing effort is not always straightforward to quantify, as in some cases, vessels spend much of their time waiting for transfer/towing vessels. The Group also noted that the actual fishing effort may also need to reflect effort from other vessels that may not actually catch fish but are associated with the fishing operations. For the purposes of analysis, SCRS/2021/037 defines effort in units of time, thereby providing a CPUE.

The Group proposed the nominal CPUE of the core fleet as being more representative of the current average nominal CPUE by vessel category and main gear. It was requested that scientists familiar with the BFT Trap operations provide proxies for the fishing effort to better define effort for nominal CPUEs. The Group noted that this analysis does not yet provide comparable information on probable yields by vessel category, as this requires: a) converting the catch rates into catch per day; and b) making an assumption regarding the number of days that the fleet might fish, on the basis of the current management regulations.

Finally, the Group noted that it would be difficult to provide the estimation of the probable yields, or the appropriate number of vessels to permit, since the previously defined 'catch rates' in Table 1 (Anon., 2008) do not fully represent the dynamics in the fishery. Compared to when this approach was introduced many years ago, management measures have changed dramatically, and there is now a predominance of JFOs, among other changes, as well as strict MCS measures.

Review of the catch size composition for the Mediterranean PS Other fleets

The 2017 E-BFT stock assessment recommended review of the catch size composition for the Mediterranean PS Other fleets, which presented a change in the size distribution of BFT destined to farm operations in 2017 and 2018 compared to previous years (Anon., 2017b). Document SCRS/2021/019 summarizes the review of the stereo-camera BFT caged size data provided by seven Turkish farms between 2014 and 2020. These data are the main source of information for the size composition of the Mediterranean PS Other fleets. Analyses confirmed that since 2017, the Turkish farms increased substantially the caging of smaller BFT (<140 cm SFL), while the proportion of fish (>200 cm SFL) has decreased. This change in the mean size of caged fish also coincides with changes in the months of catch/caging of fish; between 2014-16, fishing operations were common between June and September, with caging of the larger fish in August-September, however since 2018 all operations took place in June-July. National scientists confirmed the changes in the catch size distributions and informed that fishers have reported the absence of larger BFT in the area, and that there has been an increase in the participation of Mediterranean PS Other fleets supplying fish to their farm activity in recent years.

Turkey's national scientist indicated that fishers confirmed the changes in the size distribution of the E-BFT available in the eastern Mediterranean area in recent years. Indicating also that increases in the number of fishing operations and vessels since 2017 responded to increases in the national quota allocations, and the size of fish caught and caged follow the ICCAT regulations including increasing the number of fishing days up to 45. It was pointed out that the months reflected in this document represent the month of caging operation, which does not correspond necessarily to the date of the catch. Finally, it was also noted that current gas/oil search operations in the fishing area may have some impact on the distribution of bluefin tuna and recommended that research be done to evaluate this and other factors that have may contribute to the observed changes in the size distribution of BFT in the eastern Mediterranean region. The Group agreed that the revised size composition for the Mediterranean PS Other fleets should be included in 2022 E-BFT stock assessment.

8. Adoption of the report

The Report of the First 2021 ICCAT Intersessional Meeting of the Bluefin Tuna Species Group was adopted. Drs Rodríguez-Marín and Walter, and the SCRS Chair thanked the participants and the Secretariat for their hard work and collaboration to finalize the report on time. The meeting was adjourned.

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Table 1. Revised performance statistics calculated as part of the MSE outputs for each OM simulation and CMP. "Projection years" commence in the first year that the CMP is applied to provide TACs.

	Description
AAVC	Average annual variation in catches among CMP update times t (note that except where the resource is heavily depleted so that catches become limited by maximum allowed fishing mortalities, catches will be identical to TACs) defined by: $AAVC = \frac{1}{nt}\sum_{t=1}^{nt} \lvert C_t - C_{t-1} \rvert / C_{t-1}$
AvC10 (new)	Mean catches over first 10 projected years. Required to provide short-term vs long-term (AvC30) yield trade-offs.
AvC30	Mean catches over first 30 projected years
AvgBr (new)	Average Br (spawning biomass relative to dynamic SSB_{MSY}) over projection years 11-30
Br30	Depletion (spawning biomass relative to dynamic SSB_{MSY}) after projection year 30
C10	Mean catches over the first 10 projected years
C20	Mean catches over projected years 11-20
C30	Mean catches over projected years 21-30
D10	Depletion (spawning biomass relative to dynamic SSB0) after the first 10 projected years
D20	Depletion (spawning biomass relative to dynamic SSB0) after projection year 20
D30	Depletion (spawning biomass relative to dynamic SSB0) after projection year 30
DNC	D30 using the MP relative to D30 had no catches been taken over the 30 projected years
LD	Lowest depletion (spawning biomass relative to dynamic SSB0) over the 30 years for which the CMP is applied.
LDNC	LD using the MP relative to LD had no catches been taken over the 30 projected years.
PGT (new)	'Probability Good Trend', 1 minus probability of negative trend (Br31 – Br35) and Br30 is less than 1. Probability of 1 is biologically better. In cases where all simulations are above Br30, PGT = 1 regardless of trend. This allows further discrimination between CMPs that have comparable fraction of simulations below Br30.
POS	Probability of Over-Fished status (spawning biomass < SSB_{MSY}) after 30 projected years.

Table 2. Abundance indices for the E-BFT in the BFT MSE in 2021.

series	SPN BB		SPN-FR BB		MOR-SPN TRAP		MOR-POR TRAP		JPN LL Eatl&Med		JPN LL NEAtl1		JPN LL NEAtl2		French Aerial survey 1		French Aerial survey 2		WMed Larval Survey		GBYP aerial Survey	
age	2-3		3-6		6+		10+		6 - 10		4 - 10		4 - 10		2-4		2-4		Spawners		Spawners	
indexing	Weight		Weight		Number		Number		Number		Number		Number		Number of schools		Number of schools					
area	East Atlantic		East Atlantic		East Atl and Med		East Atl and Med		East Atl and Med		NEast Atl		NEast Atl		West Med		West Med		West Med		Barealic Sea	
method	Delta lognormal RE		Delta lognormal RE		Neg. Binom. (log) no.		Neg. Binom. (log) no.		Delta Lognormal RE		Delta Lognormal RE		Delta Lognormal RE									
time of the year	Mid-year		Mid-year		Mid-year		Mid-year		Mid-year		Begin-year		Begin-year		Mid-year		Mid-year					
source	SCRS/2014/054		SCRS/2015/169		SCRS/2014/060		SCRS/2017/030		SCRS/2012/131		SCRS/2019/195		SCRS/2019/195		SCRS/2021/020		SCRS/2021/020		SCRS/2020/067		SCRS/2018/175	
Year	Std. CPUE	CV	Std. CPUE	CV	Std. CPUE	CV	Std. CPUE	CV	Std. CPUE	CV	Std. CPUE	CV	Std. CPUE	CV	Index	CV	Index	CV	Index	CV	Index	CV
1952	179.22	0.43																				
1953	184.74	0.53																				
1954	226.46	0.41																				
1955	187.01	0.42																				
1956	470.53	0.43																				
1957	315.05	0.41																				
1958	252.25	0.41																				
1959	506.79	0.41																				
1960	485.16	0.43																				
1961	327.29	0.41																				
1962	180.12	0.46																				
1963	312.09	0.49																				
1964	457.40	0.42																				
1965	228.91	0.41																				
1966	349.10	0.42																				
1967	345.89	0.41																				
1968	447.00	0.42																				
1969	610.62	0.40																				
1970	594.66	0.43																				
1971	744.71	0.40																				
1972	525.63	0.41																				
1973	535.63	0.40																				
1974	245.39	0.44																				
1975	484.22	0.41							1.90	0.15												
1976	483.96	0.41							2.15	0.12												
1977	547.56	0.41							3.53	0.14												
1978	705.26	0.41							1.50	0.15												
1979	623.01	0.41							2.70	0.14												
1980	634.81	0.45							1.69	0.16												
1981	510.66	0.42			768.36	0.57			1.63	0.17												
1982	503.78	0.42			1038.12	0.35			3.32	0.13												
1983	625.14	0.43			1092.05	0.35			2.12	0.13												
1984	331.71	0.45			1200.27	0.35			1.62	0.12												
1985	1125.74	0.41			814.46	0.35			1.75	0.15												
1986	751.21	0.42			394.33	0.28			1.32	0.14												
1987	1008.43	0.42			433.53	0.28			2.16	0.13												
1988	1394.68	0.42			1014.56	0.28			1.35	0.14												
1989	1285.60	0.40			531.45	0.26			1.05	0.16												
1990	986.51	0.41			614.37	0.23			1.41	0.14	0.46	0.31										
1991	901.20	0.42			727.86	0.23			1.21	0.13	0.54	0.26										
1992	695.16	0.43			313.95	0.23			1.03	0.14	0.83	0.16										
1993	2093.55	0.40			325.36	0.23			1.04	0.14	0.76	0.14										
1994	1007.03	0.42			341.90	0.23			1.12	0.16	1.00	0.15										
1995	1235.91	0.41			223.43	0.23			1.42	0.15	1.02	0.14										
1996	1739.29	0.40			375.22	0.25			0.50	0.22	2.47	0.12										
1997	2246.41	0.40			992.41	0.25			0.53	0.21	1.57	0.13										
1998	879.51	0.41			925.14	0.25			0.71	0.17	0.85	0.15										
1999	339.77	0.44			1137.45	0.25			0.64	0.22	1.21	0.14										
2000	960.44	0.40			739.23	0.23			0.74	0.20	1.10	0.11			0.01	0.39						
2001	704.49	0.45			1284.62	0.23			0.96	0.17	1.42	0.12			0.01	0.42			4.11	0.42		
2002	687.42	0.42			1130.42	0.23			2.05	0.15	0.96	0.13			0.01	0.58			9.21	0.49		
2003	444.91	0.48			662.66	0.24			1.70	0.13	1.07	0.15			0.01	0.27			2.13	0.54		
2004	1210.46	0.42			332.36	0.23			0.82	0.18	0.93	0.13							10.45	0.42		
2005	2383.57	0.40			677.39	0.23			0.88	0.15	0.72	0.13							2.00	0.40		
2006	850.09	0.48			633.94	0.23			1.91	0.15	0.85	0.12										
2007			2179.98	0.31	1000.60	0.23			0.94	0.19	0.91	0.13										
2008			2154.01	0.30	634.18	0.23			1.22	0.17	1.04	0.13							2.00	0.79		
2009			955.38	0.30	876.71	0.23			1.04	0.24	1.61	0.11					0.02	0.35				
2010			2126.20	0.31	1042.24	0.24							2.34	0.12			0.01	0.52			3587.00	0.57
2011			2785.47	0.30	674.97	0.23							4.05	0.15			0.03	0.25	9.19	0.40	4371.00	0.46
2012			2306.99	0.39			95.37	0.34					8.62	0.19			0.02	0.26	24.98	0.22		
2013			1569.13	0.44			126.73	0.37					7.25	0.16					39.83	0.30	3539.00	0.41
2014			678.29	0.41			62.88	0.36					8.19	0.20			0.06	0.27	18.38	0.30		
2015							98.23	0.38					6.41	0.21			0.03	0.24	34.44	0.25	4712.00	0.42
2016							94.29	0.39					5.72	0.18			0.10	0.20	30.76	0.28		
2017							110.34	0.39					7.32	0.21			0.07	0.24	67.46	0.25	12693.00	0.41
2018							71.90	0.39					8.79	0.21			0.03	0.17			37861.00	0.40
2019							99.88	0.38					8.37	0.21			0.06	0.14	44.89	0.23		
2020							104.13	0.36									0.13	0.15				

Table 3. Total BFT catches (t) by year, stock, region, and major gear (source: T1NC, Task 1 nominal catches, which includes landings and dead discards).

	BFT-E (BFT eastern Atlantic stock)																											BFT-W (BFT western Atlantic stock)											
	ATE													MED												TOTAL	ATW											TOTAL
Year	BB	GN	HL	HP	LL	PS	RR	TN	TP	TR	TW	UN	ATE Total	BB	GN	HL	HP	LL	PS	RR	TP	TR	TW	UN	MED Total		GN	HL	HP	LL	PS	RR	TL	TP	TR	TW	UN	
1950	2975		1142			2200			13400			452	20169		507	400			1390		4246			100	6643	26812	2	79	459		1	113		356		7		1017
1951	3872		1724			6728			8906			1790	23021		816	400			1191		4684			100	7190	30211	1	148	263		100	87		518		6		1123
1952	4685		2734			14752			9471			1004	32646		966	400			1667		3228			100	6361	39007		83	323	7		70		200		11		694
1953	4135		1167			10217			13553			2202	31275		899	800			1796		4405			100	8000	39275		85	197	1		34		766		1		1084
1954	5500		1658			12145			9669			312	29284		798	600			2283		4090	2		100	7873	37157	1	44	129		55	63		531				823
1955	6559		2316			13394			12593			1921	36783		783	1200			1583		3637	6		100	7309	44092		8	135	5		19		377				544
1956	3409		1046			5313			14784			55	24608		329	900			1215		2988	45		100	5578	30186		6	47			13		181				247
1957	4017		2030		33	6437			14949			1004	28470		615	500			1097		5084	6		100	7402	35873		5	58	46		33		404				546
1958	4241		623		2	6399			15150				26415		294	700			1032		4773	39		100	6938	33353		49	61	72	138	18		869				1207
1959	3800		1828		56	6727			7927				20338		384	700			755		4054	3		100	5997	26334		49	125	283	781	30		381				1649
1960	1374		536		481	6501			10951				19842		400	900			674		4197	1		100	6272	26113		31	119	340	277	29		236				1032
1961	1597		454		223	11547			7835				21657		599	1100			816		3811	0		100	6426	28083		7	78	373	903	101		158				1620
1962	1702		370		2484	10358			9165				24079		214	1000			595		3460	9		100	5378	29457		32	44	1351	3768	380		224				5799
1963	1554		3		1618	1586			4553				9314		668	1200		800	1605		2624	46		100	7043	16357		23	22	6558	5770	1162		303				13838
1964	1263		44		645	3520			5391				10863		953	600		300	1306		3081	5		100	6345	17208		7	24	12347	5150	601		479				18608
1965	1984		23		438	3412			5189				11046		390	700		400	470		3972	17		100	6049	17095	3	4	55	9465	3331	1062		247				14167
1966	3557		2		91	2778			3221				9649			500		500	1897		2438			100	5435	15084	1	5	46	3075	1006	3726		221				8080
1967	2018		15		141	4063			4582				10819			600		300	2937		4978			100	8915	19734	5	18	53	3126	2082	343		313				5940
1968	1585		8		208	1206			2072				5079			500		600	3355		3911			100	8466	13545	2	16	61	1665	687	619		126				3176
1969	2056		1		201	1520			2475				6253			500		400	3638		4233				8771	15024	1	30	30	593	1118	1008		231		1		3012
1970	3017		14		274	876			1820			5	6007			100		69	2396		2216	20			4802	10808	2	57	72	268	4288	587		183		9		5466
1971	3055		1		254	683			713			105	4811			100		129	3906		2237	2			6374	11185	1	95	166	1390	3769	1049		106		15		6591
1972	3032		6		261	961			469			101	4831			100		236	4084		1575	4			6000	10830		270	160	362	2011	1084		58		3		3948
1973	3316		2		91	933			506	11		3	4862			100		520	4324		1149	56			6150	11012		297	86	1156	1656	519		157				3871
1974	2385				2243	1459			78			4	6168			100		2408	8119		2476	14			13117	19285		42	214	985	960	2913		276				5390
1975	3193				2923	3612			448			4	10180			114		1400	8065		1666	39			11285	21465		200	233	1586	2320	589		144				5072
1976	1868				2048	860			490			12	5278			100	12	1243	13970		1756	9			17090	22368		162	189	3185	1582	590		172				5880
1977	3055		300		1806	1426			561			5	7153			188	34	639	9563		1373	30			11827	18980		244	157	3790	1502	630		372				6695
1978	4126		451		733	257			633			2	6203			160	22	179	7299	31	1219	2			8912	15115		429	158	3252	1230	475		221				5765
1979	2216		1024		748	266			600			1	4855			153		222	6103	51	1040	11			7580	12435		457	143	3744	1381	499		31				6255
1980	1707		38		1002	437			817			2	4003			60		253	8541		1198	4			10056	14059		358	102	3983	758	535		47			1	5784
1981	1479		72		575	266			1186			2	3580	100		2	56	390	8529	50	1388	10			10525	14105		285	109	3898	910	523		41			4	5770
1982	987		27		2715	650			2309			0	6689	53		62	24	1587	12131	60	1794	21			15732	22421		151	86	374	237	531	213	68				1660
1983	3128	84	2		2626	262			1956			1	8059	391		164		980	10485	60	1550	10			13640	21699		332	159	841	384	476	355	7				2554
1984	2949	46	158		1557	373			2302	36		6	7427	1699	235	543	1	1380	10624	60	2490	14			17046	24473		275	115	844	401	401	260	3			2	2301
1985	2364		1		576	86			1630	110		40	4806	278	324	867	2	1396	12460	140	1320	54		415	17257	22063		284	166	1240	377	466	121	20		6		2680
1986	2253		13		1008	276			1057	76		4	4687		293	671	2	966	11116	140	1153	12		220	14572	19260		190	127	1285	360	328	39				0	2329
1987	2129		3		1026	255			1040			0	4453		203	667	1	974	10032	143	1382	11		404	13818	18271		187	122	1238	367	539	32	17		2	0	2504
1988	2682	149	1		1187	202			2624		100	6	6951		199	1069	1	1435	12566	141	1537	6		225	17178	24129		162	151	1479	383	439	268	14			6	2902
1989	2685	34	2		962	147			1492	101	22	6	5451		199	685	1	1364	10883	141	1714	9		714	15710	21161		229	187	825	385	557	579	1		1	2	2766
1990	1993	77	1		1510	54			2504		101	74	6313	25	86	1177	7	1178	11797	382	2382	4		247	17286	23599		224	129	856	384	780	404	2		2	1	2782
1991	1653	51			3196	46			1522		70	5	6543	148	216	355	6	3057	13805	414	1711	8		126	19846	26389		355	129	1031	237	728	447				2	2929
1992	1422	82			3618	462	7		1365		441		7396	158	193	586	5	3145	18580	366	1152	0		249	24435	31831	0	232	105	900	300	354	403	1			1	2296
1993	3884	501			2802	24			1631	2	436	37	9317	48	215	738	2	2470	20065	500	749	8		146	24941	34258		226	121	800	295	628	284	29			1	2384
1994	2284	36			2311	213	25		1630		224	330	7054		88	1492	2	6993	27948	815	1691	21		665	39715	46769	0	271	102	622	301	533	203	79			2	2113
1995	3093	155			4522	458			1152		400	0	9780	206	201	2746	4	8469	23799	816	942	17		322	37523	47303	1	75	120	629	249	1039	262	72			1	2448
1996	5369	266			4212	323			1921		7	0	12098	5	87	1828	10	9856	26021	321	951	79		241	39399	51497	4	36	128	712	245	996	298	90			3	2512
1997	7215	3	162		4057	828	75		3982		57		16379	4	167	2071	20	7313	24279	269	613	7		88	34831	51211		17	153	537	250	1178	138	59			2	2334
1998	3139	109	28		3789	700			3586		277	1	11630	11	218	1061		4117	31792	31	1074	11		55	38370	50000		29	169	887	249	1082	172	68			1	2657
1999	1554	102	33		3570	726			3960		299	3	10247	4	174	1284	5	3338	33798	248	852	10		39	39753	50000		15	154	1075	248	1110	125	44		0	0	2772
2000	2032	85	126		3736	661			2996	2	414	8	10061	38	233	1542	5	3424	33237	231	739	2		488	39939	50000		3	202	1080	275	1117	81	16			0	2775
2001	2426	86	61		3303	153			3585		462	9	10086	28	347	890	2	4144	33043	277	1177	5			39914	50000	0	9	122	715	196	1648	79	16			0	2784
2002	2635	17	63		2896	887			3235		614		10347	1	301	1158		3234	34044	362	515	17		22	39653	50000		4	68	940	208	2031	39	28				3319
2003	1409		109		2748	490			2116		521		7394	9	178	1111		3484	37291	293	221	19			42606	50000			98	418	265	1399	42	84				2305
2004	1902		87		2064	1078	2		1978		290		7402	17	186	1040		3036	37869	286	154	11			42598	50000		1	48	825	32	1137	49	32				2125
2005	2282		11		2700	1197			2408		424		9023	5	165	336	1	3427	36639	284	112	9			40977	50000		2	46	556	178	922	44	8				1756
2006	1263		4		2033	408	95		2895		831		7529		75	337		3408	38363	157	125	6			42471	50000		0	50	714	4	1005	35	3				1811
2007	2436		10		1705		1		3788	0	501		8441		85	75		3269	48994	43	93				52559	61000			40	520	28	1023	23	4				1638
2008	2393		6		2491	0	5	0	3166		181		8243			132		2376	13540	17	152				16217	24460		1	54	765		1133	24	23			0	2000
2009	1260		2		1951	2	9		3164	0	297		6684	38		101		1344	11448	58	144				13133	19818		0	84	573	11	1250	37	23				1980
2010	725		21		1194	1	23		2292	0	124		4379	1	0	260		1242	4986	188	281		1		6959	11338		3	66	703		1006	40	39				1857
2011	636		19		1125	0	32		2137	0	35		3984			276		962	4306	80	165		1		5790	9774		1	100	945		887	30	26	16	0		2007
2012	283		25		1139	0	27		2311	0	48		3834	2		194		587	6183	8	125		1		7100	10934		1	83	702	2	915	34	17				1754
2013	243		21		1167	2	26		2564	3	138		4163	2		230		605	7992	10	222	17	2		9080	13243		0	70	615	43	691	52	11				1482
2014	95		16		1194	0	26		2376	65	146		3918	9		278		588	8195	11	232	28	1		9343	13261		0	79	636	42	810	40	20	0			1627
2015	172		60		1467		44		2905	2	191		4841	25		348		784	9994	13	192	2	1	0	11360	16201		2	103	572	39	1084	35	6		1		1842
2016	1085		35		1830	42		0	2716	9	252	0	5969	0		282		1523	11319	2		32	4	1	13163	19132		14	78	591		1190	15	10		3		1901
2017	1195		101	0	2214	49	0		3363		249	46	7216	50	0	317	0	1184	14470	17	272	0	1	89	16401	23616		5	99	570		1139	23	13	0	1		1850
2018	692		118	0	2738	11	0	5	4258		333	1	8157	56		546	0	1518	17134	22	300		0	33	19610	27767		2	74	681		1262	3	3		2	0	2027
2019	845	0	348	1	3186	56	8		4595	1	317		9358	72	0	266	0	1436	19519	63	353	40	1	9	21759	31117			156	681		1450	12	4		2	0	2306
2020																													128	548		1460	5	4		4		2149

Table 4. SCRS catalogue on W-BFT area between 1991-2020 (last 30 years)

Species	Stock	Status	FlagName	GearGrp	DSet	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Rank	%	%cum
				T1 Total		2929	2296	2384	2113	2448	2512	2334	2657	2772	2775	2784	3319	2305	2125	1756	1811	1638	2000	1980	1857	2007	1754	1482	1627	1842	1901	1850	2027	2306	2149			
BFT	ATW	CP	USA	RR	t1	696	324	540	462	844	840	931	777	760	683	1244	1523	991	716	425	376	634	658	860	682	592	568	365	478	694	867	795	880	980	1041	1	33.8%	34%
BFT	ATW	CP	USA	RR	t2	abc	abc	abc	abc	abc	bc	abc	abc	abc	abc	abc	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	bc	1		
BFT	ATW	CP	Japan	LL	t1	688	512	581	427	387	436	330	691	365	492	506	575	57	470	265	376	277	492	162	353	578	289	317	302	347	345	346	407	406	408	2	18.5%	52%
BFT	ATW	CP	Japan	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	2		
BFT	ATW	CP	Canada	RR	t1	32	30	88	71	195	155	245	303	348	433	402	508	407	421	497	629	389	475	390	324	295	347	325	331	389	323	344	382	470	419	3	15.2%	68%
BFT	ATW	CP	Canada	RR	t2	ab	ab	ab	ab	ab	ab	ab	ab	bc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	3		
BFT	ATW	CP	USA	LL	t1	305	347	177	185	211	235	191	156	222	242	130	224	299	275	211	205	173	233	335	239	241	295	208	222	89	105	115	103	92	56	4	9.3%	77%
BFT	ATW	CP	USA	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	b	ab	abc	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	4		
BFT	ATW	CP	USA	PS	t1	237	300	295	301	249	245	250	249	248	275	196	208	265	32	178	4	28		11			2	43	42	39						5	5.6%	82%
BFT	ATW	CP	USA	PS	t2	bc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ab	ab	b	b	bc	bc		bc			bc	bc	bc	bc						5		
BFT	ATW	CP	Canada	TL	t1	447	403	284	203	262	298	138	172	125	81	79	39	42	49	44	35	23	24	37	40	30	34	52	40	35	15	23	3	12	5	6	4.7%	87%
BFT	ATW	CP	Canada	TL	t2	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	6		
BFT	ATW	CP	USA	HP	t1	129	105	88	68	77	96	98	133	116	184	102	55	88	41	32	30	23	30	66	29	70	52	45	68	77	53	82	44	118	85	7	3.5%	91%
BFT	ATW	CP	USA	HP	t2	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	b	b	b	b	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	7		
BFT	ATW	CP	Canada	LL	t1	6	9	25	5	4	22	12	32	31	47	20	53	28	43	36	48	58	30	64	89	112	65	67	61	74	85	74	91	143	84	8	2.3%	93%
BFT	ATW	CP	Canada	LL	t2	a	a	a	ab	ab	ab	ab	ab	abc	abc	bc	abc	abc	abc	abc	bc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	8		
BFT	ATW	CP	USA	HL	t1	341	218	224	228	66	33	17	29	15	3	9	4		1	2	0		1	0	3	1	1	0			1	5	1			9	1.8%	95%
BFT	ATW	CP	USA	HL	t2	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	bc	b	b	b	b	c		c	bc	bc	bc	bc	bc			bc	bc	bc			9		
BFT	ATW	CP	Canada	TP	t1		1	29	79	72	90	59	68	44	16	16	28	84	32	8	3	4	23	23	39	26	17	11	20	6	10	13	3	4	4	10	1.3%	96%
BFT	ATW	CP	Canada	TP	t2		ab	ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	10		
BFT	ATW	NCO	NEI (Flag related)	LL	t1									429	270	49																				11	1.1%	97%
BFT	ATW	NCO	NEI (Flag related)	LL	t2									-1	-1	-1																				11		
BFT	ATW	CP	Canada	HP	t1			33	34	43	32	55	36	38	18	20	13	10	7	14	20	17	24	18	37	30	31	25	11	26	25	17	30	38	43	12	1.1%	98%
BFT	ATW	CP	Canada	HP	t2			ab	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	12		
BFT	ATW	CP	Mexico	LL	t1	9	15	17	4	23	19	2	8	14	29	10	12	22	9	10	14	7	7	10	14	14	52	23	51	53	55	34	80	39		13	1.0%	99%
BFT	ATW	CP	Mexico	LL	t2	-1	-1	-1	ab	b	ab	ab	ab	ab	ab	bc	b	ab	ab	ab	ab	abc	ab	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	abc		13		

Table 5. SCRS catalogue on E-BFT area (upper panel: Atlantic, and lower panel: Mediterranean) between 1991-2020 (last 30 years).

Species	Stock	Status	FlagName	GearGrp	DSet	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Rank	%	%cum
					T1 Total	6313	6543	7396	9317	7054	9780	12098	16379	11630	10247	10061	10086	10347	7394	7402	9023	7529	8441	8243	6684	4379	3984	3834	4163	3918	4841	5969	7216	8157	9358			
BFT	ATE	CP	Japan	LL	t1	1464	2981	3350	2484	2075	3971	3341	2905	3195	2690	2895	2425	2536	2695	2015	2598	1896	1612	2351	1904	1155	1089	1093	1129	1134	1386	1578	1911	2270	2524	1	28.0%	28%
BFT	ATE	CP	Japan	LL	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	1		
BFT	ATE	CP	EU-España	BB	t1	1614	1200	1046	3718	1999	2878	4979	6634	2605	1278	1939	2319	2478	1278	1847	2207	1190	2307	2326	1197	641	562	197	163	92	130	983	1109	617	754	2	22.0%	50%
BFT	ATE	CP	EU-España	BB	t2	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	ac	ac	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	2		
BFT	ATE	CP	EU-España	TP	t1	2181	1040	1271	1244	1136	941	1207	2723	1926	3106	1416	1240	1548	784	862	880	1126	1348	1194	1209	887	902	1106	1370	1173	1466	968	1299	1764	1892	3	17.3%	67%
BFT	ATE	CP	EU-España	TP	t2	ac	ac	ab	ab	ac	ab	ab	ab	ac	ac	ab	ac	ac	c	c	abc	b	a	abc	abc	abc	abc	abc	abc	ab	abc	abc	abc	abc	abc	3		
BFT	ATE	CP	Maroc	TP	t1	323	482	94	387	494	210	699	1240	1615	852	1540	2330	1670	1305	1098	1518	1744	2417	1947	1909	1348	1055	990	960	959	1176	1433	1703	2164	2476	4	16.0%	83%
BFT	ATE	CP	Maroc	TP	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	-1	-1	-1	-1	bc	abc	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	4		
BFT	ATE	CP	EU-France	TW	t1	101	70	441	436	224	400		57	259	247	394	456	599	518	289	423	829	501	180	295	122	28	36	120	118	166	211	228	315	309	5	3.5%	87%
BFT	ATE	CP	EU-France	TW	t2	-1	-1	-1	-1	-1	-1		-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	abc	abc	ab	ab	abc	abc	ab	ab	b	ab	ab	a	ab	5		
BFT	ATE	CP	Maroc	PS	t1	54	46	462	24	213	458	323	828	692	709	660	150	884	490	855	871	179														6	3.3%	90%
BFT	ATE	CP	Maroc	PS	t2	b	b	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1														6		
BFT	ATE	CP	EU-France	BB	t1	367	448	372	164	66	181	310	134	282	270	91	105	150	130	47	69	65	128	67	62	83	74	85	74	2	42	99	77	71	88	7	1.8%	92%
BFT	ATE	CP	EU-France	BB	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	a	a	a	ab	ab	b	ab	a	a	ab	7		
BFT	ATE	CP	EU-Portugal	LL	t1	14	98	124	89	143	134	97	246	18	404	398	383	160	33	1	66	72	6	12	5			8	0		0	9	13	112	237	8	1.2%	93%
BFT	ATE	CP	EU-Portugal	LL	t2	-1	a	a	-1	a	-1	-1	a	a	-1	-1	a	a	a	a	ab	a	a	a	a	a		a	a		b	ab	ab	ab	ab	8		
BFT	ATE	CP	EU-Portugal	TP	t1						1	15	19	45	2	40	15	17	27	18	9	25	23	24	46	57	180	215	233	243	263	315	361	330	225	9	1.2%	94%
BFT	ATE	CP	EU-Portugal	TP	t2						b	abc	ac	ac	ab	ab	ab	ab	ab	b	b	b	b	b	b	ab	ab	b	ab	ab	ab	ab	ab	ab	ab	9		
BFT	ATE	NCC	Chinese Taipei	LL	t1				6	20	4	61	226	350	222	144	304	158			10	4														10	0.6%	95%
BFT	ATE	NCC	Chinese Taipei	LL	t2				-1	-1	ab	ab	ab	ab	ab	ab	ab	ab			ab	ab														10		
BFT	ATE	CP	EU-France	GN	t1	42	47	74	497	21	144	253	3	72	71	57	68	6																		11	0.6%	96%
BFT	ATE	CP	EU-France	GN	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1														b	b		b	11		
BFT	ATE	CP	Korea Rep	LL	t1					4	205	92	203			6	1		0	3		1										162	181	208	232	12	0.5%	96%
BFT	ATE	CP	Korea Rep	LL	t2					-1	-1	a	a			a	a		a	a		-1										abc	abc	abc	abc	12		
BFT	ATE	CP	China PR	LL	t1									85	103	80	68	39	19	41	24	42	72	119	42	38	36	36	38	37	45	54	64	79	89	13	0.5%	97%
BFT	ATE	CP	China PR	LL	t2									-1	a	a	a	a	a	a	a	a	ab	a	a	a	ab	a	a	abc	ab	abc	abc	abc	abc	13		
BFT	ATE	CP	EU-España	HL	t1								162	28	33	126	61	63	109	87	11	4	10	6	2	21	19	25	21	16	59	35	101	107	82	14	0.5%	97%
BFT	ATE	CP	EU-España	HL	t2								ab	ac	ac	ab	ac	ac	c	c	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	14		
BFT	ATE	CP	EU-Portugal	BB	t1	12	5	4	2	219	34	80	447	252	5	2	2	7	1	8	6	7	1									3	8	4	3	15	0.5%	98%
BFT	ATE	CP	EU-Portugal	BB	t2	a	-1	a	ab	ab	ab	abc	abc	ab	ab	a	a	a	ab	abc	ab	a	a			a						abc	a	ab	ab	15		

Species	Stock	Status	FlagName	GearGrp	DSet	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Rank	%	%cum
					T1 Total	17286	19846	24435	24941	39715	37523	39399	34831	38370	39753	39939	39914	39653	42606	42598	40977	42471	52559	16217	13133	6959	5790	7100	9080	9343	11360	13163	16401	19610	21759			
BFT	MED	NCO	NEI (inflated)	PS	t1									9471	16893	16458	15298	15880	18873	18376	14164	18343	28234													1	21.3%	21%
BFT	MED	NCO	NEI (inflated)	PS	t2									-1	-1	-1	-1	-1	-1	-1	-1	-1	-1													1		
BFT	MED	CP	EU-France	PS	t1	4663	4570	7346	6965	11803	9494	8547	7701	6800	5907	6780	6119	5810	5549	6339	8328	7438	9543	2536	2918	1546	678	678	1940	1944	2299	2763	3320	3930	4374	2	19.7%	41%
BFT	MED	CP	EU-France	PS	t2	bc	bc	b	b	b	b	b	b	bc	bc	bc	bc	bc	bc	bc	bc	bc	ab	abc	abc	abc	ab	ab	abc	abc	b	ab	abc	ab	ab	2		
BFT	MED	CP	EU-Italy	PS	t1	2651	2652	3846	4162	4654	3613	7060	7068	3334	1859	2801	3256	3246	3849	3752	3961	4006	4311	1854	2339	2	752	1374	1474	1539	1678	2050	2409	2885	3347	3	11.4%	52%
BFT	MED	CP	EU-Italy	PS	t2	-1	-1	-1	-1	-1	ac	-1	-1	b	b	b	-1	b	b	b	b	b	a	ab	abc	-1	abc	-1	-1	b	b	b	b	b	b	3		
BFT	MED	CP	Turkey	PS	t1	2059	2459	2817	3084	3466	4219	4616	5093	5899	1200	1070	2100	2300	3300	1075	990	806	918	879	665	409	528	536	551	544	1091	1324	1515	1273	1761	4	7.3%	60%
BFT	MED	CP	Turkey	PS	t2	-1	-1	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	ab	ab	ab	ab	ab	ab	ab	abc	abc	bc	ab	ab	a	4		
BFT	MED	CP	Tunisie	PS	t1	114	1073	975	1997	2523	1617	2147	1992	1662	2263	2134	2432	2510	740	2266	3245	2542	427	2679	1932	1042	852	1017	1057	1057	1248	1461	1755	2101	2378	5	6.4%	66%
BFT	MED	CP	Tunisie	PS	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	a	-1	-1	-1	a	b	abc	abc	ab	ab	ab	abc	ab	ab	b	abc	ab	abc	ab	5		
BFT	MED	CP	EU-España	PS	t1	635	807	1366	1431	1725	2896	1657	1172	1573	1504	1676	1453	1686	1886	1778	2242	2013	1649	1645	1167	804	877	1034	917	1122	1169	952	1523	2433	2457	6	5.6%	72%
BFT	MED	CP	EU-España	PS	t2	ab	ab	ab	ab	ab	ab	ab	ab	abc	abc	ab	ab	ab	ab	ab	ab	ab	bc	ab	ab	ab	ab	b	ab	ab	ab	ab	b	b	ab	6		
BFT	MED	CP	EU-Croatia	PS	t1		1418	1076	1058	1410	1220	1360	1088	889	921	914	890	975	1137	827	1017	1022	817	821	609	370	366	367	380	378	438	436	587	679	751	7	3.0%	75%
BFT	MED	CP	EU-Croatia	PS	t2		a	a	a	a	-1	-1	-1	-1	-1	-1	a	ab	a	ab	ab	ab	ab	ab	ab	ab	ab	a	a	ab	abc	abc	abc	ab	abc	7		
BFT	MED	CP	Libya	PS	t1	129	177	300	568	470	495	598	32	230	195	503		200	512	872	730	1140	1200	1267	1047	645		763	933	933	1153	1368	1631	1792	2052	8	2.7%	77%
BFT	MED	CP	Libya	PS	t2	-1	-1	b	-1	-1	-1	-1	-1	-1	a	a		-1	-1	-1	-1	-1	a	-1	-1	-1		ab	ab	b	ab	ab	b	b	b	8		
BFT	MED	CP	Algerie	PS	t1	547	560	773	768	1092				900	1056	778	917	922	640	753	623	850	650	972				69	244	244	370	448	1038	1300	1437	9	2.2%	80%
BFT	MED	CP	Algerie	PS	t2	-1	-1	-1	-1	-1				-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1				ab	abc	ab	ab	b	b	b	abc	9		
BFT	MED	CP	EU-Italy	LL	t1	79	102	78	135	1018	2103	2100	1620	674	515	287	260	395	475	302	310	286	217	216	193	521	670	256	180	115	312	434	411	528	566	10	1.9%	81%
BFT	MED	CP	EU-Italy	LL	t2	-1	a	a	b	ab	ab	ab	a	ab	a	ab	a	a	ab	b	b	ab	ab	abc	abc	abc	abc	abc	abc	ac	abc	abc	abc	bc	abc	10		
BFT	MED	CP	EU-España	LL	t1	149	277	371	187	245	435	416	871	253	418	493	644	436	583	529	484	668	745	804	590	240	58	26	24	34	57	490	126	232	56	11	1.4%	83%
BFT	MED	CP	EU-España	LL	t2	abc	ab	ab	ab	ab	abc	ab	ab	ab	ac	ab	ac	ac	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	abc	11		
BFT	MED	CP	Libya	LL	t1	173	164	372	67	802	865	656	925	920	900	1002	1867	331	170	393	318	187	158	51	34											12	1.3%	84%
BFT	MED	CP	Libya	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	ac	a	a	-1	-1	-1	-1	-1	a	b	b											12		
BFT	MED	CP	EU-Greece	HL	t1	124	98	348	339	766	915	784	1127	279	233	597	341	394	245	73		6	7	93	66	135	52	39	35	78	90	34	45	69	78	13	0.9%	85%
BFT	MED	CP	EU-Greece	HL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	a	a	-1	-1	a	-1		-1	-1	a	a	a	a	a	a	a	a	a	a	-1	-1	13		
BFT	MED	CP	Panama	LL	t1	74	287	484	467	1499	1498	2850	236																							14	0.9%	86%
BFT	MED	CP	Panama	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1																							14		
BFT	MED	CP	Algerie	LL	t1							482	672	175	179	801	503	806	706	501	712	748	754	339												15	0.9%	87%
BFT	MED	CP	Algerie	LL	t2							-1	-1	-1	-1	b	b	b	b	b	-1	b	ab	ab	b											15		
BFT	MED	CP	Japan	LL	t1	172	85	123	793	536	813	765	185	361	381	136	152	390	316	638	378	556	466	80	18											16	0.9%	88%
BFT	MED	CP	Japan	LL	t2	abc	abc	abc	abc	abc	abc	abc	ac	abc	ac	ac	ac	ac	ac	ac	abc	ac	abc	a	abc											16		
BFT	MED	CP	Maroc	HL	t1					373	816	541	455	634	600	650	195	407	570	597	80	187	19		2		78	120	130	134	138	140	185	265		17	0.9%	89%
BFT	MED	CP	Maroc	HL	t2					-1	c	-1	-1	-1	abc	ab	abc	b	b	b	b	b	b		b		abc	abc	abc	abc	abc	abc	abc	abc	ab	17		
BFT	MED	CP	EU-Italy	TP	t1	285	263	364	249	201	255	491	225	419	308	353	427	364	145	119	69	125	93	149	144	281	165	125	222	231	192		272	300	353	18	0.9%	90%
BFT	MED	CP	EU-Italy	TP	t2	-1	-1	c	b	bc	bc	b	b	b	b	b	b	b	b	b	b	b	ab	ab	ab	ab	abc	ac	-1	-1	-1		b	-1	-1	18		
BFT	MED	CP	EU-Malta	LL	t1	81	105	80	251	572	587	399	393	407	447	376	219	240	255	264	321	263	144	165	263	136	92	137	89	91	49	97	115	127	80	19	0.8%	90%
BFT	MED	CP	EU-Malta	LL	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	ac	ac	ac	-1	-1	-1	abc	bc	ab	ab	ab	ab	ab	abc	abc	abc	abc	abc	abc	abc	abc	19		
BFT	MED	NCO	NEI (combined)	PS	t1	19	49	49		773	211		101	1030	1995	109	571	508	610	709																20	0.8%	91%
BFT	MED	NCO	NEI (combined)	PS	t2	-1	-1	-1		-1	-1		-1	-1	-1	-1	-1	-1	-1	-1																20		
BFT	MED	CP	EU-Italy	RR	t1	332	364	336	470	775	766	277	235	9	245	217	229	340	284	284	283	157		17	58	165	66	8	10	10	11		15	18	20	21	0.7%	92%
BFT	MED	CP	EU-Italy	RR	t2	-1	-1	-1	-1	-1	b	b	-1	-1	-1	-1	-1	-1	-1	b	b	b		-1	-1	b	-1	-1	-1	-1	-1		-1	-1	-1	21		
BFT	MED	CP	EU-France	LL	t1						60	580	500	300	246				300	130	309	226	614	134	131	184	112	112	232	234	238	259	289	368	426	22	0.7%	93%
BFT	MED	CP	EU-France	LL	t2						-1	-1	-1	-1	-1				-1	-1	-1	-1	-1	-1	a	a	a	a	a	a	b	ab	ab	a	ab	22		
BFT	MED	CP	EU-Italy	HL	t1	714	197	189	152	179	226	205	301	5	340	171	184	283	229	241	229	133	16	12	14	93	130	25	51	50	79			128		23	0.6%	93%
BFT	MED	CP	EU-Italy	HL	t2	-1	b	b	-1	b	b	-1	-1	b	b	b	b	-1	b	b	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1			-1		23		
BFT	MED	NCC	Chinese Taipei	LL	t1				328	709	494	411	278	106	27	169	329	508	445	51	267	5														24	0.5%	94%
BFT	MED	NCC	Chinese Taipei	LL	t2				-1	-1	b	b	ab	ab	ab	ab	ab	ab	ab	ab	ab	ab														24		
BFT	MED	CP	Maroc	TP	t1	1118	912	201	73	703	127	15	63	35	30	39	307							3												25	0.4%	94%
BFT	MED	CP	Maroc	TP	t2	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1							-1												25		
BFT	MED	CP	Algerie	TP	t1	235	240	331	329	468	156	156	157	399	367	290	366	41																		26	0.4%	95%
BFT	MED	CP	Algerie	TP	t2	-1	-1	b	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1																		26		
BFT	MED	NCO	NEI (combined)	LL	t1	341	1750	1349																												27	0.4%	95%
BFT	MED	NCO	NEI (combined)	LL	t2	-1	-1	-1																												27		

Table 6. Summary of the evaluation CPUE table for the West Atlantic bluefin tuna stock assessment.

Document	SCRS/2021/035	SCRS/P/2018/055	SCRS/2021/034	SCRS/2021/038	SCRS/2021/041	SCRS/2021/036	SCRS/2017/020
Index	MEXUS Pelagic LL GOM	Larval survey	US Rod and Reel, Small Fish	US Rod and Reel , Large Fish	Japanese West Atl LL	Canadian Acoustics	Combined CAN rod and reel
Diagnostics	5	Most of the appropriate diagnostics appear to be included	5	N/A	4(Most of the appropriate diagnostics appear to be included)	2 Comparison to GSL CPUE	All the appropriate diagnostics were included
Appropriateness of data exclusions and classifications (e.g. to identify targeted trips).	4 (scientific observer data, extensive data summaries at 1 degree spatial scale to identify model strate, seasonality modeled, gear-fleet regultations modeled. However these are bycatch fisheries)	data collection method detailed, data come from a survey, few data exclusions	4 (Data treatments and exclusions were peer-reviewed iin workshops involveing stakeholders and expert review panels. Extensions included trips that targeted bluefin tuna during the fishing season)	4 (Data exclusions are covered and included only trip that targeted bluefin tuna during the main fishing season)	5 (Data exclusions are covered and included only main BFT target months)	3 High certainty that targets are Bluefin tuna. TS within acceptable bounds	data exclusions are indicated, classifications appropriate.
Geographical Coverage (East or west Atlantic? Or Med)	4 (covers Gulf of Mexico basin)	2 (coverage limited to northern Gulf of Mexico during May)	3 (moderate coverage of the mixed stock foraging grounds in the West Atlantic during the summer and early fall)	3 (moderate coverage of the stock foraging grounds in the West Atlantic during the summer and early fall)	5(West Atlantic. Distribution maps are provided)	2 Coverage is limited to Baie de Chaleaur. Major fishery occurs off PEI which is not covered.	Gulf of St. Lawrence and north east Scotian Shelf areas
Catch Fraction to the total catch weight (East or West)	2 (100% of US longline in GOM, but only a discard fishery)	No direct catch	2 (represents a small portion of the recreational landings of the stock by the fleet	3 (represents a moderate portion of the landings of the stock by the U.S.	20%	N/A	15%
Length of Time Series relative to the history of exploitation.	4 (26 years, 1994 to 2019)	5 (implemented since 1976, with few missing years)	4 (25 years, 1995 to present)	3 (series runs from 1993 to present)	5(yes, 1976-2009,2010-2020)	3 (1994-2019)	1984-2016
Are other indices available for the same time period?	3 (yes)	No (not with same time series coverage)	No (only juvenile to sub-adult bluefin index available for the W Atlantic)	2 (yes, but no overlap with the main U.S. fishery)	5(Yes)	3 Yes (GSL CPUE), but not fishery indepent.	this index is a derivative
Does the index standardization account for Known factors that influence catchability/selectivity?	4 (multinational LL standardized index, modeled monthly seasonailty by region, hook type gear modifications, SST at set,)	Methodology for standardisation of the series appears to be appropriate for a survey	4 (index for bluefin trips by sizeclass targeted and standardized for year, month, SST, vessel type)	4 (index for bluefin trips by sizeclass targeted and standardized for year, area, fishing method and regulatory effects)	5(gear type is included as is a selectivity proxy. area*month interaction was considered as random effect)	2 Index is area weighted. There is an Initial model-based index standardization to account for environmental, boat, and prey abundance. Work is ongoing	Yes
Are there conflicts between the catch history and the CPUE response?	4 (No conflict noted, but interannual variability is high for SSB relative to changes in catches)	NA	3 (No conflict clearly identified, but observed catches low compared to fleet observations)	No	5(No conflict noted)	Catch history for Baie de Chaleaur is mostly absent	No
Is interannual CV high, and is there potential evidence of unaccounted process error (trends in deviations from production model dynamics, high peaks, multiple stanzas, increasing or decreasing catchability)	relatively high interannual variability, mean CV = 0.2	relatively high CV and interannual variability	interannual variability expected to be higher for indices referencing smaller sizeclasses		CV=0.36 Devs 0.46 (averaged values thoughout analysis period)	CV=0.47	
Assessment of data quality and adequacy of data for standardization purpose (e.g. sampling design, sample size, factors considered)	3 (Multinational LL index, first year produced, improvement to US LL Gulf of Mexico index, models fish seasonality by region, fleet regulations, broader spatial coverage of entire Gulf region	data is presented and methodolgy for standardisation explicitly presented. Factors appear to be appropriate for a survey	3 (extensive review of sampling design and the relevant factors was conducted and reviewed by a panel of experts. Sample sizes ranged in the hundreds of intercepts per year. Expected	3 (the sampling design and the relevant factors available for consideration in the standardization are very good. The sample size is not always good, after all the data exclusions related to targeting and fishing method are applied.)	5(information includes length frequencies of catches. Multiple factors included. Sample design and sensitivity runs investigate effort distribution as well as data assumptions/concerns and effort is presented)	3 Assessed for changes in vessel/equipment change. Environmental and prey availability data assessment is ongoing	
Is this CPUE time series continuous?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Comment	Recommended to replace the USA Gulf of Mexico LL index in the asssessment						

Table 7. Abundance indices for W-BFT for the 2021 W-BFT stock assessment and MSE.

series	US RR 66-114cm		US RR 115-144cm		US RR 66-144cm		US RR >177cm		US RR<145cm		US RR>195cm		US GOM PLL1		US GOM PLL2*		MEXUS GOM LL	
age	66-114cm		115-144cm		66-144cm		>177cm		<145cm		>195cm		8-16		8-16		8-35	
indexing	Number		Number		Number		Number		Number		Number							
area	West Atl		West Atl		West Atl		West Atl		West Atl		West Atl		GOM		GOM		GOM	
method	GLMM		GLMM		Negative binomial GLM		GLMM		GLMM		GLMM		Delta Lognormal RE		Delta Lognormal RE		Negative binomial GLM	
time of the year					June to October		July to October											
source	SCRS/2021/034		SCRS/2021/034		SCRS/2021/034		SCRS/2021/038		SCRS/1993/067		SCRS/1993/067		SCRS/2021/026		SCRS/2021/026		SCRS/2021/035	
Use in VPA	no		no		yes		possibly yes		yes		yes		no		no		yes	
Use in SS3 and OM	no		no		yes		yes		yes		yes		no		no		yes	
Year	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV
1970																		
1971																		
1972																		
1973																		
1974																		
1975																		
1976																		
1977																		
1978																		
1979																		
1980									0.80	0.43								
1981									0.40	0.52								
1982									2.10	0.33								
1983									1.11	0.26	2.81	0.10						
1984											1.25	0.19						
1985									0.63	0.64	0.86	0.30						
1986									0.78	0.43	0.50	1.10						
1987									1.22	0.40	0.53	0.48	1.32	0.29				
1988									0.99	0.38	0.94	0.36	0.64	0.32				
1989									0.99	0.43	0.76	0.36	0.99	0.31				
1990									0.90	0.34	0.63	0.34	0.77	0.32				
1991									1.26	0.35	0.82	0.28	1.29	0.30				
1992									0.82	0.42	0.91	0.28			1.14	0.35		
1993							0.53	0.13							0.64	0.36		
1994							0.61	0.17							0.47	0.39	0.89	0.30
1995	1.33	0.15	0.86	0.20	1.24	0.12	1.66	0.27							0.44	0.39	0.43	0.28
1996	1.34	0.15	1.18	0.20	1.33	0.12	2.74	0.31							0.25	0.40	0.78	0.19
1997	2.69	0.12	0.30	0.22	1.97	0.10	1.17	0.21							0.47	0.36	0.22	0.53
1998	0.97	0.12	0.79	0.17	0.95	0.10	1.58	0.26							0.50	0.37	0.76	0.28
1999	0.79	0.21	1.26	0.26	0.89	0.17	1.56	0.25							0.84	0.33	0.44	0.25
2000	1.16	0.21	0.84	0.30	1.14	0.18	0.97	0.18							1.25	0.33	2.31	0.15
2001	0.47	0.14	1.70	0.16	0.76	0.11	2.00	0.29							0.71	0.38	0.95	0.18
2002	0.97	0.18	1.56	0.22	1.07	0.15	1.88	0.23							0.66	0.39	1.41	0.17
2003	0.58	0.11	0.81	0.14	0.66	0.09	0.54	0.15							1.20	0.32	1.16	0.15
2004	1.77	0.11	0.90	0.15	1.61	0.09	0.31	0.14							1.09	0.32	0.58	0.17
2005	1.68	0.12	0.86	0.18	1.57	0.11	0.41	0.16							0.82	0.34	0.55	0.16
2006	0.64	0.19	1.01	0.25	0.72	0.16	0.26	0.16							0.58	0.39	0.79	0.16
2007	0.54	0.11	1.19	0.13	0.70	0.09	0.27	0.14							0.77	0.38	0.50	0.15
2008	0.34	0.13	1.81	0.13	0.68	0.10	0.25	0.14							1.79	0.33	0.83	0.14
2009	0.54	0.14	0.68	0.20	0.55	0.12	0.29	0.14							1.47	0.35	0.70	0.14
2010	0.63	0.13	1.74	0.15	0.87	0.10	0.62	0.18							1.23	0.34	0.51	0.15
2011	0.81	0.14	0.59	0.20	0.77	0.12	0.74	0.18							1.10	0.48	0.94	0.16
2012	0.96	0.15	0.52	0.24	0.85	0.13	0.54	0.18							3.42	0.37	1.50	0.13
2013	0.99	0.15	2.36	0.18	1.31	0.13	0.39	0.14							1.24	0.42	0.73	0.14
2014	0.82	0.18	0.81	0.24	0.80	0.15	0.45	0.15							0.96	0.44	1.28	0.14
2015	0.43	0.17	0.26	0.28	0.39	0.14	0.80	0.19							1.03	0.47	1.88	0.13
2016	0.46	0.18	1.03	0.21	0.58	0.15	1.07	0.22							1.10	0.47	1.58	0.13
2017	0.96	0.17	0.87	0.24	0.95	0.14	1.54	0.27							0.82	0.48	1.17	0.15
2018	0.82	0.18	0.11	0.54	0.69	0.16	1.54	0.27							1.04	0.51	1.47	0.14
2019	1.23	0.15	1.72	0.20	1.26	0.13	1.76	0.30							0.62	0.59	1.62	0.14
2020	2.07	0.17	0.24	0.42	1.70	0.15	1.50	0.27							1.21	0.59		

Table 7. Continued.

series	GOM Larval Survey		JPN LL1		JPN LL2		JPN LL GOM		CAN Acoustic survey1		CAN Acoustic survey2		CAN GSL HL		CAN SWNS HL		CAN combined RR	
age	8-16		4 - 10		5 - 16		9-16		5-16		5-16		8-16		5-16		5-16	
indexing			Number		Number		Number											
area	GOM		West Atl		West Atl		GOM		Gulf of St Lawrence		Gulf of St Lawrence		Gulf of St. Lawrence		SW Nova Scotia		GSL & SWNS	
method	Delta-lognormal GLM		Delta Lognormal RE		Delta Lognormal RE		Delta Lognormal RE											
time of the year	May		Begin-year		Begin-year													
source	SCRS/P/2018/055		SCRS/2021/040		SCRS/2021/040		SCRS/1991/071		SCRS/2021/036		SCRS/2021/036		SCRS/2021/025		SCRS/2021/025		SCRS/2019/194	
Use in VPA	yes		yes		yes		yes		yes		no		yes		yes		no	
Use in SS3 and OM	yes		yes		yes		yes		yes		no		yes		yes		no	
Year	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV	Std. index	CV
1970																		
1971																		
1972																		
1973																		
1974							0.97	0.27										
1975							0.53	0.21										
1976			0.38	0.44			0.67	0.21										
1977	2.45	0.46	0.97	0.34			0.91	0.22										
1978	4.49	0.24	0.78	0.37			0.88	0.23										
1979			0.83	0.31			1.29	0.28										
1980			1.48	0.31			1.16	0.27										
1981	0.79	0.44	1.21	0.29			0.55	0.24										
1982	1.30	0.29	0.84	0.30														
1983	1.08	0.34	0.49	0.37														
1984	0.37	0.54	0.73	0.32													0.03	0.16
1985			0.91	0.29													0.02	0.18
1986	0.37	0.43	0.01	1.75													0.01	0.22
1987	0.31	0.48	0.41	0.36													0.01	0.37
1988	1.14	0.32	0.36	0.41									0.03	0.34			0.02	0.26
1989	0.75	0.37	0.74	0.33									0.03	0.35			0.03	0.22
1990	0.32	0.34	0.51	0.35									0.01	0.32			0.01	0.25
1991	0.37	0.57	0.63	0.33									0.01	0.39			0.02	0.23
1992	0.45	0.35	1.12	0.29									0.06	0.26			0.04	0.18
1993	0.45	0.65	1.06	0.30									0.10	0.20			0.04	0.16
1994	0.58	0.33	0.98	0.29					0.03	0.28			0.04	0.22			0.01	0.17
1995	0.26	0.55	0.67	0.37					0.03	0.14			0.12	0.18			0.04	0.14
1996	0.80	0.49	2.32	0.30					0.07	0.10			0.02	0.19	1.01	0.34	0.01	0.14
1997	0.33	0.38	1.71	0.29					0.04	0.12			0.02	0.19	0.75	0.34	0.01	0.14
1998	0.12	0.53	0.79	0.32					0.04	0.21			0.03	0.18	0.97	0.34	0.03	0.14
1999	0.46	0.49	1.16	0.29					0.04	0.12			0.05	0.18	1.20	0.36	0.03	0.14
2000	0.27	0.52	1.14	0.30					0.02	0.14			0.04	0.17	0.65	0.36	0.02	0.14
2001	0.41	0.32	0.95	0.30					0.04	0.15			0.04	0.18	0.81	0.33	0.03	0.14
2002	0.24	0.63	0.85	0.31					0.02	0.19			0.07	0.16	0.78	0.29	0.03	0.14
2003	0.72	0.38	1.28	0.32					0.04	0.14			0.08	0.16	0.85	0.31	0.03	0.14
2004	0.50	0.67	1.18	0.33					0.04	0.07			0.15	0.15	1.20	0.29	0.04	0.14
2005	0.18	0.29	1.10	0.29					0.05	0.05			0.12	0.15	1.21	0.30	0.04	0.14
2006	0.54	0.36	1.60	0.32					0.06	0.07			0.11	0.14	1.44	0.29	0.04	0.14
2007	0.44	0.37	0.95	0.44					0.04	0.13			0.18	0.15	1.29	0.29	0.04	0.14
2008	0.34	0.38	1.42	0.47					0.03	0.08			0.15	0.14	1.36	0.29	0.04	0.14
2009	0.57	0.32	2.40	0.38					0.06	0.09			0.22	0.14	2.30	0.29	0.06	0.14
2010	0.31	0.52			0.18	0.41			0.07	0.04			0.27	0.17	2.14	0.29	0.09	0.15
2011	1.04	0.39			0.64	0.29			0.05	0.08			0.19	0.15	1.79	0.29	0.08	0.14
2012	0.29	0.48			0.82	0.29			0.10	0.07			0.25	0.15	1.74	0.29	0.09	0.14
2013	1.05	0.35			0.65	0.29			0.06	0.06			0.24	0.15	1.31	0.30	0.08	0.14
2014	0.26	0.37			0.69	0.31			0.08	0.06			0.24	0.15	1.48	0.31	0.09	0.14
2015	0.38	0.30			0.45	0.29			0.08	0.10			0.20	0.14	1.48	0.30	0.07	0.14
2016	2.35	0.26			1.04	0.32			0.09	0.01			0.25	0.15	1.91	0.32	0.10	0.14
2017	0.99	0.29			1.11	0.34			0.05	0.01			0.22	0.15	1.94	0.31	0.07	0.14
2018	2.07	0.24			2.15	0.32					0.01	0.01	0.23	0.15	1.66	0.30	0.08	0.14
2019	1.59	0.29			1.88	0.31					0.02	0.01	0.24	0.15	1.94	0.30		
2020					1.38	0.34							0.22	0.21	2.28	0.33		

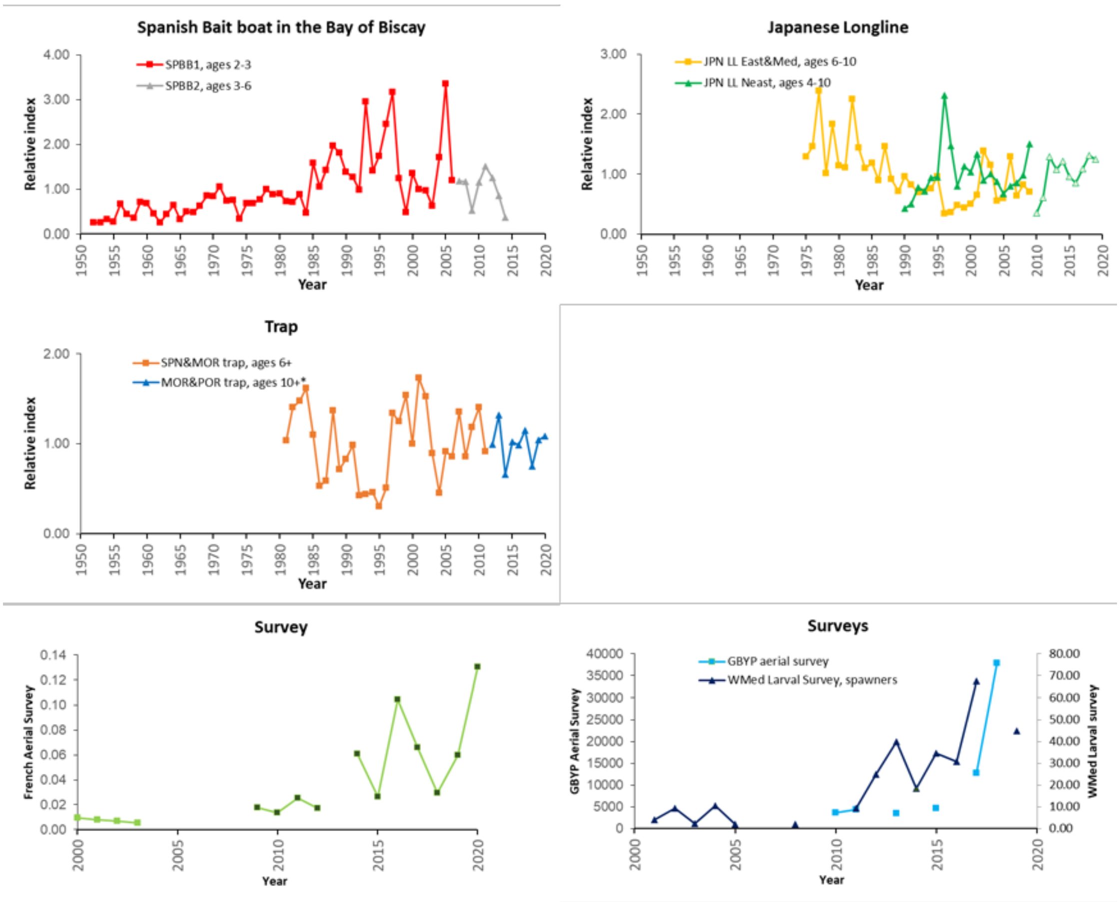
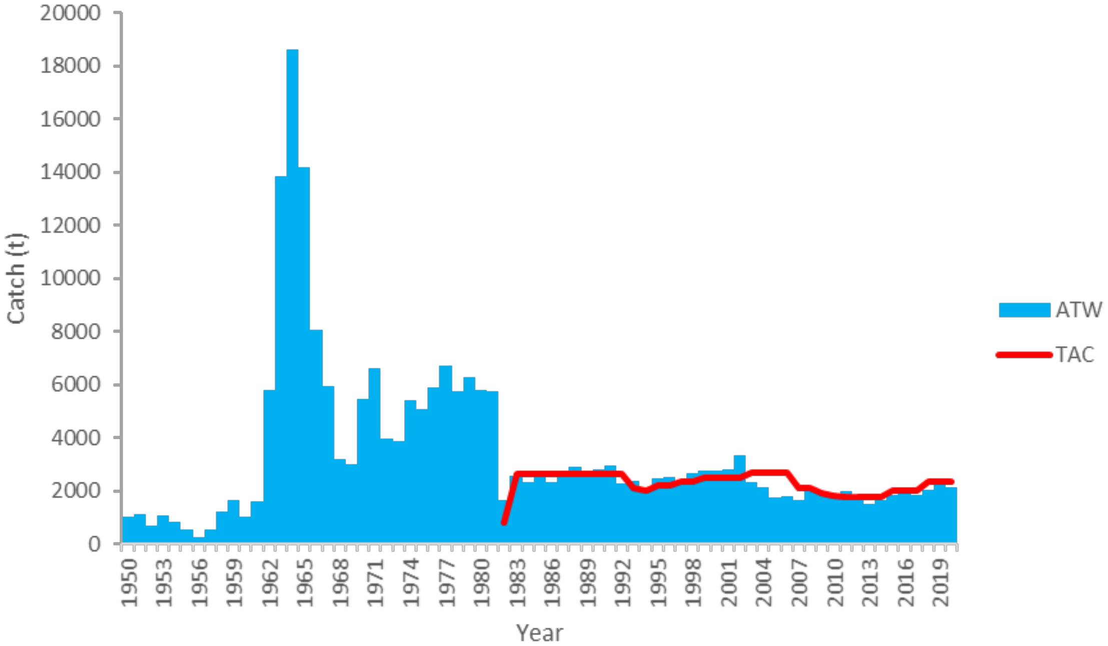


Figure 1. Abundance indices for the E-BFT in the BFT MSE in 2021.

(a) W-BFT



(b) E-BFT

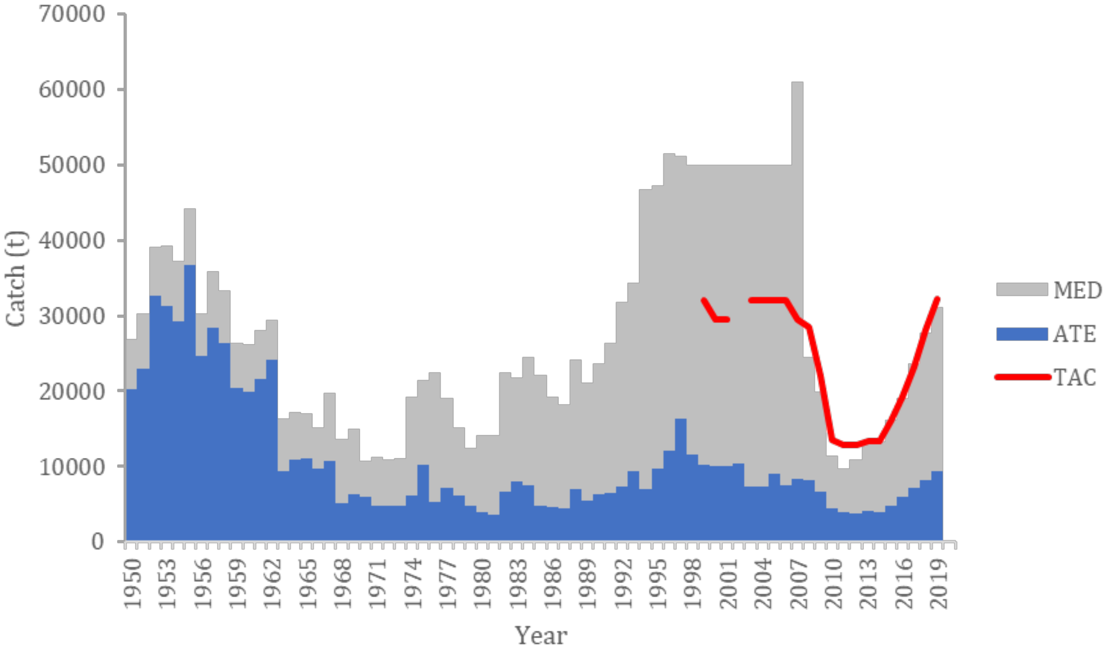


Figure 2. BFT cumulative catches (t) by year for (a) W-BFT and (b) E-BFT areas with TAC (red line), using Task 1 nominal catches, which includes landings and dead discards.

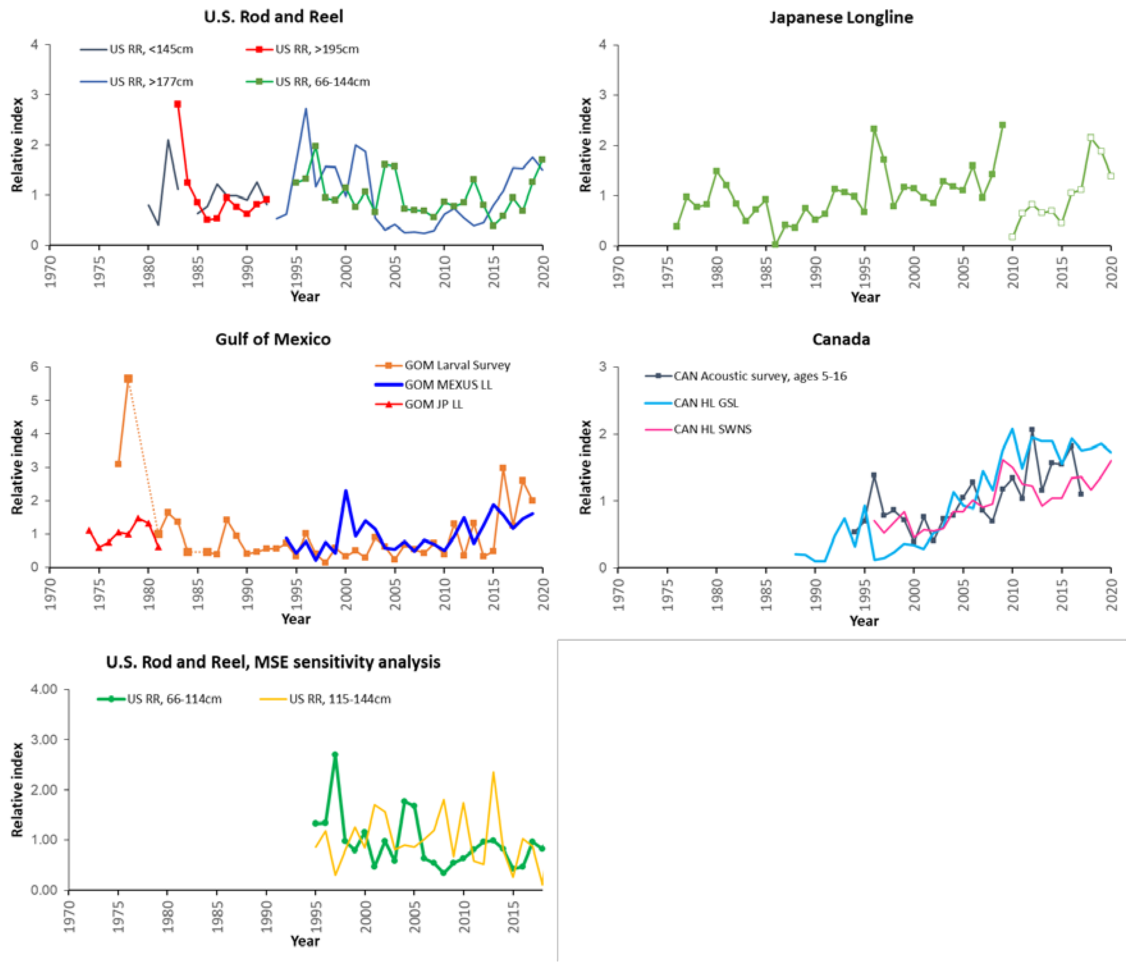


Figure 3. Abundance indices for W-BFT for the 2021 W-BFT stock assessment and the MSE.

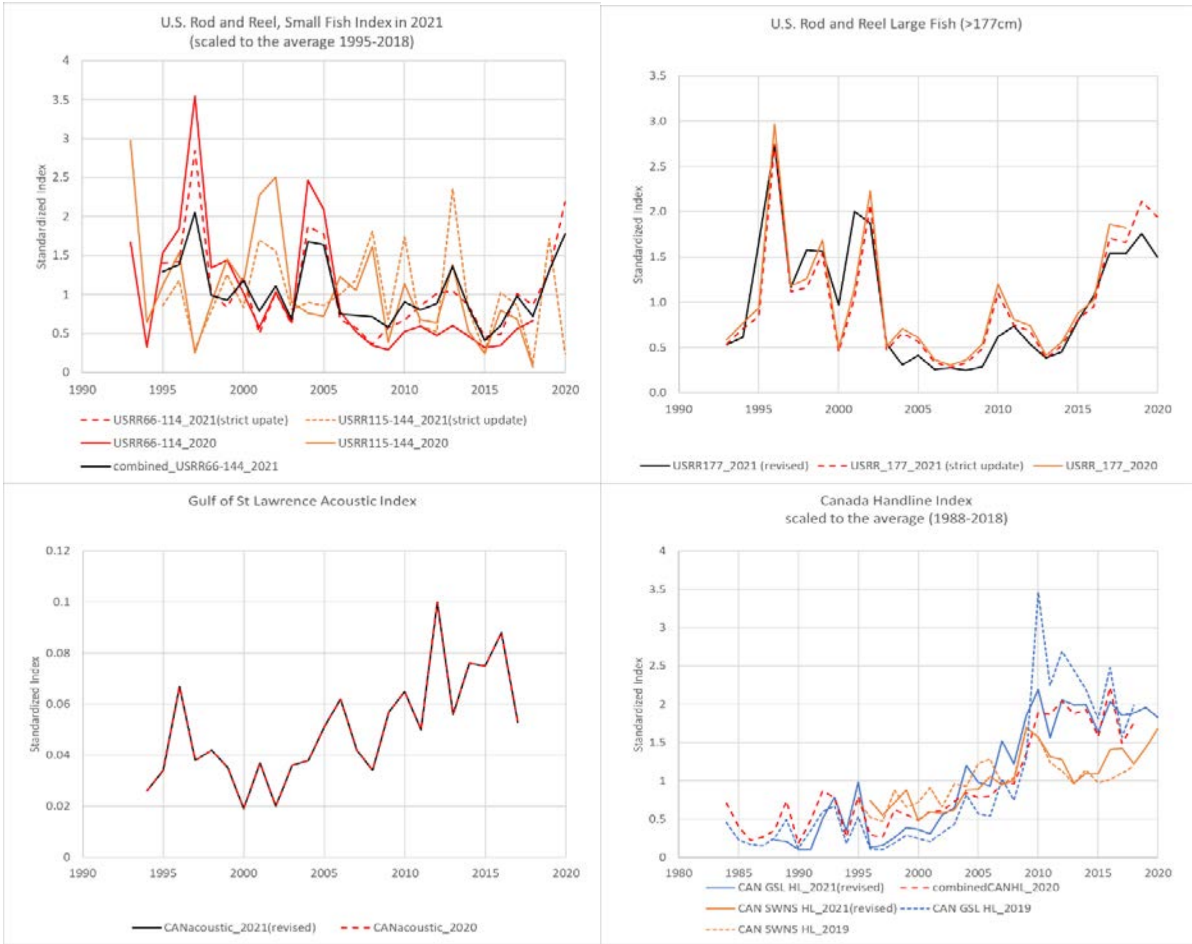


Figure 4. Comparisons of abundance indices between one used in the 2020 stock assessment or in the BFT MSE and the strict update or revised index in 2021, for W-BFT and E-BFT.

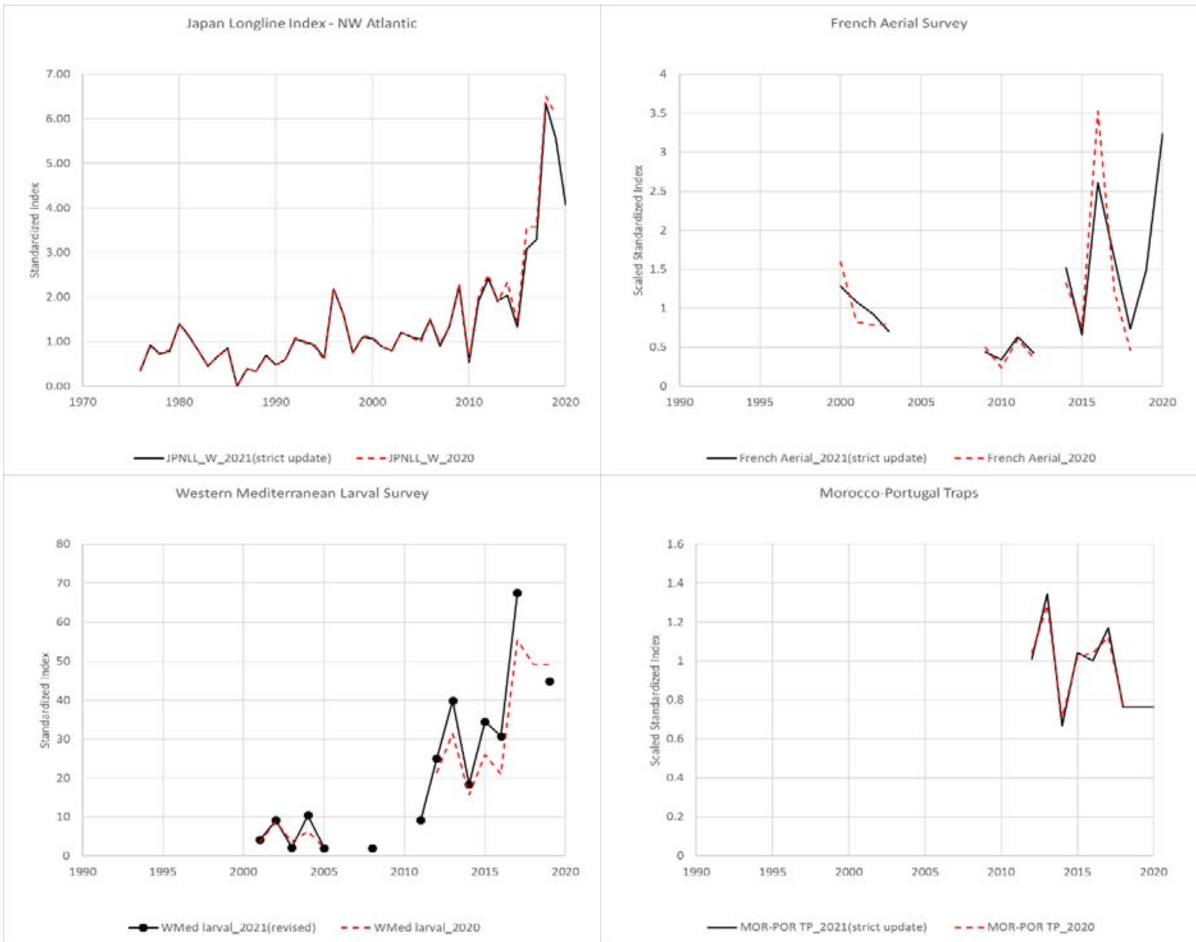


Figure 4. Continued.

Appendix 1

Agenda

1. Opening, adoption of agenda and meeting arrangements
2. Summary of SCRS response to Panel 2 meeting
3. MSE
   - 3.1 Review of the data for OM reconditioning
   - 3.2 Update from CMP developers on progress
   - 3.3 Discussion on poll results and plausibility weighting of OMs
   - 3.4 Reference Grid finalization and adoption
   - 3.5 Finalization of input data for reconditioning
   - 3.6 TOR for MSE code review
4. Progress of Technical Sub-groups
   - 4.1 Technical Sub-group on Abundance Indices
   - 4.1.1 E-BFT overview
   - 4.1.2 W-BFT overview
   - 4.2 Technical Sub-group on Assessment models
   - 4.3 Technical Sub-group on Growth in Farms
5. GBYP matters
   - 5.1 Aerial survey review
   - 5.2 Intersessional workshops
   - 5.2.1 Report from Close-Kin Workshop
   - 5.2.2 Report from Electronic Tagging Workshop
6. Preparation for the W-BFT assessment
   - 6.1 TOR for W-BFT stock assessment
   - 6.2 Biology and age data
   - 6.3 Size and age composition
   - 6.4 Catch estimates
   - 6.4.1 Task I Nominal catches
   - 6.4.2 Assumptions for projections
   - 6.5 Indices of abundance
   - 6.6 Stock assessment models and its specification
7. Other matters
8. Adoption of the report and closure

Appendix 2

List of participants

CONTRACTING PARTIES

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Appendix 3

List of papers and presentations

Number	Title	Authors
SCRS/2021/018	Further refinements of the BR CMP	Butterworth D.S., and Rademeyer R.A.
SCRS/2021/019	Review of the size distribution of caged eastern blufin tuna (*Thunnus Thynnus*) in Turkish farms 2014 -2020.	Ortiz M., Mayor C., and Paga A.
SCRS/2021/020	Update of the French aerial abundance index for 2020 and first attempt at accounting for the environmental effects on bluefin tuna availability in the Gulf of Lions	Rouyer T., Bal G., Derridj O., and Fromentin J.M.
SCRS/2021/022	On comparing CMPs across different development tunings and the associated pertinence of OM weighting	Butterworth D.S., Rademeyer R.A., and Carruthers T.R.
SCRS/2021/023	Report of the 2021 ICCAT GBYP Workshop on Close-Kin Mark Recapture for Eastern Atlantic Bluefin Tuna (Online, 8-9 February 2021)	Anonymous
SCRS/2021/024	Report of the 2021 ICCAT GBYP Workshop on Electronic Tagging for Atlantic Bluefin Tuna (Online, 15-16 March 2021)	Anonymous
SCRS/2021/025	Updated indicators of relative abundance for bluefin tuna based on revised treatments of the Canadian fisheries data	Hanke A.R. *et al.*
SCRS/2021/026	An updated index for western bluefin tuna from the US Gulf of Mexico longline fishery	Walter J.F.
SCRS/2021/027	Length frequencies in the Canadian and USA Rod and Reel Fisheries for Atlantic bluefin tuna	Maguire J.-J., Hanke A., Duprey N., and Gillepsie K.
SCRS/2021/028	Training an A.I. CMP for Atlantic bluefin tuna	Carruthers T. R.
SCRS/2021/029	Summary of the Atlantic Bluefin tuna MSE poll for plausibility weighting	Kimoto A., and Walter J.F.
SCRS/2021/030	Notes from the BFT CMP developers webinar in March 2021	Walter J.F.
SCRS/2021/031	Summary of input data (catch, size and indices) used in the Atlantic bluefin tuna operating models in 2021	Kimoto A., Carruthers T.R., Mayor C., Palma C., and Ortiz M.
SCRS/2021/032	Mathematical definition and updated progress of the EA cMPs	Andonegi E., Arrizabalaga H., Rouyer T., Gordoa A., and Rodriguez-Marín E.
SCRS/2021/033	Bluefin tuna larval indices in the Balearic Archipelago for the management strategy evaluation (strict update index for 2001-2019)	Alvarez-Berastegui D., Tugores M.P., Martín-Quetglas M, Leyva L., and Reglero P.
SCRS/2021/034	The United States rod and reel smaller sizeclass bluefin tuna (*Thunnus Thynnus*) indices of relative abundance; major revisions and recommendations	Lauretta M., Walter J.F., and Brown C.
SCRS/2021/035	Multinational pelagic longline index of bluefin tuna relative abundance in the Gulf of Mexico	Lauretta M., Ramirez K., Walter J.F., and Brown C.
SCRS/2021/036	Review of the Gulf of St. Lawrence bluefin tuna acoustic index of abundance	Minch T., and Gillespie K.
SCRS/2021/037	Preliminary Analysis of Bluefin Tuna Nominal CPUE by Vessel size category and Gear type	Ortiz M., Gallego J.L., Mayor C., Parrilla A., and Samedy V.

SCRS/2021/038	Investigation of model improvements for the U.S large (>177 cm) Atlantic bluefin tuna index of abundance	Hansell A., Becker S., Brown C., Cadrin S., Golet W., Lauretta M., Walter J.F., and Kerr L.
SCRS/2021/039	Development of a Western large (>177 cm) Atlantic bluefin tuna index of abundance based on Canadian and U.S. rod and reel fisheries data	Hansell A., Hanke A., Becker S., Cadrin S., Lauretta M., Walter J.F., Golet W., and Kerr L.
SCRS/2021/040	The standardized bluefin CPUE of Japanese longline fishery in the West Atlantic up to 2020 fishing year	Tsukahara Y., Fukuda H., and Nakatsuka S.
SCRS/2021/041	Mathematical Description and Tuning Results of a Candidate Management Procedure (TN_X) for MSE of Atlantic Bluefin Tuna	Tsukahara Y., and Nakatsuka S.
SCRS/2021/042	Yet further refinements of the BR CMP	Butterworth D.S., and Rademeyer R.A.
SCRS/2021/043	Report on the activities of the BFT Farm Growth Sub-group	Deguara S., Alemany F., Ortiz M., and Rodriguez-Marin E.
SCRS/2021/044	Recommendations of the BFT Technical sub-group on abundance indices for West Atlantic bluefin tuna	Anonymous
SCRS/2021/045	Interannual variability in the larval survival of bluefin tuna (*Thunnus Thynnus*) in the Western Mediterranean spawning ground during 1990-2020	Reglero P., Tugores P., Balbín R., Alvarez-Berastegui D., and Øyvind F.
SCRS/2021/046	Updated CMP results following second round of CMP refinements	Carruthers T. R.
SCRS/2021/047	Atlantic bluefin tuna MSE topics for consideration and decision	Butterworth D.S., and Carruthers T.R

SCRS/P/2021/005	Developing Growth Models from Back-Calculated Length Data for Atlantic Bluefin Tuna	Stewart N.D., Busawon D.S., Rodriguez-Marin E., Siskey M., and Hanke A.
SCRS/P/2021/006	Estimating Age-at-Maturity from Back-Calculated Growth Trajectories for Individual Atlantic Bluefin Tuna	Stewart N.D., Busawon D.S., Rodriguez-Marin E., Siskey M., and Hanke A.
SCRS/P/2021/007	Fish size measurement service powered by NEC cutting edge AI technology	Fujikawa I., Nasu Y., and Okabe R.
SCRS/P/2021/008	Introduction for technology of measuring fish (tuna) quantity and fish weight	Satake R., Tani M., Sidney Adhika H., Morishita M., Waki Y., Sakai T., Noda T., and Akizawa J.
SCRS/P/2021/009	Progress on GBYP aerial survey review	Alemany F.

Appendix 4

SCRS Document and Presentations Abstracts as provided by the authors

SCRS/2021/018 Imposition of a cap on the East area TAC and introduction of a downward adjustment of West area TACs if abundance indices show a downward trend leads to what are considered to be two trade-off improvements in the BR CMP performance. Respectively these are higher West area TACs (though at the expense of lower East area TACs), and improved final abundances for the Western stock for especially the most "difficult" R3 OMs. However, a concern that still needs to be addressed is cases for the R2 scenario where the TACs for the East area can drop to levels in the 10 kt vicinity; this is although the Eastern stock status has climbed to generally well above Bmsy after 30 years, and hence catches would not seem to need to have been reduced so low.

SCRS/2021/019 During the 2018 stock assessment of East-Bluefin tuna it was noted substantial changes in the size distribution of caged bluefin in Turkish farms in the period 2017/2018. The size distribution of the caged fish is measured by the Stereo-camera systems when transferred from the towing vessel to the farm cages. A review of the time series of available stereoscopic measures (2014-2020) confirmed that changes in the overall size-distribution of caged fish. Since 2017, the proportion of fish size 100-140 SFL cm increased substantially while the proportion of larger fish >200 SFL cm has reduced. Analyses with auxiliary data indicated that the fishery has concentrated in the months of June – July, while no spatial expansion of the PS fleet has been observer, however the number of fishing operations and number of PS vessels participating has increased to complete the allocated BFT catch in recent years.

SCRS/2021/020 The French aerial survey over the Gulf of Lions provides an important fisheries independent index for the stock assessment of Eastern Atlantic Bluefin Tuna (EABFT, *Thunnus thynnus*). This document presents the 2020 update of this index. Building on recent results highlighting environmentally-driven changes in the availability of young Bluefin tuna in the Gulf of Lions, we propose a modeling approach designed to account for it and we describe how this attempt could be improved in the future. The results suggest that the index obtained from the Bayesian model accounting for wind should be used. The overall results of the survey analysis across all approaches show that 2020 was the year with the highest abundance of bluefin tuna within the Gulf of Lions to date.

SCRS/2021/022 Medians and lower %iles for the East and West Br30 and AvC30 performance statistics over the interim grid of OMs are compared for the most recent versions of the Butterworth-Rademeyer (BR) and the Carruthers (TC) CMPs. To facilitate this comparison, each CMP has been tuned to the agreed development tuning targets of median values for Br30 West of 1.00, 1.25 and 1.50, and all were tuned to the same value of Br30 East. Performances are very similar, despite the rather different structures of these two CMPs. The differences between their performances is generally independent of the development tuning value selected for the western stock (for the one exception to this result, such dependence is only slight). This suggests that CMP performance comparisons can proceed without first having to wait for agreement on OM weightings; such weightings are primarily of consequence for the finalization tuning exercise that will need to be undertaken in 2022 when the Commission is scheduled to make its final choice of an MP. In due course, the performances of different CMPs will need to be compared over a much wider set of performances statistics than considered in the illustrative example of this document. This will be a large task, which will require the allocation of considerable time for discussion in meetings of the BFT WG during the remainder of 2021, for the MP development process to remain on schedule.

SCRS/2021/023 The online GBYP Workshop on Close-Kin Mark Recapture was held from 8 to 9 February 2021 with the specific objectives to evaluate the financial, logistic and scientific feasibility of implementing a CKMR study for Eastern Atlantic bluefin tuna. The requirements for a proper development of such CKMR study were reviewed and examples of application of CKMR methodology in tuna stocks were provided. Genetic analyses and sampling issues derived from the necessity of getting well-mixed samples were discussed. As a result, a list of recommendations about further steps aiming at the implementation of a CKMR study for Eastern Atlantic bluefin tuna, in the case that it be decided to go on with this initiative, was elaborated.

SCRS/2021/024 The online GBYP Electronic Tagging Workshop was held from 15 to 16 March 2021 with the specific objectives to identify the main knowledge gaps on Atlantic bluefin tuna spatial patterns, update the status of ongoing BFT electronic tagging programs, aiming at finding potential synergies among national and ICCAT programs, elaborate a list, defining priorities of research needs related to BFT spatial patterns, aiming at improving stock assessment and MSE related modelling and, finally, to agree on the best electronic tagging methodologies to fulfil the objectives derived from the SCRS research needs.

SCRS/2021/025 This paper provides updates for two indicators of relative abundance following a revised treatment of the existing data.

SCRS/2021/026 Two indices of bluefin tuna relative abundance were created from logbooks from U.S. pelagic longline fishery in the Gulf of Mexico during 1987 - 2020. The first index was a strict update following methods used in2020 assessment, and the second was a revision that accounts for spatial closures and changes in targeting. The indices use vessel as a repeated measure and are standardized using two stage Generalized Linear Mixed Models. Regulations imposed to limit bluefin tuna interactions and catches required splitting the index into two time periods between 1991 and 1992. Additionally, in 2011, weak hooks were required to further reduce bluefin tuna catches. To account for this, indices post 2010 were adjusted upward by empirical hook type effects estimated in separate studies. Since 2015, a number of other regulatory, hurricane and Deepwater Horizon restoration-related activities reduced the recorded longline effort from an average of 42 vessels per year (~1360 sets) prior to 2015 to only 8 vessels (170 sets) in 2020. Given the reduction in fleet size during the terminal years, the difficulty in modeling dynamic fleet regulations aimed to reducing bluefin tuna interactions, we do not recommend using this index until these changing fleet dynamics stabilize.

SCRS/2021/027 The Canadian and USA large fish CPUE for Western Atlantic bluefin tuna were excluded from the 2017 VPA assessment because they indicated conflicting trends. The 2020 assessment was a strict update using the same stock size indices and model configurations. Therefore, those two stock size indices were once again not included in the VPA calibrations. Discussions and analyses are underway to evaluate the possibility of combining these two indices. This paper discusses the characteristics of the two data sources and the length compositions in each country for the gears under discussion.

SCRS/2021/028 Two artificial neural networks that estimate biomass in the West and East areas respectively, were trained on simulated projected data from the 96 stochastic reference set operating models. Simulated projected data were sampled from nine exploratory CMPs, the combination of three levels of fixed harvest rate in the West area and three levels of fixed harvest rate in the East area. For each stochastic simulation, operating model and CMP, a future year was sampled at random and the simulated index and catch data were used to derive 57 independent input variables including trend in indices, index levels and total catches taken in the projection up to that point. The East area and West area neural networks were each trained to the perfectly known biomass of age 3+ fish in the corresponding area. The biomass estimation performance of the neural networks was evaluated with independent validation and testing datasets. The performance of a fixed harvest rate CMP using those estimates was evaluated in the current ABT MSE framework. The neural networks provided good to very good estimation accuracy using only catch and index data. The A.I CMP was better than conventional CMPs at tailoring catch recommendations to available biomass, providing better yield performance in productive OMs and better biological performance in less productive OMs. The use of neural networks raises important issues of CMP overparameterization, omniscience and robustness which are briefly discussed.

SCRS/2021/029 At the December 2020 BFT Species Group meeting, it was decided to conduct MSE poll for plausibility weighting of the levels within Axes. The poll was carried out between 15 January and 15 February 2021 through google form. Answers were provided by 27 participants out of 62. This document provides the summary of the poll collected on 16 February 2021, for the BFT Species Group meeting in April.

SCRS/2021/030 An informal BFT CMP developers webinar has been conducted on 8-10 March, 2021. The object of this webinar was primarily for developers for further discussion of the results which the different developers tabled in January and at the December BFT meeting. This summarizes the discussion at the webinar to support further discussions at the April 2021 BFT intersessional meeting.

SCRS/2021/031 ICCAT Atlantic Bluefin tuna Working Group (BFTWG) continuously has engaged in MSE process for Atlantic bluefin tuna and has been developing unique operating models (OMs) by taking into account the mixing of the stocks. At the 2020 December BFTWG meeting, it was decided to recondition the OMs by incorporating the most recent dataset. This study further reviewed catch data since 2019, and provides the summary of the input data (catch and size) by the 31st of March, 2021. All data will be reviewed by the BFTWG in April 2021 meeting.

SCRS/2021/032 This paper provides the mathematical definition of the EA cMPs, developed by the group of European scientist and already shown in previous presentations shown and discussed at ICCAT BFT WG meetings since 2019. Results of the development tuning exercises carried out during the last year are also shown, focusing mainly on performance statistics Br30 and AvC30. In a first exercise, the EA cMPs have first been tuned to the agreed development tuning targets of median values for Br30 West of 1.00, 1.25 and 1.50. Results showed that achieving these management objectives for the West was not significantly affecting the East in terms of catches (AvC30). However, the variability associated to the two metrics used was quite high yet. Additionally, when tuning one of the cMPs (EA5), difficulties appeared evidencing that it was not possible to reach the management objective of Br30_West=1. The last exercise focused on keeping both stocks at current management objectives, defined as Br30=1 for both, the East and the West. Results of this last exercise showed greater differences in catch levels for the East when applying both cMPs.

SCRS/2021/033 This document presents the "strict update" version of the Bluefin tuna larval index in the Balearic Archipelago (Western Mediterranean). The previous time series, with data up till 2017, is updated here with information for the year 2019. Methods applied for the sampling, processing of larvae and standardization of catches are the same as the index presented in September 2019 for the management strategy evaluation and updated in January 2020. The standardization of the CPUE is resolved with a two stage model combining a binomial and a log-normal submodel, both resolved with GAMs and corrected for unbalanced factors with a bootstrap approach.

SCRS/2021/034 This report documents the review and revisions of the U.S. Large Pelagics Survey indices of relative abundance of juvenile and sub-adult bluefin tuna. The review consisted of a series of online workshops which produced several recommendations, including: 1) modeling of a single sizeclass (66 to 144 cm straight fork length fish selected), 2) expanded spatial coverage of the samples included, 3) removed state as a fixed factor in the standardization model, 4) integrated sea surface temperature as a covariate to better model dynamic annual spatial distributions of the fish, and added vessel type (private versus charter, with headboats excluded) as a fixed factor to account for differences in the fishery related to shifts in angler composition over time. Workshop dialogues pointed to a substantive shift in the spatial distribution of the fish, as well as the fishery away from targeting smaller fish toward larger sizeclasses (>177 cm standard fork length). The changes will require modifications to the partial catch-at-age for the virtual population analysis, and it is recommended that the two previous fleet partial catches be combined for the new index. Similarly, for Stock Synthesis, the index can be applied to the rod and reel small fish fleet, with an appropriate minimum size of retention fixed at 66 cm. The revised index showed lower inter-annual variability and greater precision than the previous two separate indices, and is recommended to replace the two in the stock assessment and other population modeling applications.

SCRS/2021/035 This report summarizes the combined Mexico-United States pelagic longline data analysis and standardized index of bluefin tuna in the Gulf of Mexico. The SCRS Bluefin Tuna Species Group prioritized a joint longline CPUE analysis in the 2020 research recommendations and 2021 work plan. Two previous technical workshops evaluated the feasibility of multinational indices in the Atlantic Ocean and Gulf of Mexico. The first focused on developing methods for data compilation, and comparison of fleet characteristics and spatiotemporal dynamics. The second evaluated statistical modeling approaches to account for time-area and fleet characteristics to create a combined index. A main recommendation from the workshops was to evaluate the Gulf of Mexico data at a finer scale than 5x5 degree latitude-longitude, to better assess fleet spatial coverage and bluefin availability by month-area. The current analysis examined models at a 1x1 spatial scale. The methods for combining data and evaluating a combined index closely followed those outlined during the prior workshops. Several findings supported a combined index, mainly 1) estimation of month-region effects that corroborate observed migration patterns, 2) a non-significant Flag effect in the standardization model comparing fixed factors, and 3) random residuals of Flag-year standardized indices relative to a combined index, 4) correlation between indices that included flag-year effects versus excluding it. The multinational longline index is proposed for consideration in the next stock assessment of West Atlantic bluefin tuna, and is recommended to replace the US commercial longline index.

SCRS/2021/036 Prior to 2018, the Gulf of St. Lawrence BFT acoustic index has been relatively consistent in trend with the GSL CPUE index, however, recent updates (2018-2019) suggest a significant decline in BFT that does not appear to be consistent with CPUE. Here we investigate the effects of survey methodology, spatial distribution of Atlantic Bluefin tuna, prey species abundance and environmental co-variates as factors that may be contributing to the lower index values. Results suggest that the recent index values do not appear to be related to survey methodology and certain environmental covariates (halocline and thermocline depth). Tagging data for Bluefin in the survey area suggests that BFT may be entering the Baie-des-Chaleurs in months prior to the survey. Factors such as a decline in primary prey species (herring and mackerel) and anomalies in environmental covariates (sea-surface temperature and cold intermediate layer) may be playing a role. We present options for future use of the index in assessment and MSE.

SCRS/2021/037 The ICCAT Commission has requested to update the catch rates for E-BFT by main fishing gear and vessel size category to the SCRS. Preliminary analyses of catch rates by single vessel activity (fishing trip) are presented for the main fishing gear and by vessel size category. This is in response to the changes in the E-BFT fleet operations recently when Joint Fishing Operations (JFOs) have become the main fishing activity to account for annual catches of bluefin tuna. Preliminary results show that PS have overall higher catch rates compared to LL or BB operations, and also higher for JFOs compared to single standard vessel operations. Analyses also show that from registered vessels, a "core" fleet that has operated more consistently in the fishery, do have high catch rates compared to those vessels that are more sporadic in catch and fishing activity.

SCRS/2021/038 Standardized catch rates from the U.S. Large Pelagic Survey have been used as an index of relative abundance for large bluefin tuna (>177 cm) in the western Atlantic for decades. A series of online stakeholder meetings produced several recommendations to improve the abundance index, including: 1) investigate changing participation in the fishery ("wicked tuna effect"); 2) explore models that capture the core spatial footprint of the fishery; 3) examine different effort statistics; and 3) incorporate ocean conditions into relative abundance models. Twelve exploratory standardization models using several different frameworks were developed to address issues highlighted by workshop participants. Exploratory models were then compared to the current model that was used in previous stock assessments. Results demonstrated a similar index across all alternative standardization models.

SCRS/2021/039 United States and Canadian indices of abundance were removed from the last western Atlantic bluefin tuna virtual population analysis (VPA) stock assessment because of conflicting trends. It is hypothesized that conflicting trends result from spatial shifts rather than stock abundance. Consolidating data between the two regions should produce an annual signal that is proportional to stock abundance while less sensitive to changes in stock distribution over time. Here we use two separate statistical frameworks to combine US and Canadian data into a single index of abundance. Both model frameworks converge, agree with fishermen perceptions and indicate that abundance in the Northwest Atlantic is increasing. Results are expected to help reconcile conflicting CPUE trends, provide a framework for reincorporating US and Canadian catch rates into the western Atlantic bluefin tuna VPA, and potentially provide a reliable index of abundance for a candidate management procedure.

SCRS/2021/040 Abundance indices of bluefin tuna from the Japanese longline fishery in the West and Northeast Atlantic were provided up to 2021 fishing year, adding data for one more year from previous update (SCRS/2019/195). The index was standardized with delta-lognormal model with random effect. The standardized CPUE in the West Atlantic since 2011 fishing year remained at a relatively high level compared to those in the 1990s and early 2000s. Additionally, the spatial and temporal patterns of operation over time were investigated based on the Terms of Reference agreed by ABTWG in December 2020. Those indicted that the operation area and periods become shorter and narrower recently because of the high CPUE and individual quota system. And catch in small sized fish for longline fishery, less than 100 kg, was almost nothing since 2014 FY.

SCRS/2021/041 This document consists of mathematical description of a candidate management procedure (CMP) and its tuning results for western stock across 96 operating models for management strategy evaluation of Atlantic bluefin tuna. The basic concept of this CMP is easy to understand and simple to use. TAC from this CMP can be calculated by three indices and one tuning parameters for eastern and western area, respectively. Tuning result of CMP are also described in this document, which tunes median of Br30 to 1.00, 1.25, 1.50.

SCRS/2021/042 This paper seeks improved performance of the BR_6 CMP of Butterworth and Rademeyer (2021) so as to avoid possible very low TACs for the East area. This performance feature can be improved somewhat by placing caps on the East area TAC for the next 10 years, with an upper cap of 36 000 mt (equal to the current TAC for this area) suggested. A further modification indicated for BR_6 is to reduce the maximum downward TAC change possible from 50% to 30%, which does not increase resource risk markedly. Stochastic results for the resultant BR10 CMP show a few instances of extirpation of the eastern stock for some R2 OMs, indicating a need for further possible refinement of this CMP. Given strong differences in especially east stock trajectory projections for the different recruitment (R) scenarios, it is suggested that presenting CMP results separately for each of these scenarios, rather than as some weighted average across the three, provides a more informative basis to compare performances across different CMPs. Appendices provide mathematical specifications of the BR CMP as well as an indication of the sensitivity of BR10 performance statistics to tuning to weighted rather than unweighted OMs.

SCRS/2021/043 This report provides the conclusions of two informal meetings held to coordinate the communication of the activities carried out by the BFT Growth in Farms Sub-group to the Panel 2 of the ICCAT Commission. A summary of the main lines of research of the Sub-group is also presented. It is necessary for the BFT Group to review the current system for estimating catch weight from purse seiners to fattening farms.

SCRS/2021/044 This report succinctly summarizes the 2021 review and revisions of the indices of abundance of West Atlantic bluefin tuna. Multiple papers provide detailed documentation of individual index analyses. Readers are referred to the summaries in Tables 1 and 2, which contain document numbers.

SCRS/2021/045 We have developed a recruitment index based on the potential egg-larval survival for Atlantic bluefin tuna (*Thunnus thynnus*), combining empirical data from rearing experiments of egg and larvae and environmental data from hydrodynamic models. The experiments have been designed to cover the full range of temperature variability observed in the field and provide mechanistic understanding of the processes driving egg and larval survival including feeding. The biological model was applied to time-series of temperature in the NW Mediterranean Sea during 1990-2020 whereas food conditions were assumed constant through the years. The index shows interannual variability in recruitment explained through the effect of temperature on the egg and larval growth and survival. Values vary by a factor of three between years with the highest and lowest recruitment. We have built a mechanistic model that describes well development, feeding and bioenergetics of bluefin tuna larvae and can be implemented to take into account interannual variability in food abundance besides that already accounted for of temperature.

SCRS/2021/046 MSE performance results for the latest CMPs are presented. These include new AI CMPs and TN CMPs in addition to revised BR and TC CMPs that have borrowed aspects from each other to improve performance. Given comparable eastern Br30 tunings, the TC and BR CMPs have very similar performance. Important trade-offs are apparent among West and East areas and western and eastern stocks. Clearer presentation of East-West trade-offs are required. It may be beneficial to consider additional performance metrics that can account for biomass trends.

SCRS/2021/047 For optimal progress towards meeting deadlines for the overall MSE process, this document provides the list of issues what the BFT Species Group would consider at the April meeting. In a number of these the authors offer possible decisions, more in the sense of assisting to initiate discussion than necessarily strongly favouring the option offered.

SCRS/P/2021/005 Back-calculation increases the capacity for analyzing temporal and spatial variation in growth parameters by providing growth trajectories for individual fish. We developed back-calculation functions using Atlantic bluefin tuna (*Thunnus thynnus*) otoliths from collections in Canada (St. Andrews Biological Station), the USA (Chesapeake Biological Laboratory), and Spain (Spanish Institute of Oceanography). We then fit growth models to the back-calculated data using a mixed-modelling approach to estimate individual and cohort-specific growth parameters. By developing more complex mixed models, we provide evidence of sexually-dimorphic growth in bluefin tuna, with males having larger asymptotic length estimates than females, but found no difference in growth between bluefin tuna belonging to spawning stocks in the Mediterranean Sea and Gulf of Mexico.

SCRS/P/2021/006 Biphasic growth models provide a methodology for estimating age-at-maturity from growth data. By using a mixed-modelling approach, biphasic growth models can identify inflection points in individual growth trajectories indicative of a shift between juvenile and adult life history stages at maturity. We will provide results from our preliminary analysis of biphasic models fit to back-calculated growth trajectories for Atlantic bluefin tuna (*Thunnus thynnus*). Once refined, such an approach would provide a method for evaluating potential variation in age-at-maturity between sexes, stocks, and cohorts.

SCRS/P/2021/007 NEC provide Fish size measurement service which provide s automatic measurement of fish size in videos with AI. The benefit s are: (1) Very easy measurement of fish size and estimation of weight. No human plotting is required. (2) Fair measurement because of AI plotting not by human. It reduces manual plotting error. NEC already have many use cases in Japan for Pacific BFT (PBF), yellowtail and salmon. They are using our service periodically to check their fish growth. For example, one of major PBF farm and NEC jointly developed the service to measure PBF juvenile from 20cm to 60cm in addition to BFT longer than 60cm. NEC provide new underwater stereo camera QSC-100 which is easy to handle with light weight and compact size. It has high resolution cameras which contribute to length measurement accuracy. Once you upload fish video to NEC website, you can get analysis report on fork length, body depth and estimated weight after a few hours (time depends on video quality and length). We are developing fish counting service to count number of fish when BFT transferring .

SCRS/P/2021/008 Yanmar introduced a system (partially under development) aimed at reducing the counting and weight measurement work required when transferring and caging tuna. (1) "Fish count system": The shadow of passing fish is automatically counted from the image taken from below, and can be easily corrected manually where necessary. And best feature of this product is you can check the number of fish in situ without uploading the data to the cloud. (2) "Automatic fish weight estimation system" jointly developed with AQ1 System: Automates the work of plotting the length and height of fish with any image obtained from the existing AM-100 system. You can analyze the average weight, average length, etc. in situ without uploading the data to the cloud. If AM-100 data is shared to Yanmar, the result of automated measurement (length/height) can be provided as trial from September 2021. Moreover, Yanmer would like to participate in the demonstration through video analysis in the field to see if this system is worth using as a resource management tool.

SCRS/P/2021/009 The summary was not provided by the authors.

Appendix 5

Summaries of CMPs

Team	Butterworth, Jacobs, Rademeyer, Miyagawa	Carruthers (Blue Matter Science)		Cox, Johnson, Rossi (Landmark Fisheries Research)	
CMP Name	BR10	TC	AI	SJ	SJ
Brief description	Empirical CMP that uses a 2-year lagged moving average of a weighted combination of several management indices (J) to set TACs scaled to a reference relative harvest rate.	A multi-stock/multi-area empirical CMP, using multiple indices to estimate biomass of each stock in E/W areas, and using trend information to adjust harvest rates.	An empirical CMP, that fishes a fixed harvest rate using and artificial neural network (trained on projected data) to predict regional biomass of age 3+. The neural network uses multiple indices to estimate biomass of each stock in E/W areas, and additionally uses trend information to adjust harvest rates.	Multi-model inference from five multi-stock, multi-area delay difference models, each tuned to one of five operating models that are cluster medoids of the interim OM grid.	An empirical analogue of the mmDD CMP.
Empirical or Model Based?	Empirical	Empirical	Model based - an artificial neural network is used to interpret fishery data as regional biomass (similarly to an assessment).	Model-based	Empirical
Summary of estimator	No biomass estimation, weighted average of index J is used directly for each area, where weights are inverse variances (adjusted for autocorrelation) for each individual data series, except that west area indices for smaller fish are upweighted to accentuate detection of a recruitment reduction.	Spawning and vulnerable biomass for each stock in each area are estimated by averaging the available indices for the stock/area combination after scaling by 2016 estimates catchability, and assuming a constant mixing rate. Biomass estimates are used to estimate recent fishing mortality rates by area and stock.	Spawning and vulnerable biomass for each stock in each area are estimated by an artificial neural network (hence is operating comparably to a stock assessment).	Biomass estimates are produced by each of the five DD models fit to all available management indices, plus the historical OM SSB for the associated grid cluster medoid OM treated as a very precise absolute index.	Five spawning biomass estimates for each stock are produced from a moving average of MED and GOM larval surveys, scaled by survey catchability derived from each OM grid cluster medoid.

Indices used	FR_AER_SUV2, MED_LAR_SUV, GBYP_AER_SUV_BAR, MOR_POR_TRAP, JPN_LL_NEAtl2 (East); GOM_LAR_SUV, US_RR_66_114, US_RR_115_144, US_RR_177, USGOM_PLL2; JPN_LL_West2, CAN_SWNS (West).	MOR_POR_TRAP, JPN_LL_NEAtl2, MED_LAR_SUV, GBYP_AER_SUV_BAR, US_RR_66_114, US_RR_115_144.	All (MED_LAR_SUV, GBYP_AER_SUV_BAR, US_RR_66_114 are used for harvest rate throttling if declines are detected).	All management indices.	GOM_LAR_SUV, MED_LAR_SUV.
Summary of HCR	TACs set using a relative harvest rate (Catch/J) from reference year (2018) applied to the 2-year lagged moving average of the weighted index J.	Biomass and fishing mortality rate estimates are compared to reference F_{MSY} and B_{MSY} parameters. TAC in year t is an adjustment of TAC in year t-1, taking F/F_{MSY} and B/B_{MSY} into account. Currently only B/B_{MSY} is activated in the HCR.	Regional biomass fished at a fixed harvest rate.	Each of five biomass estimates are used in a precautionary ramped HCR with control points and target harvest rates taken from DD reference point estimates, or OM grid cluster medoid values. Five TACs are averaged using AIC weights calculated from DD model fits to index data. TACs are calculated by area and by stock, and the minimum is taken for proposed TAC.	The same HCRs as the Delay Diff model are used, but OM grid cluster medoid parameters and reference points are used for control points and target harvest rates. Additional trend based adjustments were defined in most recent CMP version. Average TAC weighted by OM grid relative cluster size.
sMeta rules (caps, floors, etc)		Linear index response, non-linear HCR.	Artificial neural network.	Ramped (hockey stick) HCR for each OM grid cluster medoid.	Ramped (hockey stick) HCR for each OM grid cluster medoid.
Control points	Introduces a quadratic decline in reference HR multipliers when J is below a nominated level set to be the value of J in 2017 for the area concerned.	No discrete control points - a joint surface of F/F_{MSY} and B/B_{MSY} is used to modify TACs.	None	Lower control point at 40% of upper control point. Used both B_{MSY} and .4B0 as upper control point candidates, and F_{MSY} and 2/3M as target HRs.	Lower control point at 40% of upper control point. Used both B_{MSY} and .4B0 as upper control point candidates, and F_{MSY} and 2/3M as target HRs.

Meta rules (caps, floors, etc)	20% constraint on TAC change, can increase to 30% down if the average index is below a certain level (linear relationship). East: 36 000t upper cap to 2032 then 45 000 t cap thereafter, 12 000 t minimum. No cap in the west. The west area TAC is reduced further if the recent trend in J for that area drops below a specified threshold.	min East TAC = 10 kt, max East TAC = 45 kt, min West TAC = 0.5 kt, max West TAC = 3 kt, max West TAC is 2.5 kt for first 4 projected years, max upward TAC change = 25%, max downward TAC change = 35%, threshold for TAC change = 0.05.	min East TAC = 10 kt, max East TAC = 50 kt, min West TAC = 0.5 kt, max West TAC = 4 kt, max West TAC is 2.5 kt for first 4 projected years, max upward TAC change = 25%, max downward TAC change = 35%, threshold for TAC change = 0.05.	OM cluster medoid specific MSY caps, trend based adjustments, AIC weights calculated over different window lengths.	OM cluster medoid specific MSY caps, trend based adjustments.
Possible tuning parameters	Tuning multipliers alpha (E) and beta (W) for scaling the relative harvest rate.	West area and East area harvest rates	Two tuning parameters alpha and beta were included, which each affect the target F (as a ratio of F_{MSY}) and target B (as a ratio of B_{MSY}), accounting for complexity mismatch and averaging of indices.	Harvest rate multipliers, TAC caps, weights on AIC components.	Harvest rate multipliers, TAC caps, trend-based adjustment thresholds.
Tuning target	Specified development tuning targets for the western stock; median Br30 = 1.55 for the eastern stock.	Br30 = 1.55 for the east.	Br30 = 1.55 for the east.		
Strengths	Includes several indices, and weights them according to their fit to past data. Avoids issue of scaling to an "average" catchability by using relative HRs. Empirical and relatively simple, which aids explanation to stakeholders.	Very flexible, truly multi-stock, enabling responses of W fishing to E abundance and vice versa.	Flexible, accounts for indices on both sides of the ocean and hence mixing.	Incorporates all indices, includes mixing of both stocks, incorporates population dynamics/growth, and uses RW in recruitment to approximate regime shift.	Simple, incorporates stock mixing in TAC calculation, focuses on spawning biomass of both stocks.

Weaknesses	Lag in index will slow response to decreases in biomass. No differentiation of indices in relation to the bluefin age ranges to which they correspond.	Smoothing procedure makes it difficult to understand the influence of each index, and equal weighting of smoothed indices may inflate the influence of uninformative data series (e.g., noisy indices). Complexity of F and B estimation, and TAC control surfaces (if activated - currently just B_{MSY} is used) could make CMP unintuitive.	Could be overparameterized and have poor robustness to alternative but similarly plausible OMs not included in the reference set. Neural network behavior requires sensitivity analysis. Hard to visualize network weights and biases.	Complex, difficult to intuitively follow, slow to run in simulations.	Still somewhat complex. Fixed weighting of TAC averages makes tuning more difficult.
Notes		Well documented.	Well documented. Invokes issues of overparameterizat-ion, 'omniscience' and robustness	Well documented, could benefit from a diagrammatic explanation of the CMP to help improve understanding. Invokes omniscience concerns.	
References	SCRS/2021/042, Appendix A	SCRS/2020/150, SCRS/2020/165	SCRS/2021/028	SCRS/2020/145; SCRS/2020/167	SCRS/2020/145; SCRS/2020/167

Team	Andonegi, Arrizabalaga, Rouyer, Gordoa, Rodriguez-Marín (EU)	Canada (DFO); Hanke *et al.*			
CMP Name	EA	RoseW/RoseE	Fzero1E/Fzero1W	F1E/F1W	RebuildE/RebuildW
Brief description	Index based empirical method that adjusts TACs up and down according to the ratio between the most recent average index and a target value.	Attempts to detect a recruitment regime shift, and scale fishing to a new MSY based on lower productivity if detected.	Constant harvest rate approach. Calculates F_0.1 fishing mortality rate for each area, then applies to a biomass estimate derived from the larval survey.	Constant harvest rate approach. Applies a harvest rate of F = .5, scaled up or down by a moving average ratio.	Constant TAC CMP, with TAC set low to promote rebuilding.
Empirical or Model Based?	Empirical	Empirical	Empirical, but F0.1 calculation relies on a population dynamics model	Empirical	Constant TAC
Summary of estimator	No biomass estimate is used, but the current stock status is approximated by Icur, a precision weighted mean or median of selected indices.	Stock-status determined by comparing recent larval survey index (4 years) to a reference period, area trend determined by recent (4 years) Japanese LL CPUE. If evidence of a regime shift is detected (appears to be based on evidence of non-stationarity in mean or variance), then reference value is scaled based on estimated change in productivity.	Stock status is not determined, but a biomass estimate is calculated via the larval survey for each stock and the associated catchability estimates from the 2015 VPA.	Stock status is not determined, but a biomass estimate is calculated via the larval survey for each stock and the associated catchability estimates from the 2015 VPA.	NA

Indices used	FR_AER_SUV2, MED_LAR_SUV, MOR_POR_TRAP, JPN_LL_NEAtl2 (East); GOM_LAR_SUV, USRR_66_114, US_GOM_PLL2; JPN_LL_West2 (West).	GOM_LAR_SUV and Japan Longline West CPUE for west area MP. MED_LAR_SUV and Japan Longline NEAtl CPUE for east area MP.	GOM and MED larval surveys for biomass. YPR is based on 3 US_RR indices for the West area, and FR_AER_SUV2, US_RR_115_144, and MED_LAR_SUV for the East area. These represent different age groups in the respective stocks.	GOM and MED larval surveys for biomass. YPR is based on 3 US_RR indices for the West area, and FR_AER_SUV2, US_RR_115_144, and MED_LAR_SUV for the East area. These represent different age groups in the respective stocks.	NA
Summary of HCR	Determines Iratio=Icur/T of weighted mean/median index Icur and the target value T, and adjusts previous year's TAC by that ratio, i.e. TAC_{t+1} = Iratio * TAC_t. An extension uses an autocorrelation factor gamma to downweight Iratio and upweight the previous year's TAC.	A precautionary ramped HCR is used to adjust the previous year's TAC up or down based on a combination of status and trend.	Constant F0.1 fishing mortality rate, estimated from last 3 years of data from three data series indexing small, medium, and large fish. TAC is then product of biomass estimate from larval survey and F0.1 estimate. If no recent catch is available for YPR calculations, then F0.1=.2 is applied.	Fishing mortality rate of F = 0.5 is adjusted by ratio of most recent larval survey data point to the same survey's 3yr moving average, and TAC is the product of adjusted F and biomass estimate.	NA
sMeta rules (caps, floors, etc.)					
Control points					
Meta rules (caps, floors, etc.)	NONE				
Possible tuning parameters	Target value T and auto-correlation factor gamma are used to tune the CMP.	Length of recent index series for trend/status, control points on HCR, regime shift scalar.	Larval survey catchability parameters could be scaled; interval for F0.1 calculation.	F, larval survey catchabilities, interval for moving average calculation.	NA
Tuning target					

Strengths	Incorporates multiple indices, and acknowledges their relative precision. Room to scale TAC with biomass.	Simple, only requires 2 indices for each stock/area. Uses both status and trend information.	TAC is relatively simple to calculate from a small amount of information, TAC is not anchored to previous year's value so will scale with stock.	Simple to calculate TACs, scales F with stock status trend.	Low TACs to promote rebuilding, simple and easy to understand.
Weaknesses	Using only most recent year introduces sensitivity to observation errors, not capped so this sensitivity could make TACs non precautionary. No precautionary reduction at low index values.	Method for determining regime shift depends on R package, so unclear how exactly this works. Non-stationarity in CPUE indices could be due to fishing, process errors, and not just regime shift, so may be overly sensitive. No cap on TACs.	YPR is somewhat complicated for an empirical CMP. In the east YPR relies on data from three separate sources to index each age group, which all have different designs. Again, relies on R package for YPR calculation so not clear what assumptions are made internally. Assumption of 2015 VPA estimates implicitly assumes no mixing between stocks in East and West area, so catch for YPR calculations is biased.	Fishes both stocks at a 50% harvest rate, plus or minus the trend adjustment, and does not ramp down HR based on status, so even in the presence of a declining trend, it will continue to harvest around 50%.	Does not scale TACs to OM specific dynamics, likely low social capital.
Notes	A new paper presented to the 2021 April BFT meeting summarizes all the information, from the mathematical description of the cMPs up to the summary of all exercises done with regards to the development tuning.	Description is given as "Pseudo-code", but is really just pasted in R code, with author's own style. Some variable definitions missing, difficult to parse.			
References	SCRS/P/2020/063; SCRS/P/2020/064; SCRS/2021/032 (includes mathematical description of both the status estimator and the HCR).	SCRS/2020/144			

Team	Tsukuhara, Nakatsuka (Japan)	Lauretta, Peterson, Walter (US NOAA)				
CMP Name	TN	constU	Juvenile	W_rebuild	constU_2Indices	constU_Refined
Brief description	Comparison of a recent and lagged moving average for TAC adjustments. Designed primarily to protect western stock.	Constant target harvest rate approach. Calculates a moving average relative harvest rate from catch and larval indices, and attempts to guide it towards a reference value using TAC adjustments.	TAC adjustments based on trends in indices of juvenile abundance.	Aims to grow W stock biomass above levels at the beginning of the projection period.	Constant target harvest rate approach. Calculates a moving average relative harvest rate from catch and larval indices, and attempts to guide it towards a reference value using TAC adjustments.	Constant target harvest rate approach. Calculates a moving average relative harvest rate from catch and larval indices, and attempts to guide it towards a reference value using TAC adjustments.
Empirical or Model Based?	Empirical	Empirical	Empirical	Empirical	Empirical	Empirical
Summary of estimator	No estimate of biomass. Uses ratio Iratio of recent and lagged moving averages of indices to determine relative stock status.	No biomass/stock status estimation, larval surveys used directly.	No biomass estimate is used.	GOM larval survey used directly.	No biomass/stock status estimation, larval + juvenile surveys used directly.	No biomass/stock status estimation, larval surveys used directly.
Indices used	GOM_LAR_SUV, JPN_LL_NEAtl2 (East), JPN_LL_West2 (West).	GOM and MED larval surveys.	US_RR (W) and GBYP (E).	GOM larval survey	GOM and MED larval surveys and US_RR (W) and GBYP (E).	GOM and MED larval surveys.
Summary of HCR	Flow charts, with different outcomes depending on the comparison of index ratios to certain thresholds. For year t+1, TAC_{t+1} = TAC_t * Iratio, with a floor of 10 kt in the East, and 1 kt in the West.	Current relative HR is compared to the reference period relative HR, and TAC is adjusted based on their ratio (called the delta ratio).	TAC is adjusted up or down based on ratio of current moving average juvenile abundance index, and a lagging reference period moving average index.	TAC is adjusted up or down based on ratio of current moving average larval index, and a lagging reference period moving average larval index.	Current relative HR is compared to the reference period relative HR (as calculated by averaging relative HR from larval and juvenile surveys), and TAC is adjusted based on their ratio (called the delta ratio).	Current relative HR is compared to the reference period relative HR, and TAC is adjusted based on their ratio (called the delta ratio).

sMeta rules (caps, floors, etc.)					25% increase / 50% decrease constraint TAC change in E; 25% constraint on TAC change in W.	25% increase / 50% decrease constraint TAC change in E; 25% constraint on TAC change in W. 45000 t cap in E catch; inclusion of a minimum W index threshold (20% below reference index) that triggers an emergency W catch=0.
Control points						
Meta rules (caps, floors, etc.)						
Possible tuning parameters	Thresholds for each index ratio are able to be used a tuning parameters.	A multiplier on the delta ratio is used to change the TAC adjustment response.	No multiplier implemented. It is unsuitable to change moving average window lengths or lags since they are defined based on BFT growth.	Length of moving average window, lag of reference period, max change in TAC.	Length of moving average window, lag of reference period, max change in TAC, weights for averaging juvenile vs. larval HR, multiplier on delta ratio.	Length of moving average window, lag of reference period, max change in TAC, multiplier on delta ratio, max catch cap in E, minimum threshold level in W.
Tuning target		Br30=1, 1.25, 1.5 in E and W			Br30=1 in W	Br30=1 in W
Strengths	Simple, and clear about its focus (western stock). Adjusts eastern TAC in response to West stock fish, which is a key management issue.	Easy to understand, low reliance on OM or assessment outputs, responsive to biomass changes.	Linked to recruitment, should be responsive to changes in juvenile abundance.	Conservative catch limits when rebuilding is prioritised, simple to understand.	Easy to understand, low reliance on OM or assessment outputs, responsive to biomass changes.	Easy to understand, low reliance on OM or assessment outputs, responsive to biomass changes.

Weaknesses	Relies on fishery CPUE, which may have time-varying catchability due to targeting effects outside of simulations. Changing catchability would mean that necessary TAC adjustments may differ from index ratios. Does not include stock status information (e.g. MED larval index) for East stock.	No TAC cap, sensitive to delta ratio adjustment thresholds and multiplier. Relies on the reference period HR being a good target.	Sensitive to noise in the data, relies on fishery dependent index in the West, so subject to time-varying catchability which will bias ratios.	Does not detect if stock is rebuilt, performance depends on TAC at beginning of projection, appears to hold stock steady in provided example.	As constU above; does not perform as well as constU.	Sensitive to delta ratio adjustment; relies on the reference period HR being a good target; performs more poorly than constU when tuned to the same Br30 in E and W.
Notes	Limited documentation, HCR presented as a flow chart with difficult to read text.	Uses pasted in R code to describe CMP, difficult to parse given author's personal style.				
References	SCRS/2019/020 SCRS/2020/151	SCRS/2020/129				

Appendix 6

Mathematical description for the BR CMPs (Butterworth and Rademeyer, SCRS/2021/018)

The CMP is empirical, based on inputs related to abundance indices which are first standardised for magnitude, then aggregated by way of a weighted average of all indices available for the East and the West areas, and finally smoothed over years to reduce observation error variability effects. TACs are then set based on the concept of taking a fixed proportion of the abundance present, as indicated by these aggregated and smoothed abundance indices. The details are set out below.

Aggregate abundance indices

An aggregate abundance index is developed for each of the East and the West areas by first standardising each index available for that area to an average value of 1 over the past years for which the index appeared reasonably stable[1], and then taking a weighted average of the results for each index, where the weight is inversely proportional to the variance of the residuals used to generate future values of that index in the future modified to take into account the loss of information content as a result of autocorrelation. The mathematical details are as follows.

J_y is an average index over *n* series (*n*=5 for the East area and *n*=7 for the West area) [2]:

$$J_y = \frac{\sum_i^n w_i \times I_y^{i*}}{\sum_i^n w_i} \qquad \text{(A1)}$$

Where

$$w_i = \frac{1}{(\sigma^i)^2}$$

and where the standardised index for each index series (*i*) is:

$$I_y^{i*} = I_y^i \Big/ Average\ of\ historical\ I_y^i$$

(A2)

σ^i is computed as

$$\sigma^i = \frac{SD^i}{1 - AC^i}$$

where SD^i is the standard deviation of the residuals in log space and AC^i is their autocorrelation, averaged over the OMs, as used for generating future pseudo-data. **Table A1** lists these values for σ^i.

2017 is used for the "average of historical I_y^i". For the East, the 2017 Mediterranean larval survey index value was not previously available, but is now and has been included in the computation.

The actual index used in the CMPs, $J_{av,y}$, is the average over the last three years for which data would be available at the time the MP would be applied, hence:

$$J_{av,y} = \frac{1}{3}\left(J_y + J_{y-1} + J_{y-2}\right) \qquad \text{(A3)}$$

where the *J* applies either to the East or to the West area.

[1] These years are for the Eastern indices: 2014-2017 for FR_AER_SUV2, 2012-2016 for MED_LAR_SUV, 2015-2018 for GBYP_AER_SUV_BAR, 2012-2018 for MOR_POR_TRAP and 2012-2019 for JPN_LL_NEAtl2; and for the Western indices: 2006-2017 for GOM_LAR_SURV, 2006-2018 for all US_RR and US_GOM_PLL2 indices, 2010-2019 for JPN_LL_West2 and 2006-2017 for CAN_SWNS.

[2] For the aerial surveys, there is no value for 2013, 2018 and 2019 (French) and 2017-2019 (Mediterranean). For GBYP aerial survey there is no value for 2012, 2014, 2016 and 2019. For MOR_POR_TRAP survey, there is no value for 2019. These years were omitted from this averaging where relevant.

CMP specifications

The BR Fixed Proportion CMPs tested set the TAC every second year simply as a multiple of the J_{av} value for the area at the time (see **Figure A1**), but subject to the change in the TAC for each area being restricted to a maximum of 20% (up or down). The formulae are given below.

For the East area:

$$TAC_{E,y} = \begin{cases} \left(\frac{TAC_{E,2020}}{J_{E,2017}}\right) \cdot \alpha \cdot J^{E}_{av,y-2} & \text{for } J^{E}_{av,y} \geq T^{E} \\ \left(\frac{TAC_{E,2020}}{J_{E,2017}}\right) \cdot \alpha \cdot \frac{(J^{E}_{av,y-2})^2}{T^{E}} & \text{for } J^{E}_{av,y} < T^{E} \end{cases}$$

(A4a)

For the West area:

$$TAC_{W,y} = \begin{cases} \left(\frac{TAC_{W,2020}}{J_{W,2017}}\right) \cdot \beta \cdot J^{W}_{av,y-2} & \text{for } J^{W}_{av,y} \geq T^{W} \\ \left(\frac{TAC_{W,2020}}{J_{W,2017}}\right) \cdot \beta \cdot \frac{(J^{W}_{av,y-2})^2}{T^{E}} & \text{for } J^{W}_{av,y} < T^{W} \end{cases}$$

(A4b)

Note that in equation (A4a), setting $\alpha = 1$ will amount to keeping the TAC the same as for 2020 until the abundance indices change. If α or $\beta > 1$ harvesting will be more intensive than at present, and for α or $\beta < 1$ it will be less intensive.

Below T, the law is parabolic rather than linear at low abundance (i.e. below some threshold, so as to reduce the proportion taken by the fishery as abundance drops); this is to better enable resource recovery in the event of unintended depletion of the stock. For the results presented here, the choices $T^{E} = 1$ and $T^{W} = 1$ have been made.

Constraints on the extent of TAC increase and decrease

Maximum increase:

If $TAC_{i,y} \geq 1.2 * TAC_{i,y-1}$ then $TAC_{i,y} = 1.2 * TAC_{i,y-1}$ (A5)

with the subscript i corresponding to either East or West area.

Maximum decrease:

If $TAC_{i,y} \leq 0.8 * TAC_{i,y-1}$

then $TAC_{i,y} = (1 - maxdecr) * TAC_{i,y-1}$ (A6)

where

$$maxdecr = \begin{cases} 0.2 & J^{i}_{av,y-2} \geq J_{i,2017} \\ \text{linear btw 0.2 and } D & J_{i,2017} < J^{i}_{av,y-2} < J_{i,2017} \\ D & J^{i}_{av,y-2} \leq 0.5 J_{i,2017} \end{cases} \quad \text{(A7)}$$

where D=0.5 or 0.3 in implementations to date.

Maximum TAC

A cap on the maximum allowable TAC is set. This can potentially improve performance, particularly in the event of a shift to a lower productivity regime. By ensuring that TACs have not risen so high that they cannot be reduced sufficiently rapidly following such an event to adjust for the lower resource productivity. In investigations to date, this has been found to be useful to implement only for the East area, where TACs can otherwise rise to in excess of 70 kt.

New trend-based term in the West

The TAC in the West is further adjusted if a measure of immediate past trend in the indices is below a threshold value:

If $s_y^W \leq s^{threshold}$

$$TAC_{W,y} \rightarrow [1 + \gamma(s_y^W - s^{threshold})]TAC_{W,y} \quad \text{(A8)}$$

where

s_y^W is a measure of the immediate past trend in the average index J_y (equation 1), and

γ and $s^{threshold}$ are control parameter values.

This trend measure is computed by linearly regressing lnJ_y *vs* year *y'* for y'=y-6 to y'=y-2 to yield the regression slope s_y^W.

Table A1. σ^i values used in weighting when averaging over the indices to provide composite indices for the East and the West areas (see equation A1).

EAST		WEST	
Index name	σ^i	Index name	σ^i
MOR_POR_TRAP	0.56	GOM_LAR_SUV	0.58
JPN_LL_NEAtl2	0.45	JPN_LL_West2	0.62
FR_AER_SUV2	1.00	US_RR_66_114	1.47
GBYP_AER_SUV_B.	0.56	US_RR_115_144	0.71
MED_LAR_SUV	0.56	US_RR_177	1.29
		US_GOM_PLL2	0.89
		CAN SWNS	1.71

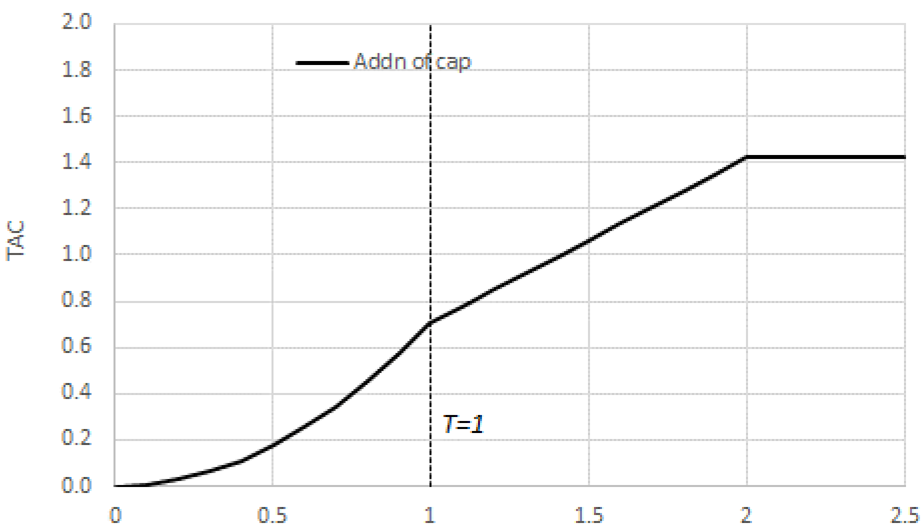

Figure A1. Illustrative relationship (the "catch control law") of *TAC* against $J_{av,y}$ for the BR CMP, which includes the parabolic decrease below T and the capping of the TAC so as not to exceed some maximum value.

Mathematical description for the base case generic EA_x CMPs (Andonegi *et al.*, SCRS/2021/032)

1. Mathematical description of the base case generic EA_x CMPs

Both CMPs, EA_{2n+1} and EA_{2n} are empirical, based on inputs related to abundance indices which are first standardised for magnitude, then aggregated by way of a weighted average of all indices available for the East and the West areas. TACs are then set based on the concept of taking a fixed proportion of the abundance present, as indicated by these aggregated abundance indices. The details are set out below.

1.1. Data sets

Same four indices have been selected for each stock in each of the two CMPs, aiming at best reflecting the dynamics of each of the stocks. For the East, the French Aerial Survey (FR_AER_SUV2), the Mediterranean Larval (MED_LAR_SUV), the Moroccan-Portuguese Trap (MOR_POR_TRAP) and the Japanese Longline (North East Atlantic - JPN_LL_NEAtl2) indices are used. For the West, the Gulf of Mexico Larval (GOM_LAR_SUV), the US Rod & Reel 66-114 (US_RR_66_114), the US Gulf of Mexico Pelagic Long Line (US_GOM_PLL2) and the Japanese Longline (West - JPN_LL_West2) indices are selected. The standard deviation and the autocorrelation values estimated for each of these indices have been published in the report of the MSE Technical Group meeting held in February 2020 (ICCAT, 2020) and can be found in **Table A1**.

1.2. Status Estimator: the aggregated abundance index

1.2.1. The EA_{2n+1} CMP

An aggregate abundance index is developed for each of the East and the West areas by first standardising each index available for that area by the average value of the last 4 years of historical observations and then taking a weighted mean of the results for each index (see **Equation 2**). Then the weighted mean of all indices was used to calculate the status estimator *Irat*. The weight of each of the indices is inversely proportional to the variance of the residuals. Future values of the indices are generated considering both the variance and autocorrelation (see **Equations 3 & 4**).

In the *EA_{2n+1} CMP, the aggregated abundance index is then calculated as follows:*

$$Irat_y = \frac{\sum_i^n w_i * I^*_{i,y}}{\sum_i^n w} \qquad (1)$$

where

$$I^*_{i,y} = \frac{I_{i,y}}{\sum_{y=1}^{i} I_{i,y}} \qquad (2)$$

and

$$w = \frac{1}{\sigma_i^2} \qquad (3)$$

being

$$\sigma_i = \frac{SD_i}{(1 - AC_i)} \qquad (4)$$

The actual index used in the *EA_{2n+1} CMP*, $Irat_{av,y}$, for both the East and the West area, is the average over the last three years for which data would be available at the time the MP would be applied:

$$Irat_{av,y} = \frac{1}{3}(Irat_y + Irat_{y-1} + Irat_{y-2}) \qquad (5)$$

1.2.2. The EA_{2n} CMP

The difference with the previous CMP is that the status estimator is now calculated as the weighted median of the aggregated index, which is previously standardized in the same way that the EA_{2n+1} one. SO, the mathematical description of this CMP is similar to the previous one, but replacing the weighted mean (Equation 1) by a weighted median.

1.3. The Harvest Control Rule (HRC)

The EAx CMPs tested set the TAC every second year simply as a multiple of the *Iratav* value for the area at the time, but subject to a maximum TAC change of 20% (up or down) for each area. The TAC is then defined as follows:

$$TAC_{y+1} = \begin{cases} TAC_y * \propto Irat_n & if \;\; 0.8 < Irat_n < 1.2 \\ 0.8 * TAC_y & if \;\; Irat_n \leq 0.8 \\ 1.2 * TAC_y & if \;\; Irat_n \geq 1.2 \end{cases} \tag{6}$$

where

$$Irat_n = \gamma * Irat + (1 - \gamma) \tag{7}$$

and

$$\propto = 1/Itar \tag{8}$$

Table A1. Indices used to estimate the aggregated index for each ABF area, together with the σ and w values obtained from equations 3 and 4, using the information published in the ICCAT BFT MSE Technical Group meeting report (ICCAT, 2020).

	Sigma (σ)	Weight (w)
EAST		
FR_AER_SUV2	1.00	1.00
MED_LAR_SUR	0.56	3.189
MOR_POR_TRAP	0.56	3.189
JPN_LL_NEAtl2	0.45	4.939
WEST		
GOM_LAR_SUR	0.58	2.977
US_RR_66-114	1.47	0.463
US_GOM_PLL2	0.98	1.041
JPN_LL_West2	0.62	2.601

Mathematical description for TN_x (Tsukahara and Nakatsuka, SCRS/2021/041)

Used index:

(West TAC) GOM_LAV, US_RR_66_114 and JPN_LL_West2
(East TAC) GOM_LAV and JPN_LL_NEAtl2

Index ratio for GOM_LAV, JPN_LL_West2 and JPN_LL_NEAtl2 are calculated by bellow:

$$Index\ ratio = \frac{mean(Index[y-2{:}y-6])}{mean(Index[y-5{:}y-9])} \quad (1)$$

West TAC

If index ratio of GOM_LAV is less than 0.8, then

$$new\ TAC = current\ TAC * \min(0.8, Ratio\ of\ JPN\_LL\_West2)$$

Else if any USRR_66_114 values in recent 5 years are less than historical third values, then

$$new\ TAC = current\ TAC * \min(0.9, Ratio\ of\ JPN\_LL\_West2)$$

Else new ratio of TAC is calculated with tuning parameter, k_west, as bellow

$$(Ratio\ of\ TAC\ change) = \begin{cases} \max(0.5, Ratio\ of\ JPN\_LL\_West2\ * k_{west}^{-1} - (0.95 * k_{west}^{-1} - 0.95)) & if\ Ratio\ of\ JPN\_LL\_West2 \leq 0.95 \\ \min(1.5, Ratio\ of\ JPN\_LL\_West2\ * k_{west} - (1.05 * k_{west} - 1.05)) & if\ Ratio\ of\ JPN\_LL\_West2 \geq 1.05 \end{cases}$$

$$new\ TAC = current\ TAC * Ratio\ of\ TAC\ change$$

Finally, the minimum TAC from this CMP is 1kt for west area, then

$$new\ TAC = \max(new\ TAC, 1kt)$$

East TAC

If index ratio of GOM_LAV is less than 0.6, then

$$new\ TAC = current\ TAC * \min(0.8, Ratio\ of\ JPN\_LL\_West2)$$

Else new ratio of TAC is calculated with tuning parameter, k_east, to be within 50% changes, as below

$$(Ratio\ of\ TAC\ change) = \begin{cases} \max(0.5, Ratio\ of\ JPN\_LL\_NEAtl2\ * k_{east}^{-1} - (0.95 * k_{east}^{-1} - 0.95)) & if\ Ratio\ of\ JPN\_LL\_NEAtl2 \leq 0.95 \\ \min(1.5, Ratio\ of\ JPN\_LL\_NEAtl2\ * k_{east} - (1.05 * k_{east} - 1.05)) & if\ Ratio\ of\ JPN\_LL\_NEAtl2 \geq 1.05 \end{cases}$$

$$new\ TAC = current\ TAC * Ratio\ of\ TAC\ change$$

Finally, the minimum TAC from this CMP is 10 kt for East area, then

$$new\ TAC = \max(new\ TAC, 10kt)$$

Mathematical description for Peterson-Walter CMPs (SCRS/2020/129)

We evaluated two candidate management procedures (CMPs) for Atlantic bluefin tuna using the ABT_MSE package in R, version 6.6.14. The first procedure is based on constant harvest rate (ConstU) strategies for both the east and west stocks. In the MSE, the indices of abundance are assumed to be proportional to vulnerable biomass, i.e. the base parameterization assumes time-invariant catchability. Therefore, a relative harvest rate for each stock can be calculated as follows:

$$harvest\ rate = catch/abundance$$

$$relative\ abundance = catchability * abundance$$

$$relative\ harvest\ rate = \frac{catch}{relative\ abundance}$$

Under this approach, management procedures for East and West stocks were designed to apply a constant harvest rate strategy tracking catches and comparing to stock-of-origin indices of spawning biomass. For the West stock, the Gulf of Mexico larval survey is used, and for the East stock, the Mediterranean larval survey is used. Both indices are assumed to be proportional to the spawning biomasses of the individual stocks, with no observation error (i.e. the “Perfect_Obs” observation model was used for all trials). These scenarios were designed to evaluate the ConstU CMP performance under the assumption of unbiased indices of SSB. The goal was to determine how well a constant F strategy would perform when accurate measures of harvest rate (or accurate catches and relative SSB indices) are available to inform empirical CMPs.

$$U_{target} = \overline{\frac{C_{t52:t50}}{I_{t52:t50}}} \cdot x$$

where
U=relative harvest rate
C=catch in mt
I=relative abundance index
t=model year, and
x=constant multiplier

$$U_{current} = \overline{\frac{C_{t-2:t-0}}{I_{t-2:t-0}}}$$

$$TAC_{t+1:t+3} = \frac{U_{current}}{U_{target}} \cdot TAC_{t-2:t-0}$$

where
TAC=total allowable catch limit

To tune the ConstU CMP, a target relative harvest rate was determined by profiling the MSE across a fixed grid of multiplier to the terminal three-year mean rates(both East and West stocks). We selected the pair of E-W tuning parameters (i.e. terminal F multipliers) that achieved mean spawning biomass ratios in a thirty-year projection closet to 1.0, measured across the five tuning Oms: OM14, OM31, OM37, OM53, OM89.

The second procedure (W_Rebuild) evaluates the strategy of achieving an SSB level of the West stock at or above current estimates (as measured by stock-of-origin indices of SSB abundance in the MSE). The CMP for the East stock in this scenario is the ConstU CMP described above for scenario one.

$$I_{target} = \overline{I_{t-5:t-3}}$$

where
I=relative SSB index, and
t=model year

$$I_{current} = \overline{I_{t-2:t-0}}$$

$$TAC_{t+1:t+3} = \frac{I_{current}}{I_{target}} \cdot TAC_{t-2:t-0}$$

where
TAC=total allowable catch limit

We evaluated each procedure against zero-catch scenarios for comparison of trade-offs among strategies. All scenarios were evaluated with a maximum allowable change in TAC of 50% every three years. This allowed for high flexibility in the CMPs to respond to changes in stock biomass. The CMPs were designed to evaluate alternative values of %TAC change and quota periods, as needed in the future.

Appendix 7

Specifications for MSE trials for bluefin tuna in the North Atlantic
Version 21-1

Specifications for the MSE trials are contained in a living document that is under constant modification. The most recent version of the document (Version 21-1: June 2, 2021) can be found here.

Appendix 8

Terms of reference for M3 and ABFTMSE R package code review

Background and objectives

ICCAT's Standing Committee on Research and Statistics (SCRS) has developed a Management Strategy Evaluation (MSE) framework for several species as recommended by the KOBE process. This approach allows current and alternative assessment and advice frameworks to be evaluated with respect to their ability to meet multiple management objectives with acceptable levels of risk.

Initial focus on an Atlantic bluefin tuna (BFT) MSE started in 2018, with some development of the framework to use in the OM development, was further developed during 2019 and 2020 and the process is ongoing in 2021. Consistent with the MSE implementation roadmap adopted by the Commission, in 2021 the SCRS is initiating an independent peer review of MSE code. Accordingly, there is a need to hire a MSE code technical expert(s) to work directly with the BFT MSE developers, the ICCAT Bluefin Tuna Species Group (BFTSG) and its Rapporteurs, the SCRS Chair and Vice-Chair, and in consultation with the Secretariat to review the code and algorithms used, and verify whether it performs as expected. The expert should also suggest improvements to the code used to perform the simulations.

For several years the BFTSG has recorded MSE technical specifications in a Trial Specifications Document (TSD). This covers a wide range of issues including data processing, fleet structure, operating model structure, likelihood functions for model conditioning and statistical properties of data for projections. Where applicable the TSD includes mathematical equations that can be directly compared to ADMB and R code. The primary purpose of the code review is to check that the description of the operating model detailed in the TSD is correctly implemented in the code of the M3 model and the ABTMSE R package. The review is not focused on the suitability of the specifications described in the TSD.

Components of code review

There are three principal components of the BFT MSE framework:

(1) The M3 ADMB model used to condition the operating model on data;
(2) R code to organize data and model inputs for use in the operating model conditioning (e.g. formatting of data, calculation of master indices, specification of selectivities for fleets and survey indices, likelihood weights for data types, etc.);
(3) An R package that recreates the ADMB conditioning model equations and allows for closed loop simulation testing of CMPs in projection years.

Code Review Contractor tasks

The code reviewer will review the code and algorithms used in the BFT MSE, and verify whether it performs as expected, including:

- Check code to ensure correct recreation of TSD equations in code of M3.tpl file and ABTMSE R package;
- Identify code that is used in modelling that is not documented in the TSD;
- Identify areas where code may be made more computationally efficient;
- Participate in the 2021 BFTSG meeting online September 20, 2021 and present the report of the review;
- Review any code revisions provided by the BFT MSE Contractor by November 1, 2021 and provide final report on or before December 1, 2021.

Deliverables

- The successful bidder shall develop a comprehensive and well documented report, detailing the review process conducted, that shall be presented as an SCRS document during the 2021 BFTSG meeting Online September 20, 2021. Written report due September 6, 2020.
- If comments are provided by the BFTSG, the SCRS and/or the Secretariat on the basis of this review, the BFT MSE Contractor shall take these into account and provide to the Secretariat a revised version as a draft final report and of the code and algorithms, mentioned in the two bullets above, no later than November 1, 2021. This will be forwarded to the MSE Code Review Contractor for a second round of review.
- The final report by the MSE Code Review Contractor shall be updated taking into account any revisions to the code and comments provided by the ICCAT SCRS Chair and Vice-Chair, the BFT MSE Coordinator and the BFTSG Rapporteurs, and the Secretariat, and be submitted to the Secretariat by December 1, 2021 at the latest.

Tentative schedule for code review

Tasks to be completed by the BFT MSE Contractor and provided to the MSE Code Review Contractor according to this schedule:

A reconditioning of the model is scheduled for April to mid-May which would alter code for organising data (component 2), conditioning and also the R code of the forward projections (component 3), but will not affect component 1. In order to make initial progress with a code review is it therefore efficient to organize it in relation to these components.

Component 1 (by the end of April). Provide fully commented M3.tpl to the MSE Code Review Contractor cross referenced against the latest version of the TSD.
Component 2 (by the end of June). Provide a complete set of R scripts for processing data and fitting the M3 model, again commenting and cross referencing all code against the relevant sections of the TSD.
Component 3 (by the end of July). Provide a complete set of R scripts for converting fitted M3 models into operating models of the ABTMSE package and then doing closed loop projections**.**

A note on 'internal' code checking completed so far

The historical reconstruction of the M3 model is recreated in the R framework and these have been checked for consistency (matching of all quantities to the sixth decimal place). It follows that any coding errors in the population and fishing dynamics of the M3 model would have to be recreated exactly in the R coding language which is relatively unlikely. The current version of the R package includes these checks as an argument to the function used to run MSEs.

Line-by-line checking of R package code for projecting indices and recruitment has gone through relatively detailed scrutiny during an informal code review in 2020.

Appendix 9

Terms of reference for the Technical Sub-group on Assessment Models

Successive stock assessment in 2012, 2014, 2017 and 2020 stock assessment showed problems with the modeling approach, which proved to be specifically recurrent for the eastern stock VPA. Moving away from the VPA to other approaches has been suggested several times. Past attempts, e.g. SS3 in 2017, were not complete enough to provide an alternative to the advice obtained from the VPA. The objectives of the Group are to identify 1) possible models suitable to provide a TAC advice for 2023, 2) modeling teams associated to modeling platforms, 3) problems and data gaps/availability to be addressed for the use of these models and 4) ways to address these.

Tristan Rouyer will serve as working group chair and working group members are:

- E. Aalto
- E. Andonegi
- H. Arrizabalaga
- D. Butterworth
- S. Cadrin
- T. Carruthers
- S. Cox
- J. De Oliveira
- C. Fernandez
- H. Fukuda
- K. Gillespie
- A. Gordoa
- A. Hanke
- W. Ingram
- S. Johnson
- A. Kimoto
- M. Lauretta
- J-J. Maguire
- M. Ortiz
- E. Rodriguez Marin
- L. Rueda Ramirez
- A. Sundelöf
- Y. Tsukahara
- J. Walter
- R. Zarrad

Tasks

1. Consolidate the following list of suitable modeling approach/platform and attribute a team leader
   a. ASAP
   b. M3
   c. VPA2BOX
   d. VPA2BOX WITH MIXING
   e. ADAPT
   f. SS3
2. Specify aspects common to all platform
   a. Perimeter for the modeling work
      i. Full benchmark ?
      ii. Synchrony with Group agenda
   b. Data aspects

        i. Reference datasets and availability
        ii. Age groups to be included for catch at age data
        iii. Age-length key to be used
    c. Modeling aspects
        i. Investigate conflict across indices
        ii. Investigate index and/or group of indices to be selected
3. For each modeling platform
    a. Identify gaps and requirements, including workforce, for feasibility
    b. Develop a comprehensive assessment
        i. Model fitting
        ii. Stock status
        iii. Projections
4. Develop a common way to provide results
    a. Standard diagnostics to provide across platforms (e.g. Zarrad *et al*. 2017)
    b. Combine results within KOBE II MATRIX (e.g. 2020 western approach)
        i. Or only keep one model?
        ii. Investigate whether the sources of uncertainty comparable between modeling platforms
        iii. Identify technical requirements to get this done
5. Other aspects
    a. Should / Could the assessment be peer reviewed?
    b. Identify financial support requirements (e.g. consultant, meeting…)

Timeline

The goal is to get in the position to provide a TAC advice for 2023 from different consolidated modeling approaches. The tasks have to be coordinated with the Group agenda and its evolution so that aspects that require the Group decision can be made in plenary in a timely manner and Commission requests can be integrated within the workflow.

Previous discussions have led to identify the following list of specific aspects to be considered for each platform that can be used for guidance:

- VPA2BOX
    - Extend plus group / Fratio
    - Index selection (SEE 2020 JACKKNIFE ON INDICES) and/or group of indices?
    - Scale Issue
    - Age-Length key?
    - Get a 2box running?
- SS3
    - Applicability to the eastern stock?
    - Rishi and Ai 2017 attempt: identify issues
    - Need for a consultant?
- ASAP
    - Can a complete set of diagnostics be provided?
    - Other steps: projections, MCMC, reference points, comparability of MCMC compared to VPA bootstraps
- ADAPT
    - Can a complete set of diagnostics be provided?
    - Other steps: projections, bootstraps, reference points, comparability of bootstraps compared to VPA

- M3
    - What does it take to turn M3 into “Assessment mode”?
    - Who would be able to do the work?
    - Could output be made comparable to other platforms?
    - How much energy/time/resource would this take?

Appendix 10

Detailed specifications for 2021 West Atlantic bluefin tuna stock assessment advice

The Committee outlined the specifications of an update of the stock assessment for West Atlantic bluefin tuna (W-BFT) for the provision of TAC advice between 2022 and 2023. The Committee considers that the default specifications for this assessment should be very similar to the 2020 assessment (Anon., 2020) unless there are strong rationale for changes. One specific change is that the indices considered have undergone extensive review and may be revised from the 2020 treatments.

1. General specifications

- Two models (SS3 and VPA) will be equally weighted to provide:
  - Fishery status determination ($F/F_{0.1}$), and
  - Kobe 2 F strategy matrix across constant TACs between 500 and 3500 by 100mt increments, projections should be run to 2024.
- Two alternative spawning-at-age scenarios to be equally weighted. Low/high spawning fraction at age

Model specifications

Model platforms and set-up will follow the 2020 assessment, with exception of revised indices of abundance and including data to 2020. The same model parameter settings (F-ratio) and variance scaling will be used for VPA and the same model structure will be used for Stock Synthesis with modification as necessary. We anticipate a number of modifications (outlined in section 3) to indices that will likely also require some modifications to the models. Other slight model modifications may be addressed as itemized below. Analysts will summarize model standard diagnostics and raise any modeling issues that may arise to the BFT Rapporteurs, which can then be addressed and reported to the BFT Species Group (BFTSG). This gives the modelers the ability to handle problems/issues that can arise when revisions are made.

Recommended models

VPA (1976-2020)

- Modified PCAAs for US RR Indices and any other revised indices
- Possible time-varying catchability on the US RR indices?
- End selectivity Random walk on selectivity on JPNLL index from 2015-2020, according to modelers discretion.
- Evaluate F-ratio assumptions and parameter settings and index variance scaling

Stock Synthesis (1950-2020)

- Conduct standard model diagnostics (jitter starting values, likelihood profiling) and address issues as needed, e.g. changing phase of parameters.
- Evaluate statistical assumptions of size composition modeling, explore Dirichlet multinomial options or conduct iterative reweighing of input age/length data.
- Modeling team will consider how to address index CV, recommend changing the index CVs to allow for interannual variability in estimated precision e.g. with equal common CV (or input SE), rescale the model-estimated CV to 0.2 to allow for interannual variability in precision of the index CV, or allowing for variance scaling.
- Conduct iterative reweighting of the index to estimate the additive variance adjustment.
- Retention function on US RR FB at size limit in recent years commensurate with the change to general category, consider time block selectivity on US > 150 fleet.
- Possibly, reconsider later starting date for SS, estimate numerous initial Fs as a sensitivity.
- Consider constant selex for JLL after ~2015 at modelers best discretion.
- Conduct standard review of fits to composition data to evaluate possible time blocks for selex or RW to address systematic lack of fit.
- Group is to investigate implications possible model mis-specifications e.g. fits to composition data, stock recruitment relationship and other processes.

2. Index specifications

Indices to be used for the update to advice for W-BFT in 2021. Below describes the recommended indices for use in the stock assessment by the Technical Subgroup. The indices were updated at the SCRS meetings in April 2021.

The following indices will be used in 2021 assessment:

- Indices with major revisions to data or methods:
  - U.S. rod and reel small fish index (66-144cm) to replace prior two indices for separate sizeclasses (66-114 and 115-144cm)
  - Gulf of Mexico longline combined MEX-U.S. observer index to replace the U.S. pelagic longline index in the Gulf of Mexico
  - Canada handline indices for the Gulf of St. Lawrence (GSL) and Southwest Nova Scotia (SWNS) regional indices to replace the combined CAN rod and reel index (used in Stock Synthesis in 2020)
- Indices with minor revisions:
  - U.S. rod and reel large fish (>177cm) index updated model to include environmental data (used in Stock Synthesis in 2020)
- Indices that are strict updates adding the recent years:
  - Gulf of Mexico larval survey (1976-2019)
  - Japanese longline index in the northwest Atlantic (1976-2009, 2010-2020)
  - Gulf of St. Lawrence acoustic index (1994 - 2017)

3. Catch at size data

- Analysts need catch at size data (VPA) and size composition data through 2020 as soon as possible (April 21, 2021).
  - The Group requests the same method for calculating the catch-at-size data be used as was used to process the catch-at-size data for the 2020 assessment
  - 2008 CAS data for Canada needs to revised (e.g. do not use for now) [Canada can resubmit 2008 by April 16]
- Age composition data (for Stock Synthesis) will not be requested, but if an input SS datafile that includes updated age data is provided to the analysts it can be considered in a sensitivity run.

4. Biology

- Biological inputs (natural mortality, fecundity assumptions (young/old spawning fraction at age) will not be changed from the 2020 assessment
- Growth will remain parameterized as before (estimated in SS); fixed at Ailloud-Richards (Ailloud *et al*., 2017) for VPA/Pro2Box
- Weight at age input for Pro2Box will need to be updated

5. Projections/benchmarks

- Explore more robust F metric e.g. exploitation rate in biomass?
- Project years 2021-2024, same recruitment specifications as in 2020
- We will need a specific SRSC document prior to the August meeting that provides options here and a recommendation, likely authored by the BFTSG chairs

6. Modeling teams

- VPA Team: M. Lauretta (lead), A. Kimoto, J-J. Maguire, D. Butterworth, T. Rouyer, M. Ortiz
- Stock Synthesis Team: Y. Tsukahara (lead), K. Gillespie, J. Walter, M. Lauretta, A. Hansell, A. Kimoto, J-J. Maguire, D. Butterworth, H. Fukuda, M. Ortiz

7. Deadlines

April 16, 2021	: Deadline to accept any data revisions
April 21, 2021	: CAS, comp and any index revisions due
June 15, 2021	: Preliminary model documents submitted (diagnostics, initial model fits, etc.)
Late June, 2021	: Webinar check in on model progress (4 hour)
Early Aug, 2021	: Webinar on models to date
Apr 21 -> Aug 15	: Update VPA/SS model setups, conduct diagnostics and incorporate new data
August 15, 2021	: Assessment model papers due
Aug 30-Sep 1	: W-BFT assessment meeting
Sep 2-9	: BFT Species Group meeting (Primarily MSE topics)
Sep 20-25	: SCRS species Group
Sep 27-Oct2	: SCRS

References

Anon. 2020. Report of the 2020 Second Intersessional Meeting of the ICCAT BFT Species Group (Online, 20-28 July 2020). ICCAT Collect. Vol. Sci. Pap., 77 (2): 441-567.

Ailloud, L.E., Lauretta, M.V., Hoenig, J.M., Hanke, A.R., Golet, W.J., Allman, R., and Siskey, M.R. 2017. Improving growth estimates for western Atlantic Bluefin tuna using an integrated modelling approach. Fish. Res. 191: 17-24.

Appendix 11

Terms of reference for WBFT stock assessment external review

Introduction

The ICCAT SCRS Bluefin tuna Species Group (BFTSG) is conducting a stock assessment for the western bluefin tuna (W-BFT). The overall objective of the review is to assist the SCRS in providing the most robust scientific advice possible. Unlike reviews conducted ex post facto, the external expert will be required to participate actively in the discussions, providing advice and expert opinion where he/she considers this to be warranted in time to support the process. As such, the reviewer will attend several online meetings and be required to give a brief report or presentation (with the format at the discretion of the reviewer) during each meeting.

Tasks of the reviewer

1. Attend 2, 4 hour, online webinars prior (late June and early August)
2. Attend the 3 day (4.5 hours/day) online August 30-September 1 W-BFT assessment meeting and participate in discussions
3. Attend the online SCRS Species Group meeting (3 days) in September and provide a presentation of their final report
4. Provide draft of initial presentation or report on each deliverable in advance of each successive meeting, and then present that at the meeting so that the BFTSG can consider the advice in the process.

The review will have three interim deliverables and one final written report.

1. **Interim Deliverable 1: Report in broad terms on the adequacy, appropriateness and use of data used in the assessment. Initial presentation or report due July 15, 2021.**

    a. Broadly evaluate indices and index development methods.
    b. Broadly evaluate and discuss the appropriateness of statistical methods used to develop indices considering how the raw data was/is collected.
    c. Broadly evaluate the adequacy of the biological assumptions (especially natural mortality, growth, fecundity).

2. **Interim Deliverable 2: Report in broad terms on the adequacy of assessment models being used and associated modeling decisions. Initial presentation or report due August 15, 2021 in advance of the W-BFT assessment meeting.**

    a. Broadly evaluate the adequacy, appropriateness, and application of assessment methods.
    b. Broadly evaluate CPUE treatment in models (variance scaling, selectivity and linkages to environmental factors).
    c. Address in broad terms whether model diagnostic performance criteria have been sufficiently applied, sufficiently documented and sufficiently met to provide a basis for models to be used to provide management advice.
    d. Put forward any recommendations for assessment models, model structure or parameterization or sensitivity tests, if considered necessary.

3. **Interim Deliverable 3: Report in broad terms on the adequacy and reliability of the advice framework. Initial presentation or report due September 15, 2021.**

    a. Comment on whether changes to models between 2020 and 2021 have been appropriate and adequately documented.
    b. Broadly evaluate the methods used to estimate population benchmarks and stock status (e.g., target fishing mortality proxy for, e.g., $F_{0.1}$).
    c. Broadly evaluate the adequacy, appropriateness and application of the methods used to conduct projections, given the Commission's objectives.

d. Broadly evaluate the adequacy, appropriateness and application of the methods used to characterize the uncertainty and to provide probabilistic catch limit advice. Comment on whether the implications of uncertainty in technical conclusions are clearly stated.
e. Comment on whether the stock assessment results have been presented clearly and accurately in the detailed report of the stock assessment.

4. **Final deliverable will be a written report that incorporates Interim deliverables 1-3** (due September 24, 2021).

For Interim Deliverable 1, the reviewer will have access to the entire meeting files (posted on the W-BFT data preparatory meeting OwnCloud and the W-BFT assessment meeting) and assessment data immediately upon signing the contract. The reviewer will receive papers describing the **initial model specifications and data by June 15, 2021.**

For Interim Deliverable 2, the reviewer will have access to the initial model specifications, diagnostics and model files and **papers on model diagnostics by July 15, 2021**.

For Interim Deliverable 3, the reviewer will have all models, projections and papers related to this by **September 2, 2021**. Model results and projections conducted after this time will not be addressed by the review.