9.2 BET - Bigeye

A stock assessment for bigeye tuna was conducted in 2021 through a process that included a data preparatory meeting in April and an assessment meeting in July. The stock assessment used fishery data from the period 1950-2019 and indices of relative abundance used in the assessment were calculated through 2019. The complete description of the stock assessment process and the development of management advice is found in the Report of the 2021 Bigeye Tuna Data Preparatory Meeting (Anon., 2021a) and the Report of the 2021 Bigeye Tuna Stock Assessment Meeting (Anon., 2021b).

BET-1. Biology

Bigeye tunas are distributed throughout the Atlantic Ocean between 50ºN and 45ºS, but not in the Mediterranean Sea. This species swims at deeper depths than other tropical tuna species and exhibits extensive vertical movements. Similar to the results obtained in other oceans, pop-up tagging and archival acoustic tracking studies conducted on adult fish in the Atlantic have revealed that they exhibit clear diurnal patterns: they are found much deeper during the daytime than at night. In the eastern tropical Pacific, this diurnal pattern is exhibited equally by juveniles and adults. In the western Pacific these daily patterns have been associated with feeding and are synchronized with depth changes in the deep scattering layer. Spawning takes place in tropical waters when the environment is favorable. From nursery areas in tropical waters, juvenile fish tend to diffuse into temperate waters as they grow. Catch information from surface gears indicate that the Gulf of Guinea is a major nursery ground for this species. Dietary habits of bigeye tuna are varied and prey organisms like fish, mollusks, and crustaceans are found in their stomach contents. Bigeye tuna exhibit relatively fast growth: about 110 cm fork length at age three, 145 cm at age five and 163 cm at age seven. Recently, however, reports from other oceans suggest that growth rates of juvenile bigeye are lower than those estimated in the Atlantic. Based on Indian Ocean tagging data, growth rates of bigeye tuna differ between sexes, males reaching around 10 cm larger L_{INF} than females. Bigeye tuna become mature around 100 cm at around 3 years old. Young fish form schools mixed with other tunas such as skipjack and young yellowfin tuna. These schools are often associated with drifting objects, whale sharks and sea mounts. This association weakens as bigeye tuna grow.

Extensive growth information obtained during the Atlantic Ocean Tropical Tuna Tagging Programme (AOTTP) has confirmed previous assumptions about growth rates and the Richards curve published by Hallier *et al*. (2005) continues to be used in the BET assessment. It is assumed that natural mortality (M) is larger for young fish than for old fish. Age-specific M assumptions were modified significantly from the 2018 assessment. Modifications were based on new information recently obtained by ageing otoliths of Atlantic BET showing that fish reach 17 years of age (in contrast to previous estimates of 15 years) and by the decision to use a better procedure to derive natural mortality from maximum age. Various pieces of evidence, such as a lack of identified genetic heterogeneity, the time-area distribution of fish and movements of tagged fish, as confirmed by the recent data obtained from the AOTTP programme (**BET-Figure 1**), suggest an Atlantic-wide single stock for this species. However, the possibility of other more complex scenarios of stock structure should not be disregarded. Knowledge about the relationship between recruitment and spawning stock remains limited, so assumptions about the steepness of this relationship for small spawning stock sizes and the interannual variation in recruitment remain the same as the assumptions of the 2018 assessment. These uncertainties in stock structure, natural mortality, and the relationship between spawning stock and recruitment have important implications for the stock assessment as described in the Report of the 2021 Bigeye Tuna Stock Assessment Meeting (Anon., 2021b).

BET-2. Fisheries indicators

The stock has been exploited by three major gears (longline, baitboat and purse seine fisheries) and by many countries throughout its range. ICCAT has detailed data on the fishery for this stock since the 1950s. Scientific sampling at landing ports for purse seine vessels from the EU and other fleets has been conducted since 1980 to estimate bigeye tuna catches (**BET-Figure 2, BET-Table 1**). The size of fish caught varies among fisheries: medium to large fish for the longline fishery and purse seine free school sets, small to large for subtropical baitboat fishery, and small for tropical baitboat, western handline and purse seine floating object (FOB) / fish aggregating device (FAD) fisheries.

The major historical baitboat fisheries are located in Ghana, Senegal, the Canary Islands, Madeira and the Azores. Since 2012, a "vessel associated-school" fishing method using handline, where the vessels acts as a fish aggregating device developed in the western equatorial area, with bigeye catches increasing from 555 t in 2012 to an average of 4,670 t in 2015-2019. The tropical purse seine fleets operate in the Gulf of Guinea in the eastern Atlantic and across the tropical equatorial area. The longline fleets operate across a broader geographic range, covering tropical and temperate regions (**BET-Figure 2**). While bigeye tuna is a primary target species for most of the longline and some baitboat fisheries, this species has always been of secondary importance for the other surface fisheries. In the purse seine fishery, unlike yellowfin tuna, bigeye tunas are mostly caught while fishing on floating objects such as logs or manmade fish aggregating devices (FOB/FADs). The estimated total numbers of FADs released yearly has increased since the beginning of the FAD fishery, especially in recent years. During 2018-2022, bigeye landings in weight caught by longline fleets represent 47%, purse seine fleets 34%, baitboat 11% and other surface fleets 8% of the total landings (**BET-Table 1**).

The total annual Task 1 catch (**BET-Table 1**, **BET-Figure 3**) increased continuously up to the mid-1970s reaching 60,000 t and fluctuated over the next 15 years. In 1992, catch reached about 100,000 t and continued to increase, reaching a historic high of about 135,000 t in 1994. Since then, reported and estimated catch continuously declined and fell to 59,192 t by 2006. From the low level of 2006, catches increased again and reached 80,000 t in 2015. Catches averaged close to 73,000 t in the period 2016-2020. Catches of all tropical tunas declined considerably in 2021, and the reported catch of bigeye tuna was only 47,568 t. The preliminary catch reported for 2022 was 62,513 t, slightly above the TAC of 62,000 t.

After the historic high catch in 1994, all major fisheries exhibited a decline in catch while the relative share of each fishery in total catch remained relatively constant until 2008. These reductions in catch were related to declines in fishing fleet size (longline) as well as decline in catch per unit effort (CPUE) (longline and baitboat). Although the general trend of decreasing catches continued for longline and baitboat, the purse seiner catches increased, as did the relative contribution of purse seine in the total catches for the period 2010-2019. Other surface fisheries, from CPCs with no specific catch limits under Rec. 16-01, also increased the catches from around 500 t in 2011 to around 4,500 t in 2016-2020, mainly due to the development of a handline vessel associated-school fishery in the equatorial western Atlantic.

Nominal purse seine effort, expressed in terms of carrying capacity, has decreased regularly since the mid-1990s up to 2006. However, after that year, several European Union purse seiners have transferred their effort to the eastern Atlantic, due to piracy in the Indian Ocean, and a fleet of new purse seiners have started operating from Tema (Ghana). All this has contributed to the growth in carrying capacity of the purse seiners, which is gradually nearing the level observed in the early 1990s. More detailed information on carrying capacity is included in item 21.10 of the *Report for Biennial Period, 2020-21 Part II (2021), Vol. 2*.

Small bigeye tuna continues to be diverted to local West African markets, predominantly in Abidjan, and sold as *faux poissons* in ways that make their monitoring and official reporting challenging. Monitoring of such catches has recently progressed through a coordinated approach that allows ICCAT to properly account for these catches and thus increase the quality of the basic catch and size data available for assessments. Currently those catches are included with those from the main purse seine fleet in the ICCAT Task 1 data used for the assessments. The 2020-22 catch for *faux poissons* was estimated by the Group to be 4% of the total purse seine BET catch.

In the 2018 assessment mean average weight of bigeye tuna was reviewed. It showed mean weight decreased prior to 2004 but has remained relatively stable at around 10 kg for the last decade. Average weight, however, is quite different for the different fishing gears. In 2017 it was around 55 kg for longliners, 10 kg for baitboats, and 6 kg for purse seiners. Since 2000, several longline fleets have shown increases in the mean weight of bigeye tuna caught, with the average longline-caught fish increasing from 40 kg to 60 kg between 2000 and 2008. The average weight of bigeye tuna caught in free schools is more than double the average weight of those caught around FOB/FADs. Since 1991, when tuna catches were identified separately for FADs for EU and other CPCs purse seine fleets, the majority of bigeye tuna are caught in sets associated with FADs; particularly since the mid-2000s (60%-80%). Similarly, baitboat-caught bigeye tuna weighed between 6 and 10 kg up to 2011, but with greater inter-annual variability in average weight compared to longline or purse seine caught fish.

During the 2018 assessment a Joint Longline standardized abundance index (Hoyle *et al*., 2019) was used instead of each individual CPC's standardized CPUE indices used in the 2015 assessment. The joint longline standardized index for 1959-2017 was constructed using detailed operational data (including set by set and vessel identifiers) from major longline fleets, (Japan, Korea (Rep.), United States and Chinese Taipei). The index was broken down into two periods, 1959-1978 ("early") and 1979-2017 ("late") because of changes in the level of information available on fishing operations.

The development of this joint standardized CPUE index was motivated to reduce data conflicts that arise when CPUE trends differ for different fleets in the same period. This can occur when available data are sparse, when the fishery occurs at the extremes of the spatial distribution of the stock and/or does not represent a meaningful proportion of the stock biomass, or when the index references only a small portion of the age or size distribution. This can also occur when there are important changes in fisheries operations (e.g., targeting, regulations, spatial distribution) that cannot be addressed in the standardization process.

The 2018 joint longline indices were an improvement over fleet-specific indices and, for the "late" period, was able to account for differences in fishing efficiency of longline vessels. The "early" joint longline index developed in 2018 for the period 1959-1978 was included in the assessment of 2021 (**BET-Figure 4**).

A new joint longline index was produced in 2021 for the "late" period 1979-2019 (**BET-Figure 4**). Unfortunately, it was not possible to update this index by using the same level of detailed data and same set of fleet-specific longline data sets as it was done during the 2018 assessment due to restrictions on analyses caused by the COVID-19 pandemic. The 2021 "late" joint longline index used data aggregated to monthly catches by fleet and 1x1 latitude longitude. This index was developed without set-by-set data.

A new quarterly acoustic echosounder buoy index associated with FADs covering the period 2010-2019 is now available for all three species of tropical tunas and helped the assessment account for changes in abundance of juvenile BET (**BET-Figure 5**). This new index is a significant improvement in the available information set for the stock assessment given the challenges faced up until now to develop an index from the purse seine fisheries of tropical tunas. The index is developed from tuna biomass estimates obtained from the acoustic buoys placed in FADs. Observations of tropical tuna species composition from purse seine FAD catch sets conducted in similar places and times to the acoustic observations are used to develop a buoy index for each species of tropical tuna.

In the assessment, the joint longline index was assumed to have a selectivity for older fish, equivalent to the Japan longline fleet in the tropical Atlantic. As the acoustic buoy index represents BET abundance associated with FADs it was assumed that it represents the same range of sizes and ages of BET as those caught in the purse seine FAD fishery.

BET-3. State of the stock

The 2021 stock assessment was conducted using similar assessment models to those used in 2018, updating the data until 2019, but with some significant changes in natural mortality assumptions, derived from new information and new assumptions on maximum age, the relative abundance indices used and the fleet structure of the model used for providing management advice. As in 2018, stock status evaluations for Atlantic bigeye tuna used in 2021 several modeling approaches, ranging from non-equilibrium (MPB) and Bayesian state-space (JABBA) production models to integrated statistical assessment models (Stock Synthesis). Different model formulations considered to be plausible representations of the stock dynamics were used to characterize stock status and the uncertainties in stock status evaluations.

The Stock Synthesis integrated statistical assessment model allows the incorporation of more detailed information, both for the biology of the species as well as fishery data, including the size data and selectivity by different fleet and gear components. As Stock Synthesis allows modelling of the changes in selectivity of different fleets as well as to investigate the effect of the length/age structure of the catches of different fisheries in the population dynamic, productivity and fishing mortality, it was the agreed model to be used for the management advice. The Stock Synthesis uncertainty grid includes 27 model configurations, all of which were given equal weight, that were investigated to ensure that major sources of structural uncertainty were incorporated and represented in the assessment results (**BET-Table 2**). Although the results of two production models, non-equilibrium and Bayesian state-space, are not used for management advice they provide comparative perception of stock status. The median relative biomass (B/B_{MSY}) and relative fishing mortality (F/F_{MSY}) trajectories from production models and the Stock Synthesis models depicted similar patterns. The set of 27 Stock Synthesis models has wide uncertainty bounds for these trajectories, and the biomass trajectories from all the production models are within these bounds.

Results of the uncertainty grid of Stock Synthesis runs show a long-term decline in spawning stock biomass (SSB) from the beginning of the fishery, accelerating from 1970 to 2000 and a relative stable SSB in the last 20 years. Relative fishing mortality increased from the beginning of the fishery until 1999, rapidly declined from 1999 to 2008 and has been relatively stable since. Recruitment estimates for the recent period of 2015-2019 show an increasing trend (**BET-Figure 6**), in spite of the relative stability of recent SSB (**BET-Figure 7**).

The stock synthesis uncertainty grid shows 1950-2019 trajectories of increasing F and decreasing biomass (B) towards the red area of the Kobe plot ($F > F_{MSY}$ and $SSB < SSB_{MSY}$) (**BET-Figure 7 and 8**). Overfishing starts in around 1993 and the stock becomes overfished around 1997, therefore reaching the red quadrant of the Kobe plot and mostly remained in the red quadrant until 2019 when overfishing ceased (**BET-Figure 8**). The results of the assessment, based on the median of the entire uncertainty grid shows that in 2019 the Atlantic bigeye tuna stock was overfished (median SSB_{2019}/SSB_{MSY} = 0.94 and 80% confidence interval (CI) of 0.71 and 1.37) and was not undergoing overfishing (median F_{2019}/F_{MSY}=1.00 and 80% CI of 0.63 and 1.35). The average of MSY was estimated as 86,833 t with (80% CI of 72,210 t and 106,440 t) from the uncertainty grid deterministic runs.

Calculations of the time-varying benchmarks from the stock synthesis uncertainty grid show a long-term increase in SSB_{MSY} and a general long-term decrease in MSY. This change in benchmarks is the result of the change in overall selectivity caused by the shift to catch greater proportions of smaller fish. The current estimate of MSY is below what was achieved in past decades because of this shift. Other potential sources of changes in stock productivity have not been accounted in the assessment as no evidence for such changes has been presented to the Committee (**BET-Figure 9**).

Current estimates of stock status in 2019 are more optimistic than the 2017 stock status estimated at the 2018 assessment. Sensitivity analyses demonstrated that such changes in stock status partially result from replacing the 2018 “late” joint longline index with the new “late” joint longline index and incorporating new mortality at age vectors (**BET-Figure 10**).

The effect of natural mortality, steepness, and Sigma R (variability on the log of recruitment) on the uncertainty around current stock status are shown in **BET-Figure 11**. Of the three axes of uncertainty, natural mortality contributes the most to changing the perception of stock status. Assumptions about natural mortality are the greatest contributors to this uncertainty (**BET-Figure 11a**).

Uncertainty regarding the change in the longline index methodology was not incorporated into the uncertainty grid because it was not clear to the Committee on an appropriate way to do so. The scale of the impact of such change in methodology can be seen in **BET-Figure 10.** Therefore, the current stock status (**BET-Figure 8**) is more uncertain than the SCRS has been able to quantify with the uncertainty grid.

BET-4. Outlook

During the 2021 assessment projections were conducted for the uncertainty grid Stock Synthesis for a range of fixed catches from 35,000 to 90,000 t for 15 years (which corresponds to 2 generation times of bigeye) from 2020-2034. Projections results are driven by all the assumptions made for the projection period: by the catch estimate for 2020, by the assumption that removals equal the TAC from 2021 onwards, by the assumption that the relative contribution of different fleets to catches from 2020 onwards are the same as the contributions for 2017-2019 and that future recruitment is determined by spawning stock. The 2020 catch in the projections is 22% lower than the average catches of the period 2015-2019, and, for the first time since 2015, this catch did not exceed the TAC.

Under the projections of 2021 the assumed catch for 2020, and 2021 were 59,919 t and 61,500 t, respectively. As of September 2023, the reported catch of 2020 was 57,971 t, smaller than the catch used in the projections made in 2021. The 2021 catches reported of 47,568 t were lower in comparison, but the 2022 preliminary catches of 62,513 t were slightly higher than the TAC of 62,000 t. Therefore, projections conducted in 2021 have to be interpreted with caution as none of the projection tables were calculated with catches for 2020-2022 that match the current reported catches for such period.

For some of the projections, the modelled stock could not sustain some of the constant high TACs in the long term, as SSB was predicted to decline below a safe threshold (**BET-Table 3**). This safe threshold is an indicator of very low SSBs that may compromise the rebuilding ability of a stock when such low levels of biomass are reached. The value of 20% SSB at MSY is used by the Committee for both YFT and BET. The results of projections of the Stock Synthesis are provided in the form of Kobe II Strategic Matrices including with probabilities that overfishing is not occurring ($F<=F_{MSY}$), stock is not overfished ($SSB>=SSB_{MSY}$) and the joint probability of being in the green quadrant of the Kobe plot (i.e., $F<=F_{MSY}$ and $SSB>=SSB_{MSY}$) (**BET-Table 4**).

The rapid change in probabilities of overfishing and overfished during 2020 and 2021 (**BET-Figure 12**). are the result of the fact that estimated stock status in 2019 is close to the center point of the Kobe plot. When a stock is at such center point decreases in fishing mortality initially lead to large changes in these probabilities as can be seen from the marginal histograms (**BET-Figure 8**).

The more optimistic outlook presented in the 2021 assessment compared to the one obtained in 2018, is the result of a combination of factors: updates to the data and biological parameters, changes in the methodology and data used for the joint longline index, use of the buoy index, changes to the fleet structure in the stock synthesis models, and the assumed catches of BET for 2020 and 2021 which were low in comparison to catches for 2015-2019. There was some disagreement among Committee members on whether all these changes represent improvements to the information used to provide the determination of stock status and the outlook for the stock. Therefore, the Kobe II matrix should be interpreted with caution.

BET-5. Effect of current regulations

During the period 2005-2008 an overall TAC was set at 90,000 t. The TAC was later lowered (Rec. 09-01 and later modified by Rec. 14-01) to 85,000 t. Estimates of reported catch for 2009-2015 (**BET-Table 1**) have been always lower than 85,000 t. The TAC was again reduced to 65,000 t in Rec. 15-01 which entered into force in 2016 and Rec. 18-01, and in Rec. 19-02 to 62,500 t and 61,500 t for 2020 and 2021, respectively. TACs for 2022 and 2023 were set to 62,000 t in Rec. 21-01 and Rec. 22-01, respectively. Catches exceeded the TAC by more than 20% every year from 2016-2019 except 2018 when catches were 12% higher than the TAC. Note that because TACs do not limit catches of all countries and fleets that can catch bigeye tuna, the total catch removed from the stock can exceed the TAC. Rec. 19-02 included new catch limits for CPCs not previously under catch limits that took effect in 2020. Such limits were somewhat modified in subsequent recommendations. Current limits are described in Rec. 22-01. Such limits may have contributed to the declines in reported catch for 2020 and 2021 which were lower than the TAC, although such decline may have also been partly due to the effects of COVID-19 in fishing operations. Preliminary reported catches for 2022, however, overpassed the TAC by about 500 t.

Concern over the catch of small bigeye tuna partially led to the establishment of spatial closures to surface fishing gear in the Gulf of Guinea (Recs. 04-01, 08-01, 11-01, 14-01, 15-01 and 19-02). The Committee examined trends on average bigeye tuna catches by areas as a broad indicator of the effects of such closures as well as changes in juvenile bigeye and yellowfin catches due to the moratorium. The efficacy of the area-time closure agreed in Rec. 15-01 was evaluated by examining fine-scale (1ºx1º) skipjack, yellowfin, and bigeye catch by month distributions. After reviewing this information, the Committee concluded that the moratorium has not been effective at reducing the mortality of juvenile bigeye tuna, and any reduction in bigeye tuna mortality was minimal, largely due to the redistribution of effort into areas adjacent to the moratorium area and increase in number of fishing vessels. The FAD fishing closure in Rec. 19-02 was implemented in 2020 and 2021, however its effects cannot yet be evaluated. Although such closure may have contributed to the lower catches of BET estimated for 2020 and 2021, it was maintained during 2022 when catches have again slightly exceeded the TAC.

BET-6. Management recommendations

The Atlantic bigeye tuna stock in 2019 was estimated to be overfished but not undergoing overfishing. According to the Kobe II Strategy Matrix (K2SM), a future constant catch of 61,500 t, which is the TAC established in Rec. 19-02, will have a high probability (97%) of maintaining the stock in the green quadrant of the Kobe plot by 2034. This would leave the stock in a state consistent with the Convention objectives and the recovery plan in Rec. 19-02 (**BET-Table 4**). The K2SM, incorporates some of the known main sources of uncertainty, however, some other sources of relevant uncertainties were not been included in the development of the K2SM, including the appropriateness of the range of natural mortalities used in the uncertainty grid and the change in methodology used to develop the Joint Longline index. Therefore, current stock status and the outlook for the stock are more uncertain than portrayed in the summary table and the K2SM. Projection probabilities should be interpreted with caution. Until such additional sources of uncertainty can be properly incorporated in the estimation of stock status and the K2SM, the Commission should consider adopting a TAC that would shift the stock status of BET towards the green zone of the Kobe plot with a high probability.

The Commission should be aware that increased harvests on small fishes could have had negative consequences for the productivity of bigeye tuna fisheries (e.g., reduced yield at MSY and increased SSB required to produce MSY) (**BET-Figure 9**). Rec. 19-02 contains measures adopted by the Commission aimed at increasing long-term sustainable yield by reducing the catch of juveniles of tropical tunas. It is too early to know the extent by which these measures have reduced mortality of juvenile BET.

ATLANTIC BIGEYE TUNA SUMMARY	
Maximum Sustainable Yield	86,833 t with (72,210 -106,440 t)[1]
Current (2022) Yield	62,513 t[2]
Relative Spawning Biomass (SSB_{2019}/SSB_{MSY})	0.94 (0.71-1.37)[1]
Relative Fishing Mortality (F_{2019}/F_{MSY})	1.00 (0.63-1.35)[1]
Stock Status (2019)	Overfished: Yes[3] Overfishing: No[3]
Conservation & management measures in effect:	Rec. 16-02, Rec. 17-01 and Rec. 22-01 – Total allowable catch (TAC) for 2022 and 2023 was set to 62,000 t for Contracting Parties and Cooperating non-Contracting Parties, Entities or Fishing Entities. – No fishing with natural or artificial floating objects from 1 January to 13 March in 2023, throughout the Convention area. – No more than 300 FADs active at any time by vessel. – Use of non-entangling FADs. – Prohibition of discarding from purse seine.

[1] Combined result of stock synthesis 27 uncertainty grid runs. Median and 10 and 90% percentile in brackets.
[2] Reports for 2022 reflect the most recent data but should be considered provisional.
[3] Probability of overfished 58%, probability of overfishing 50%.

BET-Table 1. Estimated catches (t) of bigeye tuna (*Thunnus obesus*) by area, gear and flag.

			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	2021	2022
TOTAL	A+M		113790	134932	128047	120767	110255	107954	121425	103434	91636	75802	87596	90043	67954	59192	69895	63172	76427	76074	76749	71317	66977	75308	80000	79897	78665	73077	75384	57971	47568	62513
Landings		Bait boat	16466	20352	25687	18342	21277	19173	22197	12141	14430	8460	11233	20238	13104	10605	10561	6307	11548	7842	12659	10459	9195	8715	7970	6710	8366	7932	7341	6811	6141	6855
		Longline	62891	78908	74872	74930	68312	71857	77227	72011	56123	47351	55356	49400	37961	34182	46231	41063	43533	42516	37899	34930	32245	36770	40379	36345	35190	32065	33890	27288	21649	32620
		Other surf.	628	973	561	363	546	445	678	459	723	226	451	293	733	552	449	220	258	487	1146	1012	2783	4960	6002	6472	7217	4616	6054	5461	5339	5167
		Purse seine	31515	32667	25260	26592	19127	15490	20139	17460	20103	19552	19689	19094	15129	13310	11962	14810	20007	24235	23767	24080	22122	24253	24418	28624	26838	27284	26929	17026	13762	16793
Landings(FP)		Bait boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
		Purse seine	2290	2032	1667	540	993	989	1184	1363	257	214	867	1019	1026	542	692	772	1081	994	1277	823	632	609	1193	1744	1015	1151	1145	1355	646	1028
Discards		Bait boat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	2	0	0	26	15	27	29	41
		Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Purse seine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	38	2	10	3	1	2
Landings	CP	Angola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	**0**
		Barbados	0	0	0	0	24	17	18	18	6	11	16	19	27	18	14	14	7	12	7	15	11	26	30	19	16	29	14	20	25	24
		Belize	0	0	10	0	5	195	0	134	96	0	0	0	0	4	60	70	234	249	1218	1242	1336	1502	1877	1764	1961	2135	2307	991	600	1002
		Brazil	1256	601	1935	1707	1237	776	2024	2768	2659	2582	2455	1496	1081	1479	1593	958	1189	1173	1841	2120	3623	6456	7750	7660	7258	5096	6249	6284	6499	7341
		Canada	124	111	148	144	166	120	263	327	241	279	182	143	187	196	144	130	111	103	137	166	197	218	257	171	214	237	193	104	253	330
		Cape Verde	319	385	271	299	228	140	9	2	0	1	1	1	1077	1406	1247	444	545	554	1037	713	1333	2271	2764	1680	1107	1418	880	576	171	2
		China PR	70	428	476	520	427	1503	7347	6564	7210	5840	7890	6555	6200	7200	7399	5686	4973	5489	3720	3231	2371	2232	4942	5852	5514	4823	5718	3614	1638	3249
		Curaçao	0	0	0	1893	2890	2919	4016	3098	3757	2221	3203	3526	27	416	252	1721	2348	2688	3441	2890	1964	2315	2573	3598	2844	3530	2787	1519	1701	824
		Côte d'Ivoire	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	790	576	47	507	635	441	12	544	1239	384	2334	141	59	386
		EU-España	16782	22096	17849	15393	12513	7110	13739	11250	10133	10572	11120	8365	7618	7454	6675	7494	11966	11272	13100	10914	10082	10736	10058	11469	11544	8400	9117	5997	6598	6424
		EU-France	12648	12262	8262	9135	5955	5583	5413	5873	5533	4437	4048	2989	2814	2984	1525	1130	2313	3355	3507	3756	3222	3837	2801	4772	4039	4055	5118	2104	1809	3678
		EU-Ireland	0	0	0	0	4	0	0	0	10	0	0	0	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		EU-Italy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	7	0	**0**
		EU-Poland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		EU-Portugal	5616	3099	9662	5810	5437	6334	3314	1498	1605	2590	1655	3204	4146	5071	5505	3422	5605	3682	6920	6128	5345	3869	3135	2187	3146	4405	3146	3069	3106	3123
		El Salvador	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	992	1450	1826	2634	2464	1518	1492	1479
		FR-St Pierre et Mi	0	0	0	0	0	0	0	0	90	21	0	28	6	0	2	3	0	2	0	0	0	0	0	0	0	0	0	0	0	**0**
		Gabon	1	87	10	0	0	0	184	150	121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Gambia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Ghana	3577	4738	5517	4751	10174	10647	11704	5632	9864	6480	9061	17888	8860	2307	2559	3372	4515	6253	3541	4468	2963	4175	5918	5194	3838	3636	2917	3160	1925	3672
		Great Britain	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Grenada	20	10	10	0	1	0	0	0	0	0	0	0	0	0	10	31	0	0	0	0	0	0	18	23	33	27	19	11	0	10
		Guatemala	0	0	0	0	0	0	0	0	0	0	736	831	998	949	836	998	913	1011	282	262	163	993	340	1103	1602	1488	1623	906	768	855
		Guinea Ecuatorial	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	50	0	58	0	3	10	17	4	11	7	8	6	6	5
		Guinée Rep	0	0	334	2394	885	0	0	0	0	0	0	0	0	0	0	0	0	328	322	1516	1429	902	0	0	0	0	0	0	0	5
		Honduras	0	0	61	28	59	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Iceland	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Japan	35053	38503	35477	33171	26490	24330	21833	24605	18087	15306	19572	18509	14026	15735	17993	16684	16395	15205	12306	15390	13397	13603	12390	10365	10994	9854	9327	8973	9332	12132
		Korea Rep	377	386	423	1250	796	163	124	43	1	87	143	629	770	2067	2136	2599	2134	2646	2762	1908	1151	1039	675	562	432	623	540	587	674	763
		Liberia	65	53	57	57	57	57	57	57	57	57	57	0	0	0	0	0	0	0	0	0	0	0	0	27	98	1	3	222	29	0
		Libya	1085	500	400	400	400	400	400	400	31	593	593	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Maroc	774	977	553	654	255	336	1444	1160	1181	1154	1399	1145	786	929	700	802	795	276	300	300	308	300	309	350	410	500	850	1033	1239	1363
		Mauritania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**0**
		Mexico	1	4	0	2	6	8	6	2	2	7	4	5	4	3	3	1	1	3	1	1	2	1	2	2	3	3	3	3	3	4
		Namibia	0	715	29	7	46	16	423	589	640	274	215	177	307	283	41	146	108	181	289	376	135	240	465	359	141	109	79	568	1185	2070
		Nigeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	**0**
		Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Panama	10138	13234	9927	4777	2098	1252	580	952	562	211	0	1521	2310	2415	2922	2263	2405	3047	3462	1694	2774	2315	1289	2337	1664	2067	3052	1648	1107	1328
		Philippines	0	0	0	0	0	1154	2113	975	377	837	855	1854	1743	1816	2368	1874	1880	1399	1267	532	1323	1964	0	0	0	0	0	0	0	**0**
		Russian Federatio	0	0	0	13	38	4	8	91	0	0	0	0	1	1	26	73	43	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		S Tomé e Príncipe	4	3	6	4	5	6	5	4	4	4	4	11	6	4	0	92	94	97	100	103	107	110	633	421	393	2	81	46	90	149
		Senegal	8	123	357	190	272	789	1372	915	1159	497	322	490	770	1318	1293	734	1144	969	479	436	606	369	1031	1500	2978	2870	2272	2772	856	746
		Sierra Leone	0	0	0	0	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		South Africa	88	79	27	7	10	53	55	249	239	341	113	270	221	84	171	226	159	145	153	47	435	332	193	121	257	282	432	357	380	464
		St Vincent and Gr	1740	812	519	596	545	1937	2940	1921	1143	130	103	18	0	114	567	171	293	396	38	25	16	30	496	622	889	428	504	220	136	568
		Trinidad and Toba	3	29	27	37	36	24	19	5	11	30	6	5	9	12	27	69	56	40	33	33	37	59	77	37	25	17	13	10	9	10
		UK-Bermuda	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1
		UK-Sta Helena	6	6	10	10	12	17	6	8	5	5	4	6	18	25	18	28	17	11	190	51	19	17	44	77	70	45	4	0	0	1
		UK-Turks and Cai	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	**0**
		USA	1090	1402	1209	882	1138	929	1263	574	1085	601	482	416	484	991	527	508	515	578	866	727	903	892	1082	568	836	921	829	801	968	1203
		USSR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		Uruguay	48	37	80	124	69	59	28	25	51	67	59	40	62	83	22	27	201	23	15	2	30	0	0	0	0	0	0	0	0	**0**
		Venezuela	809	457	457	189	274	222	140	221	708	1241	847	1060	243	261	318	122	229	85	264	98	94	169	132	156	318	165	28	79	129	39

			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	2021	2022
	NCC	Chinese Taipei	13426	19680	18023	21850	19242	16314	16837	16795	16429	18483	21563	17717	11984	2965	12116	10418	13252	13189	13732	10805	10316	13272	16453	13115	11845	11630	11288	9226	4093	8181
		Costa Rica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	4	4	1	0	6	1
		Guyana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	25	34	53	2	4	1	**0**
	NCO	Argentina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Benin	8	9	9	9	30	13	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Cambodia	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Congo	14	9	9	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Cuba	36	7	7	5	0	0	0	0	0	16	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Dominica	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Faroe Islands	0	0	0	0	0	0	11	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		NEI (ETRO)	42	356	915	0	7	0	0	0	362	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		NEI (Flag related)	4378	8964	10697	11862	16565	23484	22190	15092	7907	383	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Saint Kitts and Ne	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1	0	0	1	0	
		Seychelles	0	0	0	0	0	0	0	58	0	162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Sta Lucia	0	0	0	0	0	0	0	0	1	2	2	0	2	0	0	0	0	0	0	0	0	0	6	10	24	13	13	9	3	3
		Togo	86	23	6	33	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Vanuatu	1807	2713	2610	2016	828	0	314	0	0	0	0	104	109	52	132	91	34	42	39	23	9	4	0	0	0	0	0	0	0	
Landings(FP)	CP	Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	46	42	16	41	23	0	0	0	0	0	0	0	**0**
		Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	75	28	37	38	61	102	40	22	45	97	165	121	38	53	42	54	0	**0**
		Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	13	25	20	13	117	59	46	60	34	42	0	0	0	0	0	0	57	**0**
		Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	95	45	0	0	0	0	0	0	0	0	**0**
		EU-España	764	605	371	58	255	328	487	474	0	0	223	244	143	88	49	190	250	211	216	98	80	143	334	398	323	216	265	200	224	299
		EU-France	1032	970	713	314	437	467	553	607	229	205	446	397	222	79	26	51	150	122	394	192	56	54	191	233	108	213	201	233	289	689
		El Salvador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21
		Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	56	28	15	26	9	18	6	11	5	15	0	0	0	0	0	0	23	13
		Guinée Rep	0	0	0	0	0	0	0	0	0	0	0	0	72	0	60	20	22	74	203	288	245	209	0	0	0	0	0	0	0	**0**
		Panama	0	0	0	0	0	0	0	0	0	0	0	0	151	106	135	97	85	38	70	41	80	27	0	0	0	0	0	0	53	12
	NCO	Mixed flags (EU t	494	457	582	169	301	193	143	281	28	8	198	378	294	189	348	337	375	324	257	0	0	0	503	993	546	669	637	868	0	
Discards	CP	Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2
		EU-France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	38	2	10	3	1	2
		EU-Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Japan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	15	18	19	35
		Korea Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**0**
		Mexico	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		UK-Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		USA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	6	5
	NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	**0**

BET-Table 2. Details of the specifications for the 27 Stock Synthesis models of the uncertainty grid for the Atlantic bigeye tuna. The 27 models are constructed as a fully crossed design of the 3 uncertainty parameters below (3x3x3=27). Max age represents the assumption of lifespan used to estimate age specific natural mortality. Sigma R represents the variability of recruitment not explained by the spawning stock recruitment relationship and Steepness represents the shape of the SSB vs recruitment relationship. The bold values represent the model combination that the Committee defined as 'reference' case. This reference case model was defined solely for the purpose of constructing the initial runs of the assessment and for comparison with sensitivity runs. The reference case model was given the same weight than any of the other models of the uncertainty grid in the estimation of stock status and development of forecasts.

Parameter	Value1	Value2	Value3
Max_Age	17	20	25
Steepness	0.7	0.8	0.9
Sigma R	0.2	0.4	0.6

BET-Table 3. Percent of the model runs that resulted in SSB levels <= 20% of SSB_{MSY} during the projection period for a given catch level (in 1000 t) for Atlantic bigeye tuna.

TAC (1000s mt)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
35	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
37.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
40	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
42.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
45	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
47.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
50	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
52.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
55	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
57.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
60	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
61.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
62.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
65	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
67.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
70	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
72.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
75	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
77.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
80	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
82.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
85	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	8%
87.5	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%	13%	27%
90	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	3%	14%	28%	32%

BET-Table 4. Estimated probabilities of the Atlantic bigeye tuna stock being below F_{MSY} (overfishing not occurring), above B_{MSY} (not overfished) and above B_{MSY} and below F_{MSY} (green zone) in a given year for a given catch level ('000 t), based upon Stock Synthesis 2021 assessment outcomes.

a) Probability of Overfishing Not Occurring (F <= F_{MSY}).

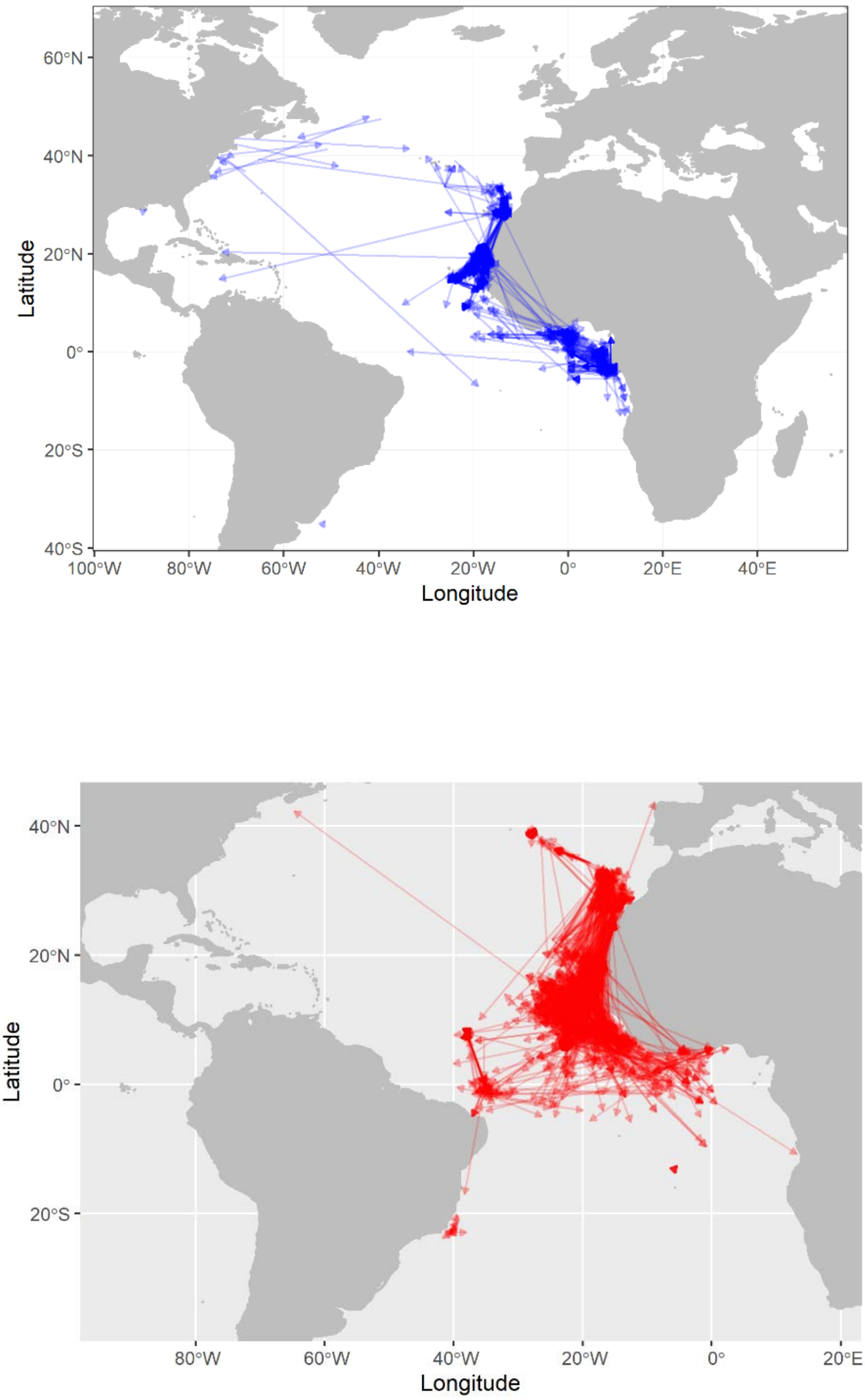
TAC (1000s mt)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
35	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
37.5	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
40	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
42.5	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
45	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
47.5	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
50	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
52.5	98%	99%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%
55	97%	98%	98%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%
57.5	96%	97%	98%	98%	99%	99%	99%	99%	100%	100%	100%	100%	100%
60	94%	96%	96%	97%	98%	98%	99%	99%	99%	99%	99%	99%	99%
61.5	93%	95%	95%	96%	97%	97%	98%	98%	98%	98%	98%	98%	99%
62.5	92%	94%	95%	96%	96%	97%	97%	98%	98%	98%	98%	98%	98%
65	90%	92%	92%	93%	94%	95%	95%	95%	96%	95%	95%	95%	95%
67.5	88%	89%	90%	91%	92%	92%	93%	93%	92%	92%	92%	92%	91%
70	85%	86%	87%	87%	88%	88%	89%	89%	88%	87%	87%	86%	85%
72.5	82%	83%	83%	83%	84%	84%	83%	83%	82%	81%	80%	79%	78%
75	78%	80%	79%	79%	79%	78%	77%	76%	75%	74%	73%	71%	69%
77.5	75%	76%	75%	74%	73%	72%	70%	69%	67%	66%	65%	63%	61%
80	71%	72%	70%	69%	67%	65%	62%	60%	58%	56%	55%	53%	52%
82.5	67%	67%	65%	64%	60%	57%	55%	52%	50%	47%	46%	44%	43%
85	63%	63%	60%	58%	53%	50%	47%	44%	41%	39%	38%	37%	36%
87.5	59%	59%	55%	53%	47%	43%	40%	36%	34%	32%	31%	31%	31%
90	55%	54%	50%	48%	41%	37%	33%	30%	28%	27%	26%	27%	26%

b) Probability of Not Overfished (SSB >= SSB_{MSY}).

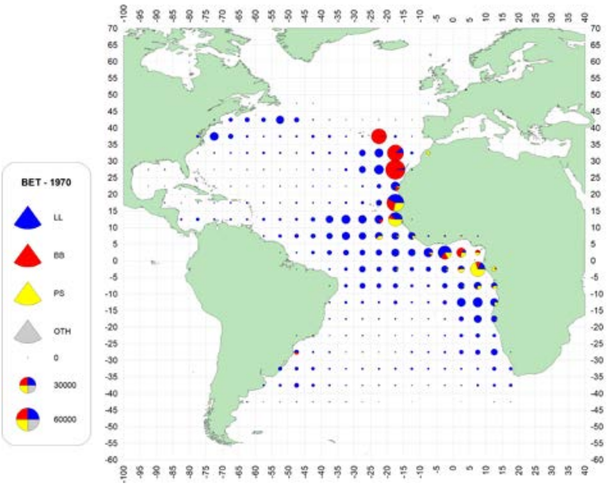
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
35	85%	91%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
37.5	85%	91%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
40	84%	90%	95%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
42.5	84%	90%	94%	97%	99%	99%	100%	100%	100%	100%	100%	100%	100%
45	84%	89%	94%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%
47.5	83%	89%	93%	96%	97%	99%	99%	100%	100%	100%	100%	100%	100%
50	83%	88%	92%	95%	97%	98%	99%	99%	100%	100%	100%	100%	100%
52.5	83%	87%	91%	94%	96%	97%	98%	99%	99%	100%	100%	100%	100%
55	82%	87%	91%	93%	95%	96%	97%	98%	99%	99%	100%	100%	100%
57.5	82%	86%	90%	92%	93%	95%	96%	97%	98%	98%	99%	99%	99%
60	82%	86%	89%	90%	92%	93%	94%	95%	96%	97%	98%	98%	98%
61.5	81%	85%	88%	89%	91%	92%	93%	94%	95%	96%	97%	97%	98%
62.5	81%	85%	87%	89%	90%	91%	91%	93%	94%	95%	96%	96%	97%
65	81%	84%	86%	87%	88%	88%	89%	90%	91%	91%	92%	93%	93%
67.5	80%	84%	85%	85%	85%	85%	85%	85%	86%	87%	88%	87%	88%
70	80%	83%	83%	83%	82%	82%	81%	80%	81%	81%	81%	81%	82%
72.5	80%	82%	82%	81%	79%	77%	75%	74%	74%	74%	74%	73%	73%
75	79%	81%	80%	78%	76%	73%	70%	68%	68%	66%	66%	65%	64%
77.5	79%	81%	79%	75%	72%	68%	64%	62%	60%	58%	57%	55%	54%
80	78%	80%	77%	72%	68%	63%	58%	56%	52%	50%	48%	47%	46%
82.5	78%	79%	75%	69%	64%	58%	53%	47%	45%	42%	41%	40%	39%
85	77%	78%	73%	66%	59%	52%	47%	41%	38%	36%	35%	34%	35%
87.5	77%	77%	71%	63%	55%	47%	40%	35%	32%	31%	30%	31%	31%
90	76%	76%	69%	60%	50%	43%	35%	30%	27%	26%	28%	28%	27%

c) Probability of Not Overfished (SSB >= SSB_{MSY}) and Overfishing not occurring (F <= F_{MSY}).

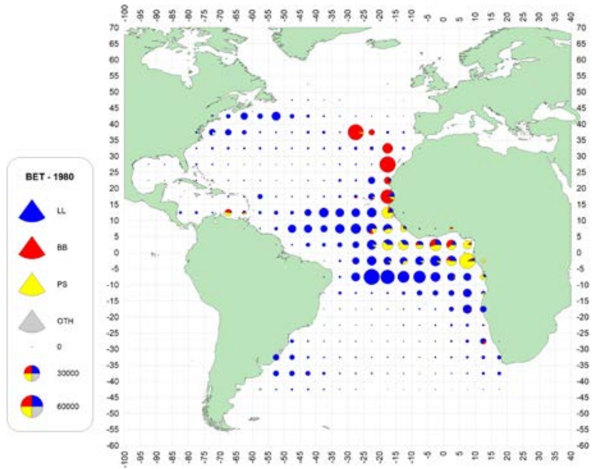
TAC (1000s mt)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
35	85%	91%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
37.5	85%	91%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
40	85%	90%	95%	98%	99%	100%	100%	100%	100%	100%	100%	100%	100%
42.5	84%	90%	94%	97%	99%	99%	100%	100%	100%	100%	100%	100%	100%
45	84%	89%	94%	96%	98%	99%	100%	100%	100%	100%	100%	100%	100%
47.5	83%	89%	93%	96%	97%	99%	99%	100%	100%	100%	100%	100%	100%
50	83%	88%	92%	95%	97%	98%	99%	99%	100%	100%	100%	100%	100%
52.5	83%	88%	92%	94%	96%	97%	98%	99%	99%	100%	100%	100%	100%
55	82%	87%	91%	93%	95%	96%	97%	98%	99%	99%	100%	100%	100%
57.5	82%	86%	90%	92%	93%	95%	96%	97%	98%	98%	99%	99%	99%
60	81%	86%	89%	90%	92%	93%	94%	95%	96%	97%	98%	98%	98%
61.5	81%	85%	88%	89%	91%	92%	93%	94%	95%	96%	97%	97%	97%
62.5	81%	85%	87%	89%	90%	91%	92%	93%	94%	95%	96%	96%	97%
65	81%	84%	86%	87%	87%	88%	89%	90%	90%	92%	92%	93%	93%
67.5	80%	83%	84%	85%	85%	85%	85%	85%	86%	87%	87%	87%	88%
70	79%	82%	83%	82%	82%	81%	81%	80%	81%	81%	80%	81%	82%
72.5	78%	80%	80%	79%	79%	77%	75%	74%	74%	74%	74%	73%	73%
75	76%	78%	77%	76%	74%	72%	70%	68%	68%	66%	65%	65%	64%
77.5	73%	74%	74%	72%	70%	67%	64%	62%	59%	58%	57%	56%	54%
80	70%	71%	70%	68%	64%	61%	57%	55%	52%	50%	48%	47%	46%
82.5	67%	67%	65%	63%	59%	55%	52%	47%	44%	42%	41%	40%	39%
85	63%	63%	60%	58%	53%	48%	45%	40%	37%	36%	34%	34%	34%
87.5	59%	58%	55%	53%	47%	42%	38%	34%	31%	30%	29%	29%	30%
90	55%	54%	50%	48%	41%	37%	32%	28%	26%	25%	25%	26%	25%



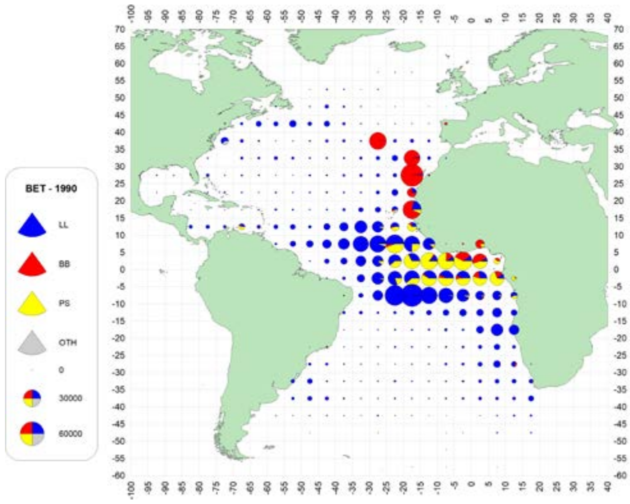
BET-Figure 1. Apparent movements (straight line distance between the tagging location and that of recovery) calculated from conventional tagging of Atlantic bigeye tuna from the historical ICCAT tagging database (top panel) and the current AOTTP activities (bottom panel).



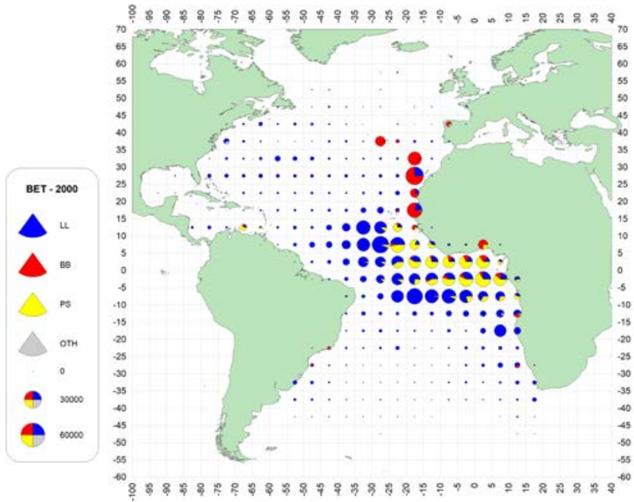
a. BET (1970-79)



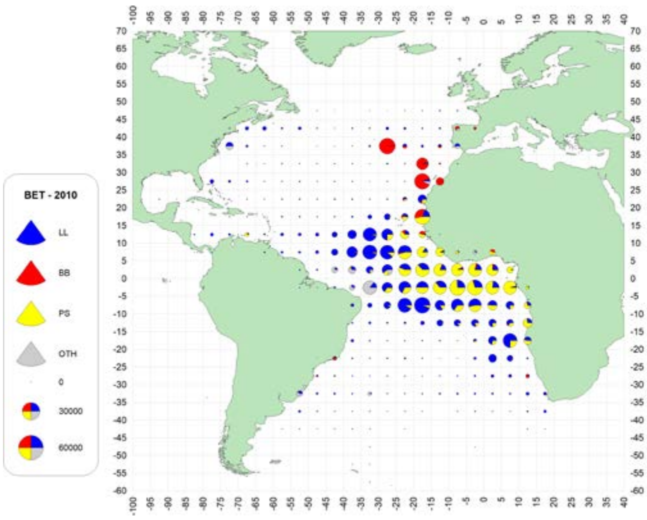
b. BET (1980-89)



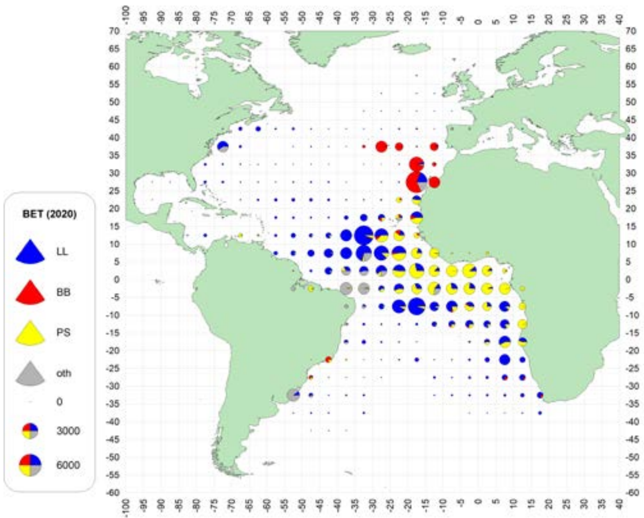
c. BET (1990-99)



d. BET (2000-09)

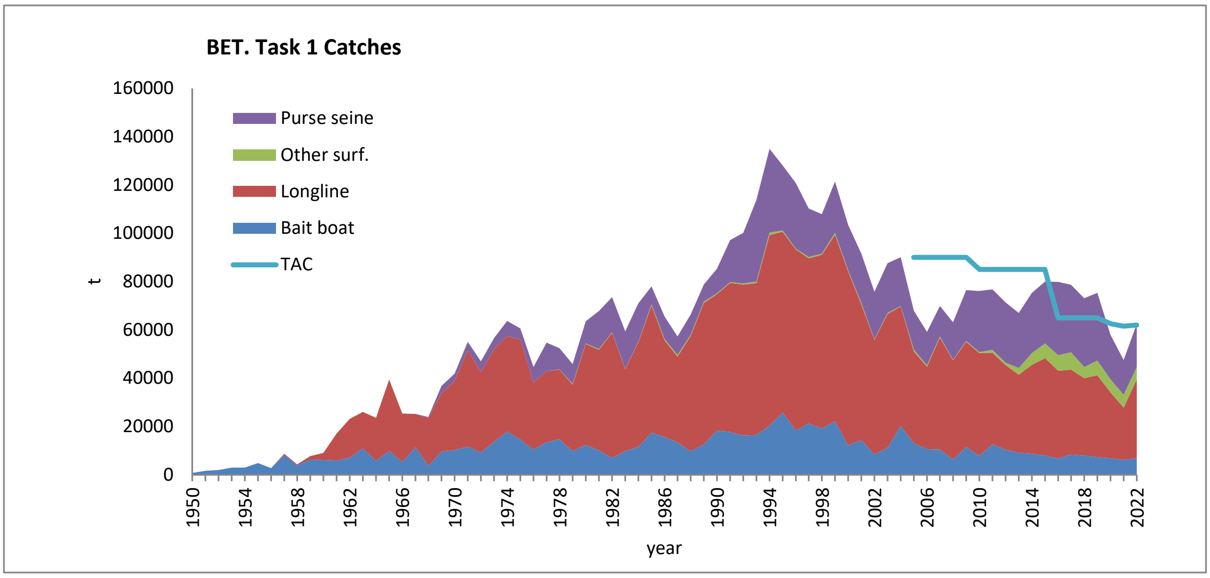


e. BET (2010-19)

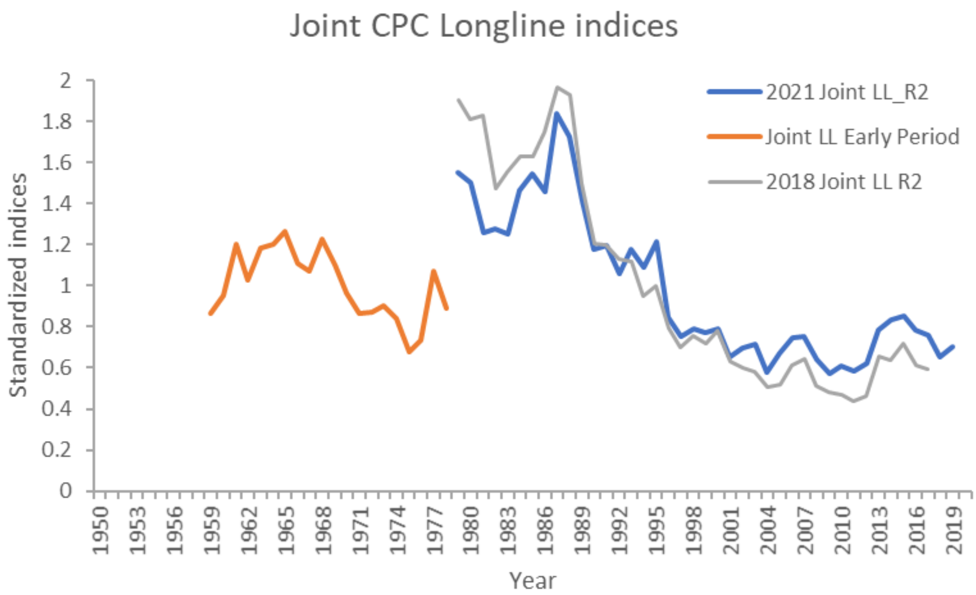


f. BET (2020-21)

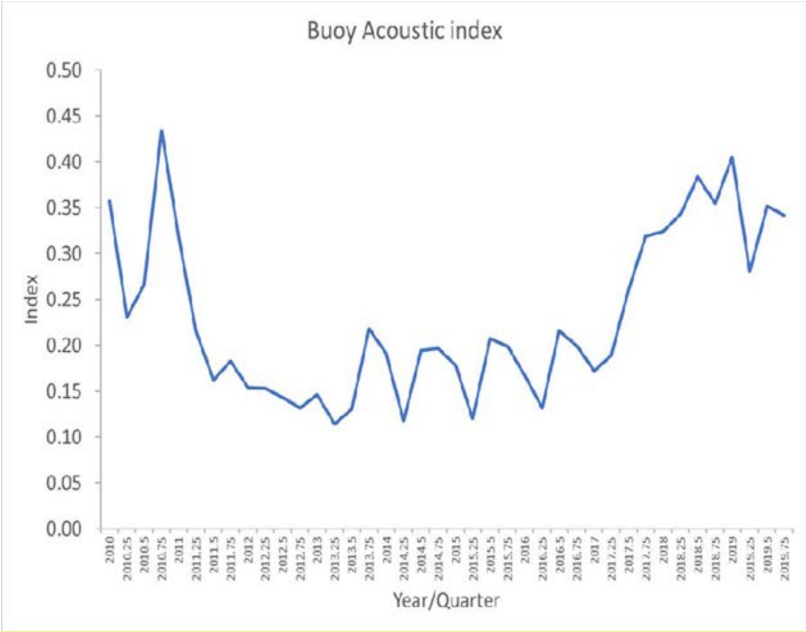
BET-Figure 2 [a-f]. Geographical distribution of the bigeye tuna catch by major gears and decade. The maps are scaled to the maximum catch observed during 1970-2021 (the last decade only covers 2 years).



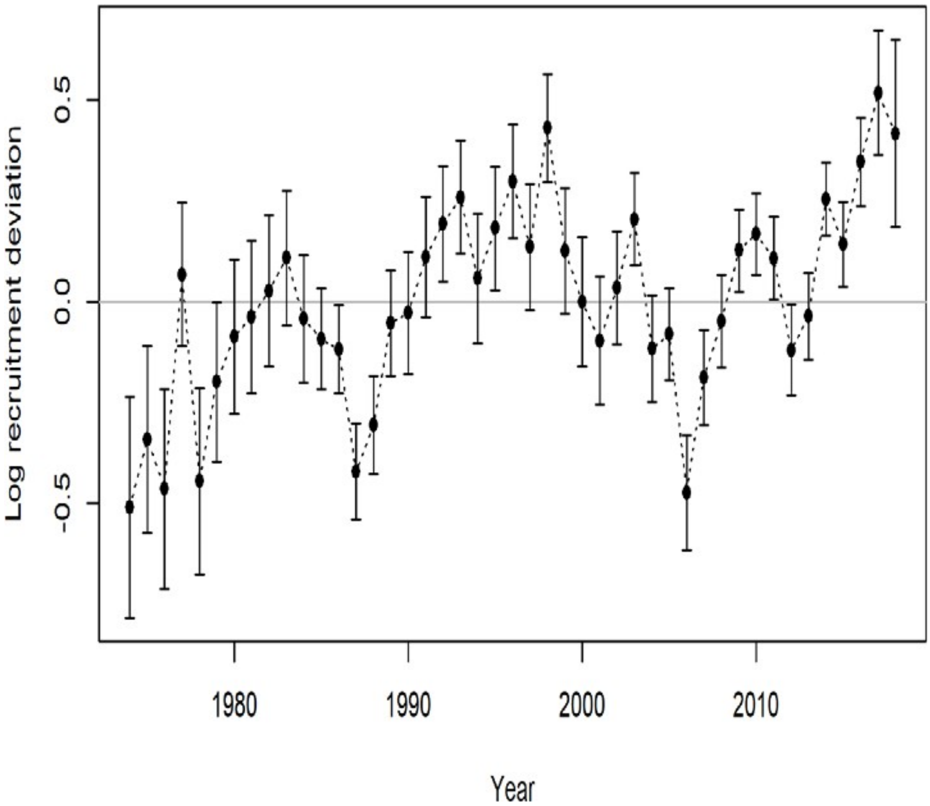
BET-Figure 3. Bigeye tuna estimated and reported catches for all the Atlantic stock (t).



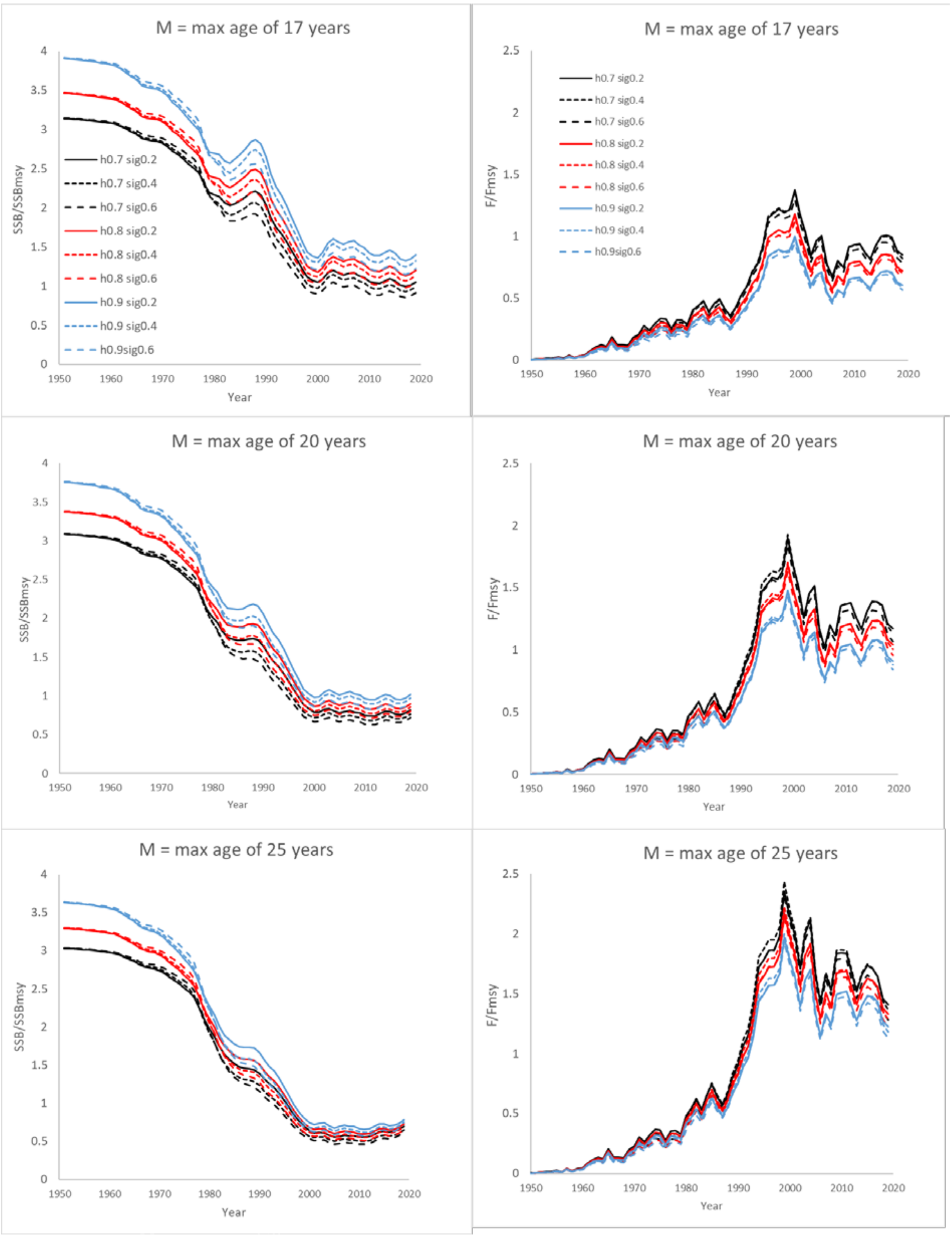
BET-Figure 4. Annual joint longline index for 1959 to 2019 that include two series Early period (1959-1978, Joint LL Early Period) and the late period (1979-2019, 2021 joint LL_R2) used in the 2021 stock assessment. For comparison the 2018 joint index late period (1979-2017) is presented (2018 Joint LL R2) which was used for sensitivity runs. Indices are split in 1979 because of the lack of vessel ID data prior to that year. 2018 index for the late period was developed with set by set and vessel data, but 2021 index for the late period was not.



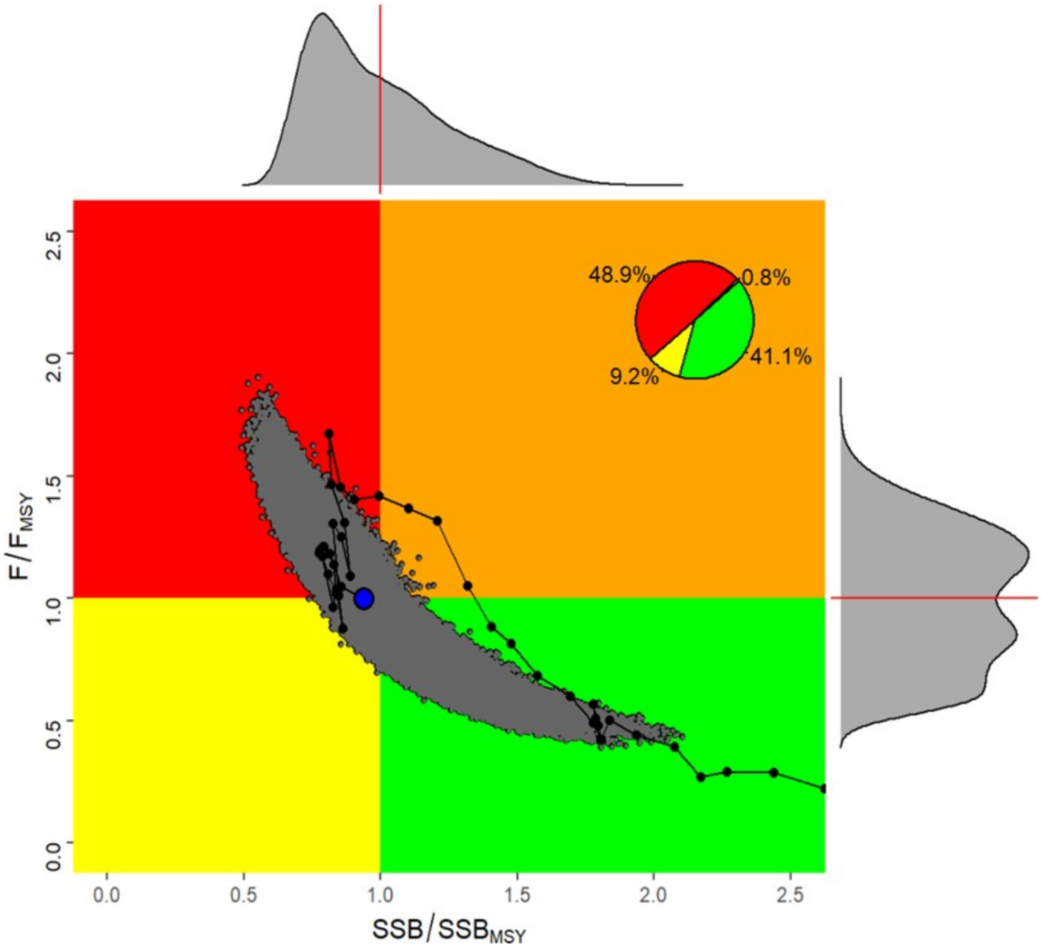
BET-Figure 5. Quarterly abundance index from acoustic buoys used in the FAD fishery for 2010 to 2019.



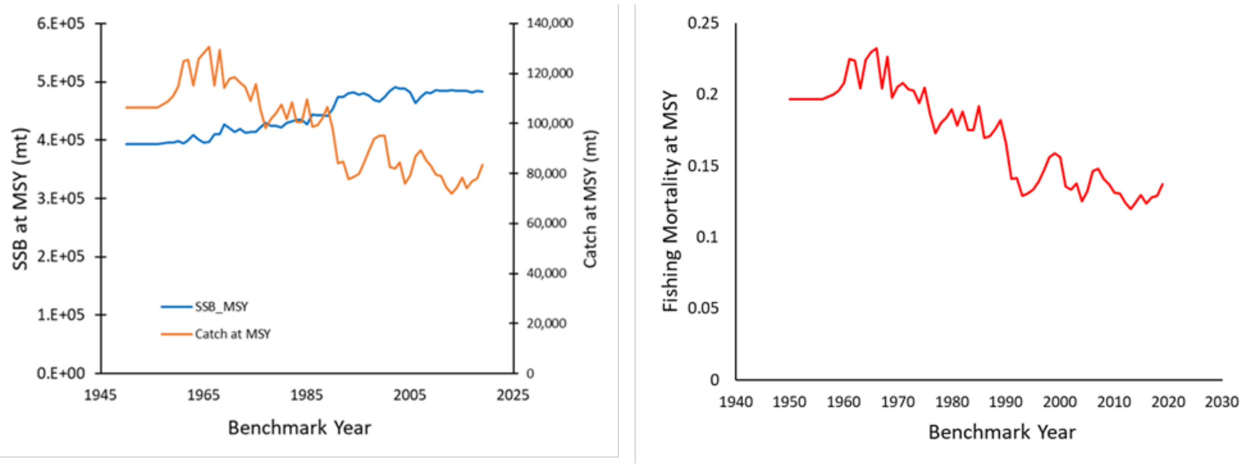
BET-Figure 6. Estimated recruitment deviations for the period 1974-2018 for Stock Synthesis reference case (see **BET-Table 2** for definition). The zero line represents the expected recruitment resulting from the previous year spawning stock biomass. Positive values represent better than expected recruitments, negative values, worse than expected recruitment.



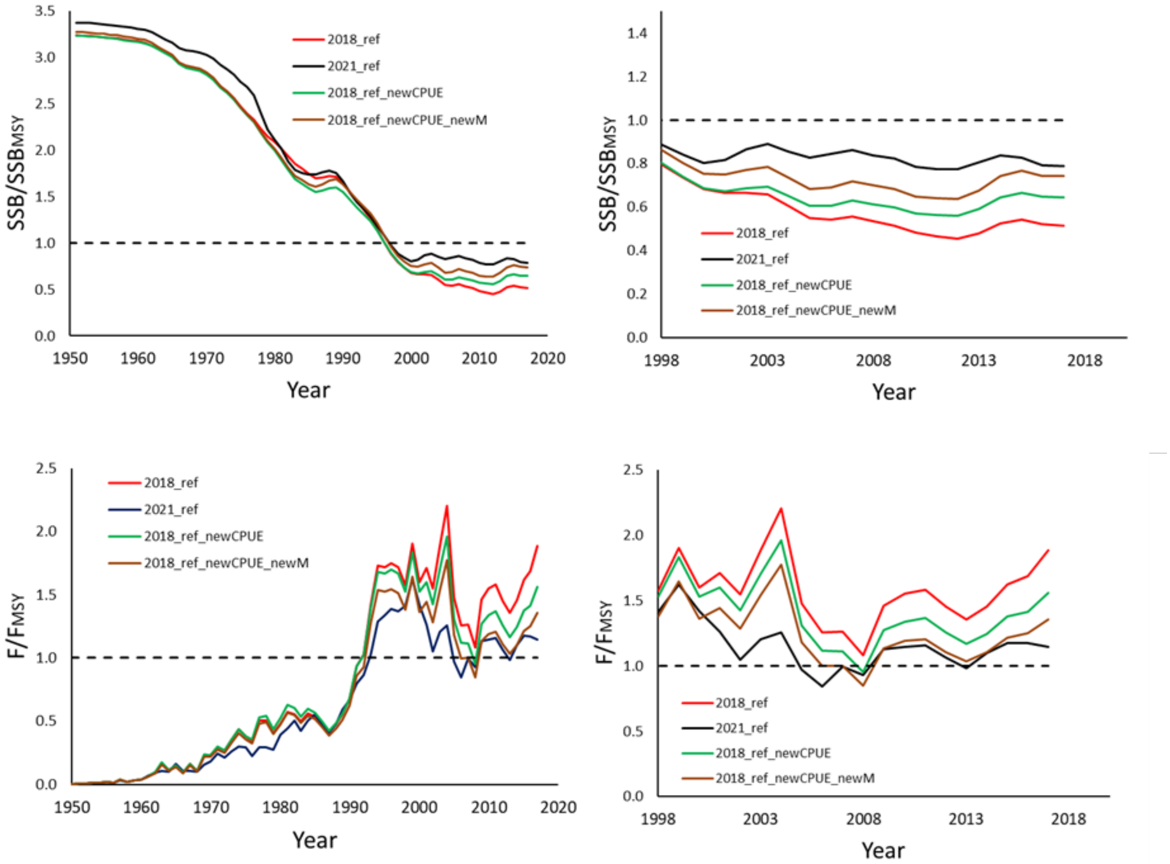
BET-Figure 7. Time series of stock status trends across the 27 Stock Synthesis models of the uncertainty grid. Panels in each row represent the different assumptions of maximum age and thus natural mortality. Left panels represent SSB/SSB_{MSY} trends and right panels F/F_{MSY} trends. Individual lines represent different combinations of steepness and Sigma R.



BET-Figure 8. Stock Synthesis: Kobe plot of SSB/SSB_{MSY} and F/F_{MSY} for stock status of Atlantic bigeye tuna in 2019 based on the log multivariate normal approximation across the 27 uncertainty grid model runs of Stock Synthesis with an insert pie chart showing the probability of being in the red quadrant (48.9%), green quadrant (41.1 %), orange (0.8%) and in yellow (9.2 %). Blue circle is the median and marginal histograms represent distribution of either SSB/SSB_{MSY} or F/F_{MSY}.

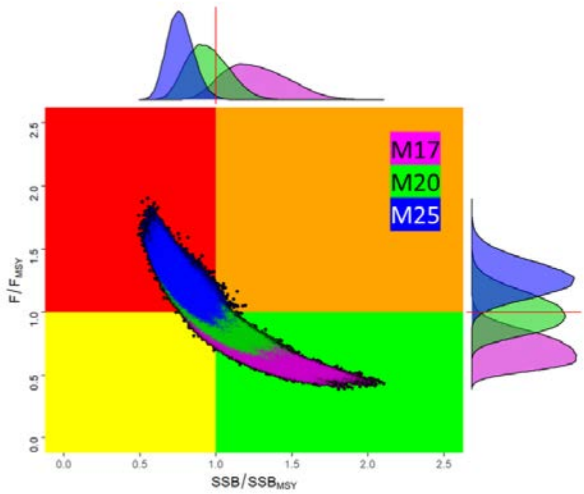


BET-Figure 9. Dynamic estimated SSB at MSY (mt) and Catch at MSY (left panel) and estimated of fishing mortality at MSY (right panel) benchmarks by year, demonstrating the effects of changes in selectivity for bigeye tuna using the Stock Synthesis 2021 reference case.

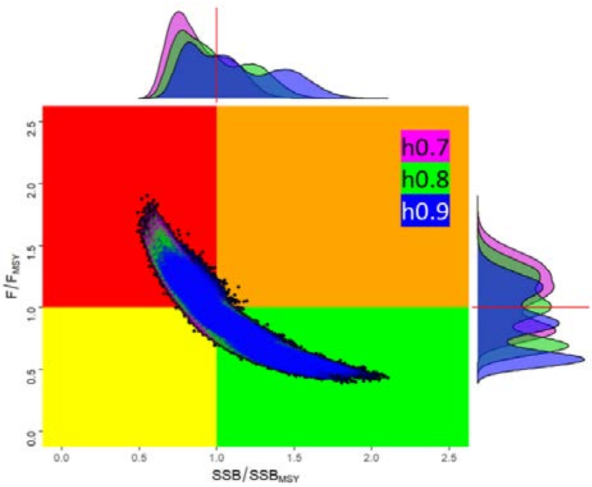


BET-Figure 10. Sensitivity runs showing time series of stock status trends (left panels 1950-2017, right panels 1998-2017, upper panels SSB/SSB$_{MSY}$ and lower panels F/F$_{MSY}$) demonstrating the effects of changes in stock status resulting from the incorporation of the 2021 joint longline index and the new assumptions about natural mortality. Lines represent the 2018 (2018_ref) and 2021 (2021_ref) reference cases, the 2018 reference case replacing the 2018 joint longline index with the 2021 joint longline index (2018_ref_new_CPUE) and this last case with the replacement of the 2018 natural mortality with the 2021 natural mortality (2018_ref_new_CPUE_new_M). The natural mortality of the 2021 reference case corresponds to the maximum age of 20.

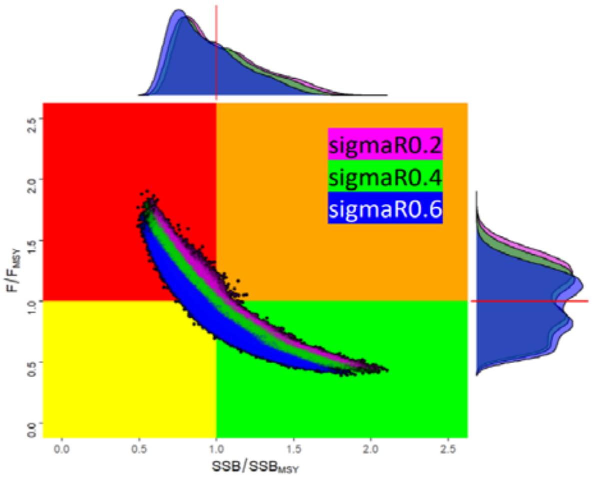
(a) effect of Maximum age(M)



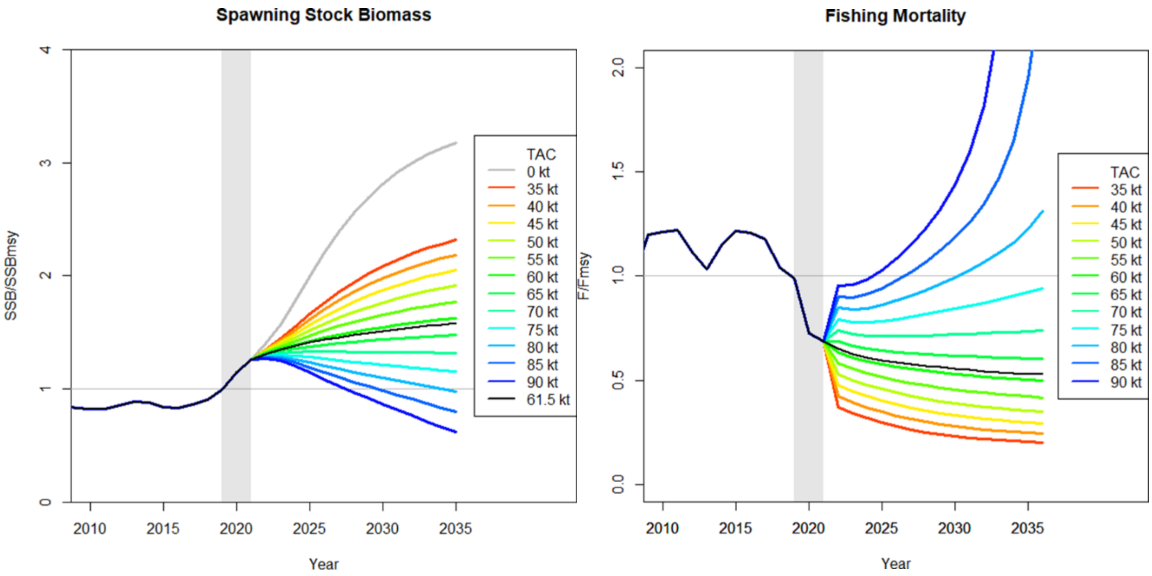
(b) effect of steepness (h)



(c) effect of sigma R



BET-Figure 11. Effects of the main axes of uncertainty parameters (a: Natural mortality associated with maximum age assumption, b: Steepness, c: Sigma R) on Kobe phase plot for the 27 Stock Synthesis uncertainty grid for Atlantic bigeye tuna. In each plot the cloud of points and the marginal histograms colors match the level in each uncertainty parameter.



BET-Figure 12. Deterministic projections of SSB/SSB_{MSY} (left panel) and fishing mortality (right panel) for the 27 Stock Synthesis uncertainty grid runs at 35,000-90,000 t constant catch for Atlantic bigeye tuna. The lines are the mean of 27 deterministic runs and the black line is for the current TAC (61,500 t). The grey bar represents the period when catches for 2020 and 2021 are fixed to 59,919 t and 61,500 t respectively.