9.16 SMA - Shortfin mako

Both shortfin mako (*Isurus oxyrinchus*) stocks, North and South Atlantic, were assessed in 2017 (ICCAT, 2017e). In 2019, an intersessional meeting (ICCAT, 2020d) was held to update projections on the North Atlantic shortfin mako (*Isurus oxyrinchus*) stock based on the 2017 stock assessment.

SMA-1. Biology

Shortfin mako is a large pelagic shark that shows a wide geographic distribution, from tropical to temperate waters worldwide. Shortfin mako is an aplacental viviparous shark, with oofagy, which limits its fecundity to an average litter size of around 12 but increases the probability of survival of their young. Although there is still high uncertainty regarding its biology, available life history traits (slow growth, late maturity and small litter size) indicate that it is vulnerable to overfishing. A behavioral characteristic of this species is its tendency to segregate temporally and spatially by size and/or sex, during feeding, mating-reproduction, gestation and birth processes. Tagging studies have suggested that it exhibits large-scale migratory behaviour and periodic vertical movement, but the lack of information on some components of the populations precludes a complete understanding of its distribution/migration pattern by ontogenetic stage and in some cases identifying its pupping/mating grounds. Numerous aspects of the biology of this species are still poorly understood or completely unknown, particularly for some regions, which contributes to increased uncertainty in quantitative and qualitative assessments.

SMA-2. Fishery indicators

Earlier reviews of the shark database resulted in recommendations to improve data reporting on shark catches. Though global statistics on shortfin mako shark catches included in the database have improved, they are still insufficient to permit the Committee to provide quantitative advice on stock status for most stocks with sufficient precision to guide fishery management toward optimal harvest levels. While reported and estimated catches for shortfin mako are still generally subject to higher levels of uncertainty than the major tuna stocks, they have been considered sufficiently complete for the purpose of quantitative stock assessment, and are provided in **SMA-Table 1** and **SMA Figure 1**.

The CPUE series available for the 2017 shortfin mako stock assessments showed decreasing trends since approximately 2010 for the North Atlantic stock and generally increasing trends since approximately 2008 for the South Atlantic stock (**SMA-Figures 2 and 3**).

SMA-3. State of the stocks

The 2017 assessment of the status of North and South Atlantic stocks of shortfin mako shark was conducted with updated time series of relative abundance and annual Task 1 catches (C1), life history, and with the inclusion of length composition data. An alternative series of catch data based on ratios of shark catches to catches of the main target species (C2) was also estimated and used in the assessments. The results obtained in this evaluation are not comparable to those obtained in the last assessment conducted in 2012 (ICCAT, 2013) because the input data and model structures have changed significantly: the catch time series are different (1950-2015 for the 2017 assessment and 1971-2010 for the 2012 assessment) and were derived using different assumptions; the catch per unit effort (CPUE) series in the North have been decreasing since 2010 (the last year in the 2012 assessment models); some of the biological inputs have changed (growth curve, natural mortality at age) and some are now sex specific for the North; with the new biological inputs the intrinsic rate of population growth (r_{MAX}) for the North Atlantic used to construct prior distributions is now about half that used in the 2012 assessment; and additional length composition data also became available for the North. Additionally, in 2012 only a Bayesian production model (BSP1) and a catch-free age structured production (CFASPM) model were used, whereas more modeling platforms that more fully use the data available were explored in the current assessment (BSP2JAGS (Just Another Gibbs Sampler emulating the Bayesian production model), JABBA (Just Another Bayesian Biomass Assessment), C_{MSY} (Catch at MSY), and SS3 (Stock Synthesis 3)). It is the Committee's view that the 2017 stock assessment represents a significant improvement in our understanding of current stock status, for North Atlantic shortfin mako in particular. In particular, the production models assuming both observation and process errors fit the indices of abundance considerably better than models assuming only observation errors as used in the 2012 stock assessment.

For the North Atlantic stock, results of nine stock assessment model runs were selected to provide stock status and management advice. Although all results indicated that stock abundance in 2015 was below B_{MSY}, results of the production models (BSP2JAGS and JABBA) were more pessimistic (B/B_{MSY} deterministic estimates ranged from 0.57 to 0.85) and those of the age-structured model (SS3), which indicated that stock abundance was near MSY (SSF/SSF_{MSY} = 0.95 where SSF is spawning stock fecundity), were less pessimistic. F was overwhelmingly above F_{MSY} (**SMA-Figure 4**), with a combined 90% probability from all the models of being in an overfished state and experiencing overfishing (**SMA-Figure 5**).

For the South Atlantic stock, 4 assessment model runs (2 BSP2JAGS runs and 2 C_{MSY} runs) were considered to provide stock status and management advice. The combined probability of the stock being overfished was 32.5% and that of experiencing overfishing was 41.9% (**SMA-Figure 6**). The combined probabilities from all the models of being in the red, yellow, and green quadrants of the Kobe plot are provided in **SMA-Figure 7**. Based on the diagnostics of model performance, the estimates of unsustainable harvest rates appear to be fairly robust at this stage whereas the biomass depletion and B/B_{MSY} estimates must be treated with caution. The Committee considers results for the South Atlantic to be highly uncertain owing to the conflict between catch and CPUE data. For both stocks, the CPUE series generally showed a trend similar to that of the catches, particularly the South Atlantic stock, which was problematic for the stock assessments based on production models.

SMA-4. Outlook

In 2017, projections could only be carried out with the BSP2JAGS production model for the North Atlantic and no projections could be conducted for the South Atlantic due to the uncertainty in stock status. The Committee noted that the Kobe II strategy matrices presented in 2017 may not reflect the full range of uncertainty in the outlook because projections were not carried out with SS3 due to technical reasons and because the model was still under development. In 2019, projections for the North Atlantic were carried out with Stock Synthesis only. The Committee noted that because the fishery mainly focuses on juvenile animals, the production models (BSP2JAGS and others) are only tracking juvenile abundance and thus the projections are not informative about trends in the mature population, which would lag behind the trends in the exploitable population by the number of years it takes new recruits to reach maturity.

The Committee combined the Stock Synthesis status results from two runs that were reflective of different productivity hypotheses (run 1 and run 3) for making projections (**SMA-Figure 8**). Projections were carried out to 2070 because they incorporate two generation times. Run 1 was added because the Committee recognized that it incorporates another hypothesis on the productivity of the stock (expressed through a different stock-recruit relationship) more in line with some of the production model estimates of productivity, but unlike production models, it can incorporate the necessary time lag effects caused by gear selectivity and the maturity of the stock. The projection results from the combined models showed that (**SMA-Table 2**): i) a zero total allowable catch (TAC) will allow the stock to be rebuilt and without overfishing (in the green quadrant of the Kobe plot) by 2045 with a 53% probability; ii) regardless of the TAC, the spawning stock fecundity will continue to decline until 2035 before any increases can occur owing to the time it takes juveniles to reach maturity; iii) to be in the green quadrant of the Kobe plot with at least 60% probability by 2070, the realized TAC has to be 300 t or less; and iv) a TAC of 700 t would end overfishing immediately with a 57% probability, but it would only have a 41% probability of rebuilding the stock by 2070. Although there is large uncertainty in the future productivity assumption for this stock, the projections show that there is a long lag time (ca. 20 years) between when management measures are implemented and when stock size starts to rebuild due to the biology of the species.

SMA-5. Effect of current regulations

The Commission adopted Rec. 17-08, which aims to reduce the fishing mortality to end overfishing of the northern stock of shortfin mako. It does this by strengthening data collection (including collection of statistics on discards, biological parameters, weight of landing products, etc.) and establishing regulatory options (including promoting fish releases in a manner that increases survival, establishing minimum sizes, etc.) for ICCAT CPCs. In response to this recommendation several CPCs have adopted national regulations. Rec. 17-08 was reviewed by the Commission in 2019.

The Committee conducted projections incorporating different hypotheses about stock productivity which suggested that the stock could rebuild to the biomass that supports MSY with a 60% probability if the TAC=0 by 2050. Additionally, the Committee also reviewed the probability of success of several of the measures contemplated in ICCAT Rec. 17-08 through additional projections for shortfin mako (using only the base run from Stock Synthesis – run 3). Specifically, alternative TAC, minimum size limit, and live release measures were explored with two tools: Stock Synthesis and the Decision Support Tool (DST). The Committee noted that fixed TACs with size regulations (210 cm fork length for females and 180 cm fork length for males) accelerated stock recovery. However, these projections implicitly assumed that fish released below the size limit had 100% post-release survival. The Committee also explored the effect of live release regulations (through reduction in fishing mortality but considering a post-release mortality rate of 25%) contemplated in Rec. 17-08 and found that all projection scenarios resulted in population declines until 2035 regardless of the fixed level of fishing mortality used and that the biomass that supports MSY was only reached by 2070 for the fishing mortality equal zero scenario.

Projections with the DST revealed that if fishers are unable to avoid catching shortfin makos and those discarded have a substantial mortality rate, then it is necessary to greatly decrease the retained catch to allow the stock to rebuild. Size limits and other strategies to release live sharks must be accompanied by a reduction in retained catch. The Committee thus concluded that a live release approach may be a way to reduce F if discard mortality rates are low, but other management measures such as reduction of soak time, time-area closures, and safe handling and best practices for the release of live specimens may also be required to further reduce incidental mortality. The Committee also noted that a slot limit that protects some mature age groups may be appropriate, although selectivity on those ages is low.

The Committee noted that North Atlantic catches increased from 3,282 t in 2015 to 3,357 t in 2016 and then decreased to 3,119 t in 2017, and that they further decreased to 1,461 t in 2018. It is not clear if the decrease can be attributed to Rec. 17-08 or to continued decrease in stock size. Projections (**SMA-Table 2**) indicate that this current catch will not allow the stock to rebuild by 2070 and overfishing will continue. 2019 is the first full year during which Rec. 17-08 applied.

The Committee had insufficient information to determine which ICCAT recommendations regarding possible conservation measures (Rec. 17-08) were implemented for which fleet, making it difficult to evaluate the effect of the possible conservation measures by fleet in the projections. Nevertheless, a general evaluation of the effect of the conservation measures was undertaken which showed that they are insufficient to rebuild the stock within the specified timeframe.

SMA-6. Management recommendations

Precautionary management measures should be considered particularly for stocks where there is the greatest biological vulnerability and conservation concern, and for which there are very few data and/or great uncertainty in assessment results. Management measures should ideally be species-specific whenever possible.

Considering the need to improve stock assessments of pelagic shark species impacted by ICCAT fisheries and bearing in mind Rec. 12-05 as well as the various previous recommendations which made the submission of shark data mandatory, the Committee strongly urges the CPCs to provide the corresponding statistics, including discards (dead and alive), of all ICCAT fisheries, including recreational and artisanal fisheries, and to the extent possible non-ICCAT fisheries capturing these species. The Committee considers that a basic premise for correctly evaluating the status of any stock is to have a solid basis to estimate total removals.

The Committee reiterates that the CPCs provide estimates of shortfin mako shark catches in both ICCAT and non-ICCAT fisheries for species that are oceanic, pelagic, and highly migratory within the ICCAT Convention area. The magnitude of shark entanglements in fish aggregating devices (FADs) should be investigated. Methods for mitigating shark bycatch in fisheries also need to be investigated and applied.

The Committee conducted new projections using two Stock Synthesis model scenarios that incorporated important aspects of shortfin mako biology. This was a feature that was not possible with the production model projections developed in the 2017 assessment (ICCAT, 2017e) and, therefore, the Committee considers the new projections as a better representation of the stock dynamics. The stock synthesis projections indicated that: i) a zero TAC will allow the stock to be rebuilt and without overfishing (in the green quadrant of the Kobe plot) by 2045 with a 53% probability; ii) regardless of the TAC (including a TAC of 0 t), the stock will continue to decline until 2035 before any biomass increases can occur; iii) a TAC of 500 t, including dead discards has only a 52% probability of rebuilding the stock to the green quadrant in 2070; iv) to be in the green quadrant of the Kobe plot with at least 60% probability by 2070, the realized TAC has to be 300 t or less; v) lower TACs achieve rebuilding in shorter time frames; and vi) a TAC of 700 t would end overfishing immediately with a 57% probability, but this TAC would only have a 41% probability of rebuilding the stock by 2070.

The Committee agreed that the projections that addressed the exceptions in Rec. 17-08 indicated that any retention of shortfin makos will not permit the recovery of the stock by year 2070. A range of TAC options with a range of time frames and associated probabilities of rebuilding are included in **SMA-Table 2**. Given the vulnerable biological characteristics of this stock and the pessimistic projections, to accelerate the rate of recovery and to increase the probability of success the Committee recommends that the Commission adopt a non-retention policy without exception in the North Atlantic as it has already done with other shark species caught as bycatch in ICCAT fisheries.

Given that fishery development in the South predictably follows that in the North and that the biological characteristics of the stock are similar, there is a significant risk that this stock could follow a similar history to that of the North stock. If the stock declines it will, like the North stock, require a long time for rebuilding even after significant catch reductions. To avoid this situation and considering the uncertainty in the stock status, the Committee recommends that at a minimum, catches should not exceed the minimum catch in the last five years of the assessment (2011-2015; 2,001 t with catch scenario C1 (Task 1 catches)).

The Committee emphasized that reporting all sources of mortality is an essential element to decrease the uncertainty in stock assessment results, and particularly the report of estimated dead discards for all fisheries. Although the reporting of dead discards is already part of the ICCAT data reporting obligations (Rec. 17-08), the requirement has been ignored by many CPCs. The reporting of dead discards and live releases is of the utmost importance.

The Committee indicated that additional measures can potentially further reduce incidental mortality, including safe handling and best practices for the release of live specimens (since post release survival can reach 77%). These and other measures are documented in papers published on the Bycatch Management Information System webpage of the Western Central Pacific Fisheries Commission (WCPFC). Gear restrictions/modification and time area closures also have the potential to reduce mortality. However, gear restriction/modification would require dedicated field work (e.g. the deployment of hook timers to measure the time that sharks are on the line), while the level of catch and effort data currently submitted to the Secretariat makes it difficult to evaluate time/area closures.

The Committee emphasized that the Kobe II Strategy Matrix (K2SM) does not capture all the uncertainties associated with the fishery and the biology of the species. In addition, the length of the projection period (50 years) requested by the Commission implies that estimates at the end of the projection period are highly uncertain. Therefore, the Committee advised that the results of the K2SM should be interpreted with caution. In particular, if the decrease in mature females is related not only to the catch of immature females, but to other, unknown causes, the management measures above may not lead to the recovery of the stock.

The Committee emphasizes that there will be a need for CPCs to strengthen their monitoring and data collection efforts by species to monitor the future status of the stocks, including but not limited to total estimated dead discards and the estimation of CPUEs using observer data.

NORTH ATLANTIC SHORTFIN MAKO SUMMARY TABLE

Current Yield (2023)		1,108 t[1]
Yield (2015)		3,227 t[2]
Relative Biomass	B_{2015}/B_{MSY}	0.57-0.95[3]
	B_{2015}/B_0	0.34-0.57[4]
Relative Fishing Mortality	F_{MSY}	0.015-0.056[5]
	F_{2015}/F_{MSY}	1.93-4.38[6]
Stock Status (2015)	Overfished	YES
	Overfishing	YES
Management Measures in Effect:		Rec. 21-09, Rec. 04-10, Rec. 07-06

[1] Task 1 catch as of 22 September 2024.
[2] Task 1 catch used in the stock assessment.
[3] Range obtained from 8 Bayesian production and 1 SS3 model runs. Value from SS3 is SSF/SSF_{MSY}. Low value is lowest value from 4 production model (JABBA) runs and high value is from the SS3 base run.
[4] Range obtained from 8 Bayesian production and 1 SS3 model runs. Value from SS3 is SSF/SSF_0. Low value is lowest value from 4 production model (JABBA) runs and high value is highest value from 4 production model (BSP2JAGS) runs.
[5] Range obtained from 8 Bayesian production and 1 SS3 model runs. Value from SS3 is SSF_{MSY}. Low value is lowest value from 4 production model (JABBA and BSP2JAGS) runs and high value is from the SS3 base run.
[6] Range obtained from 8 Bayesian production and 1 SS3 model runs. Values from the production models are H (harvest rates). Low value is lowest value from 4 production model (BSP2JAGS) runs and high value is from the SS3 base run and highest value from 4 production model (JABBA) runs.

SOUTH ATLANTIC SHORTFIN MAKO SUMMARY TABLE

Current Yield (2023)		1,355 t[1]
Yield (2015)		2,686 t[2]
Relative Biomass	B_{2015}/B_{MSY}	0.65-1.75[3]
	B_{2015}/B_0	0.32-1.18[4]
Relative Fishing Mortality:	F_{MSY}	0.030-0.034[5]
	F_{2015}/F_{MSY}	0.86-3.67[6]
Stock status (2015)	Overfished	Possibly[7]
	Overfishing	Possibly[7]
Management Measures in Effect:		Rec. 22-11, Rec. 04-10, Rec. 07-06

[1] Task 1 catch as of 22 September 2024.
[2] Task 1 catch from the stock assessment.
[3] Range obtained from 2 Bayesian production (BSP2JAGS) and 2 catch-only (C_{MSY}) model runs. Low value is lowest value from the C_{MSY} model runs and high value is highest value from the BSP2JAGS model runs.
[4] Range obtained from 2 Bayesian production (BSP2JAGS) and 2 catch-only (C_{MSY}) model runs. Low value is lowest value from the C_{MSY} model runs and high value is highest value from the BSP2JAGS model runs.
[5] Range obtained from 2 Bayesian production (BSP2JAGS) and 2 catch-only (C_{MSY}) model runs. Low value is from the BSP2JAGS model runs and high value is from the C_{MSY} model runs.
[6] Range obtained from 2 Bayesian production (BSP2JAGS) and 2 catch-only (C_{MSY}) model runs. Low value is lowest value from the BSP2JAGS model runs and high value is highest value from the C_{MSY} model runs.
[7] The Committee considers that results have a high degree of uncertainty.

SMA-Table 1. Estimated catches (t) of shortfin mako (*Isurus oxyrinchus*) by area, gear, and flag.

				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	2023
TOTAL				5844	8407	7702	5730	5863	4470	5190	4796	5531	7225	6528	6970	6620	6946	5684	6606	7270	6982	7347	5787	6743	6056	6122	5906	5552	4195	4597	3448	3313	2463
	ATN			3662	5307	5307	3537	3847	2859	2598	2682	3426	3987	4000	3695	3574	4158	3802	4542	4783	3722	4440	3604	3469	3282	3357	3119	2392	1886	1740	1194	829	1108
	ATS			2182	3100	2395	2187	2008	1606	2588	2107	2103	3235	2526	3259	3036	2786	1881	2063	2486	3258	2905	2183	3274	2774	2765	2786	3158	2309	2857	2254	2484	1355
	MED			0	0	0	6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	2	0	0	0	0	0	1	0	0	0	1	0
Landings	ATN		Longline	3310	3829	5054	3352	3672	2756	2270	2451	3155	3970	3572	3387	3302	3976	3623	4345	4588	3499	4147	3313	2578	2639	3119	2714	1998	1622	1625	521	18	19
			Other surf.	331	1448	252	183	175	99	320	231	271	17	429	308	273	175	169	177	193	215	273	286	880	632	230	401	369	207	39	31	29	1
	ATS		Longline	2162	3085	2379	2163	1996	1596	2566	2090	2088	3204	2450	3245	2992	2745	1799	2057	2485	3196	2842	2149	3241	2760	2748	2620	3149	2291	2820	2234	2462	762
			Other surf.	21	15	16	25	12	10	22	18	15	31	76	14	43	30	82	7	1	62	55	34	31	12	13	162	7	8	29	9	3	1
	MED		Longline	0	0	0	6	8	5	4	7	2	2	2	17	10	2	1	1	2	2	2	0	0	0	0	0	0	0	0	0	0	0
			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	1	0	0	0	0	0
Discards	ATN		Longline	21	29	0	2	0	1	8	0	0	0	0	0	0	7	9	20	2	9	19	5	12	10	8	4	24	56	74	642	782	1087
			Other surf.	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	2	0	0	1
	ATS		Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	8	0	2	2	3	3	2	9	7	12	19	591
			Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
	MED		Longline	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	1	0
Landings	ATN	CP	Barbados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	3	3	0	0	0	0	0	0
			Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	28	69	114	99	1	1	1	9	12	2	0	3	0	0
			Brazil	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	16
			Canada	0	111	67	110	69	70	78	69	78	73	80	91	71	72	43	53	41	37	29	35	55	85	82	109	53	63	1	0	0	0
			China PR	0	0	0	0	0	0	0	0	0	0	0	0	0	81	16	19	29	18	24	11	5	2	4	2	0	0	0	0	0	0
			Costa Rica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	1	2	1	1	0	1	0	0	0	0	0
			Curaçao	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-España	2164	2209	3294	2416	2223	2051	1561	1684	2047	2068	2088	1751	1918	1814	1895	2216	2091	1667	2308	1509	1481	1362	1574	1784	1165	866	870	0	0	0
			EU-France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	2	0	0	0	1	1	2	1	0	1	0	1	1	0
			EU-Netherlands	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	649	657	691	354	307	327	318	378	415	1249	473	1109	951	1540	1033	1169	1432	1045	1023	820	219	222	264	276	272	289	342	202	1	0
			FR-St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	4	0	0	4	0	0	0	0	0	0	0	0	0	0
			Great Britain	0	0	0	0	0	2	3	2	1	1	1	0	0	0	1	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Guatemala	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	214	592	790	258	892	120	138	105	438	267	572	0	0	82	131	98	116	53	56	33	69	45	74	89	20	4	0	0	0	0
			Korea Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	27	15	8	2	1	3	5	4	0	0	0	0
			Liberia	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	10	0	0	0
			Maroc	0	0	0	0	0	0	0	0	0	147	169	215	220	151	283	476	636	420	406	667	624	947	1050	450	594	501	382	299	0	0
			Mauritania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	
			Mexico	0	10	0	0	0	0	10	16	0	10	6	9	5	8	6	7	8	8	8	4	4	4	3	5	2	2	2	2	3	2
			Panama	0	0	0	0	0	1	0	0	0	0	0	0	0	49	33	39	0	0	0	19	7	0	0	0	0	0	0	0	0	0
			Philippines	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Russian Federation	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
			Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	8	17	21	0	0	2	0	2	2	2	68	68	26	0	0	0	0
			St Vincent and Grenadines	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0	0	0	
			Trinidad and Tobago	3	1	1	1	2	1	3	6	2	3	1	2	1	1	1	1	1	0	2	1	1	1	1	2	2	1	1	1	1	0
			UK-Bermuda	0	0	0	1	2	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	574	1658	400	345	297	198	414	350	372	106	477	422	353	319	296	314	350	332	371	363	961	572	271	302	165	57	48	39	41	0
			Venezuela	7	7	17	9	8	6	9	24	21	28	64	27	14	19	8	41	27	20	33	9	13	7	7	9	7	8	8	3	1	0
		NCC	Chinese Taipei	29	32	45	42	47	75	56	47	53	37	70	68	40	6	23	11	14	13	14	8	4	13	7	1	0	0	0	0	0	0
		NCO	Sta Lucia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	
	ATS	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	31	0	0	0	7	23	14
			Belize	0	0	0	0	0	0	0	0	0	0	0	38	0	17	2	0	32	59	78	88	1	15	14	34	15	7	2	1	0	0
			Brazil	95	119	83	190	233	27	219	409	226	283	238	426	210	145	203	99	128	192	196	276	268	173	124	275	399	739	542	477	557	106
			China PR	45	23	27	19	74	126	305	22	208	260	68	45	70	77	6	24	32	29	8	9	9	5	3	1	0	0	0	0	0	0
			Curaçao	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
			Côte d'Ivoire	20	13	15	23	10	10	9	15	15	30	15	14	16	25	0	5	7	0	20	34	19	11	13	161	4	8	14	9	1	
			EU-España	552	1084	1482	1356	984	861	1090	1235	811	1158	703	584	664	654	628	922	1192	1535	1207	1083	1077	862	882	1049	1044	1090	799	650	657	0
			EU-Portugal	0	92	94	165	116	119	388	140	56	625	13	242	493	375	321	502	336	409	176	132	127	158	393	503	300	243	449	357	358	0
			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	0
			Great Britain	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Guatemala	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	1369	1617	514	244	267	151	264	56	133	118	398	0	0	72	115	108	103	132	291	114	182	109	77	96	93	53	1	0	0	0
			Korea Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	13	7	7	4	4	18	8	9	1	0	0	0	0
			Namibia	0	0	0	0	0	1	0	0	459	375	509	1415	1244	1002	295	23	307	377	586	9	950	661	799	194	980	0	945	637	789	545
			Panama	0	0	0	0	0	24	1	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Philippines	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Russian Federation	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
			Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	34	23	0	11	6	39	4	7	0	0	0	0
			South Africa	24	49	37	31	171	67	116	70	12	116	101	111	86	224	137	146	152	218	108	250	476	613	339	305	244	110	46	70	66	96
			UK-Sta Helena	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	12	17	26	20	23	21	35	40	38	188	249	146	68	36	41	106	23	76	36	1	0	0	0	0	0	0	0	0	0	0
		NCC	Chinese Taipei	65	87	117	139	130	198	162	120	146	83	180	226	166	147	124	117	144	203	150	157	158	152	92	85	64	42	52	35	13	2
		NCO	Vanuatu	0	0	0	0	0	0	0	0	0	0	52	12	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	MED	CP	EU-Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
			EU-España	0	0	0	6	7	5	3	2	2	2	2	2	4	1	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0
			EU-France	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-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	1	0	0	0	0	0
			EU-Portugal	0	0	0	0	1	0	1	5	0	0	0	15	5	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	0	0	0	0	0
			Maroc	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
Discards	ATN		Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	20	22	26	12
			China PR	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	20	2	1	5	4
			Curaçao	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-España	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	585	588	936
			EU-France	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	1
			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	11	14	141	87
			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	0
			Guatemala	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	30	28	15	10	14
			Korea Rep	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	0
			Mexico	0	1	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	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
			Russian Federation	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	2	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	21	28	0	2	0	1	8	0	0	0	0	0	0	7	10	20	2	9	18	5	11	8	6	4	2	1	3	4	10	29
		NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	22	5	12	1	2	7

			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	2023
ATS	CP	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
		China PR	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	1	1	4	3
		Curaçao	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-España	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	187
		EU-France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
		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	388
		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	**0**
		Guatemala	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	2	5	9	3	3
		Korea Rep	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	5	0	0	0	0
		Panama	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**
	NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	2	2	3	3	2	2	2	2	13	9
MED	CP	EU-España	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	1	0

SMA-Table 2. Stock Synthesis model runs 1 and 3 combined Markov Chain Monte Carlo (MCMC, long chain) Kobe II risk matrix for North Atlantic shortfin mako projection results: Probability that the fishing mortality (F) will be below the fishing mortality rate at MSY ($F < F_{MSY}$; top panel), probability that the spawning stock fecundity (SSF) will exceed the level that will produce MSY ($SSF > SSF_{MSY}$; middle panel), and the probability of both $F < F_{MSY}$ and $SSF > SSF_{MSY}$ (bottom panel).

Probability that $F<F_{MSY}$.

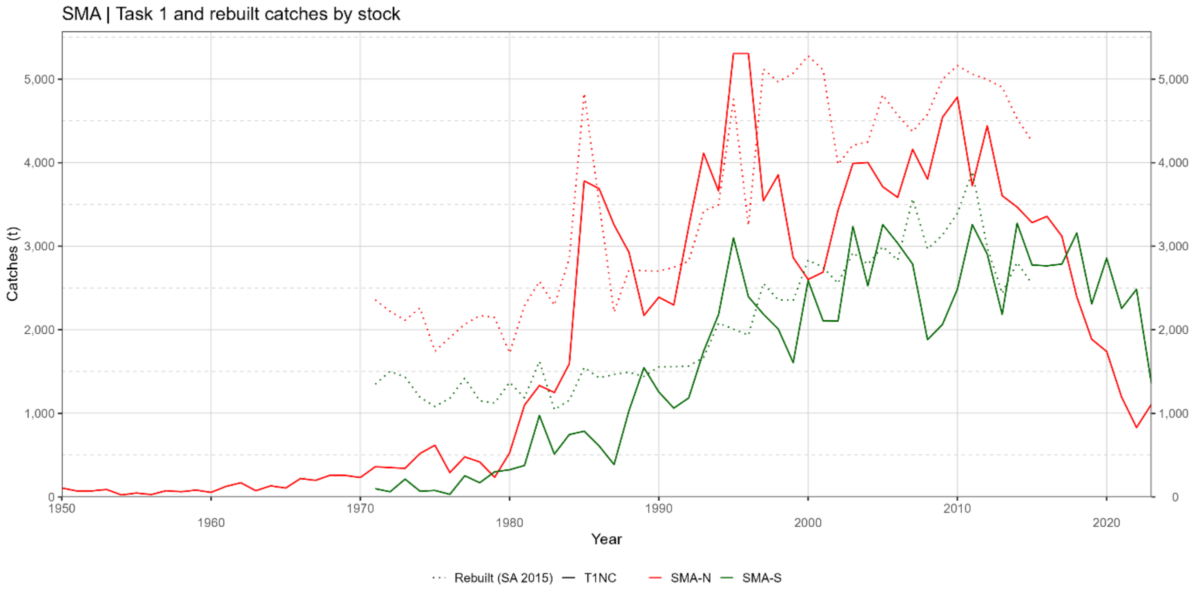
TAC (t)	2019	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
0	100	100	100	100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100	100	100	100	100
200	100	100	100	100	100	100	100	100	100	100	100	100
300	100	100	100	100	100	100	100	100	100	100	100	100
400	100	100	100	100	100	100	100	100	100	100	100	100
500	96	99	100	100	100	100	100	100	100	100	100	100
600	81	89	99	99	98	96	95	97	97	97	96	95
700	57	69	93	92	88	82	80	83	84	85	82	82
800*	32	45	76	77	70	63	62	64	67	67	65	63
900	15	24	57	58	51	46	44	47	51	49	49	48
1000	5	11	37	38	31	27	26	28	30	31	30	30
1100	2	4	19	21	17	13	11	13	14	14	14	13

Probability that $SSF>SSF_{MSY}$.

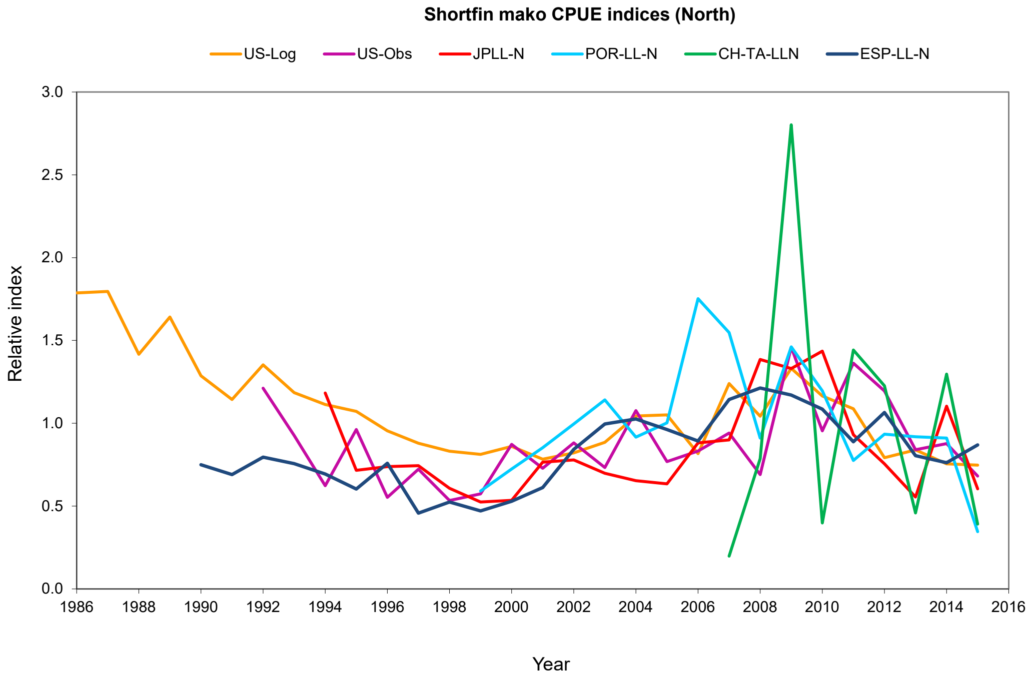
TAC (t)	2019	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
0	46	42	24	14	11	33	53	60	63	67	72	81
100	46	42	24	13	10	29	49	56	59	61	66	73
200	46	42	24	13	9	26	47	54	55	57	61	66
300	46	42	24	12	9	22	42	50	52	53	56	60
400	46	42	24	12	8	19	39	47	49	50	52	55
500*	46	42	24	12	7	17	34	42	45	47	49	52
600	46	42	24	12	7	14	28	37	40	41	43	47
700	46	42	24	11	6	11	23	31	34	35	37	41
800	46	42	23	11	6	10	19	26	27	28	30	32
900	46	42	23	11	5	8	16	20	21	21	23	24
1000	46	42	23	11	5	7	12	16	16	15	15	17
1100	46	42	23	10	5	6	10	12	12	11	10	10

Probability of being in the green zone ($F<F_{MSY}$ and $SSF>SSF_{MSY}$).

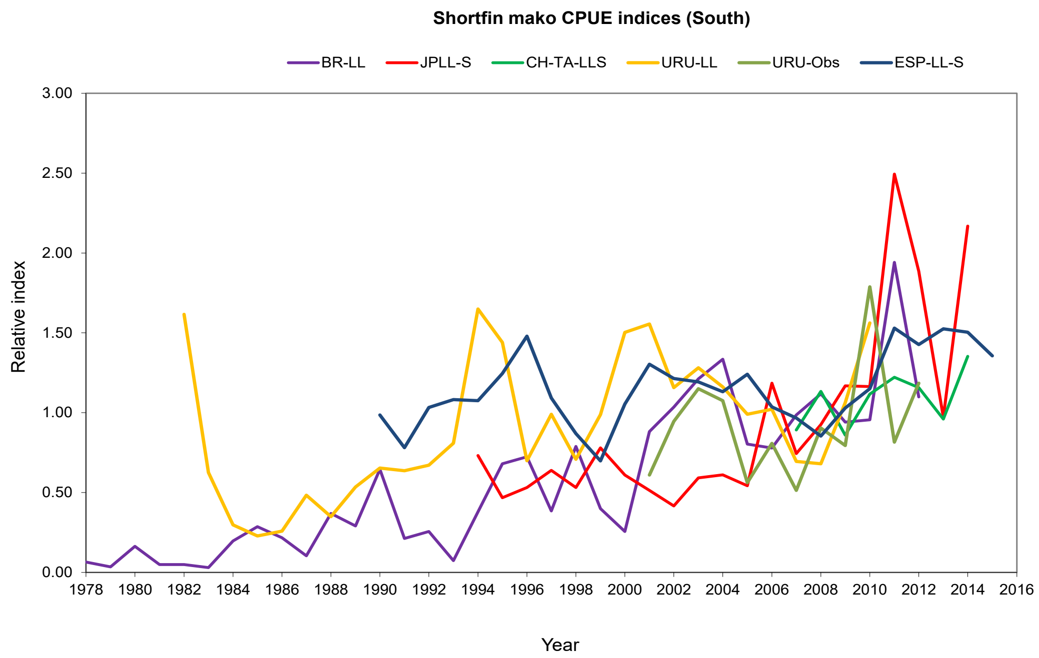
TAC (t)	2019	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
0	46	42	24	14	11	33	53	60	63	67	72	81
100	46	42	24	13	10	29	49	56	59	61	66	73
200	46	42	24	13	9	26	47	54	55	57	61	66
300	46	42	24	12	9	22	42	50	52	53	56	60
400	46	42	24	12	8	19	39	47	49	50	52	55
500*	46	42	24	12	7	17	34	42	45	47	49	52
600	45	42	24	12	7	14	28	37	40	41	43	47
700	41	41	24	11	6	11	23	31	34	35	37	41
800	27	34	23	11	6	10	19	26	27	28	30	32
900	14	21	23	11	5	8	15	20	21	21	23	24
1000	5	10	20	10	5	7	12	15	15	14	14	16
1100	2	4	14	9	4	5	7	9	9	8	8	8



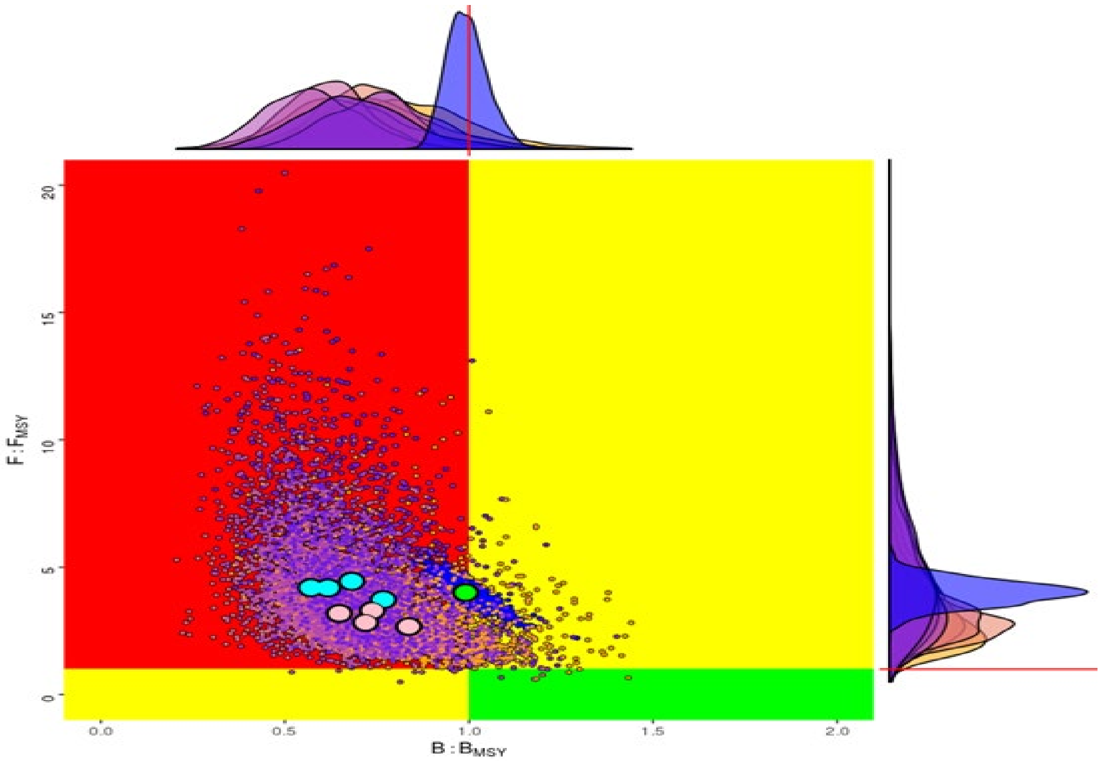
SMA-Figure 1. Shortfin mako (SMA) catches up to 2023 of both stocks (SMA-N in red, SMA-S in green) reported to ICCAT (Task 1) and estimated by the Committee.



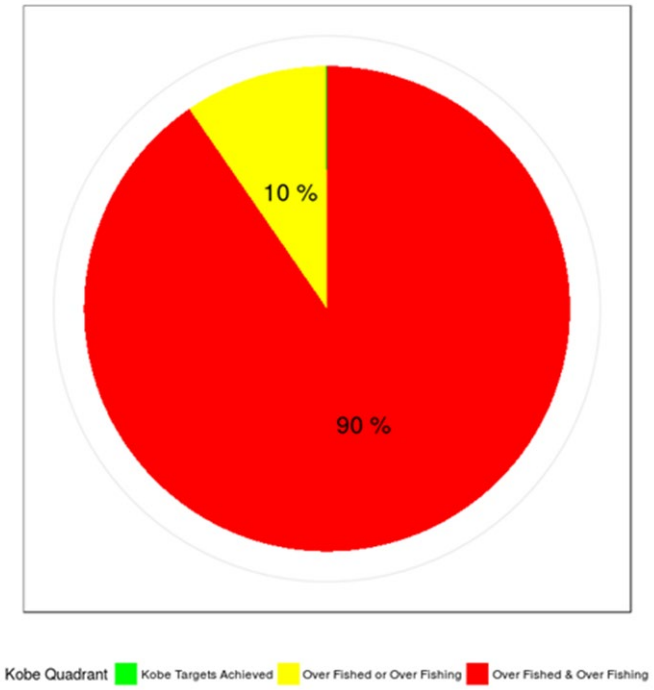
SMA-Figure 2. Indices of abundance for North Atlantic shortfin mako shark used in the 2017 Stock Assessment.



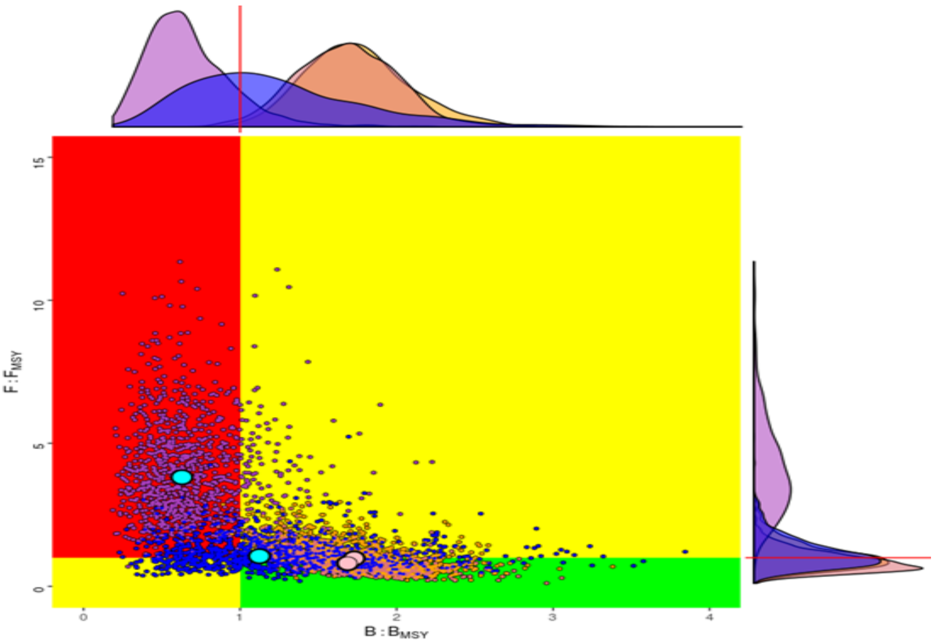
SMA-Figure 3. Indices of abundance for South Atlantic shortfin mako shark used in the 2017 Stock Assessment.



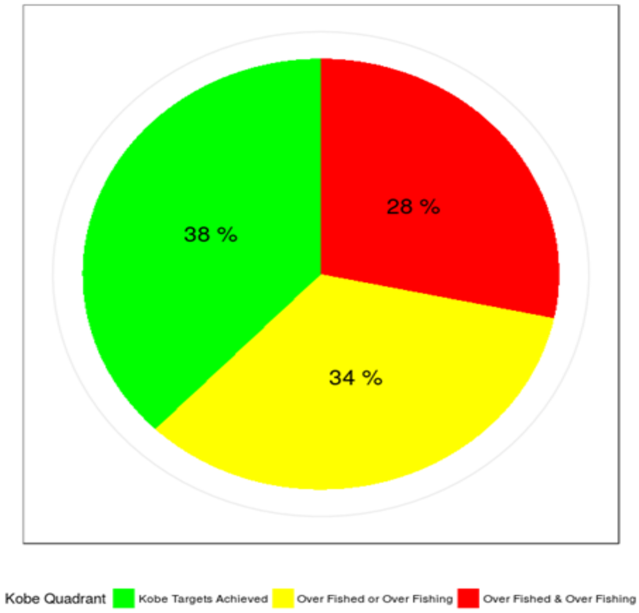
SMA-Figure 4. Stock status (2015) of North Atlantic shortfin makos based on Bayesian production models (4 BSP2JAGS and 4 JABBA runs) and 1 length-based, age-structured model (SS3). The clouds of points are the bootstrap estimates for all model runs showing uncertainty around the median point estimate for each of nine model formulations (BSP2JAGS: solid pink circles; JABBA: solid cyan circles; SS3: solid green circle). The marginal density plots shown are the frequency distributions of the bootstrap estimates for each model with respect to relative biomass (top) and relative fishing mortality (right). The red lines are the benchmark levels (ratios equal to 1).



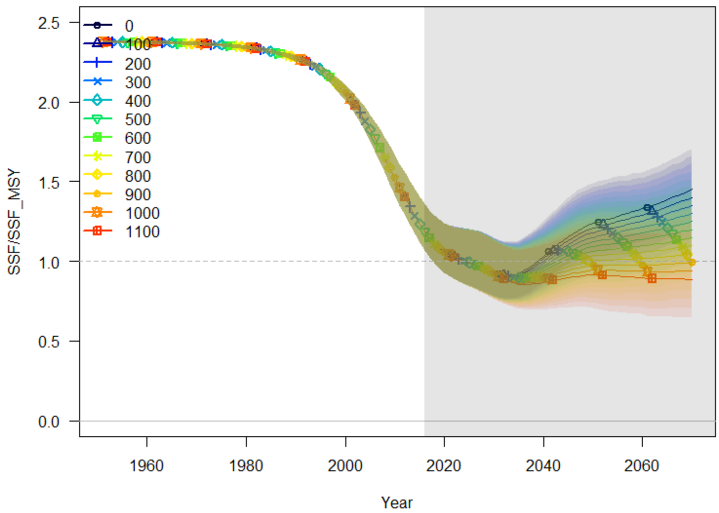
SMA-Figure 5. Kobe pie chart summarizing stock status (for 2015) for North Atlantic shortfin mako based on Bayesian production models (4 BSP2JAGS and 4 JABBA runs) and 1 length-based age-structured model (SS3). Probability of being in the green quadrant is less than 0.5%.

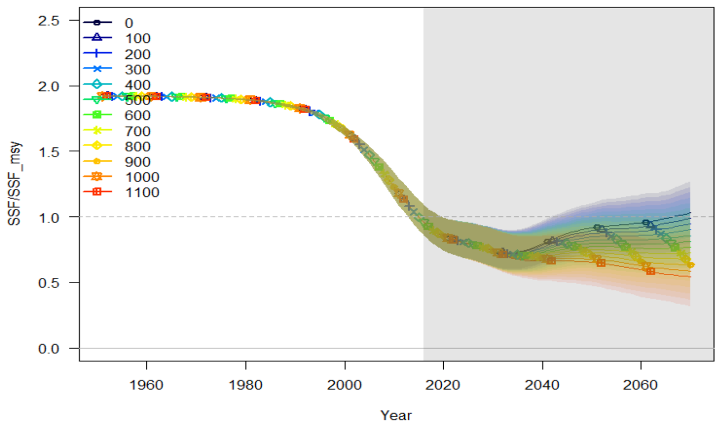


SMA-Figure 6. Stock status (2015) of South Atlantic shortfin makos based on a Bayesian production model (BSP2JAGS) and a catch-only model (C_{MSY}). The clouds of points are the bootstrap estimates for all models combined showing uncertainty around the median point estimate for each of four model formulations (BSP2JAGS: solid pink circles; CMSY: solid cyan circles). The marginal density plots shown are the frequency distributions of the bootstrap estimates for each model with respect to relative biomass (top) and relative fishing mortality (right). The red lines are the benchmark levels (ratios equal to 1).



SMA-Figure 7. Kobe pie chart summarizing stock status (for 2015) for South Atlantic shortfin makos based on a Bayesian production model (2 BSP2JAGS runs) and a catch-only model (2 C_{MSY} runs).





SMA-Figure 8. Constant catch projections (0 – 1100 t) from Stock Synthesis model run 1 (top panel) and run 3 (bottom panel) for the North Atlantic shortfin mako (ICCAT, 2020d). Solid lines are medians and shaded areas are 95% credible intervals.