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Sardine (*Sardina pilchardus*) in divisions 8.c and 9.a (Cantabrian Sea and Atlantic Iberian waters)

ICES advice on fishing opportunities

ICES advises that when the MSY approach is applied, there should be zero catches in 2019.

Stock development over time

The biomass of age 1 and older fish has decreased since 2006, has been below B_{lim} since 2009, and has stabilized to a historical low since 2012. Recruitment has been below the long-term average since 2005 and in 2017, it was estimated as the lowest in the time-series. Fishing mortality has been above F_{lim} for most of the time-series but has been decreasing from a peak in 2011. In 2017, it is the lowest in the time-series and around F_{pa}.

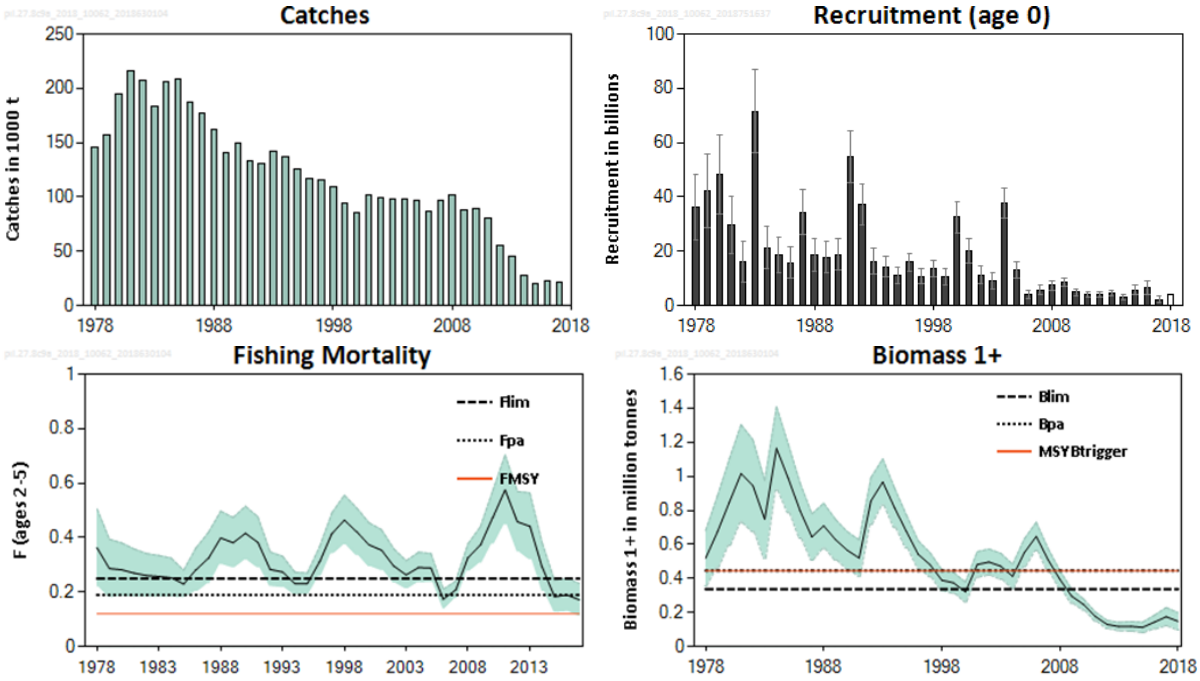

Figure 1 Sardine in divisions 8.c and 9.a. Summary of the stock assessment. Recruitment in 2018 assumed to be equal to the geometric mean of 2013–2017. Recruitment, fishing mortality and biomass have 95% confidence intervals. Reference points are based on the stock–recruitment relationship in the period 1993–2015.

Stock and exploitation status

ICES assesses that fishing pressure on the stock is above F_{MSY}, just below F_{pa} and below F_{lim}. Biomass 1+ is well below MSY $_{Btrigger}$, B_{pa}, and B_{lim}.

Table 1 Sardine in divisions 8.c and 9.a. State of the stock and fishery relative to reference points.

		Fishing pressure				Stock size			
		2015	2016	2017		2016	2017	2018	
Maximum sustainable yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{trigger}$	✗	✗	✗ Below trigger
Precautionary approach	F_{pa},F_{lim}	✓	✓	✓	Harvested sustainably	B_{pa},B_{lim}	✗	✗	✗ Reduced reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	– Not applicable

Catch scenarios

Table 2 Sardine in divisions 8.c and 9.a. Assumptions made for the interim year and in the forecast. Weights in tonnes. Recruitment in millions.

Variable	Value	Source	Notes
Fages 2–5 (2018)	0.104	ICES (2018)	F that corresponds to the assumed catch in 2018
B1+ (2019)	154254	ICES (2018)	Obtained from the short-term forecast
R_{age0} (2018)	4192	ICES (2018)	Geometric mean (2013–2017)
R_{age0} (2019)	4192	ICES (2018)	Geometric mean (2013–2017)
Total catch (2018)	14600	ICES (2018)	Consistent with the amount of provisional catches agreed by Portugal and Spain
Discards (2018)	Negligible	ICES (2018)	

Table 3 Sardine in divisions 8.c and 9.a. Annual catch scenarios. All weights are in tonnes.

Basis	Catch (2019)	F (2019)	Biomass 1+ (2020)	% Biomass 1+ change *	% Catch change **
ICES advice basis					
MSY approach: F=0	0	0	169327	9.8	-100
Other scenarios					
$F=F_{MSY}$*(B1+ 2019)/MSY $B_{trigger}$	5934	0.041	164858	6.9	-72.7
$F= F_{MSY}$	16660	0.120	156805	1.6	-23.5
$F_{2019} = F_{2018}$	14521	0.104	158409	2.7	-33.3
F = 0.08	11278	0.080	160842	4.3	-48.2
F = 0.10	13990	0.100	158807	2.9	-35.7
F_{pa}	25687	0.190	150053	-2.7	19
F_{lim}	33049	0.250	144567	-6.3	51.8
SSB (2020) = B_{lim} (337448)^	-	-	-	-	-
SSB (2020) = B_{pa} (446331)^	-	-	-	-	-
SSB (2020) = MSY $B_{trigger}$ (446331)^	-	-	-	-	-

* Biomass 1+ in 2020 relative to Biomass 1+ in 2019 (t).
** Catch in 2019 compared to 2017 catches (21 911 t).
^ The B_{lim}, B_{pa}, and MSY $B_{trigger}$ options were left blank, because B_{lim}, B_{pa}, and MSY $B_{trigger}$ cannot be achieved in 2020 even with zero catch in 2019.

As last year, catch advice is for zero catches since no scenario will result in the stock recovering to B_{lim} by 2020.

Basis of the advice

Table 4 Sardine in divisions 8.c and 9.a. The basis of the advice.

Advice basis	MSY approach
Management plan	The sardine management plan of 2013 was re-evaluated in 2017 and found to be not precautionary (ICES, 2017). A new management and recovery plan is under development by Spain and Portugal.

Quality of the assessment

The current low abundance and patchy spatial distribution of sardine are likely to decrease the accuracy and precision of acoustic estimates in comparison with past periods of higher abundance.

The last 2017 DEPM survey was not included in the present assessment, because the results were considered preliminary.

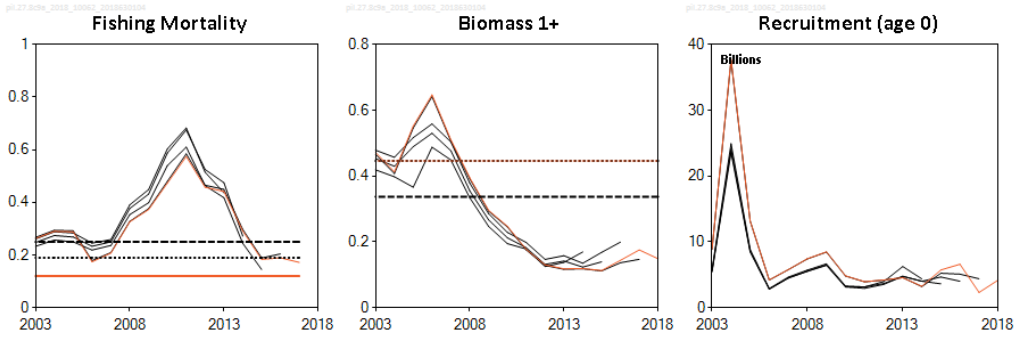

Figure 2 Sardine in divisions 8.c and 9.a. Historical assessment results. For each line in the recruitment plot, the last value is an assumption.

Issues relevant for the advice

The biomass of 1+ fish is less than half of B_{lim} since 2011, and thus recruitment is considered to be impaired. Recruitment has been at the lowest historical level since 2006, and in 2017 was estimated as the lowest in the time-series.

In the present situation, it is not possible to identify any non-zero catch that would be compatible with the MSY approach (i.e. increase B1+ above B_{lim} in the short term). Fishing mortality has to be reduced significantly from the present level if the stock should recover in the medium term.

Reference points

Table 5 Sardine in divisions 8.c and 9.a. Reference points, values, and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	446331 tonnes	B_{pa}	ICES (2017)
	F_{MSY}	0.12	F that maximizes long-term yield under the constraint that the long-term P(SSB < B_{lim}) ≤ 5% when applying the ICES MSY advice rule; calculated by stochastic simulation	ICES (2017)
Precautionary approach	B_{lim}	337448 tonnes	Break point of segmented regression fitted to stock–recruitment estimates for 1993–2015	ICES (2017)
	B_{pa}	446331 tonnes	$B_{pa} = B_{lim} * \exp(1.645 * \sigma)$, with σ = 0.17 (coefficient of variation of SSB_{2016}, from the assessment at the 2017 benchmark)	ICES (2017)
	F_{lim}	0.25	F that results in long-term P(SSB < B_{lim}) = 50%; calculated by stochastic simulation	ICES (2017)
	F_{pa}	0.19	$F_{pa} = F_{lim} / \exp(1.645 *\sigma)$, with σ = 0.17 (coefficient of variation of apical F_{2015}, from the assessment at the 2017 benchmark)	ICES (2017)
Management plan	SSB_{mgt}	Not defined		
	F_{mgt}	Not defined		

Basis of the assessment

Table 6 Sardine in divisions 8.c and 9.a. Basis of assessment and advice.

ICES stock data category	1 (ICES, 2016)
Assessment type	Age-based analytical assessment (SS3) that uses catches in the model and in the forecast (ICES, 2018)
Input data	Commercial catches (international landings, ages from catch sampling); annual acoustic spring survey indices (ages from PELAGO and PELACUS), triennial spawning–stock biomass (SSB) indices (PT-DEPM and SP-DEPM); triennial stock weights and maturity data from DEPM (PT-DEPM and SP-DEPM), interpolated for other years; natural mortalities based on the Gislason formula (Gislason *et al*., 2010).
Discards and bycatch	Not included and considered negligible
Indicators	None
Other information	This stock was benchmarked in February 2017 (WKPELA; ICES, 2017)
Working group	Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)

Information from stakeholders

There is no additional available information.

History of the advice, catch, and management

Table 7 Sardine in divisions 8.c and 9.a. ICES advice and official landings. All weights are in tonnes.

Year	ICES advice	Catch corresponding to advice	Agreed TAC	Official landings 8 & 9	ICES catch*
1987	No increase in F; TAC	140000	-		177696
1988	No increase in F; TAC	150000	-	167000	161531
1989	No increase in F; TAC	212000	-	146000	140961
1990	Room for increased F	-	-	150000	149429
1991	Precautionary TAC	176000	-	135000	132587
1992	No advice	-	-	139000	130250
1993	Precautionary TAC	135000	-	153000	142495
1994	No advice	-	-	147000	136582
1995	No advice; apparently stable stock	-	-	137000	125280
1996	Lowest possible level	-	-	134000	116736
1997	Lowest possible level	-	-	n/a	115814
1998	Significant reduction	-	-	n/a	108924
1999	Reduce F to 0.2	38000	-	n/a	94091
2000	F below 0.2	< 81000	-	n/a	85786
2001	F below 0.2	< 88000	-	n/a	101957
2002	F below 0.25	< 95000	-	n/a	99673
2003	No increase in F	100000	-	n/a	97831
2004	No increase in F	128000	-	n/a	98020
2005	No increase in F	106000	-	n/a	97345
2006	No increase in F	96000	-	n/a	87023
2007	No increase in F	114000	-	n/a	96469
2008	No increase in F	92000	-	n/a	101464
2009	No increase in F	71000	-	n/a	87740
2010	No increase in F	75000	-	n/a	89571
2011	Maintain F at 2002–2007 level	75000	-	77000	80403

Year	ICES advice	Catch corresponding to advice	Agreed TAC	Official landings 8 & 9	ICES catch*
2012	Reduce F to the 2002–2007 level	36000	-	52000	54857
2013	Reduce F to the 2002–2007 level	< 55000	-	46000	45818
2014	Reduce F to the 2002–2007 level adjusted to low biomass	< 17000	-	27937	27937
2015	Reduce F to the 2002–2007 level adjusted to low biomass	< 16000	-	20595	20595
2016**	Management Plan	≤ 12000	-	22704	22704
2017	Management Plan	≤ 23000	17000	21911	21911
2018	MSY approach	0	-		
2019	MSY approach	0			

n/a = not available.
* Includes only divisions 8.c and 9.a.
** Catch advice for 2016 updated in July 2016.

History of the catch and landings

Table 8 Sardine in divisions 8.c and 9.a. Catch distribution by fleet in 2017 as estimated by ICES.

Catch (2017)	Landings		Discards
21911 tonnes	99% purse-seine	1% other gear types	negligible
	21911 tonnes		

Table 9 Sardine in divisions 8.c and 9.a. History of ICES catch and landings; values are presented by area. All weights are in tonnes.

Year	8.c	9.a North	9.a Central North	9.a Central South	9.a South Algarve	9.a South Cadiz	Total 9.a	Total catch (8.c and 9.a)
1940	66816		42132	33275	23724		99131	165947
1941	27801		26599	34423	9391		70413	98214
1942	47208		40969	31957	8739		81665	128873
1943	46348		85692	31362	15871		132925	179273
1944	76147		88643	31135	8450		128228	204375
1945	67998		64313	37289	7426		109028	177026
1946	32280	1231	68787	26430	12237		107454	139734
1947	43459	21855	55407	25003	15667		117932	161391
1948	10945	17320	50288	17060	10674		95342	106287
1949	11519	19504	37868	12077	8952		78401	89920
1950	13201	27121	47388	17025	17963		109497	122698
1951	12713	27959	43906	15056	19269		106190	118903
1952	7765	30485	40938	22687	25331		119441	127206
1953	4969	27569	68145	16969	12051		124734	129703
1954	8836	28816	62467	25736	24084		141103	149939
1955	6851	30804	55618	15191	21150		122763	129614
1956	12074	29614	58128	24069	14475		126286	138360
1957	15624	37170	75896	20231	15010		148307	163931
1958	29743	41143	92790	33937	12554		180424	210167
1959	42005	36055	87845	23754	11680		159334	201339
1960	38244	60713	83331	24384	24062		192490	230734
1961	51212	59570	96105	22872	16528		195075	246287
1962	28891	46381	77701	29643	23528		177253	206144
1963	33796	51979	86859	17595	12397		168830	202626
1964	36390	40897	108065	27636	22035		198633	235023
1965	31732	47036	82354	35003	18797		183190	214922

Year	8.c	9.a North	9.a Central North	9.a Central South	9.a South Algarve	9.a South Cadiz	Total 9.a	Total catch (8.c and 9.a)
1966	32196	44154	66929	34153	20855		166091	198287
1967	23480	45595	64210	31576	16635		158016	181496
1968	24690	51828	46215	16671	14993		129707	154397
1969	38254	40732	37782	13852	9350		101716	139970
1970	28934	32306	37608	12989	14257		97160	126094
1971	41691	48637	36728	16917	16534		118816	160507
1972	33800	45275	34889	18007	19200		117371	151171
1973	44768	18523	46984	27688	19570		112765	157533
1974	34536	13894	36339	18717	14244		83194	117730
1975	50260	12236	54819	19295	16714		103064	153324
1976	51901	10140	43435	16548	12538		82661	134562
1977	36149	9782	37064	17496	20745		85087	121236
1978	43522	12915	34246	25974	23333	5619	102087	145609
1979	18271	43876	39651	27532	24111	3800	138970	157241
1980	35787	49593	59290	29433	17579	3120	159015	194802
1981	35550	65330	61150	37054	15048	2384	180967	216517
1982	31756	71889	45865	38082	16912	2442	175190	206946
1983	32374	62843	33163	31163	21607	2688	151463	183837
1984	27970	79606	42798	35032	17280	3319	178035	206005
1985	25907	66491	61755	31535	18418	4333	182532	208439
1986	39195	37960	57360	31737	14354	6757	148168	187363
1987	36377	42234	44806	27795	17613	8870	141319	177696
1988	40944	24005	52779	27420	13393	2990	120587	161531
1989	29856	16179	52585	26783	11723	3835	111105	140961
1990	27500	19253	52212	24723	19238	6503	121929	149429
1991	20735	14383	44379	26150	22106	4834	111852	132587
1992	26160	16579	41681	29968	11666	4196	104090	130250
1993	24486	23905	47284	29995	13160	3664	118009	142495
1994	22181	16151	49136	30390	14942	3782	114401	136582
1995	19538	13928	41444	27270	19104	3996	105742	125280
1996	14423	11251	34761	31117	19880	5304	102313	116736
1997	15587	12291	34156	25863	21137	6780	100227	115814
1998	16177	3263	32584	29564	20743	6594	92747	108924
1999	11862	2563	31574	21747	18499	7846	82229	94091
2000	11697	2866	23311	23701	19129	5081	74089	85786
2001	16798	8398	32726	25619	13350	5066	85159	101957
2002	15885	4562	33585	22969	10982	11689	83787	99673
2003	16436	6383	33293	24635	8600	8484	81395	97831
2004	18306	8573	29488	24370	8107	9176	79714	98020
2005	19800	11663	25696	24619	7175	8391	77545	97345
2006	15377	10856	30152	19061	5798	5779	71646	87023
2007	13380	12402	41090	19142	4266	6188	83088	96469
2008	13636	9409	45210	20858	4928	7423	87828	101464
2009	11963	7226	36212	20838	4785	6716	75777	87740
2010	13772	7409	40923	17623	5181	4662	75798	89571
2011	8536	5621	37152	13685	6387	9023	71867	80403
2012	13090	4154	19647	9045	2891	6031	41768	54857
2013	5272	2128	15065	9084	4112	10157	40546	45818
2014	4344	1924	6889	6747	2398	5635	23593	27937
2015	1916	1946	7117	4848	1812	2956	18679	20595
2016	2886	2887	7695	4031	1972	3233	19818	22704
2017	2251	2225	5182	6676	2836	2741	19660	21911

Summary of the assessment

Table 10 Sardine in divisions 8.c and 9.a. Assessment summary. High and low refer to 95% confidence intervals. Weights are in tonnes. Recruitment in thousands.

Year	Recruitment (age 0)	High	Low	Biomass 1+	High	Low	Catch	Fishing Mortality (ages 2–5)	High	Low
1978	36254400	48435260	24073540	519250	681161	357339	145609	0.36	0.51	0.22
1979	42282000	56015640	28548360	673759	884216	463302	157241	0.29	0.39	0.179
1980	48279400	62933460	33625340	847100	1099904	594296	194802	0.28	0.38	0.183
1981	29888500	40398020	19378980	1016040	1302875	729205	216517	0.27	0.36	0.181
1982	16093600	23713500	8473700	945305	1215241	675369	206946	0.26	0.34	0.180
1983	71388800	86662840	56114760	747620	975785	519455	183837	0.26	0.33	0.181
1984	21284100	29095200	13473000	1163730	1408436	919024	206005	0.25	0.32	0.181
1985	18615200	25193000	12037400	987669	1188337	787001	208439	0.23	0.28	0.179
1986	15832200	21789720	9874680	797987	960115	635859	187363	0.28	0.36	0.20
1987	34436500	42779760	26093240	643902	779540	508264	177696	0.32	0.42	0.23
1988	18675400	24606620	12744180	709409	841823	576995	161531	0.40	0.50	0.30
1989	17827500	23433280	12221720	628061	747019	509103	140961	0.38	0.47	0.29
1990	18664000	24444260	12883740	565453	674503	456403	149429	0.42	0.51	0.32
1991	54589000	64160220	45017780	520169	626679	413659	132587	0.38	0.48	0.29
1992	37157900	44535640	29780160	855475	992578	718372	130250	0.28	0.35	0.22
1993	16291400	20913540	11669260	966562	1102589	830535	142495	0.27	0.33	0.22
1994	14177300	17988280	10366320	814927	930284	699570	136582	0.23	0.27	0.189
1995	11103300	14139440	8067160	675905	772542	579268	125280	0.23	0.27	0.192
1996	15876700	19332400	12421000	541822	621746	461898	116736	0.31	0.37	0.26
1997	10671500	13482900	7860100	481004	551959	410049	115814	0.42	0.49	0.34
1998	13613200	16777740	10448660	389790	451681	327899	108924	0.46	0.56	0.37
1999	10490400	13399720	7581080	374188	435390	312986	94091	0.42	0.51	0.33
2000	32442700	38097680	26787720	320879	378422	263336	85786	0.37	0.45	0.29
2001	20113300	24529540	15697060	482370	557202	407538	101957	0.35	0.43	0.28
2002	11336900	14566620	8107180	496553	573052	420054	99673	0.30	0.36	0.23
2003	8913870	11888950	5938790	471972	547425	396519	97831	0.26	0.32	0.21
2004	37750200	43156440	32343960	412877	483871	341883	98020	0.29	0.35	0.23
2005	13165100	16073120	10257080	552191	633671	470711	97345	0.29	0.34	0.23
2006	4211350	5693490	2729210	647079	729964	564194	87023	0.174	0.21	0.138
2007	5787690	7352958	4222422	509834	575831	443837	96469	0.21	0.24	0.175
2008	7428350	9071960	5784740	394772	447214	342330	101464	0.33	0.38	0.28
2009	8483120	10064766	6901474	295909	336503	255315	87740	0.37	0.44	0.31
2010	4832010	5975504	3688516	247453	280046	214860	89571	0.47	0.57	0.38
2011	3949080	4945576	2952584	177018	203244	150792	80403	0.57	0.70	0.45
2012	4202470	5200714	3204226	130021	153844	106198	54857	0.46	0.57	0.35
2013	4556910	5711584	3402236	118062	142445	93679	45818	0.44	0.56	0.32
2014	3254200	4287154	2221246	119032	147190	90874	27937	0.29	0.38	0.20
2015	5736580	7543358	3929802	112943	143184	82702	20595	0.183	0.24	0.125
2016	6596320	8928520	4264120	143795	184079	103511	22704	0.189	0.25	0.128
2017	2307970	3617824	998116	175449	229217	121681	21911	0.172	0.23	0.112
2018	4192373*			148695	199321	98069				

*Geometric mean (2013–2017)

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