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

ICES stock advice

ICES advises that when the MSY approach is applied, there should be zero catches in 2018.

Stock development over time

The biomass of age 1 and older fish has decreased since 2006 and has been below the B_{lim} since 2009. Recruitment has been below the long-term average since 2005. Fishing mortality has been above F_{lim} for most of the time-series. Fishing mortality has decreased from a peak in 2011 and is currently around the lowest in the time-series.

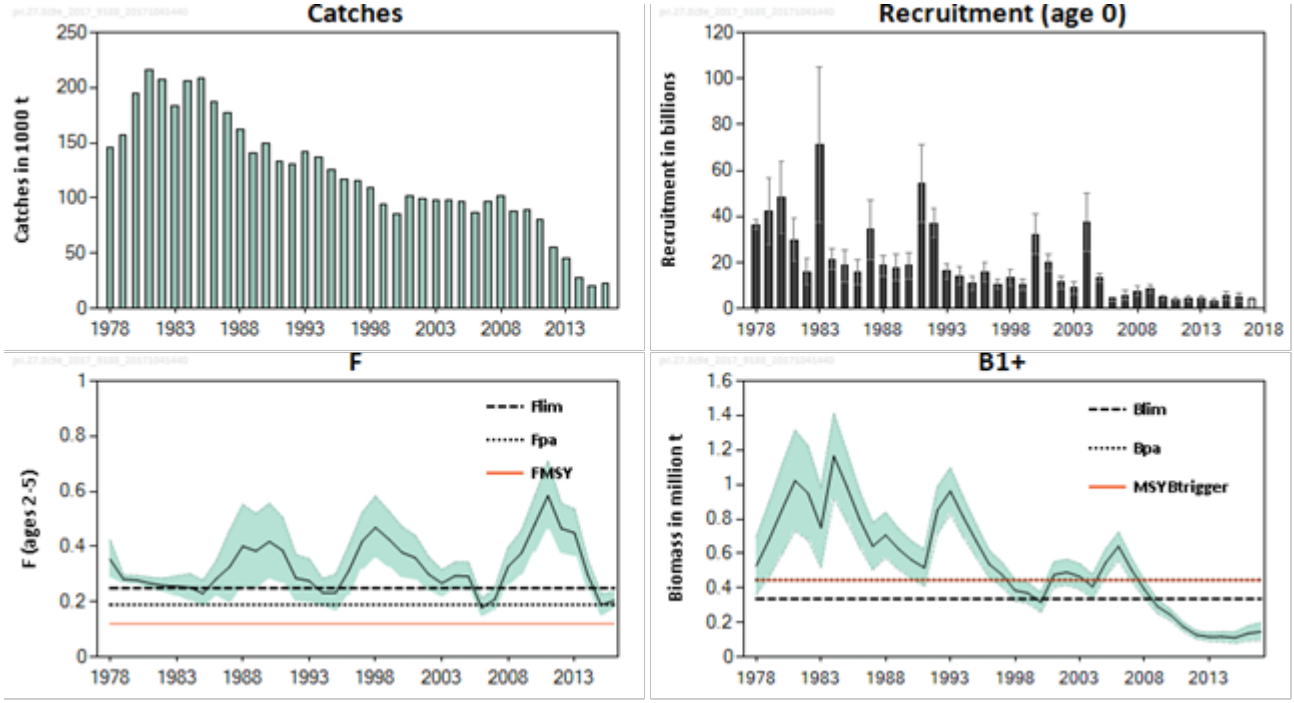

Figure 1 Sardine in divisions 8.c and 9.a. Summary of the stock assessment. Recruitment in 2017 assumed to be equal to the geometric mean of 2012–2016 (unshaded bar). Recruitment, fishing mortality and biomass have 95% confidence intervals. Reference points are based on the stock-recruitment relationship in the period 1993 – 2015.

Stock and exploitation status

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

		Fishing pressure				Stock size			
		2014	2015	2016		2015	2016	2017	
Maximum Sustainable Yield	F_{MSY}	✗	✗	✗	Above	MSY $B_{Trigger}$	✗	✗	✗ Below trigger
Precautionary Approach	F_{pa}, F_{lim}	✗	✓	○	Increased risk	B_{pa}, B_{lim}	✗	✗	✗ Reduced reproductive capacity
Management plan	F_{MGT}	–	–	–	Not applicable	B_{MGT}	–	–	– Not applicable

Catch options

Table 2 Sardine in divisions 8.c and 9.a. The basis for the catch options.

Variable	Value	Source	Notes
$F_{ages\ 2\text{-}5}$ (2017)	0.18	ICES (2017a)	F that corresponds to the assumed catch in 2017
B_{1+} (2018)	151884 tonnes	ICES (2017a)	Obtained from short-term forecast
R_{age0} (2017)	4391480 thousand	ICES (2017a)	Geometric mean (2012–2016)
R_{age0} (2018)	4391480 thousand	ICES (2017a)	Geometric mean (2012–2016)
Total catch (2017)	23000 tonnes	ICES (2017a)	Consistent with official catches known to ICES in October 2017
Discards (2017)	Negligible	ICES (2017a)	

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

Basis	Catch (2018)	F (2018)	Biomass 1+ (2019)	% Biomass 1+ change *	% Catch change **
ICES advice basis					
MSY approach: F=0	0	0	171018	12.6	-100
Other options					
Management plan^ Catch 2018 = 0.36 × (B1+2017 – B_0), where B_0 = 135000 tonnes	4259	0.029	167881	10.5	-81
$F=F_{MSY}$*(B1+ 2018)/MSY $B_{trigger}$	5908	0.041	166667	9.7	-74
$F= F_{MSY}$	16796	0.12	158676	4.5	-26
F2018 = F2017	24650	0.18	152936	0.7	9
F_{pa}	25925	0.19	152006	0.1	14
F_{lim}	33386	0.25	146576	-3.5	47
SSB (2019) = B_{lim}^^			337448		
SSB (2019) = B_{pa}^^			446331		
SSB (2019) = MSY $B_{trigger}$^^			446331		

** Biomass 1+ in 2019 relative to Biomass 1+ in 2018 (151884 t).
*** Catch in 2018 compared to 2016 catches (22704 t).
^ This management plan has been evaluated and found to be not precautionary (ICES, 2017b)
^^ 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 2019 even with zero catch in 2018.

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 advice is not based on the management plan agreed by Portugal and Spain (Sardine Fishery Management Plan (2012-2015)) because ICES considers it to be not precautionary, since under recent stock recruitment (based on the years 1993–2015) it can not guarantee that the stock will recover to above B_{lim} with high (≥95%) probability in the short, medium, or long term (ICES, 2017b).

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 low abundance estimated in the PELAGO 2017 survey off the northern Portuguese waters was supported by data on egg distribution and by the estimates of an additional acoustic survey conducted in August 2017 (ICES, 2017a).

The current assessment is comparable to the benchmark assessment (ICES, 2017c). The benchmark led to moderate revisions relative to previous assessments. The upward scaling of recruitment in the current assessment in comparison with last year's assessment results from the increase of the assumed natural mortality. The model resulting from the benchmark shows a better fit to the data and provides more precise estimates of biomass, recruitment, and fishing mortality in comparison with last year's assessment.

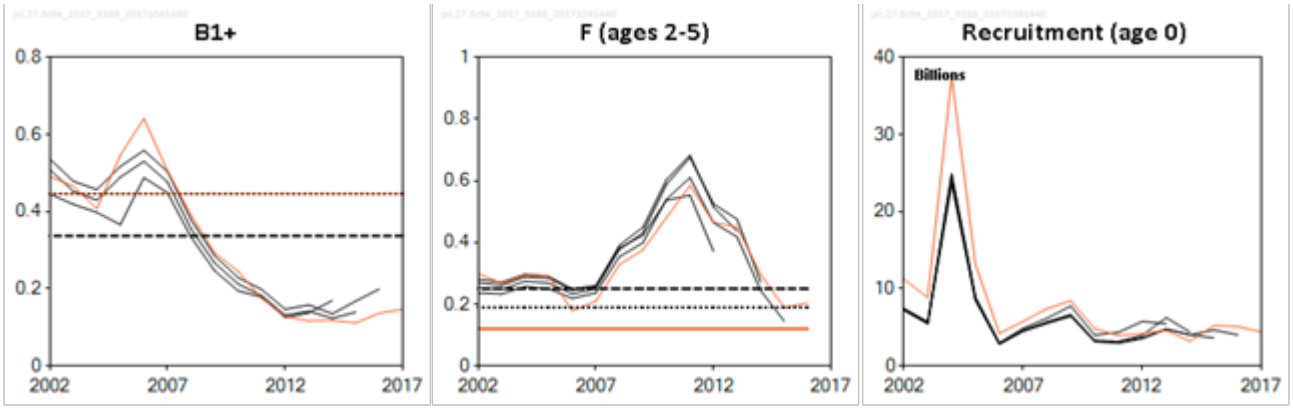

Figure 2 Sardine in divisions 8.c and 9.a. Historical assessment results.

Issues relevant for the advice

The benchmark assessment for the stock led to a slightly more pessimistic perception of the stock development relative to previous assessments. The estimation of reference points revealed that the stock is well below B_{lim}.

Stock recruitment has been around the lowest historical level for approximately a decade. The biomass of the stock is also around the lowest historical level and has been below the limit biomass (B_{lim}) since 2009.

The advice last year was given according to the management plan agreed by Portugal and Spain. Following the benchmark and the estimation of reference points, the plan is now considered not precautionary and the basis of the advice this year is the MSY approach. Because of the low biomass and recruitment, it is not possible to identify any non-zero catch that would be compatible with the MSY approach.

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 (2017c)
	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 (2017c)
Precautionary approach	B_{lim}	337448 tonnes	Break point of segmented regression fitted to stock-recruitment estimates for 1993–2015	ICES (2017c)
	B_{pa}	446331 tonnes	B_{pa} = Blim * exp(1.645 * σ), with σ = 0.17 (coefficient of variation of SSB_{2016}, from the assessment at the 2017 benchmark)	ICES (2017c)
	F_{lim}	0.25	F that results in long-term P(SSB < B_{lim}) = 50%; calculated by stochastic simulation	ICES (2017c)
	F_{pa}	0.19	F_{pa} = F_{lim} / exp(1.645 *σ), with σ = 0.17 (coefficient of variation of apical F_{2015}, from the assessment at the 2017 benchmark)	ICES (2017c)
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, 2017a)
Input data	Commercial catches (international landings, age groups from catch sampling); annual acoustic survey indices (age groups from PELAGO&PELACUS-Q1-2), triennial spawning-stock biomass (SSB) indices (PT-DEPM&SP-DEPM); triennial stock weights and maturity data from DEPM (PT-DEPM&SP-DEPM), interpolated in 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, 2017b).
Working group	Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)

Information from stakeholders

There is no 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	Predicted catch corresp. 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	227000**	-	150000	149429
1991	Precautionary TAC	176000	-	135000	132587
1992	No advice	-	-	139000	130250
1993	Precautionary TAC	135000	-	153000	142495
1994	No advice	118000***	-	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
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

Year	ICES advice	Predicted catch corresp. to advice	Agreed TAC	Official landings 8 & 9	ICES catch*
2017	Management Plan	≤ 23000			
2018	MSY approach	0			

n/a = not available.
* Includes only divisions 8.c and 9.a.
** Catch corresponding to 20% increase in F.
*** Estimated catch at *status quo* F.
^ 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 2016 as estimated by ICES.

Catch (2016)	Landings		Discards
22704 tonnes	99% purse-seine	1% other gear types	negligible
	22704 tonnes		

Table 9 Sardine in divisions 8.c and 9.a. History of ICES catch and landings; values are presented by area for each country participating in the fishery. 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
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

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)
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

Summary of the assessment

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

Year	Recruitment (age 0) thousands	High	Low	Biomass 1+ tonnes	High	Low	Total catch tonnes	F (ages 2-5)	High	Low
1978	36397500	38582060	34212940	527924	694427	361421	145609	0.354	0.423	0.285
1979	42401000	56733546	28068454	681861	897195	466527	157241	0.282	0.297	0.266
1980	48364900	64134086	32595714	854519	1112004	597034	194802	0.278	0.295	0.262
1981	29882200	38971054	20793346	1022610	1313511	731709	216517	0.267	0.288	0.246
1982	16027500	21670170	10384830	950240	1223246	677234	206946	0.259	0.285	0.234

1983	71216200	105014913	37417487	750638	981082	520194	183837	0.256	0.293	0.22
1984	21183900	25708614	16659186	1164160	1409880	918440	206005	0.252	0.301	0.203
1985	18525200	25327157	11723243	986777	1187731	785823	208439	0.23	0.277	0.183
1986	15748900	21312907	10184893	796254	958191	634317	187363	0.283	0.348	0.219
1987	34315800	47231339	21400261	641588	776693	506483	177696	0.326	0.456	0.196
1988	18605100	23102804	14107396	706336	837678	574994	161531	0.401	0.552	0.25
1989	17756400	23392397	12120403	624982	742789	507175	140961	0.384	0.519	0.249
1990	18582200	24421898	12742502	562405	670328	454482	149429	0.418	0.556	0.281
1991	54386600	71224957	37548243	517014	622451	411577	132587	0.386	0.506	0.267
1992	37011900	43475171	30548629	851022	986566	715478	130250	0.286	0.371	0.2
1993	16215800	19426145	13005455	961595	1095831	827359	142495	0.276	0.355	0.197
1994	14106600	18106465	10106735	810320	924053	696587	136582	0.233	0.284	0.182
1995	11029800	13991972	8067628	671641	766804	576478	125280	0.233	0.299	0.166
1996	15777200	20088960	11465440	537842	616478	459206	116736	0.314	0.405	0.223
1997	10595000	12895342	8294658	476988	546680	407296	115814	0.419	0.522	0.316
1998	13509300	17062979	9955621	385962	446681	325243	108924	0.469	0.583	0.356
1999	10398000	12808660	7987340	370140	430148	310132	94091	0.427	0.528	0.325
2000	32198800	41116982	23280618	316919	373339	260499	85786	0.379	0.471	0.286
2001	19957800	23414124	16501476	477129	550365	403893	101957	0.359	0.44	0.279
2002	11244200	13702500	8785900	491012	565756	416268	99673	0.3	0.363	0.237
2003	8848150	11363564	6332736	466378	540037	392719	97831	0.267	0.315	0.219
2004	37572100	50094166	25050034	407553	476821	338285	98020	0.294	0.344	0.245
2005	13159400	15027664	11291136	546486	625767	467205	97345	0.292	0.344	0.24
2006	4191320	5114274	3268366	641708	722235	561181	87023	0.179	0.211	0.146
2007	5777120	7811997	3742243	505658	569733	441583	96469	0.209	0.251	0.168
2008	7411240	9413968	5408512	391465	442354	340576	101464	0.328	0.396	0.26
2009	8451030	10319768	6582292	293440	332824	254056	87740	0.376	0.457	0.296
2010	4808120	5705572	3910668	245342	276999	213685	89571	0.48	0.581	0.379
2011	3923130	4854800	2991460	175298	200905	149691	80403	0.585	0.709	0.46
2012	4185820	5254506	3117134	128336	151857	104815	54857	0.465	0.556	0.375
2013	4577090	5696415	3457765	116511	141157	91865	45818	0.45	0.536	0.364
2014	3198270	4051736	2344804	118014	147361	88667	27937	0.297	0.352	0.242
2015	5229320	7022593	3436047	111536	143590	79482	20595	0.189	0.229	0.149
2016	5097110	6945913	3248307	136611	179227	93995	22704	0.204	0.236	0.173
2017	4391480*			146831	198758	94904				
Average	18906463	24912670	13644613	539226	646988	431464	121393	0.325	0.398	0.252

*Geometric mean (2012-2016)

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