9.15 BSH - Blue shark

A stock assessment for blue shark (*Prionace glauca*) was conducted for both Atlantic stocks in 2023 through a process that included the Blue Shark Data Preparatory Meeting (hybrid/Olhão, Portugal, 17-21 April 2023) and the Blue Shark Stock Assessment Meeting (hybrid/Madrid, Spain, 17-21 July 2023). The complete description of the stock assessment process and the development of management advice is found in the Report of the 2023 Blue Shark Data Preparatory Meeting (ICCAT, 2023c) and the Report of the 2023 Blue Shark Stock Assessment Meeting (ICCAT, 2023d). The previous Blue Shark Stock Assessment Session was held in Lisbon, Portugal, 27-31 July 2015 (ICCAT, 2016).

BSH-1. Biology

Blue shark is a large pelagic shark that shows a wide geographic distribution in all oceans, from tropical to temperate waters worldwide, between 62º N and 54º S. It is distributed mainly in waters with temperatures ranging between 12ºC and 20ºC, although it can be found in a greater temperature range. Temperature preference is related to size and sex, and relative abundance decreases in equatorial waters and increases with latitude.

The blue shark is placental viviparous and has an average litter size of 35 individuals. Although high uncertainty regarding their biology remains, available life history traits (slow growth, late maturity and small litter size compared to teleosts) indicate that they are vulnerable to overfishing. A behavioral characteristic of this species is their tendency to segregate temporally and spatially by size and/or sex, during feeding, mating-reproduction, gestation and birth processes.

Tagging studies have suggested that they exhibit large-scale migratory behaviour and periodic vertical movement, but the lack of information on some components of the populations precludes a complete understanding of their distribution/migration pattern by ontogenetic stage and in some cases identifying their pupping/mating grounds. Although being one of the most well-know species, numerous aspects of its biology (such as natural mortality or steepness) are still poorly understood, particularly for some regions, which contributes to increased uncertainty in quantitative and qualitative assessments.

BSH-2. Fishery indicators

Reviews of the shark database resulted in recommendations to improve data reporting on shark catches. While reported and estimated catches for blue shark are still generally subject to higher levels of uncertainty than the major tuna stocks, they have been considered sufficiently complete for the purpose of stock assessment.

Due to the broad geographical distribution of blue shark in the Atlantic Ocean, in coastal and off-shore areas, this species is available to a large number of fisheries (mainly longline) and fishing countries. Total estimate catches of blue shark for the North and South Atlantic stocks are presented in **BSH-Table 1** and **BSH-Figure 1**. For the 2015 blue shark stock assessment, a reconstruction process of historical catches of blue shark was done by expert scientists from each CPC, using the most appropriate methodology for each case. Considerable differences between reported and reconstructed catches were noted for years prior to 2000 for the northern stock and prior to 2010 for the southern stock. After the years 2000 and 2010 for the northern and southern stocks, respectively, the reconstructed time series matches the reported Task 1 time series reasonably well. The reconstructed time series is still considered the best available estimations of catches for the northern and southern stocks. The Committee agreed during the 2023 blue shark stock assessment to submit those estimates for approval at the Subcommittee on Statistics for the inclusion in the official Task 1 nominal catch data.

Catches of both stocks of blue shark have had an increasing trend since early 1970s (**BSH-Figure 1**). Peak of reported catches for the North Atlantic corresponds to year 2016, with 44,085 t, and for the South Atlantic corresponds to year 2019, with 38,508 t (**BSH-Table 1**). The more recent reported catches in the North have decreased until 2022 (21,999 t) to increase slightly in 2023 (24,773 t), while captures in the South have increased steadily until 2019 (38,508 t) before decreasing every year until 2023 (30,602 t). Reported catches of blue shark in the Mediterranean still remain scarce, with a peak of 737 t in 2016 (**BSH-Table 1**). The Committee encourages CPCs fishing in the Mediterranean to submit their blue shark data.

Multiple standardized CPUE data series for blue shark were presented and evaluated during the 2023 Data Preparatory Meeting. For the North Atlantic stock eight indices of abundance were used (EU-Spain, EU-Portugal, Japan, Morocco, Venezuela, United States early and late, and Chinese Taipei), and six for the South (EU-Spain, Japan time blocks 1 and 2, a combined Brazil and Uruguay index, time blocks 1 and 2, and Chinese Taipei) (**BSH-Figure 2**).

BSH-3. State of the stocks

The 2023 Blue Shark Stock Assessment was conducted for the northern and southern Atlantic stocks only.

The 2023 Blue Shark Stock Assessment was conducted using two modeling approaches, Just Another Bayesian Biomass Assessment (JABBA), and integrated statistical assessment model, Stock Synthesis (SS3). Different model formulations considered to be plausible representations of the stock dynamics were used to characterize stock status. A more detailed description of the assessment is contained in the Report of the 2023 Blue Shark Stock Assessment Meeting (ICCAT, 2023d).

The Committee acknowledged the progress made for the 2023 blue shark assessment, with the improvements on the implementation of SS3 for the North stock, and the implementation for the first time for the South stock.

North Atlantic blue shark

Based on the combined results from the two stock assessment model platforms (SS3 and JABBA), the North Atlantic blue shark stock in 2021 was at the B_{MSY} level (B_{2021}/B_{MSY} = 1.00, with 95% confidence interval: 0.75-1.31) and was not experiencing overfishing (F_{2021}/F_{MSY} = 0.70, with a 95% confidence interval: 0.50-0.93) (**BSH-Figure 3**). The estimated joint MSY was 32,689 t (the geometric mean of both models, with a 95% confidence interval range of 30,403-36,465 t).

The joint Kobe phase plot indicates that there is a 49.6% probability that the stock currently falls within the yellow quadrant (overfished but not subject to overfishing), a 49.7% probability that the stock falls within the green quadrant (not overfished not subject to overfishing), and less than a 1% chance that it is in the red (overfished and subject to overfishing) or orange quadrants (not overfished but subject to overfishing) (**BSH-Figure 4**).

South Atlantic blue shark

Based on the combined results from the two stock assessment model platforms (SS3 and JABBA), the South Atlantic blue shark stock in 2021 was not overfished (B_{2021}/B_{MSY} = 1.29, with 95% confidence interval: 0.89-1.81) but is undergoing overfishing (F_{2021}/F_{MSY} = 1.03 with 95% confidence interval: 0.45 – 1.55) (**BSH-Figure 5**). The combined joint MSY was 27,711 t (geometric mean of both models, with 95% confidence interval range of 23,128 – 47,758 t).

The joint Kobe phase plot indicates that there is a 46.5% probability that the stock currently falls within the orange quadrant (not overfished but subject to overfishing), a 44.7% probability that the stock falls within the green quadrant (not overfished not subject to overfishing), and 8.02% probability of being in the red quadrant (overfished and subject to overfishing), with less than 1% chance that it is in the yellow quadrant (overfished but not subject to overfishing) (**BSH-Figure 6**).

BSH-4. Outlook

Based on the results obtained during the 2023 stock assessment, the Committee agreed to conduct stochastic stock status projections based on both the selected JABBA and SS3 Reference cases for both North and South Atlantic blue shark stocks, giving equal weighting to each model platform.

As the official reported blue shark Task 1 nominal catches for 2022 were not available at the time of the stock assessment meeting, the Committee agreed to use the average mean catch value of 2019-2021 in Task 1 nominal catches as the best estimate of the 2022 and 2023 expected catches. The estimated value for catches in 2022 and 2023 for the North Atlantic stock was 23,418 t and for the southern stock it was 34,983 t. These values were reviewed with the official catch reports at the species group meeting in September 2023 to evaluate if the catch assumptions for 2022 for both stock projections need further refinement. As estimated values for both stocks were above, but not much, the reported captures, the Committee considered that there was no need to modify projections.

North Atlantic blue shark

Projections were conducted for a range of fixed catches for the period 2024 to 2033. Eleven catch scenarios were applied, starting in a zero-catch scenario, and in intervals of 2,500 t from 20,000 t to 40,000 t, also including the estimated combined MSY level 32,689 t (**BSH-Table 2**). Additional information on projection settings is described in the Report of the 2023 Blue Shark Stock Assessment Meeting (ICCAT, 2023d).

The annual trends of the relative B/B_{MSY} and F/F_{MSY} stochastic projections of the current combined stock status for North Atlantic blue shark stock are presented in **BSH-Figure 7**. Projections indicated that future constant catches at or above 35,000 t would result in fishing mortality above F_{MSY}.

There is a transition period in the projections (2025-2029) where, the stock's probability of being in the green quadrant will decline and then will begin increasing (**BSH-Table 2**). This transition period may reflect the age structure and recent predicted average recruitment trends.

South Atlantic blue shark

Projections were conducted for a range of fixed catches for the period 2024 to 2033. Ten catch scenarios were applied, starting in a zero-catch scenario, and in intervals of 2,500 t from 15,000 t to 32,500 t, also including the estimated combined MSY level 27,711 t (**BSH-Table 3**). Additional information on projection settings is described in the Report of the 2023 Blue Shark Stock Assessment Meeting (ICCAT, 2023d).

The annual trends of the relative B/B_{MSY} and F/F_{MSY} stochastic projections of the current combined stock status for South Atlantic blue shark stock are presented in **BSH-Figure 8**. If current catch levels (average of 2019-2021) of about 35,000 t are maintained, the stock is expected to rapidly decline in biomass, with a risk of falling below 20% of the estimated B_{MSY} reference level in a few years (**BSH-Table 4**).

BSH-5. Effect of current regulations

For the northern stock, Rec. 23-10 was adopted in 2023 with an annual TAC of 30,000 t. It set annual catch limit for certain CPCs (EU 24,449 t, Japan 3,012 t, Morocco 1,644 t, United Kingdom 25 t). Other CPCs were requested to maintain their catches below the level of their highest annual catches over the last ten years. This Recommendation repeals and replaces Rec. 21-10, and Rec. 19-07.

For the South Atlantic stock of blue shark, the Commission adopted Rec. 23-11, which in paragraph 2 established a catch limit of 27,711 t. It set annual catch limit for certain CPCs (EU 17,405 t, Brazil 3,481 t, Namibia 3,238 t, Japan 1,520 t, Chinese Taipei 867 t). All other CPCs shall endeavour to maintain or reduce their catches. The Committee noted that it appears that since the implementation of a TAC for the North Atlantic stock, catches have increased in the South Atlantic (**BSH-Figure 1**). Since 2018, reported catches for the South Atlantic stock have been over the TAC set by Rec. 19-08, with average catches of 32,917 t for the period 2020-2022. However, trends in catches of the most recent years appear to be decreasing (30,602 t in 2023).

BSH-6. Management recommendations

The results from the 2023 stock assessment showed that while the 2022 realized catch (22,057 t) for the North Atlantic stock will maintain the stock in the green quadrant of the Kobe plot with a high probability, the Committee noted that the current TAC (39,102 t) would have a very low probability (3%) of maintaining the stock in the same quadrant by 2033. Therefore, the Committee recommends that the Commission reduces the current TAC to catch levels that will maintain the stock in the green quadrant of the Kobe plot with a high probability (see **BSH-Table 2**). The Commission established a TAC of 30,000 t for North Atlantic blue shark (Rec. 23-10).

The results from the 2023 stock assessment showed that the 2021 South Atlantic blue shark stock status was estimated not to be overfished but undergoing overfishing. Recent catches (2019-2021; 34,983 t mean catch) are above the highest catch scenario used in the Kobe II Strategy Matrix and are not sustainable in the long term. Constant catches of 32,500 t (the highest constant catch scenario in the Kobe matrix) only have a 28% probability of being in the green Kobe quadrant by 2033. The Committee indicates that catches of 27,711 t (the estimated 2021 MSY) or less will immediately stop overfishing and will keep in stock in the green quadrant of the Kobe plot with at least a 54% probability (**BSH-Table 3**). The Commission established a TAC of 27,711 t for the South Atlantic blue shark (Rec. 23-11).

NORTH ATLANTIC BLUE SHARK SUMMARY TABLE

Current Yield (2023)		24,773 t[1]
Maximum Sustainable Yield (MSY)		32,689 t (30,403 - 36,465 t)[2]
Relative Biomass	B_{2021}/B_{MSY}	1.00 (0.75 - 1.30)[3]
Relative Fishing Mortality	F_{2021}/F_{MSY}	0.70 (0.50 - 0.93)[4]
Stock Status (2021)	Overfished	No
	Overfishing[5]	No
Management measures in effect:		Rec. 23-10
		Rec. 04-10, Rec. 07-06

[1] Task 1 catch as of 22 September 2024.
[2] Geometric mean of both models, SS3 and JABBA, with a 95% confidence interval.
[3] Median from SS3 and JABBA, with a 95% confidence interval.
[4] Combined result of SS3 multi-variate lognormal iterations and JABBA posterior. Median and 95% confidence interval in brackets.
[5] The probability of being overfished is 50%.

SOUTH ATLANTIC BLUE SHARK SUMMARY TABLE

Current Yield (2023)		30,602 t[1]
Maximum Sustainable Yield (MSY)		27,711 t (23,128 - 47,758 t)[2]
Relative Biomass	B_{2021}/B_{MSY}	1.29 (0.89 - 1.81)[3]
Relative Fishing Mortality	F_{2021}/F_{MSY}	1.03 (0.45 - 1.55)[4]
Stock Status (2021)	Overfished	No
	Overfishing	Yes
Management measures in effect:		Rec. 23-11
		Rec. 04-10, Rec. 07-06

[1] Task 1 catch as of 22 September 2024.
[2] Geometric mean of both models, SS3 and JABBA, with a 95% confidence interval.
[3] Combined results from both models, SS3 and JABBA, with a 95% confidence interval.
[4] Combined result of SS3 multi-variate lognormal iterations and JABBA posterior. Median and 95% confidence interval in brackets.

BSH-Table 1. Estimated catches (t) of blue shark (*Prionace glauca*) 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				11315	11588	10989	39566	36145	36972	40655	35243	34329	38161	37500	43778	45474	50607	54481	59146	66986	76230	65375	58585	64792	63355	70239	68662	68551	65784	54746	55101	53684	55410
	ATN			8605	8472	6740	29271	26668	26122	28161	21151	20458	23184	22054	22660	23517	27070	30882	35354	38929	40292	38912	37813	38131	40191	44085	40004	33979	27212	20963	21650	21999	24773
	ATS			2704	3108	4246	10145	9414	10828	12448	14044	13854	14966	15320	21046	21768	23487	23518	23607	27799	33898	26421	20672	26253	22498	25417	28555	34514	38508	33709	33392	31650	30602
	MED			6	8	2	150	63	22	45	47	17	11	126	72	182	50	81	185	239	40	42	100	408	660	737	103	58	64	73	92	36	36
Landings	ATN		Longline	7660	7551	6136	28820	26266	25650	27573	20856	19644	22926	21780	22385	23278	26811	30518	35035	38644	39983	38725	37604	37886	39335	42875	38831	32779	25994	19566	20180	20657	23432
			Other surf.	373	300	560	289	313	422	475	189	746	204	210	209	194	205	235	216	117	102	67	100	117	731	1123	1035	1087	1025	986	1087	673	728
	ATS		Longline	2704	3108	4246	10135	9405	10801	12448	14043	13849	14960	15320	21043	21762	23417	23503	23601	27785	33427	25878	20387	24308	21736	24643	27662	33561	37610	32630	32683	30029	29031
			Other surf.	0	0	0	6	4	27	0	1	4	6	0	3	6	10	0	6	14	468	411	152	1831	635	634	688	854	538	603	495	1329	1203
	MED		Longline	6	8	2	150	63	22	45	47	17	11	77	72	142	48	81	18	176	40	42	68	341	664	735	90	54	51	71	53	34	29
			Other surf.	0	0	0	0	0	0	0	0	0	0	48	0	47	2	0	167	83	0	0	32	67	1	2	13	4	13	3	6	1	1
Discards	ATN		Longline	572	621	45	161	88	49	113	105	68	55	63	66	45	53	129	102	167	205	119	109	128	124	88	138	112	193	411	383	667	611
			Other surf.	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	2	1	0	0	6	0	0	0	0	0	0	1	2
	ATS		Longline	0	0	0	5	5	0	0	0	0	0	0	0	0	60	14	0	0	4	132	132	114	122	139	218	99	340	477	213	291	368
			Other surf.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	7	0	0	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	0	6
			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
Landings	ATN	CP	Barbados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	6	7	4	2	2	2	2	3	2
			Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	114	461	1039	903	1216	392	4	6	201	317	369	301	349	311	567
			Brazil	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	274
			Canada	1260	1494	528	831	612	547	624	581	836	346	965	1134	977	843	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
			Cape Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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	185	104	148	146	132	142	367	109	88	33	109	98	327	178	1	27	2	6	18	65	2	13	9
			Costa Rica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	6	14	8	5	3	2	0	0	0	0	0	0	1
			EU-Denmark	1	2	3	1	1	0	2	1	13	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU-España	0	0	0	24497	22504	21811	24112	17362	15666	15975	17314	15006	15464	17038	20788	24465	26094	27988	28666	28562	29041	30078	29019	27316	21685	16314	12325	13125	13057	14896
			EU-France	350	266	278	213	163	369	395	207	221	57	135	120	99	161	119	84	122	113	31	216	112	262	352	124	94	80	57	49	46	45
			EU-Ireland	0	0	0	0	0	66	31	66	11	2	0	0	0	0	0	0	0	1	3	2	1	0	0	0	0	0	0	0	0	0
			EU-Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU-Portugal	4669	4722	4843	2630	2440	2227	2081	2110	2265	5643	2025	4027	4338	5283	6167	6252	8261	6509	3768	3694	3060	3829	7819	5664	5195	4507	3836	4300	4102	4026
			FR-St Pierre et Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	153	0
			Great Britain	0	12	0	0	1	0	12	9	6	4	6	5	3	6	6	96	8	10	8	10	10	12	17	11	6	3	3	4	5	4
			Iceland	0	0	0	0	0	0	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	1203	1145	618	489	340	357	273	350	386	538	1035	1729	1434	1921	2531	2007	1763	1227	2437	1808	3287	4011	4217	4444	4111	3740	2130	1608	1972	2396
			Korea Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	537	299	327	113	0	10	103	92	113	48	16	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	7	10	3	8	0	2
			Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	661	975	1072	999	1389	873	1623	1475	1644	1524	1498	1636	1532	1644
			Mauritania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	0	0	0	0	0	0	
			Mexico	0	0	0	0	0	0	0	6	2	3	4	3	3	0	2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
			Panama	0	0	0	0	0	9	0	0	0	0	0	0	254	892	613	1575	1026	1071	1224	289	153	555	262	324	437	242	162	84	111	189
			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	456	0	0	0	0	43	134	255	56	148	5	12	17	13	17	19	15	14	14	14	0	0
			St Vincent and Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	119	0	0	0	2	0	0	
			Trinidad and Tobago	13	4	5	4	7	8	12	19	6	3	2	1	1	0	2	8	9	11	11	8	10	4	2	2	0	0	0	0	1	0
			UK-Bermuda	0	0	0	1	2	0	3	4	5	4	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			USA	31	24	284	214	256	217	292	40	182	172	137	163	156	150	164	158	69	73	61	61	44	32	31	24	19	17	8	10	1	7
			Venezuela	18	16	6	27	7	47	43	47	29	40	10	28	12	19	8	73	75	117	98	52	113	130	117	108	112	56	59	11	9	16
		NCC	Chinese Taipei	487	167	132	203	246	384	165	59	203	171	206	240	588	292	110	73	99	148	94	113	77	220	259	42	122	8	38	49	11	52
			Suriname	0	0	0	0	0	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
	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	16	0	0	0	17	64	22
			Belize	0	0	0	0	0	0	0	0	0	0	37	259	99	236	109	148	273	243	483	234	171	105	167	200	222	165	15	21	0	
			Brazil	0	0	743	1103	616	179	1687	2173	1971	2166	2103	2523	3334	2258	2407	1274	1501	2808	1607	2013	2551	2420	1334	2177	3011	3784	3435	4629	3328	1848
			China PR	0	0	0	0	0	0	0	565	316	452	444	404	434	585	40	109	41	131	84	64	48	20	30	283	127	52	45	15	3	67
			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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	16	9	8	247	1202	8	0	15	15
			EU-España	0	0	0	5272	5574	7173	6951	7743	5368	6626	7366	6410	8724	8942	9615	13099	13953	16978	14348	10473	11447	10133	10107	11486	13515	18497	14717	16778	14061	14388
			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-Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU-Portugal	0	847	867	1336	876	1110	2134	2562	2324	1841	1863	3184	2751	4494	4866	5358	6338	7642	2424	1646	1622	2420	5809	6663	8015	6753	7350	5524	6092	5504
			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
			Ghana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1583	396	436	479	416	414	413	446	1287	1150
			Great Britain	0	0	0	0	0	0	0	0	0	0	0	0	239	0	0	14	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
			Guinea Ecuatorial	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	6	0	0	0	0	0	0	1
			Japan	1388	437	425	506	510	536	221	182	343	331	209	236	525	896	1789	981	1161	1483	3060	2255	3232	2277	2127	3112	3495	2338	1795	1327	902	1182
			Korea Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	222	125	112	61	10	72	252	87	192	156	55	6	0	0
			Namibia	0	0	0	0	0	0	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	168	22	0	0	0	0	0	0	0	521	0	0	0	0	0	0	0	0	0	0	15	0	1	1	9
			Russian Federation	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			S Tomé e Príncipe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	143	147	152	156	206	183	182	190	94	11	30	25	54
			Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	203	51	60	105	18	15	11	15	39	22	25	0	0
			South Africa	0	0	0	0	23	21	0	83	63	232	128	154	90	82	126	119	125	318	158	179	524	402	356	418	403	292	52	181	100	51
			St Vincent and Grenadines	0	0	0	0	0	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	4	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Uruguay	84	57	259	180	248	118	81	66	85	480	462	376	232	337	359	942	208	725	433	130	0	0	0	0	0	0	0	0	0	0
		NCC	Chinese Taipei	1232	1767	1952	1737	1539	1496	1353	665	1172	521	800	866	1805	2177	1843	1356	1625	2138	1941	2125	2128	1731	1853	1852	1276	716	1179	922	785	1461
		NCO	Benin	0	0	0	6	4	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	MED	CP	Algeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	7	4	2	3	5	2
			EU-Cyprus	0	0	0	0	0	0	9	0	0	3	6	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			EU-España	0	0	0	146	59	20	31	6	3	3	4	8	61	3	2	7	48	38	39	37	53	65	59	40	19	18	34	14	8	5
			EU-France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	5	15	7	0	2	2	2	2	1	1
			EU-Italy	0	0	0	0	0	0	0	0	0	0	113	1	106	46	75	176	208	0	0	57	347	0	18	39	17	33	26	33	13	16
			EU-Malta	1	1	1	2	2	2	1	1	1	0	0	0	0	1	1	2	1	1	2	2	4	5	3	4	2	2	2	1	3	1
			EU-Portugal	0	0	0	0	2	0	5	41	14	3	0	56	22	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
			Japan	5	7	1	1	0	0	0	0	0	1	1	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	380	650	0	0	10	6	6	5	6	4
Discards	ATN		Canada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	16	32	71	4	193	173	365	161
			EU-Denmark	0	0	0	0	0	0	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-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	5	3
			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	115	157	180	212	372
			Korea Rep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	1	29	0	25	1	0	36	35
			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

			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
		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	3	1	0	0	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
		USA	572	618	44	161	88	41	113	106	68	55	65	66	45	54	130	103	167	206	106	99	122	82	43	42	11	20	24	25	36	19
	NCC	Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	10	6	19	27	34	31	30	36	4	14	23
ATS	CP	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	60	14	0	0	0	0	0	0	0	0	0	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	2	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	1	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	6	0	1	0	0	0	0	0	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	1	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	1	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	175	316	81	99	143
		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	17	2	19	2	2	55	34
		Panama	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**
		South Africa	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	1
		USA	0	0	0	5	5	0	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	4	132	132	112	122	139	201	97	146	139	130	138	191
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	0	6
		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

BSH-Table 2. Kobe II Strategic Matrices for the North Atlantic blue shark stock combined models: a) the probability that overfishing is not occurring ($F \leq F_{MSY}$); b) the probability that the stock is not overfished ($B \geq B_{MSY}$); and c) the joint probability of being in the green quadrant of the Kobe plot (i.e., $F \leq F_{MSY}$ and $B \geq B_{MSY}$). The constant catch scenario of 32,689 tons corresponds to the estimated MSY.

a) Probability $F \leq F_{MSY}$.

Catch (t)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
0	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
20000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
22500	99%	99%	99%	100%	100%	100%	100%	100%	100%	100%
25000	95%	96%	96%	97%	98%	98%	99%	99%	99%	100%
27500	87%	87%	88%	89%	90%	92%	93%	94%	95%	95%
30000	75%	74%	74%	75%	76%	77%	78%	79%	80%	81%
32500	62%	60%	59%	59%	59%	59%	59%	59%	59%	59%
32689	61%	59%	58%	57%	58%	58%	58%	58%	58%	57%
35000	50%	47%	44%	43%	41%	39%	38%	37%	36%	35%
37500	40%	35%	31%	27%	24%	21%	19%	17%	15%	14%
40000	31%	24%	19%	14%	11%	8%	7%	5%	4%	4%

b) Probability $B \geq B_{MSY}$.

Catch (t)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
0	71%	83%	95%	100%	100%	100%	100%	100%	100%	100%
20000	59%	58%	62%	73%	84%	91%	95%	97%	98%	99%
22500	58%	56%	59%	68%	78%	85%	90%	93%	95%	97%
25000	56%	53%	55%	63%	71%	77%	82%	86%	88%	91%
27500	55%	51%	52%	58%	64%	69%	73%	76%	78%	81%
30000	54%	49%	50%	53%	58%	61%	63%	65%	67%	68%
32500	53%	48%	47%	49%	51%	53%	53%	54%	54%	54%
32689	53%	47%	46%	48%	50%	52%	53%	53%	53%	53%
35000	53%	46%	44%	43%	44%	43%	42%	41%	40%	38%
37500	52%	44%	40%	38%	35%	33%	30%	27%	24%	22%
40000	51%	42%	36%	32%	27%	22%	18%	15%	13%	10%

c) Probability $F \leq F_{MSY}$ and $B \geq B_{MSY}$.

Catch (t)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
0	71%	83%	95%	100%	100%	100%	100%	100%	100%	100%
20000	59%	58%	62%	73%	84%	91%	95%	97%	98%	99%
22500	58%	56%	59%	68%	78%	85%	90%	93%	95%	97%
25000	56%	53%	55%	63%	71%	77%	82%	86%	88%	91%
27500	55%	51%	52%	58%	64%	69%	73%	76%	78%	80%
30000	53%	49%	50%	53%	57%	60%	63%	65%	66%	67%
32500	51%	47%	46%	47%	49%	51%	51%	52%	52%	53%
32689	50%	46%	46%	47%	49%	50%	51%	51%	51%	51%
35000	46%	42%	40%	39%	38%	37%	36%	35%	34%	33%
37500	38%	33%	29%	26%	23%	21%	19%	17%	15%	14%
40000	30%	23%	18%	14%	11%	8%	7%	5%	4%	3%

BSH-Table 3. Kobe II Strategic Matrices for the South Atlantic blue shark stock combined models: a) the probability that overfishing is not occurring ($F<=F_{MSY}$); b) the probability that the stock is not overfished ($B>=B_{MSY}$); and c) the joint probability of being in the green quadrant of the Kobe plot (i.e., $F<= F_{MSY}$ and $B>= B_{MSY}$). The constant catch scenario of 27,711 t corresponds to the estimated MSY.

a) Probability $F \leq F_{MSY}$.

Catch (t)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
0	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
15000	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
17500	98%	99%	99%	99%	99%	99%	100%	100%	100%	100%
20000	95%	96%	97%	97%	97%	97%	98%	98%	98%	98%
22500	89%	90%	91%	91%	91%	91%	91%	92%	92%	92%
25000	80%	81%	80%	80%	79%	79%	78%	78%	78%	77%
27500	70%	69%	68%	66%	65%	64%	62%	61%	60%	59%
27711	69%	68%	67%	65%	63%	62%	61%	60%	59%	58%
30000	58%	57%	54%	52%	50%	48%	47%	45%	44%	43%
32500	47%	45%	42%	40%	37%	36%	34%	33%	32%	32%

b) Probability $B \geq B_{MSY}$.

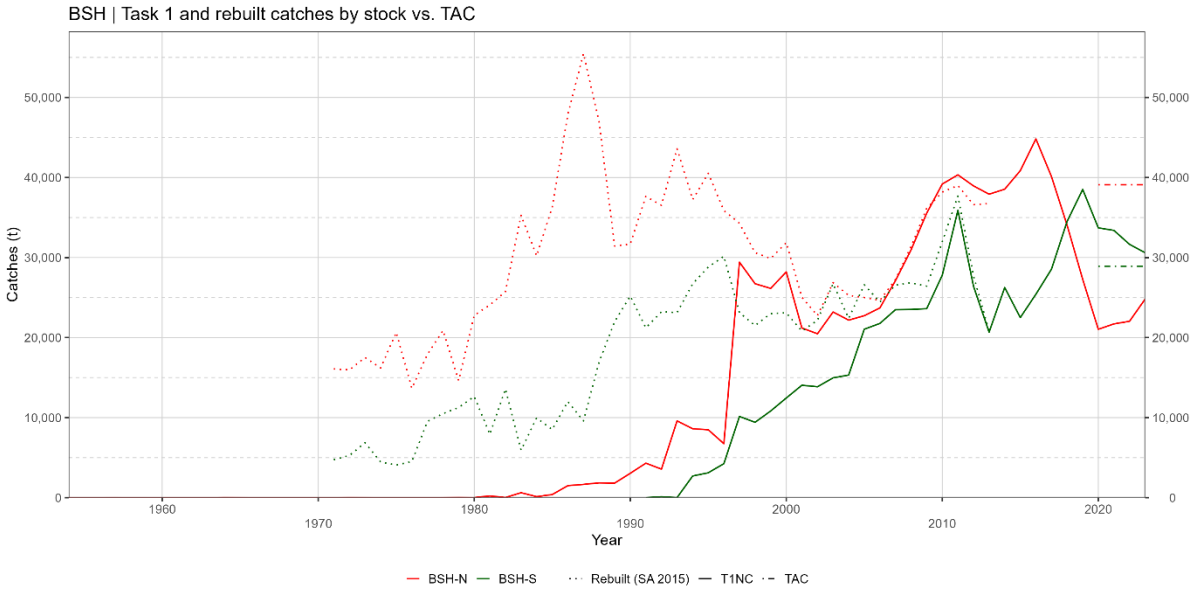
Catch (t)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
0	93%	99%	100%	100%	100%	100%	100%	100%	100%	100%
15000	83%	89%	93%	95%	97%	98%	99%	99%	99%	99%
17500	81%	86%	90%	92%	94%	95%	96%	97%	97%	98%
20000	79%	83%	86%	88%	89%	90%	91%	92%	93%	94%
22500	77%	79%	81%	82%	82%	83%	84%	84%	85%	86%
25000	75%	75%	75%	75%	75%	74%	74%	74%	74%	73%
27500	72%	71%	69%	68%	66%	64%	63%	61%	60%	60%
27711	72%	70%	69%	67%	65%	63%	62%	61%	60%	58%
30000	70%	67%	63%	60%	57%	54%	52%	50%	48%	47%
32500	68%	62%	57%	52%	48%	45%	42%	40%	39%	38%

c) Probability $F \leq F_{MSY}$ and $B \geq B_{MSY}$.

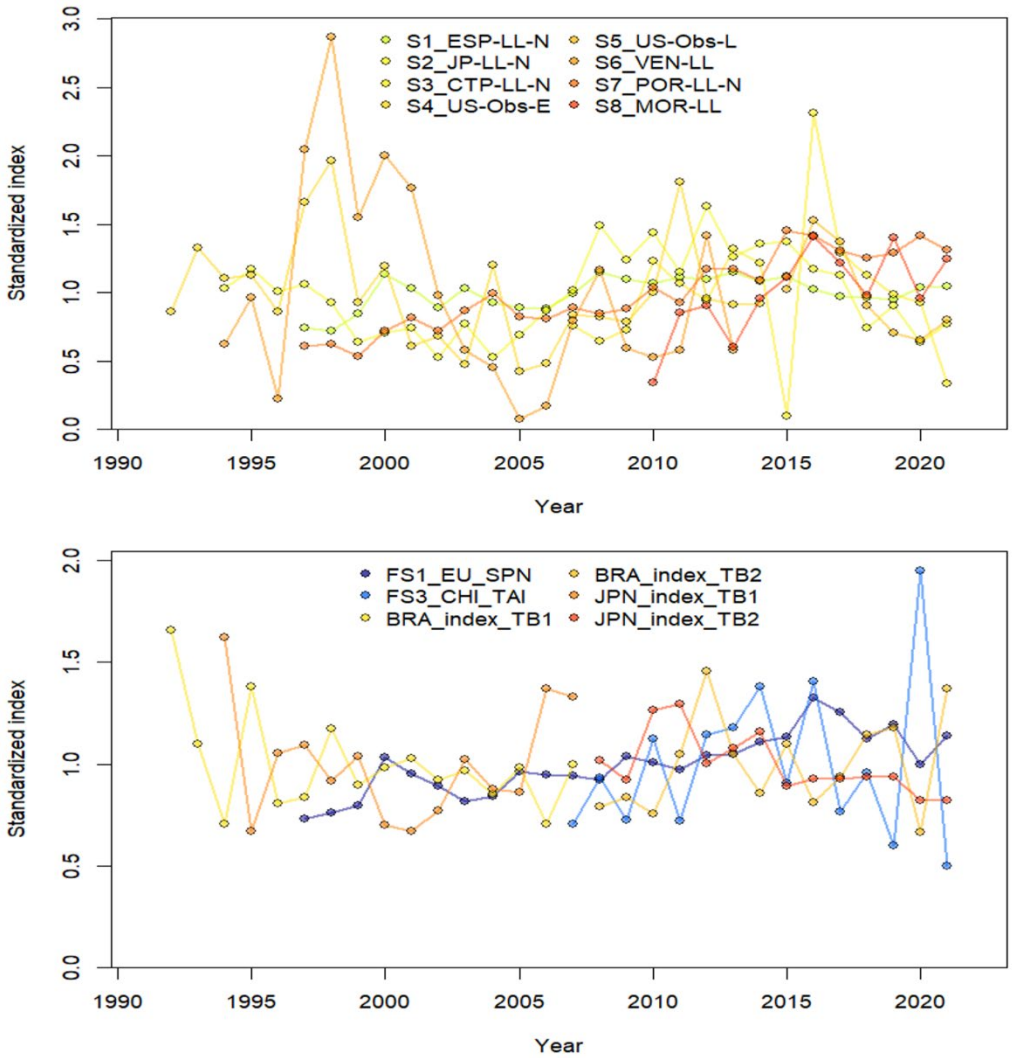
Catch (t)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
0	93%	99%	100%	100%	100%	100%	100%	100%	100%	100%
15000	83%	89%	93%	95%	97%	98%	99%	99%	99%	99%
17500	81%	86%	90%	92%	94%	95%	96%	97%	97%	98%
20000	79%	83%	86%	88%	89%	90%	91%	92%	93%	94%
22500	77%	79%	81%	82%	82%	83%	84%	84%	85%	86%
25000	74%	75%	75%	75%	74%	74%	73%	73%	73%	72%
27500	68%	68%	67%	65%	63%	61%	59%	59%	54%	53%
27711	67%	67%	66%	63%	61%	60%	58%	56%	55%	54%
30000	58%	57%	54%	51%	49%	47%	44%	43%	41%	40%
32500	47%	45%	42%	39%	37%	34%	32%	31%	29%	28%

BSH-Table 4. Table Percent of the model runs that resulted in B levels ≤20% of B_{MSY} during the projection period for a given catch level for the South Atlantic blue shark stock.

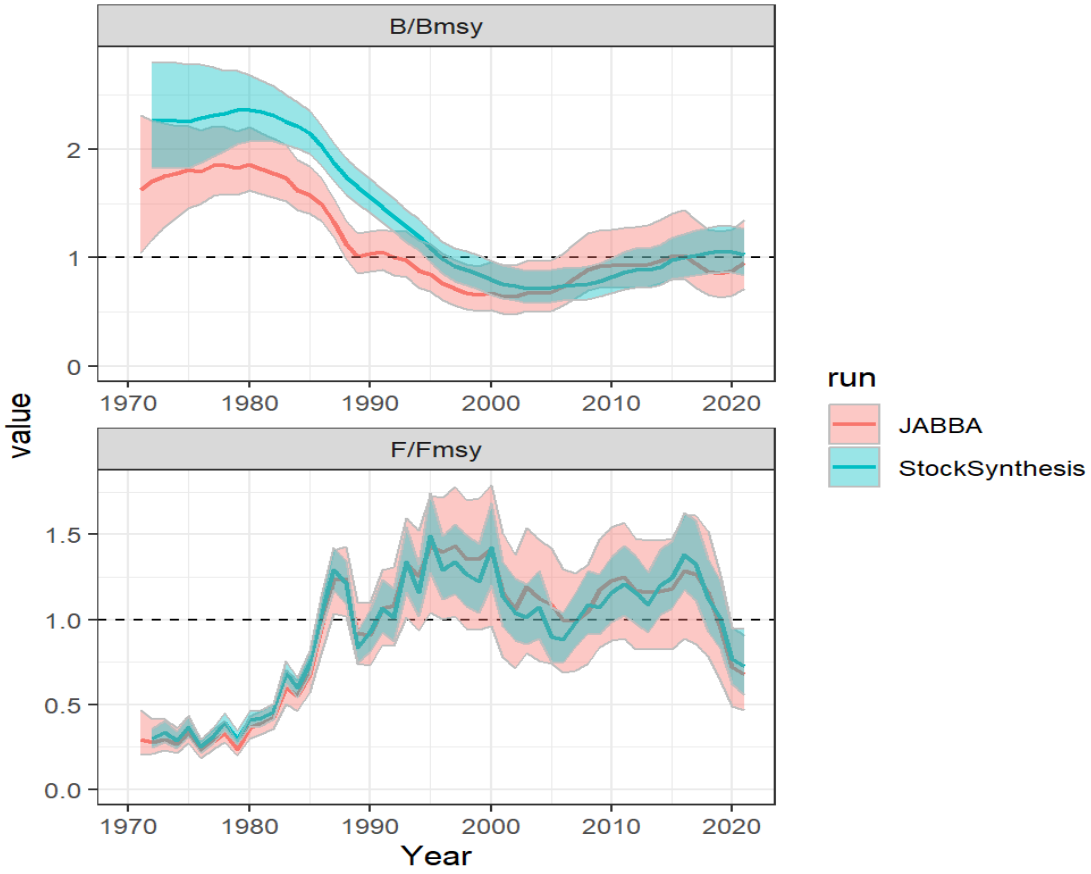
Catch (t)	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
15000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
17500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
20000	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
22500	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
25000	0%	0%	0%	0%	0%	0%	1%	1%	1%	1%
27500	0%	0%	0%	0%	1%	1%	1%	1%	2%	3%
27711	0%	0%	0%	0%	1%	1%	1%	2%	2%	3%
30000	0%	0%	0%	1%	1%	1%	2%	3%	5%	6%
32500	0%	0%	0%	1%	2%	3%	5%	8%	11%	16%



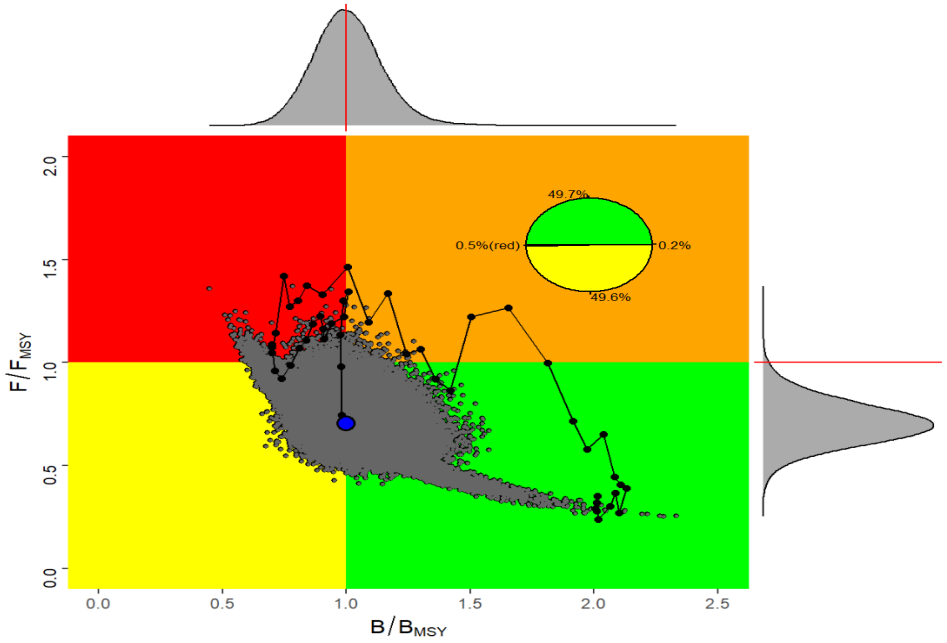
BSH-Figure 1. Blue shark (BSH) catches up to 2023 of both stocks (BSH-N in red, BSH-S in green) reported to ICCAT (Task 1) and the rebuilt catch series estimated by the Committee.



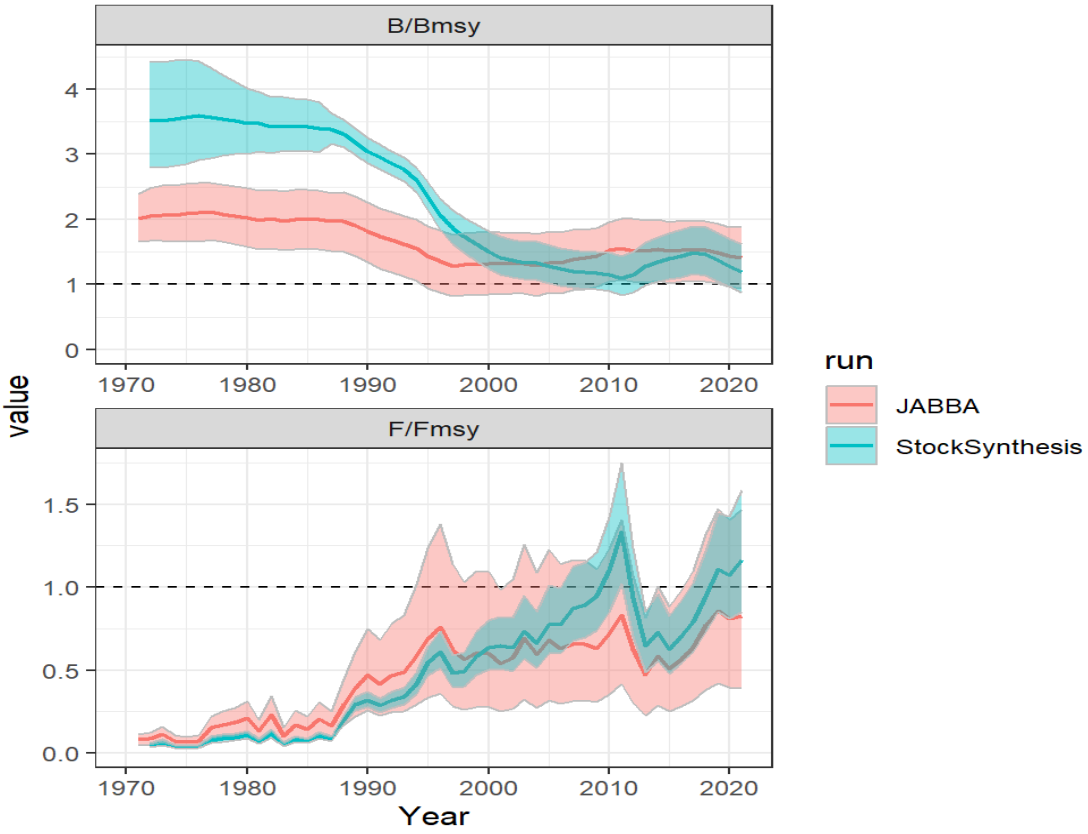
BSH-Figure 2. Standardized indices of abundance of blue shark for the northern stock (upper) and the southern stock (lower). All the indices shown were used in the 2023 stock assessments of North and South Atlantic blue shark (BSH) stocks.



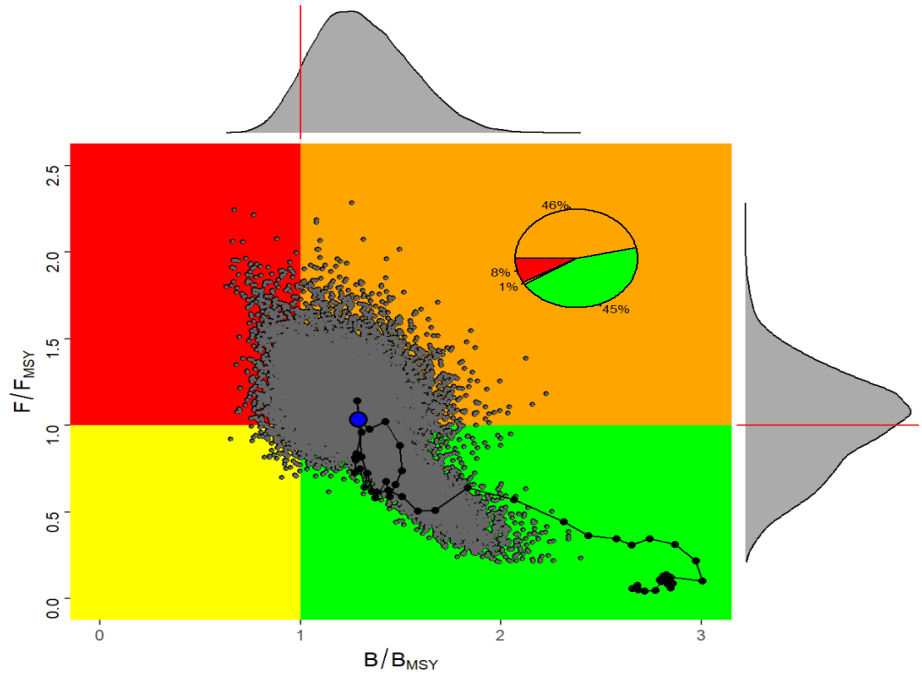
BSH-Figure 3. Estimated annual trends for the northern stock from JABBA (orange lines) and Stock Synthesis (green lines) for B/B_{MSY} (JABBA) or SSB/SSB_{MSY} (Stock Synthesis) (upper panel), and F/F_{MSY} (lower panel) with 95% confidence interval.



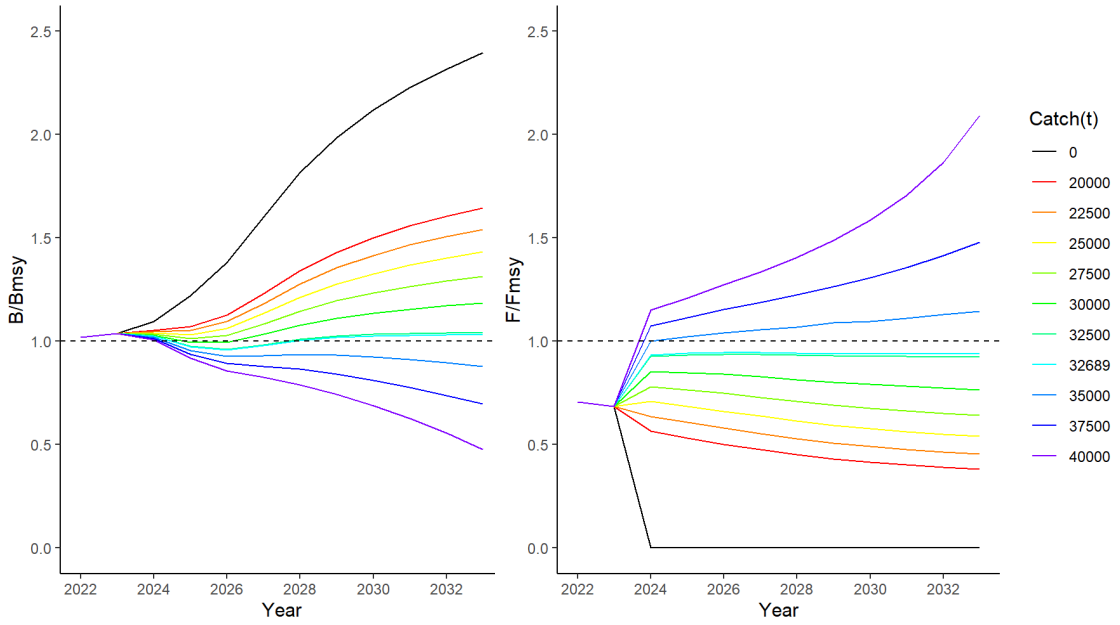
BSH-Figure 4. Joint Kobe phase plot from JABBA and Stock Synthesis for the North Atlantic blue shark stock. Solid black dots and solid line indicate the stock status trajectory, with the blue dot indicating the terminal year (2021), grey dots are the interactions from each model for the terminal year with the marginal distributions plotted in the lateral axis.



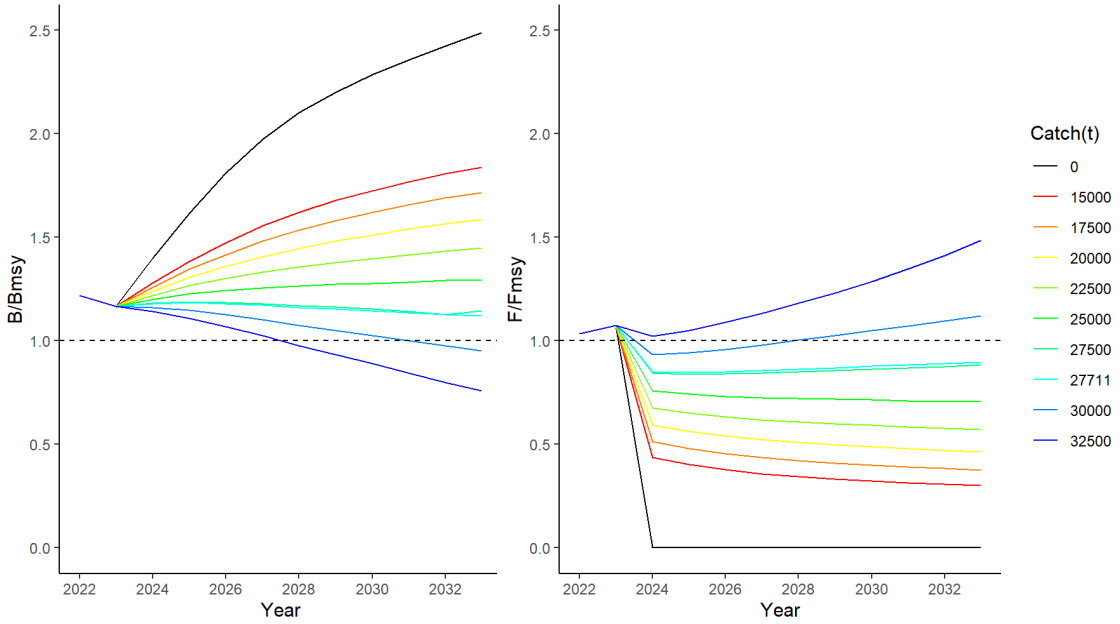
BSH-Figure 5. Estimated annual trends for the southern stock from JABBA (orange lines) and Stock Synthesis (green lines) for B/B_{MSY} (JABBA) or SSB/SSB_{MSY} (Stock Synthesis) (upper panel), and F/F_{MSY} (lower panel) with 95% confidence interval.



BSH-Figure 6. Joint Kobe phase plot from JABBA and Stock Synthesis for the South Atlantic blue shark stock. Solid black dots and solid line indicate the stock status trajectory, with the blue dot indicating the terminal year (2021), grey dots are the interactions from each model for the terminal year with the marginal distributions plotted in the lateral axis.



BSH-Figure 7. Projections for B/B_{MSY} and F/F_{MSY} based on both Stock Synthesis and JABBA reference cases for North Atlantic blue shark stock for various levels of future constant catch ranging from 20,000 – 40,000 t, including a zero-catch scenario starting in 2024. The initial catch for the years 2022-2023 was set to 23,418 t, which is the average catch of the recent three years (2019-2021). The projections were run until 2033 (10 years).



BSH-Figure 8. Projections for B/B_{MSY} and F/F_{MSY} based on both Stock Synthesis and JABBA reference cases for South Atlantic blue shark stock for various levels of future constant catch ranging from 15,000-32,500 t, including a zero-catch scenario starting in 2024. The initial catch for the years 2022-2023 was set to 34,983 t, which is the average catch of the recent three years (2019-2021). The projections were run until 2033 (10 years).