

5.3 SWO-MED – MEDITERRANEAN SWORDFISH

In 2019 the Mediterranean swordfish landings were the lowest observed since the full development of the fisheries in the mid-1980s. The most recent assessment of the stock was conducted in 2020, making use of the available catch, effort and size information through 2018. The present report summarizes assessment results and readers interested in more detailed information on the state of the stock should consult the report stock assessment session (Anon. 2020b).

SWO-MED-1. Biology

Research results based on genetic studies have demonstrated that Mediterranean swordfish compose a unique stock separated from the Atlantic ones, although there is incomplete information on stock mixing and boundaries. Although mixing between stocks is believed to be low, past biological, genetic and tagging studies have suggested the possible occurrence of mixing between the Mediterranean and North Atlantic stocks, but further studies need to identify the degree of mixing. A brief review of past tagging experiments indicated that the existing results cannot provide robust information about mixing patterns and confirmed that further work is needed on this aspect.

According to previous knowledge, the Mediterranean swordfish have different biological characteristics compared to the Atlantic stocks. The growth parameters are different, and the sexual maturity is reached at younger ages than in the Atlantic.

In the western Mediterranean, mature females as small as 110 cm LJFL have been observed and the estimated size at which 50% (L50) of the female population is mature occurs at 142.2 cm. According to the growth curves used by the SCRS, these two sizes correspond to 2 and 3.5 year-old fish, respectively. An even lower L50 size for females has been estimated for the central Mediterranean, even though further confirmation is needed. Males reach sexual maturity at smaller sizes and mature specimens have been found at about 90 cm LJFL. Research on this aspect is on-going in the frame of the ICCAT swordfish project.

SWO-MED-2. Fishery indicators

Mediterranean swordfish landings showed an upward trend from 1965-1988, reaching a peak of 20,365 t (**SWO-MED-Table 1, SWO-MED-Figure 1**). The sharp increase between 1983 and 1988 may be partially attributed to improvement in the national systems for collecting catch statistics; thus, earlier catches may be higher than those appearing in Task I tables. Since 1988 and up to 2011, the reported landings of swordfish in the Mediterranean Sea have declined fluctuating mostly between 12,000 to 16,000 t. In the last eight years (2012-2019), following the implementation of the three-month fishery closure and the establishment of the list of authorized vessels, overall nominal fishing effort has been decreased and catches are less than 10,000 t. In general, these catch levels are relatively high and similar to those of bigger areas such as the North Atlantic. Updated information on Mediterranean swordfish catch by gear type is provided in **SWO-MED-Table 1** and **SWO-MED-Figure 1**.

The Task 1 removals, including estimates of dead discards for 2018 that was used in the assessment was 8,677 t, which is the lowest annual catches since 1972. The biggest producers in the recent years of the assessment (2008-2018) are EU-Italy (40%), EU-Spain (15%), EU-Greece (9%), Morocco (11%), Tunisia (11%) and Algeria (5%). Also, EU-Cyprus, EU-Malta and Turkey have fisheries targeting swordfish in the Mediterranean. Minor catches of swordfish have also been reported by EU-Croatia, EU-France, Japan, and Libya.

In recent years (2008-2019), the main fishing gears used are longlines (on average, representing around 96% of the annual catches) and gillnets. Since 2003, gillnets have been gradually eliminated following ICCAT recommendations for a general ban of driftnets in the Mediterranean. Minor catches are also reported from harpoon, trap and fisheries targeting other large pelagic species (e.g. albacore). From 1999 a deep longline (100-600 m depth; mesopelagic longline) gear has been gradually introduced and nowadays has partially replaced the surface longline gears in several Italian, French and Spanish swordfish fleets. This is particularly noteworthy, as these fisheries are among the largest within the stock area, and the changes have implications for the use of catch rates as indices of abundance in the stock assessments.

Standardised CPUE series from different longline fisheries targeting swordfish that were used in the 2020 stock assessment session, do not show a consistent pattern but most of them indicate declining trends in the most recent years. It should be noted that CPUE series did not cover the earlier years of the reported landings. No trend over the past 30 years was identified regarding the mean fish weight in the catches, but it should be noted that the volume of undersized discards in the Task 1 data may be underestimated in the last decade (**SWO-MED-Figure 2**).

SWO-MED-3. State of the stocks

Since the 2016 assessment, there have been several changes both in fisheries operations and in the data available as input to the assessment models, which have undergone substantial revisions and the integration of new information. In addition, in 2020 stock assessment a Bayesian surplus production model, using a long series of data (1950 - 2018), was examined and was chosen for providing the scientific advice for the Mediterranean swordfish stock. Until 2016, advice was based on age structured models which were re-examined again. However, due to lack of indices of abundance for the earlier period, the input data for the age-structured models started in 1985, when the stock was already under high exploitation. From the age-structured models it was estimated that the stock was already overfished in 1985, although total catches had never exceeded MSY estimates from either age-structured or surplus production models prior to 1985. This was considered biologically implausible and it was deduced that these models were unable to properly estimate stock productivity due to data limitations (insufficient data series).

Under different assumptions about reporting levels of undersized fish in the catch, age-structured analysis including data from 1985-2018 indicated that current SSB levels are much lower than those in the 80s, while recruitment shows a declining trend in the last decade. Due to limited data for the earlier period of the fishery (See data catalogue in the 2020 Mediterranean swordfish stock assessment meeting report (Anon 2020), Table 2), the age structured analysis failed to provide reliable estimates of stock productivity, and conclusions on the state of the stock were based on the surplus production model approach.

Results of the Bayesian surplus production model that used the whole catch series from 1950 to 2018, assuming also discard under-reporting in the last decade, indicated that stock biomass started declining from 1970 onwards, while fishing mortality starting exceeding F_{MSY} in the late 1980's when catches peaked (**SWO-MED-Figure 3**). The stock became overfished in the early 1990's following the full development of the fishery and the relatively high catches observed in middle-late 1980's. The analysis concluded that there is a 41.1% probability that the stock is overfished and overfishing is still occurring (red) and a 45.6% probability that the stock is overfished but overfishing is not occurring (yellow) (**SWO-MED-Figure 4**).

The Committee again noted the large catches of swordfish less than 4 years old and the relatively low number of large individuals in the catches. Fish less than four years old usually represent more than 70% of the total yearly catches in terms of numbers.

SWO-MED-4. Outlook

The assessment of Mediterranean swordfish indicates that the stock is most likely overfished and current fishing mortality is just below F_{MSY} levels. The stock has been in overfished state since the early 1990s because of the large catches in the 1980s and the selection pattern which captures many immature fish. Current catches are dominated, in terms of number, by fish less than 4 years old and the highest fishing mortality is corresponding to fish of age 3. Additionally, estimated recruitment has been declining for the last 10 years.

Projections of different catch levels, based on the output of the production model assessment indicate that TAC equal to 10,000 t would result in stock rebuilding with a 60% probability by the end of the projections period (2028). Projections were not carried out beyond 2028 due to uncertainty with the models. Probabilities increase if lower TACs are adopted. Projection results are summarized in **SWO-MED-Figure 5** and **SWO-MED-Table 2**. It should be noted, however, that these projection estimates are based on the assumption that future stock productivity will be around the average of the whole studied period. The declining recruitment in the most recent years, may indicate that stock productivity has decreased and in that case stock projections may be optimistic and should be interpreted with caution.

SWO-MED-5. Effect of current regulations

ICCAT imposed a Mediterranean-wide one-month fishery closure for all gears targeting swordfish in 2008, followed by a two-month closure since 2009. Through Recommendations 11-03 and 13-04 the Commission has adopted additional management measures intended to bring the stock back to levels that are consistent with the ICCAT Convention objective. Those measures include an additional one-month closure accompanied by minimum catching size regulations, a list of authorized vessels, specifications on the technical characteristics of the longline gear, and onboard domestic observers on a given percentage of longline vessels. Recently, through Rec. 16-05, which replaced Rec. 13-04, a 15-year recovery plan has been adopted. In addition, increased catching size, and fishing capacity limitations were established, accompanied by TACs (10,500 t in 2017 Rec. 16-05, with a 3% annual reduction over the period 2018-2022) and a seasonal closure of the albacore fishery to reduce juvenile swordfish by-catches. The European Union introduced a driftnet ban for highly migratory species in 2002 and in 2003 ICCAT adopted a recommendation for a general ban of this gear in the Mediterranean [Rec. 03-04]. Rec. 04-12 forbids the use of various types of nets and longlines for sport and recreational fishing for tuna and tuna-like species in the Mediterranean.

After the adoption of the aforementioned ICCAT Recommendations, reported catches have decreased significantly from the 2000s' level, making the catches of the period 2012-2019 among the lowest of the last three decades. In addition, reported catches of undersized swordfish have also decreased more than 50%, compared with the levels of the decade of 2000s. Importantly, based on observations onboard, the recent increase of the minimum catching size from 90 to 100 cm has resulted in discard increases (up to 600%) in some fisheries. Both hooking and post-release mortality are unknown for this stock. However, for the Atlantic very high values of hooking mortality (ranging between 78-88%) have been reported for swordfish less than 125 cm LJFL, and it is possible that similar high values also occur in the Mediterranean. The Committee showed concern that such discards are not being fully reported and reiterated that all dead discards should be reported in Task I NC for all fisheries. Additionally, they should be included in the analysis of CPUE data trends. The additional measures foreseen under Rec. 16-05 have only recently been adopted and their effects cannot be fully evaluated.

SWO-MED-6. Management recommendations

Over the last 50 years stock biomass shows declining trends, starting with the period around 1970-1990, when the fishery was in a strong developing phase. In the following period until about 2010, declining trends were rather modest accompanied by small-scale fluctuations. In the most recent period, the stock biomass has continued to decline. As expected, fishing mortality followed an opposite trend with sharper increases during the 1980s. Current stock biomass is about 30% lower than that corresponding to MSY, while fishing mortality is around F_{MSY} . According to the Commission objectives the stock requires rebuilding and relevant scenarios were simulated assuming different levels of TACs. Analysis indicated that the probability of stock rebuilding by the end of the projection period (2028) is 60% if a TAC equal to 10,000 t is implemented. The probability increases if lower TACs levels are selected. As there are uncertainties on stock productivity, these estimates may be optimistic and should be interpreted with caution.

The Committee noted that since the establishment of minimum catching sizes, particularly after the recent size increase imposed through Rec. 16-05 the discard levels of undersized swordfish are increasing at least for certain fisheries and are largely dead. However, discards are not being reported for all fleets. Though an attempt has been made to statistically estimate discard levels and consider them in stock assessment models, the real volume of total discards is unknown due to this under-reporting. Such under-reporting leads to false estimates of the overall catch volume and consequently bias stock status estimates and projections of future stock size under different management measures.

MEDITERRANEAN SWORDFISH SUMMARY

Maximum Sustainable Yield	13,325 t (10,899 – 17,346 t) ¹
Current (2019) Yield	8,150 t
B _{MSY}	71,319 t (42,562 – 113,758) ¹
F _{MSY}	0.19 (0.12 - 0.34) ¹
Relative Biomass (B ₂₀₁₈ /B _{MSY})	0.72 (0.38 - 1.29) ¹
Relative Fishing Mortality (F ₂₀₁₈ /F _{MSY})	0.93 (0.42 - 1.68) ¹
Stock Status (2018)	Overfished: Yes
	Overfishing: No
Management Measures in Effect:	Driftnet ban [Rec. 03-04]
	Three-month fishery closure, gear specifications (number and size of hooks and length of gear), minimum catching size regulations, list of authorized vessels, fishing capacity restrictions, domestic observers onboard on longlines.
	TAC [Rec. 16-05]: 10,500 t in 2017, 10,185 t in 2018, 9,879 in 2019, 9,583 in 2020, 9,296 in 2021 and 9,017 in 2022.

¹ 95% credibility intervals of 30,000 MCMC iterations from Bayesian surplus production models

SWO-MED-Table 1. Estimated catches (t) of swordfish (*Xiphias gladius*) in the Mediterranean by gear and flag. Longline dead discards of Algeria, EU-Italy, Maroc, Tunisia and Turkey (2008-2018) were estimated by the SG-SWO (Anon, 2020b). These discards represent about 20% of the total catches in 2018 and were not estimated for 2019. The estimation method is detailed in the assessment report (Anon 2020b).

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
TOTAL	MED	16018	15746	14709	13265	16082	13015	12053	14693	14369	13699	15569	15006	12814	15694	14405	14622	14915	14227	13683	13235	14754	12640	11046	10070	10969	11983	12300	10390	8677	8150	
Landings	Longline	7346	7365	7631	7377	8985	6319	5884	5389	6674	6223	7129	7498	8042	10748	10877	10954	11323	11113	11479	11020	11918	10288	9131	9047	9718	10675	10878	8345	6934	8015	
	Other surf.	8671	8381	7078	5888	7097	6696	6169	9304	7695	7476	8440	7508	4772	4945	3519	3555	3576	3094	658	819	1347	1162	782	49	83	78	53	57	61	45	
Discards	Longline	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	113	16	19	1546	1396	1488	1191	1133	973	1168	1230	1369	1988	1682	89	
Landings	CP	Albania	0	0	0	0	0	13	13	13	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		Algerie	712	562	395	562	600	807	807	807	825	709	816	1081	814	665	564	635	702	601	802	468	459	216	387	403	557	568	671	550	528	517
		EU.Croatia	0	0	0	0	0	0	0	0	10	20	0	0	0	0	0	0	0	4	3	6	6	4	10	16	10	25	20	28	33	
		EU.Cyprus	173	162	56	116	159	89	40	51	61	92	82	135	104	47	49	53	43	67	67	38	31	35	35	51	59	54	53	50	45	24
		EU.España	1523	1171	822	1358	1503	1379	1186	1264	1443	906	1436	1484	1498	1226	951	910	1462	1697	2095	2000	1792	1744	1591	1607	2073	2283	1733	1487	1387	1460
		EU.France	0	0	0	0	0	0	0	0	0	0	0	12	27	20	19	22	20	14	14	16	78	81	12	66	127	182	179	113	86	71
		EU.Greece	1344	1904	1456	1568	2520	974	1237	750	1650	1520	1960	1730	1680	1230	1120	1311	1358	1887	962	1132	1494	1306	877	1731	1344	761	761	392	350	745
		EU.Italy	9101	8538	7595	6330	7765	7310	5286	6104	6104	6312	7515	6388	3539	8395	6942	7460	7626	6518	4549	5016	6022	5274	4574	2862	3393	4272	3946	2987	1779	2473
		EU.Malta	135	129	85	91	47	72	72	100	153	187	175	102	257	163	195	362	239	213	260	266	423	532	503	460	376	489	410	330	308	407
		EU.Portugal	0	0	0	0	0	0	0	0	0	0	13	115	8	1	120	14	16	0	0	0	0	0	0	0	0	0	0	0	0	0
		Egypt	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	2	1	2	4	2	4	5	5	7	4	2	1	1	0	2	4	0	3	1	1	0	0	0	0	0	0	0	0	0	0
		Korea Rep.	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	0	0	0
		Libya	0	0	0	0	0	0	0	0	11	0	8	6	0	10	2	0	16	0	0	0	0	0	0	0	0	585	960	30	70	
		Maroc	1249	1706	2692	2589	2654	1696	2734	4900	3228	3238	2708	3026	3379	3300	3253	2523	2058	1722	1957	1587	1610	1027	802	770	770	480	1110	1000	1013	982
		Syria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	28	0	0	9	4	0	0	0	0	0	0	0
		Tunisie	176	181	178	354	298	378	352	346	414	468	483	567	1138	288	791	791	949	1024	1011	1012	1016	1040	1038	1036	1030	1034	1007	1003	974	934
		Turkey	243	100	136	292	533	306	320	350	450	230	370	360	370	350	386	425	410	423	386	301	334	190	80	97	56	35	77	441	427	414
	NCC Chinese Taipei	0	0	0	1	1	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NCO NEI (MED)	1360	1292	1292	0	0	0	0	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	CP	Algerie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	175	102	100	42	78	84	145	147	176	205	197		
		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	7	0	0	84	89	
		EU.Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	9	113	16	19	27	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	724	751	817	734	618	456	538	670	623	907	535		
		Maroc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	343	278	301	160	201	193	198	123	285	350	355		
		Tunisie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	221	221	222	227	227	226	272	273	266	374	364		
		Turkey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	43	48	27	10	14	16	10	20	151	148		

SWO-MED-Table 2. Estimated probabilities of the Mediterranean swordfish stock (a) being below F_{MSY} (overfishing not occurring), (b) above B_{MSY} (not overfished) and (c) above B_{MSY} and below F_{MSY} (green zone) for a range of fixed total catches (0 – 15,000 t) over the projection horizon 2021-2028 based on joint projection MCMC posteriors of JABBA model runs ('Reference' and 'ASEM' models).

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

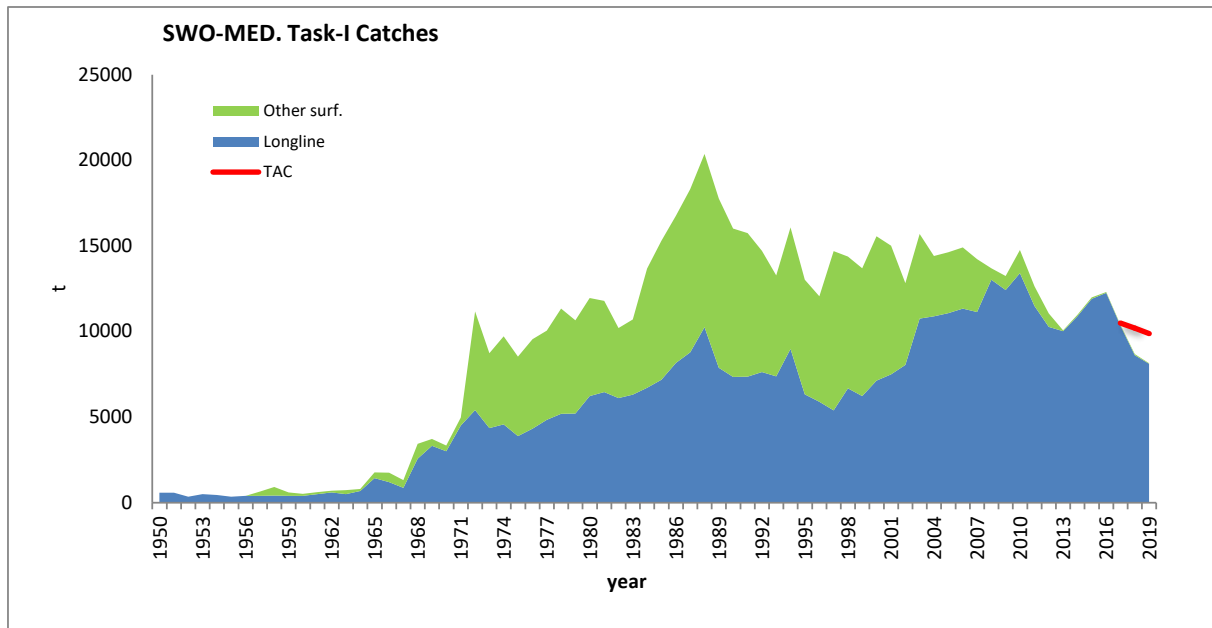
TAC Year	2021	2022	2023	2024	2025	2026	2027	2028
0	100	100	100	100	100	100	100	100
7000	84	87	90	91	93	94	94	95
8000	76	80	83	85	87	88	90	90
9000	68	72	75	77	80	81	82	84
10000	58	62	65	68	70	72	73	74
10250	56	60	62	65	67	69	71	72
10500	54	57	60	62	64	66	68	69
10750	51	54	57	59	61	63	64	66
11000	49	52	55	57	59	60	61	63
11250	47	50	52	54	56	57	58	59
11500	45	47	49	51	53	54	55	56
11750	43	45	47	48	50	51	52	53
12000	41	43	44	46	47	48	49	50
12250	39	40	42	43	44	45	45	46
12500	37	38	39	40	41	42	42	43
12750	35	36	37	38	38	39	39	40
13000	33	34	35	35	36	36	36	36
14000	27	27	27	26	26	26	26	25
15000	22	21	20	20	19	18	18	17

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

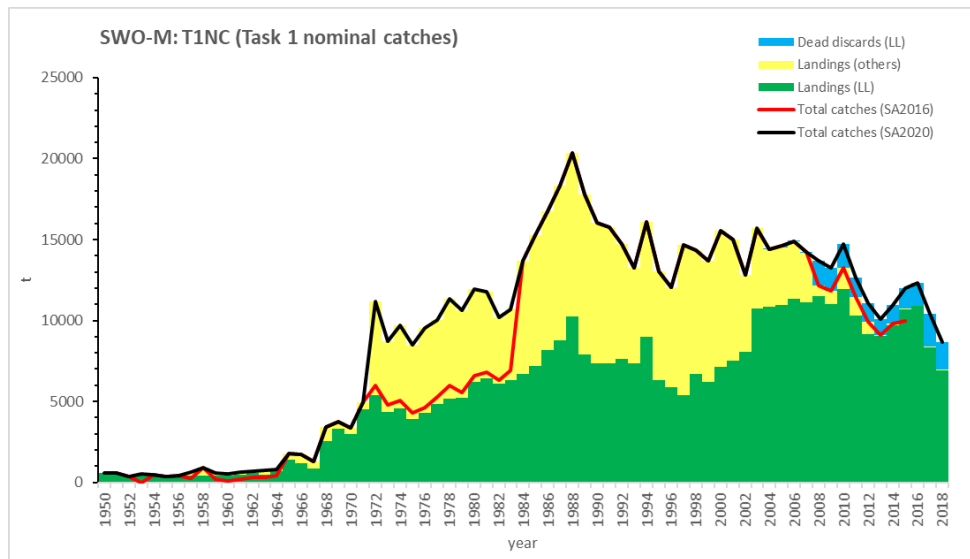
TAC Year	2021	2022	2023	2024	2025	2026	2027	2028
0	31	52	71	84	92	96	98	99
7000	31	41	51	59	67	72	77	81
8000	31	39	47	55	61	67	71	75
9000	31	38	44	50	56	60	64	68
10000	31	36	41	46	50	53	57	60
10250	31	36	40	45	49	52	55	58
10500	31	35	39	43	47	50	53	56
10750	31	35	39	42	45	48	51	53
11000	31	35	38	41	44	47	49	51
11250	31	34	37	40	43	45	47	50
11500	31	34	37	39	42	44	45	47
11750	31	34	36	38	40	42	43	45
12000	31	33	35	37	39	41	42	43
12250	31	33	35	36	37	38	39	40
12500	31	32	33	35	36	37	38	38
12750	31	32	33	34	35	35	36	36
13000	31	32	33	33	34	34	34	34
14000	31	30	30	29	29	28	28	27
15000	31	29	27	26	24	23	22	21

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

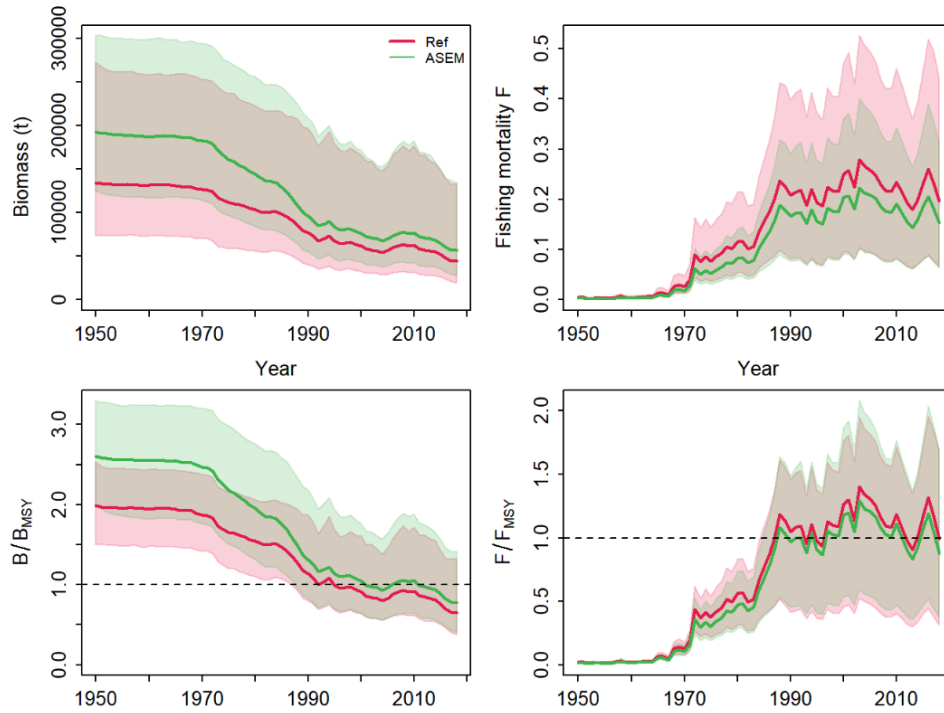
TAC Year	2021	2022	2023	2024	2025	2026	2027	2028
0	31	52	71	84	92	96	98	99
7000	31	41	51	59	67	72	77	81
8000	31	39	47	55	61	67	71	75
9000	31	38	44	50	56	60	64	68
10000	31	36	41	46	50	53	57	60
10250	31	36	40	45	49	52	55	58
10500	31	35	39	43	47	50	53	56
10750	31	35	39	42	45	48	51	53
11000	31	34	38	41	44	47	49	51
11250	31	34	37	40	43	45	47	49
11500	30	34	37	39	41	44	45	47
11750	31	33	36	38	40	42	43	45
12000	30	33	35	37	38	40	41	43
12250	30	32	34	35	37	38	39	40
12500	30	31	32	34	35	36	37	38
12750	29	31	32	33	33	34	35	35
13000	29	30	31	31	32	32	33	33
14000	25	25	25	25	25	25	25	24
15000	21	20	20	19	18	18	17	17



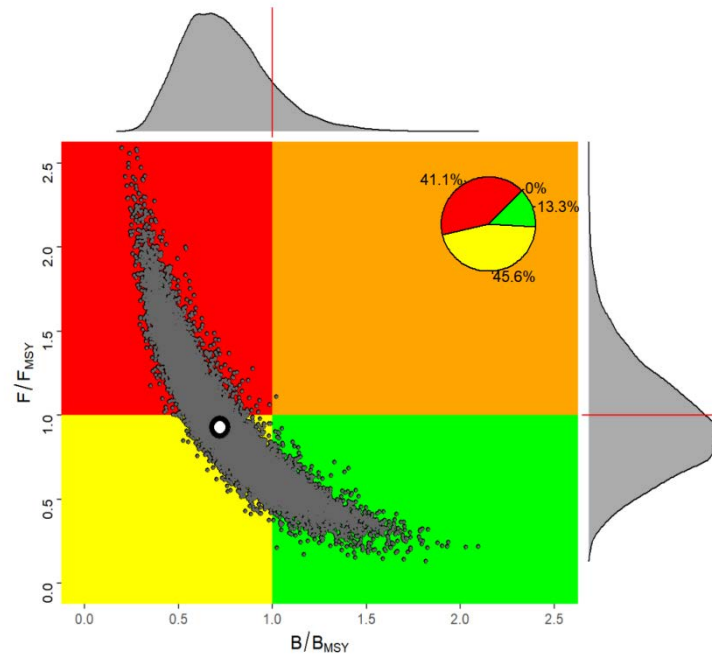
SWO-MED-Figure 1. Estimates of Task I swordfish catches (t) in the Mediterranean by major gear types, for the period 1950-2019, and corresponding annual TACs since 2017 [Rec.16-05].



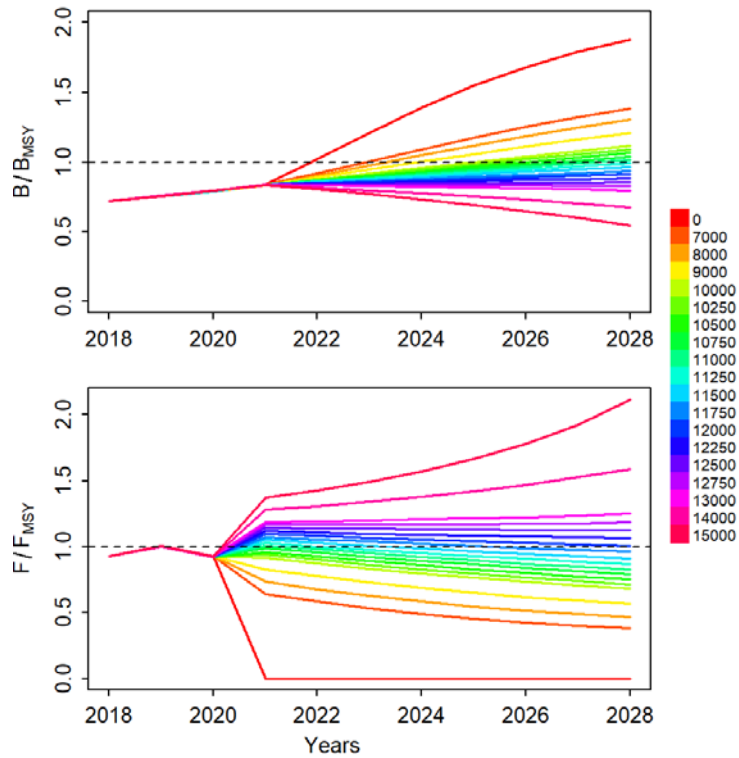
SWO-MED-Figure 2. SWO-M total nominal catches (T1NC, t) by year, showing total landings (LL and other gears) and dead discards (reported and estimated in SCRS/2020/028). The total catches used in the 2016 stocks assessment (SA2016) is shown for comparative purposes.



SWO-MED-Figure 3. Trends in biomass and fishing mortality (upper panels) and biomass relative to B_{MSY} (B/B_{MSY}) and fishing mortality relative to F_{MSY} (F/F_{MSY}) (bottom panels) for each scenario from the Bayesian state-space surplus production model fits to Mediterranean swordfish.



SWO-MED-Figure 4. Kobe phase plot showing the combined posteriors of B_{2018}/B_{MSY} and F_{2018}/F_{MSY} presented in the form of joint MCMC posteriors of JABBA model runs for Mediterranean swordfish. The probability of posterior points falling within each quadrant is indicated in the pie chart.



SWO-MED-Figure 5. Trends of projected relative stock biomass (at begin of year, upper panel, B/B_{MSY}) and fishing mortality (at end of year, bottom panel, F/F_{MSY}) of Mediterranean swordfish under different TAC scenarios (0 – 15,000 t), based upon the combined projections of JABBA model runs. Each line represents the median of 30000 MCMC iterations by projected year.