

9.7 WHM – WHITE MARLIN

The most recent assessment for white marlin was conducted in 2019 through a process that included a data preparatory meeting in March 2019 (Anon., 2019) and an assessment meeting held in June 2019 (Anon., 2019). The last year of fishery data used in the assessment was 2017.

WHM-1. Biology

White marlin spawning areas occur mainly in the tropical western North and South Atlantic, predominantly in the same offshore locations in their normal range. In the North Atlantic, spawning activity has been reported off eastern Florida (USA), the Windward Passage (between La Hispaniola and Cuba), and north of Puerto Rico. Seasonal spawning concentrations have been noted northeast of Hispaniola and Puerto Rico, and off the east coast of Hispaniola. Spawning activity has also been reported for the equatorial Atlantic (5°N-5°S) off northeastern Brazil, and in the South Atlantic off southern Brazil.

Previous reports have mentioned that spawning takes place during austral and boreal spring-summer. In the North Atlantic, reproduction events occur from April to July, with spawning activity peaking around April-May. In the equatorial Atlantic (5°N-5°S), spawning occurs during May to June, and in the South Atlantic, reproduction events take place from December to March.

White marlin inhabits the surface mixed layer of the open ocean. Although they spend about 50% of daylight hours and 81% of nighttime hours in the warmer waters of the mixed surface layer, they do explore temperatures ranging 7.8-29.6°C. However, a negligible amount of time is spent at temperatures less than 7 °C below the mixed surface layer. Information from pop-up satellite archival tag (PSAT) data indicated frequent short-duration dives extending to >300 m depths, although most dives ranged from 100 to 200 m. Two types of diving behavior have been identified for white marlin, (1) a shorter duration V-shaped dive, and (2) a U-shaped dive characterized as those confined to a specific depth range for a prolonged period. These patterns, however, can be highly variable between individuals and also vary depending on the temperature and dissolved oxygen of the surface mixed layer. Therefore, it is important to consider vertical habitat use and the environmental factors that influence it during the standardization of CPUE data.

All white marlin biological material sampled prior to the confirmation of the presence of roundscale spearfish (*T. georgii*) in 2006, are now presumed to contain an unknown proportion of roundscale spearfish. Therefore, reproductive parameters, growth curves and other biological studies previously thought to describe white marlin may not accurately represent this species. The Committee reviewed recent scientific nomenclature for billfish (Colette *et al.*, 2006) and recommends adopting the scientific name of *Kajikia albida* (Poey 1860) for white marlin in ICCAT.

WHM-2. Fishery indicators

It has now been confirmed that white marlin landings reported to ICCAT include roundscale spearfish in significant numbers, so that historical statistics of white marlin most likely comprise a mixture of the two species. Studies of white marlin/roundscale spearfish ratios in the western Atlantic have been conducted, with overall estimated ratios between 23-27%, although they varied in time and space. Previously, these were thought to represent only white marlin. However, there is little information on these species ratios in the eastern Atlantic.

The decadal geographic distribution of the catches is given in **WHM-Figure 1**. The Committee used Task I catches as the basis for the estimation of total removals (**WHM-Figure 2**). Total removals for the period 1990-2017 were obtained during the 2019 White Marlin Stock Assessment Session by modifying Task I values with the addition of white marlin that the Committee estimated from catches reported as billfish unclassified. The dead discards were estimated for those longline fleets that have not reported dead discards (2010-2018) based on data from fleets that had reported dead discards.

Additionally, the reporting gaps for some fleets were completed using estimates based on catch values reported for years before and/or after the gap(s) years.

Preliminary Task I catches of white marlin and roundscale spearfish, as well as the combined WHM/RSP Task I used in the stock assessment is presented in **WHM-Table 1**. For combined white marlin and roundscale spearfish the catches in 2018 were 313 t, compared to 458 t reported for 2017. Landings for 2018 are preliminary. Due to the work conducted by the Committee and improved reporting by CPCs the amount of unclassified billfish in the Task I table has been minimized.

A series of indices of abundance for white marlin were presented and discussed during the 2019 data preparatory and assessment meetings. Following the guidelines developed by the SCRS Working Group on Stock Assessment Methods (WGSAM), 14 CPUE series were available and 13 selected for their inclusion in the final assessment models. In general, the indices showed no discerning trend during the latter part of the time series examined (**WHM-Figure 3**). During the 2019 assessment, all standardized CPUE index for white marlin showed a sharp decline during the period 1960-1991, and variables patterns and no consistent trend among indices thereafter (**WHM-Figure 3**).

WHM-3. State of the stock

A full stock assessment was conducted for the combined white marlin/roundscale spearfish in 2019, applying to the available data through 2017, using both surplus production and age-structured models, which included estimations of management benchmarks. As recommended by the working group in 2010, the model configuration was an effort to use all available data on white marlin, including lengths, dimorphic growth patterns, steepness and other biological data. Although it is believed that the modeling methods employed were relatively robust, the input data for the models were very likely less so. Perhaps the most important uncertainty was that associated with the catch data and some of the biological parameters of their life history. The uncertainty of the magnitude of the catch is especially a problem with the landings and discards data reported after 1998 when recommendations promoting or mandating the release of billfish that were alive at haulback. This led to a decrease in reported landings but not necessarily a decrease in fishing and/or release mortality. This apparent drop in landings led to a marked decrease in the estimates of F/F_{MSY} from 2002-present, however the Committee considers that this trend is likely overly optimistic due to unreported catch and unaccounted release mortality. The Group addressed this issue by including estimates of dead discards for the longline fisheries.

The results of the 2019 assessment indicated that the stock of Atlantic white marlin was overfished but not undergoing overfishing (**WHM-Figure 4**). The probability of being in the red quadrant of the Kobe plot was estimated to be 1%. The probability of being in the yellow quadrants of the Kobe plot was estimated to be 99% and that of being in the green quadrant less than 1%. The estimated MSY was determined to be 1,495 t with approximate 95% confidence intervals of 1,316 t - 1,745 t.

Generally, all models estimated similar annual trends and values of both B/B_{MSY} and F/F_{MSY} . Relative fishing mortality has been declining since the late 1990's and is now most likely to be below F_{MSY} (**WHM-Figure 5**). Relative biomass has probably stopped declining over the last ten years, but still remains well below B_{MSY} (**WHM-Figure 5**). There is considerable uncertainty in these results. These results are conditional on the reported catch being a true reflection of the fishing mortality experienced by white marlin. The Group reiterated that this evaluation is for both stocks of white marlin and roundscale spearfish, and that the presence of unknown quantities of roundscale spearfish in the catches and data used to estimate relative indices of abundance increases the uncertainty of white marlin stock status and outlook for this species.

WHM-4. Outlook

All assessment models estimated that the stock has been less productive than usual (e.g. lower recruitment) since the 1990s, which can be observed in **Figure 5** wherein relative biomass has not increased by much despite relative fishing mortality having declined considerably over that time period. Projections were carried out using the assessment models, but those projections assumed higher productivity into the future. This resulted in projections of the stock building quickly in the future, responding with much more productivity in the future than has been observed for the past two decades, even when the same levels of catch are assumed into the future as have been experienced by the stock in the past 20 years.

As such, the Group considered the projections to be overly optimistic and didn't support their use to develop Kobe strategy matrices.

WHM-5. Effect of current regulations

A 2006 recommendation (Rec. 06-09) established that the annual amount harvested by pelagic longline and purse seine vessels and retained for landing must be no more than 33% for white marlin and 50% for blue marlin of the 1996 or 1999 landing levels, whichever is greater. Furthermore, in 2012, the Commission established a TAC for 2013, 2014, and 2015 of 400 t (Rec. 12-04), placed additional catch and commerce restrictions in recreational fisheries for blue marlin and white marlin, and requested methods for estimating live and dead discards of blue marlin and white marlin/spearfish. In 2015, the Commission further strengthened the plan to rebuild white marlin stock by extending for 2016, 2017, 2018 and 2019 the annual limit of 400 t for white marlin/spearfish (Rec. 15-05, Rec. 18-04).

The Committee is concerned with the significant increase in the contribution from fishing by artisanal and small-scale fleets to the total white marlin harvest and that these fisheries are not fully accounted for in the current ICCAT statistics. The Committee expressed its serious concern over this limitation on data for future assessments. Such data limitation precludes any analysis of the current regulations. In addition, the Committee expressed concern of the status of white marlin due to the misidentification of spearfishes in the white marlin catches. This situation adds uncertainty to the stock assessment results.

Currently, four ICCAT Contracting Parties (Brazil, Canada, Mexico, and the United States) mandate the use of circle hooks on their pelagic longline fleets. Research has demonstrated that in some longline fisheries the use of non-offset circle hooks resulted in a reduction of billfish mortality, while the catch rates of several of the target species remained the same or were greater than the catch rates observed with the use of conventional J hooks or offset circle hooks.

The Committee noted that more countries have started reporting data on live releases in 2006. However, there is not enough information on the proportion of fish being released alive to evaluate the effectiveness of the ICCAT recommendation, relating to the live release of white marlin.

WHM-6. Management recommendations

The Group notes that Rec. 15-05 states "*An annual limit of [2,000 t for blue marlin and] 400 t for white marlin/spearfish*". As written, this text implies the annual limit of 400 t applies to all species of spearfish. This is inconsistent however with the scientific advice, which includes only white marlin and round scale spearfish and not all species of spearfish. It is recommended that future management recommendations be written such as to be consistent with the scientific advice by explicitly stating only white marlin and round scale spearfish.

In 2012, the Commission adopted Rec. 12-04, intended to reduce the total harvest to 400 t in 2013-2015 to allow the rebuilding of the white marlin stock from the overfished condition. Subsequently, the Commission extended the 400 t annual catch limit to 2016-2018 (Rec. 15-05), and 2019 (Rec. 18-04). Although there is some evidence of slow rebuilding in recent years, the Group noted that catches have exceeded the 400 t TAC in every year since its initial implementation and warns that if catches continue to exceed the TAC, the rebuilding of the stock will proceed more slowly, or be put at risk of further declines. Further reductions in fishing mortality are likely to speed up the rebuilding of the stock. Unfortunately, the inability to accurately estimate fishing mortality will continue to compromise the Group's ability to predict and monitor the stock's recovery period. This is due to the inadequate reporting of discards, as well as the lack of reports from some artisanal and recreational fisheries that take marlin species.

- Measures should be taken to ensure that monitoring and reporting of all landings and discards, including live releases, are appropriate, accurate, and complete. This will likely require improvements to the observer programs of many CPCs, as well as the implantation of discard estimation methods using those data.
- Efforts should be made, building on previous work, to fully account for the catches of artisanal and all recreational fisheries.

Given the overfished status of the stock and the uncertainties in the data, including for both total removals and indices of abundance:

- the Commission, at the minimum, should ensure that catches do not exceed current TAC until the stock has fully recovered.

Given that experimental research has demonstrated that in longline fisheries the use of circle hooks resulted in a reduction of marlin catch rates and haulback mortality, and noting that they have different impacts on both target and by-catch species; then to reduce the chance of exceeding any established TAC, the Commission should consider:

- the use of non-offset circle hooks.
- the release of all marlins that are alive at haul back in ways that maximize their survival.

ATLANTIC WHITE MARLIN/ROUNDSCALE SPEARFISH SUMMARY

MSY	1,495 (1,316 – 1,745) t ¹
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Current (2018) Yield	314 t ²
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Relative Biomass: B ₂₀₁₇ /B _{MSY}	0.58 (0.27-0.87) ¹
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Relative Fishing Mortality: F ₂₀₁₇ /F _{MSY}	0.65 (0.45-0.93) ¹
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Stock Status (2017)	Overfished: Yes Overfishing: Not
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Conservation and Management Measure in Effect:	Recommendations [Rec. 15-05] and [Rec. 18-04] Landing limit of 400 t in 2016 - 2019
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¹ Median of combined estimates from 2 Stock Synthesis models and 1 JABBA model with approximate 95% confidence intervals.

² 2018 yield should be considered provisional.

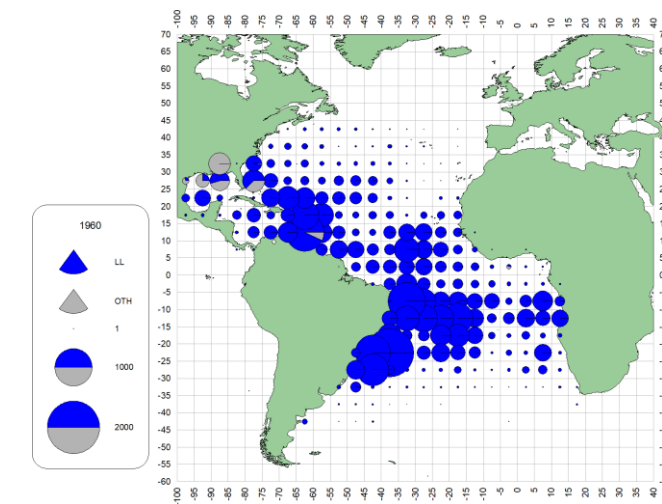
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WHM/RSP -Table 1. Estimated catches (t) of Atlantic white marlin (*Tetrapturus albidus*) and Roundscale spearfish (*Tetrapturus georgii*) by area, gear and flag. (v2, 2019-10-02)WHM/RSP -Tableau 1. Prises estimées (t) de makaire blanc de l'Atlantique (*Tetrapturus albidus*) et Makaire épée (*Tetrapturus georgii*) par zone, engin et pavillon. (v2, 2019-10-02)WHM/RSP -Tabla 1. Capturas estimadas (t) de aguja blanca del Atlántico (*Tetrapturus albidus*) y Marlin peto (*Tetrapturus georgii*) por area, arte, y bandera. (v2, 2019-10-02)

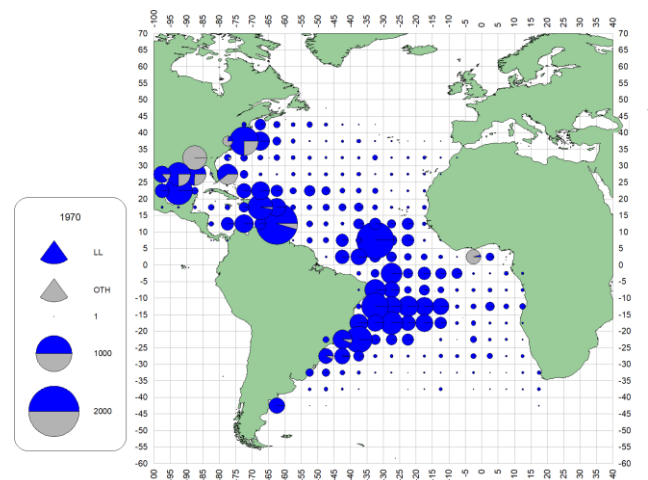
				1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
WHM+RSP	TOTAL	A+M		2202	1880	1679	1513	1945	1786	1535	1078	1012	845	841	768	612	748	714	755	506	530	465	647	452	491	465	459	314	
	Landings	A+M	Longline	2065	1720	1535	1367	1717	1638	1403	970	834	756	757	689	532	629	607	632	419	414	372	464	373	444	419	400	255	
			Other surf.	64	36	56	62	189	85	89	86	139	71	55	60	65	81	84	95	68	85	62	56	61	34	33	41	40	
			Sport (HL+RR)	30	22	24	14	6	6	2	4	6	1	1	1	2	1	2	2	6	4	6	116	7	3	4	5	10	
	Discards	A+M	Longline	43	101	65	70	32	57	41	17	29	17	27	17	12	36	21	24	12	27	24	11	11	10	9	12	8	
Other surf.			0	0	0	0	1	0	0	1	4	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0		
RSP	TOTAL	A+M		0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	2	0	1	8	16	12	22	36	9	
	Landings	A+M	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	1	0	1	7	16	11	22	36	9	
			Sport (HL+RR)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
	Landings	A+M	CP	EU.España	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	0	1	5	5	11	7	8	9	
			South Africa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0		
			U.S.A.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		
			Venezuela	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	11	0	16	28		
WHM	TOTAL	A+M		2202	1880	1679	1513	1945	1786	1535	1078	1012	845	841	768	612	748	711	753	504	530	464	640	436	480	442	422	304	
	Landings	A+M	Longline	2065	1720	1535	1367	1717	1638	1403	970	834	756	757	689	532	629	603	630	418	414	371	456	357	433	396	364	246	
			Other surf.	64	36	56	62	189	85	89	86	139	71	55	60	65	81	84	95	68	85	62	56	61	34	33	41	40	
			Sport (HL+RR)	30	22	24	14	6	6	2	4	6	1	1	1	2	1	2	2	6	4	6	116	7	3	4	5	10	
	Discards	A+M	Longline	43	101	65	70	32	57	41	17	29	17	27	17	12	36	21	24	12	27	24	11	11	10	9	12	8	
			Other surf.	0	0	0	0	1	0	0	1	4	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	
	Landings	A+M	CP	Barbados	26	43	15	41	33	25	25	24	15	15	18	16	33	22	24	26	6	3	5	6	6	10	14	17	22
			Belize	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Brazil	91	105	75	105	217	158	106	172	407	266	80	244	90	52	55	53	35	75	71	352	102	121	67	47	62	
			Canada	4	4	8	8	8	5	5	3	2	1	2	5	3	2	2	1	2	1	2	3	5	3	1	2	1	
			China PR	9	11	9	11	15	30	2	20	23	8	6	9	6	10	5	9	8	3	4	2	0	0	0	3	2	
			Curaçao	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	
			Côte d'Ivoire	0	0	1	2	1	5	1	2	2	3	1	1	1	1	3	2	1	1	0	1	1	1	1	1	1	
			EU.España	26	36	151	93	101	119	186	61	6	22	64	58	51	46	32	16	111	4	34	37	93	113	89	110	0	
			EU.France	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	
			EU.Portugal	0	0	0	0	1	1	0	0	1	5	19	30	22	2	35	40	11	18	25	10	9	7	11	13	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	
			Gabon	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	
			Ghana	1	2	1	3	7	6	8	21	2	1	1	1	0	1	4	4	3	1	1	1	1	1	1	1	0	0
			Grenada	0	0	0	0	0	0	1	15	8	14	33	10	12	11	17	14	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	
			Honduras	0	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			92	57	112	58	56	40	83	56	16	33	36	34	39	21	34	43	41	31	42	24	6	8	9	10	6		
Korea Rep.			43	23	59	23	35	39	0	0	0	11	40	7	0	113	96	78	43	43	0	0	0	0	0	0	0	0	
Liberia			0	0	1	1	3	8	4	3	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
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	1	
Mexico	7	11	3	1	3	6	11	13	16	15	28	25	16	14	14	19	20	28	36	30	20	26	20	12	16				

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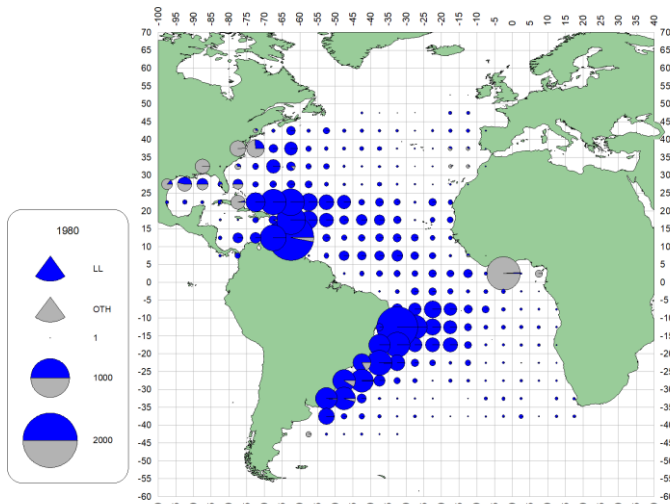
			1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018		
		Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Philippines	0	0	0	0	1	12	0	0	0	0	0	0	0	0	1	1	2	2	1	2	2	0	0	0	0		
		S. Tomé e Príncipe	21	21	30	45	40	36	37	37	37	37	37	21	33	29	35	36	37	38	39	40	41	42	17	15	13	15	
		Senegal	0	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	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		St. Vincent and Grenadines	0	0	0	0	0	0	0	1	0	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	8	
		Trinidad and Tobago	11	18	8	32	10	13	4	2	5	12	6	6	5	12	10	11	15	14	39	33	38	32	20	0	0		
		U.S.A.	13	7	12	8	5	5	1	3	6	1	1	1	1	1	0	2	2	2	2	1	4	2	2	1	2	2	
		U.S.S.R.	0	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	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	
		UK.British Virgin Islands	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	
		Uruguay	3	0	1	24	22	16	21	20	1	9	2	5	9	3	6	5	5	0	0	0	0	0	0	0	0	0	
		Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Venezuela	236	286	270	177	310	228	178	182	215	168	136	156	190	131	63	128	116	160	121	75	89	119	172	165	152		
	NCC		Chinese Taipei	1350	907	566	441	506	465	437	152	178	104	172	56	44	54	38	28	20	28	15	7	7	10	10	5	6	
			Costa Rica	0	0	0	0	0	3	14	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	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	
			Cambodia	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	
			Cuba	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
			Mixed flags (FR+ES)	11	9	7	7	9	8	12	13	12	13	13	11	10	9	10	12	12	37	0	0	0	0	0	0	0	
		NEI (BIL)	0	0	0	0	0	0	34	77	4	30	134	42	37	170	204	199	0	11	0	0	0	0	0	0	0		
		NEI (ETRO)	214	237	285	359	526	498	322	180	11	9	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	0	0	0	0	0	0	0	0	0	0	2	1	1	1	0	1	1		
		Togo	0	0	0	0	0	1	1	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Discards	A+M CP	Brazil	0	0	0	0	0	0	0	0	0	0	0	0	0	2	19	1	0	0	0	0	0	0	0	0	0		
		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		
		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		
		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	2		
		Korea Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	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		
		U.S.A.	42	100	65	70	33	58	41	18	33	17	27	17	10	8	10	14	8	23	21	10	11	8	3	5	2		
		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		
		NCC		Chinese Taipei	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	2	2	1
		NCO		NEI (BIL)	1	1	0	0	0	0	1	0	0	0	0	0	1	10	11	11	2	2	2	1	0	0	4	6	3



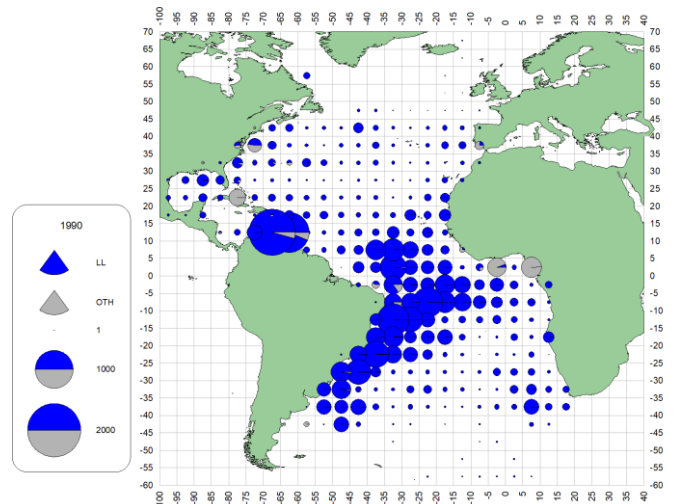
a. WHM (1960-69)



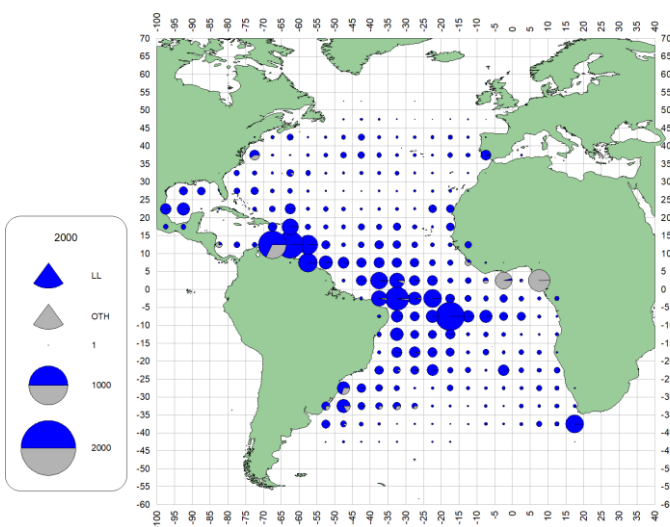
b. WHM (1970-79)



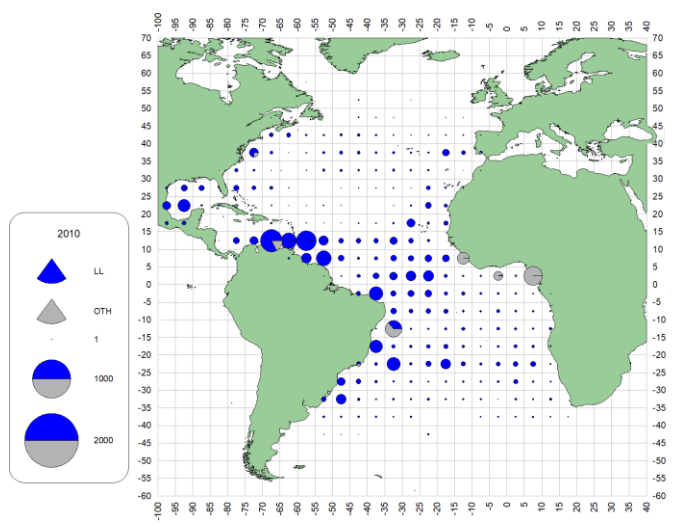
c. WHM (1980-89)



d. WHM (1990-99)

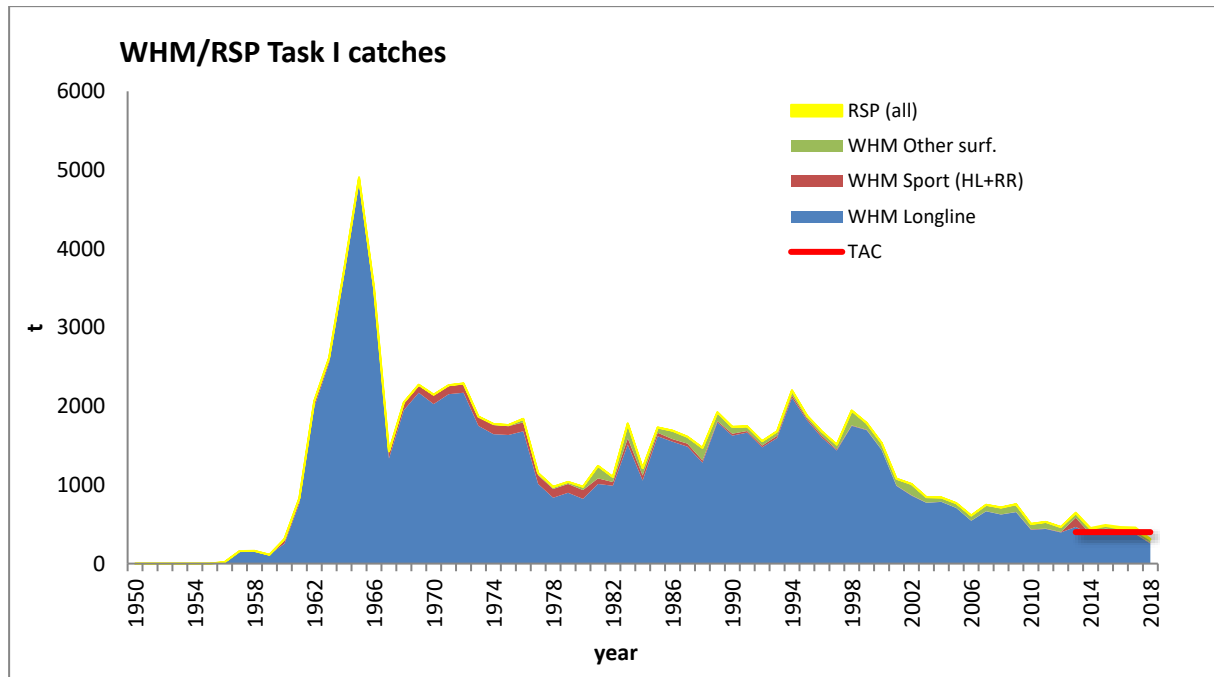


e. WHM (2000-09)

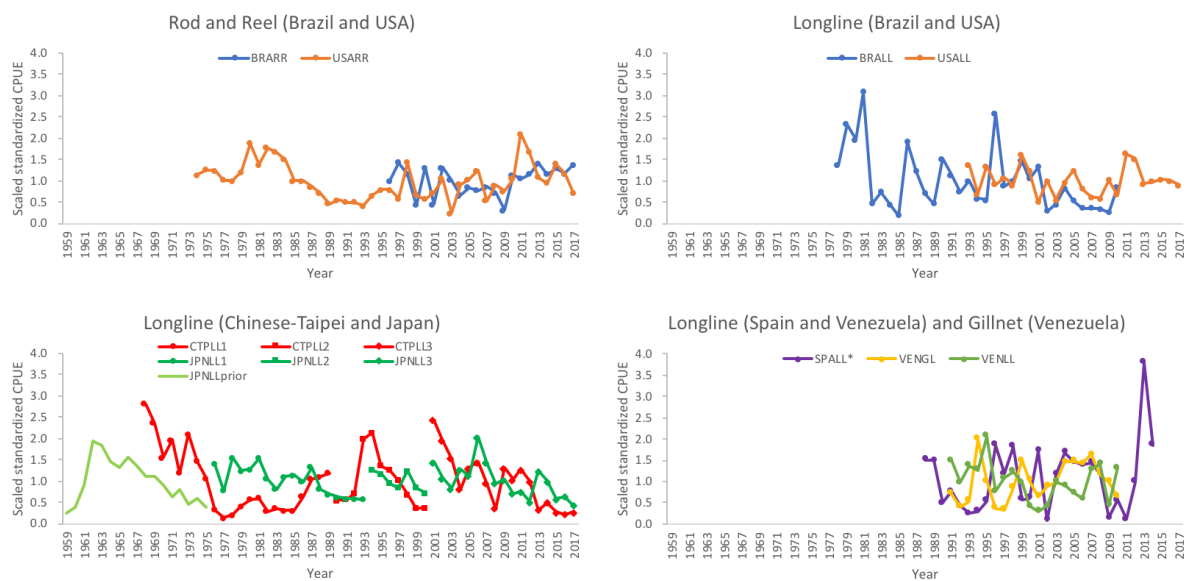


f. WHM (2010-17)

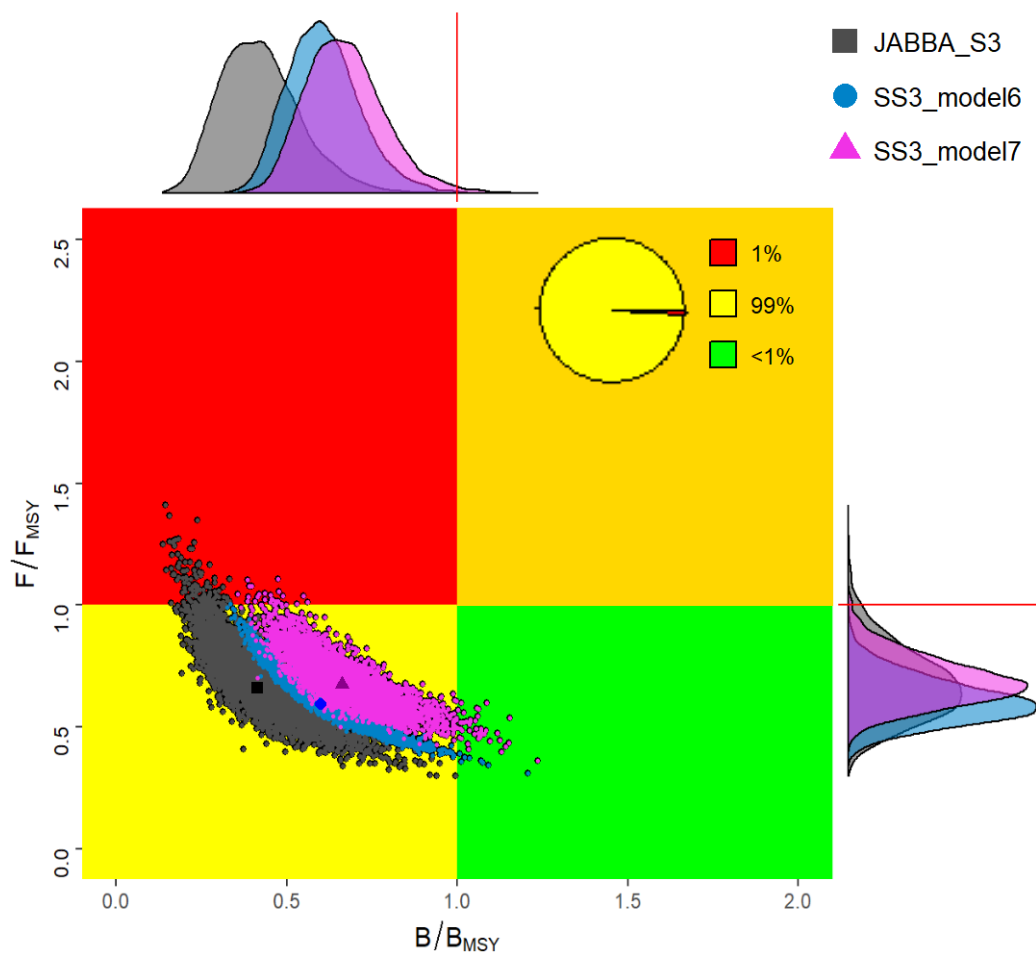
WHM-Figure 1. Geographic distribution of white marlin total catches by decade (last decade only covers 8 years).



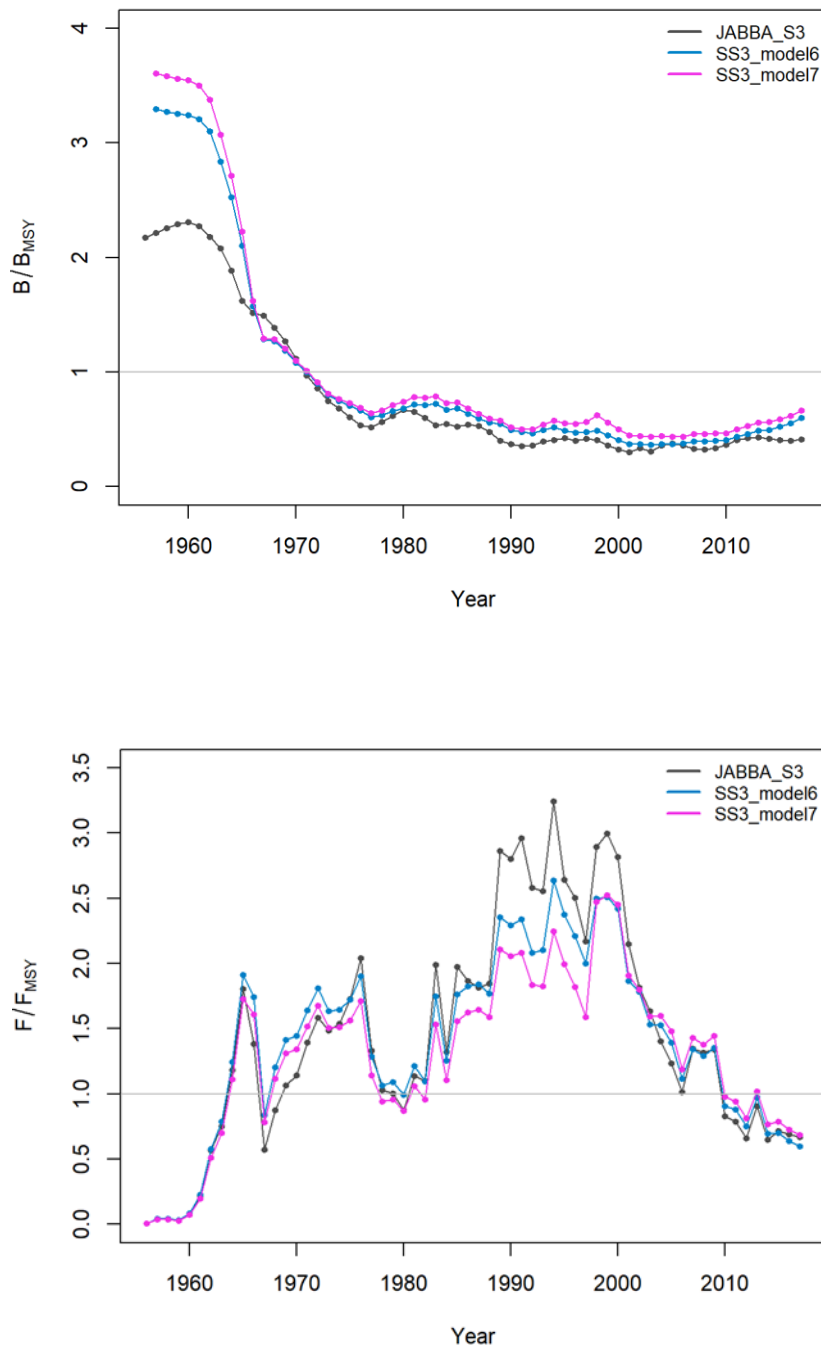
WHM-Figure 2. Total catch of white marlin and roundscale spearfish reported in Task I for the period 1956-2018.



WHM-Figure 3. Standardized CPUE series used in the 2019 White Marlin stock assessment. Spanish longline index* is used only for sensitivity analysis by JABBA.



WHM-Figure 4. Combined Kobe phase plots and pie chart from 2 Stock Synthesis runs (models 6 and 7, blue and pink, respectively) and 1 JABBA run (grey) in 2019 Atlantic white marlin stock assessment. The green quadrant corresponds to the stock not being overfished and no overfishing occurring and the red quadrant to the stock being overfished and overfishing occurring. The marginal densities plots for stock relative to B_{MSY} and harvest rate relative to F_{MSY} are also shown (top and right of large panel) are individual probabilities of Stock Synthesis and JABBA runs overlaid.



WHM-Figure 5. Historical estimates of biomass over biomass at MSY ratio (upper panel) and fishing mortality overfishing mortality at MSY ratios (lower panel) for the final base cases of JABBA (S3, black) and Stock Synthesis (models 6 and 7, blue and pink, respectively) models for the Atlantic white marlin.