

ECOREGION Bay of Biscay and Atlantic Iberian waters
STOCK Sardine in Divisions VIIIc and IXa

Advice for 2015

ICES advises on the basis of precautionary considerations, and taking into account the current low biomass that catches in 2015 should be no more than 16 000 tonnes. Discards are considered to be negligible and all catches are assumed to be landed.

Stock status

Fishing pressure				
	2011	2012	2013	
MSY (F_{MSY})	?	?	?	Unknown
Precautionary approach (F_{pa}, F_{lim})	?	?	?	Unknown
Quality considerations	↗	↗	↘	Above average
Stock size				
	2012	2013	2014	
MSY ($B_{trigger}$)	?	?	?	Unknown
Precautionary approach (B_{pa}, B_{lim})	?	?	?	Unknown
Quality considerations	✘	✘	✘	Well below average

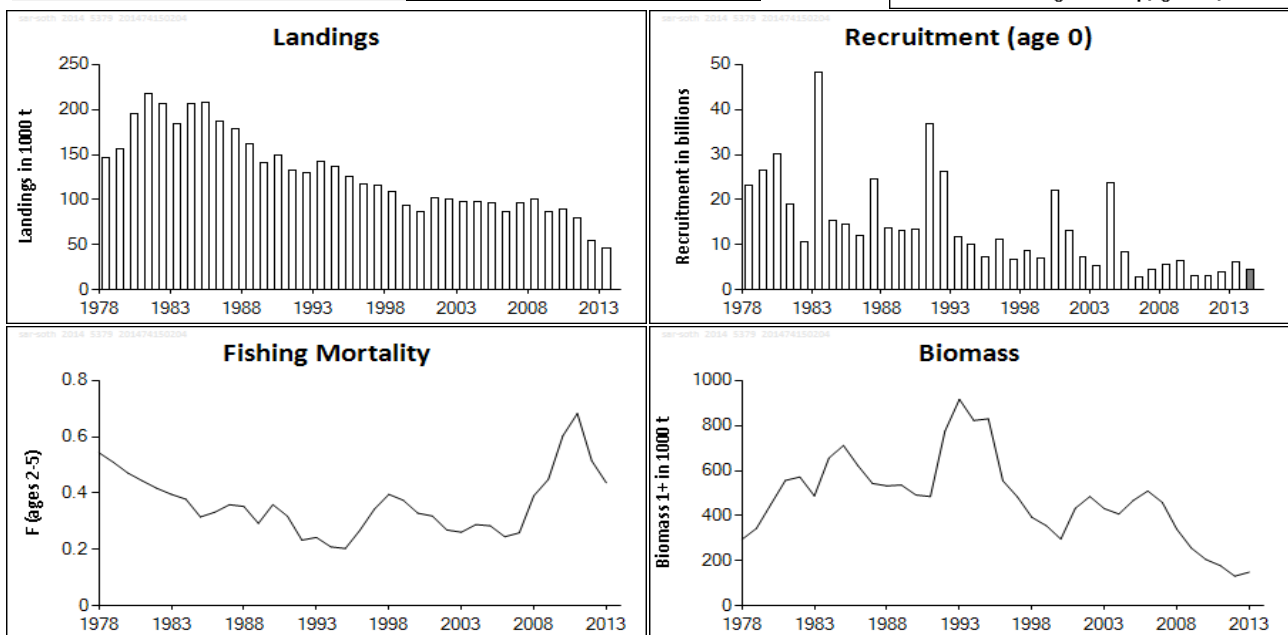
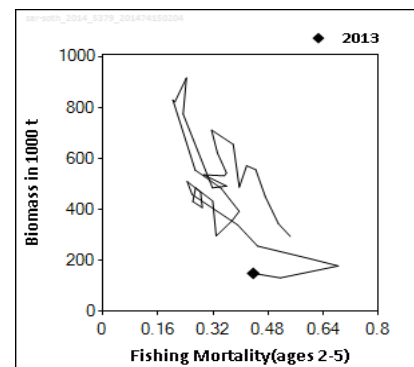


Figure 7.3.19.1 Sardine in Divisions VIIIc and IXa. Summary of stock assessment (weights in thousand tonnes, biomass expressed in weight-at-age 1 and older fish; Biomass 1+). Top right: Biomass 1+ and F over the years. Assumed recruitment values are shaded.

The biomass of age 1 and older fish has decreased since 2006 and is currently around the historic low. Recruitment has been below the long-term average since 2005. Fishing mortality since 2009 has been above the average of the last two decades prior to 2009.

Management plans

ICES has evaluated a proposed management plan developed by Portugal and Spain (ICES, 2013a, Annex 7.3.19). ICES concluded that the proposed management plan is provisionally precautionary.

Biology

Sardine is prey for a range of fish and marine mammal species. Sardine is an omnivorous predator able to feed on both phytoplankton and zooplankton. In addition, sardines have been found to ingest their own eggs (and probably those of other species) and this cannibalism may act as a density control mechanism.

Environmental influence on the stock

As one of the most abundant pelagic forage fish species in Iberian waters, sardine may exert bottom-up control of their predators or top-down control of their prey, or they may control both prey and predators.

The fisheries

Most catch is taken by purse-seiners. Sardine catches are highest in the second half of the year and catches are traditionally concentrated mainly in western part of Portugal, Galicia and Cantabrian Sea. Catches in the Gulf of Cadiz and Algarve areas have increased since 2011. In Spain, vessels target anchovy, mackerel, sardine, and horse mackerel; in summer, part of the fleet switches to tuna fishing. In Portugal, sardine is the main target species, but chub mackerel, horse mackerel, and anchovy are also landed. Most catches are taken off the northern coast. Discards are uncertain but are assumed to be negligible. Slipping estimates are available for the Portuguese fleet, but with a limited coverage in time and extent.

Catch distribution Total catch (2013) = 46 kt, where 46 kt were official landings (99% purse-seine and 1% other gear types). Discards are assumed to be negligible.

Effects of the fisheries on the ecosystem

Purse-seines have a low bycatch of non-target species: when targeting sardine, the catches are mostly monospecific. Observer data and interview surveys of fishers also indicate a low impact on megafauna such as cetaceans, seabirds, and turtles. Because purse-seiners operate in open waters, there is little impact on the seabed. The overall effect of the sardine fishery on the pelagic ecosystem of the Atlantic Iberian waters has not been evaluated. The most likely impacts will take place in alterations of prey-predator relationships via modification of sardine abundance, size structure, and behaviour.

Quality considerations

The main uncertainties in the assessment relate to the discrepant signals about the stock trends provided by the daily egg production method (DEPM) and acoustic surveys. Uncertainty continues regarding the extent of sardine movement across the northern stock boundary, on the comparability of Portuguese and Spanish acoustic surveys, on survey and fishery selection patterns, and on the weighting of the different data sources in the assessment.

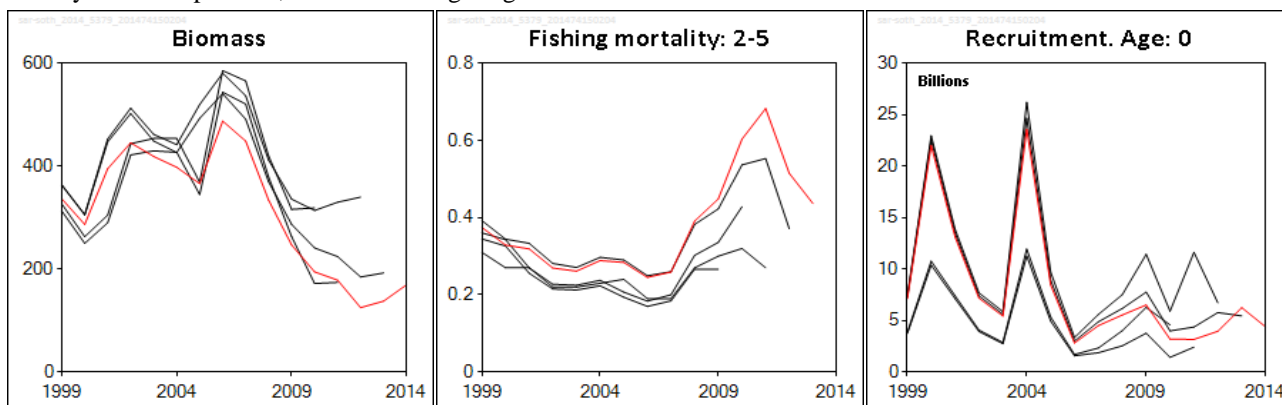


Figure 7.3.19.2 Sardine in Divisions VIIIc and IXa. Historical assessment results (final-year recruitment and biomass estimates included). The stock was benchmarked in 2012.

Scientific basis

Stock Data Category	1 (ICES, 2014a)
Assessment type	Age-based analytical assessment (SS3).
Input data	Commercial catches (international landings, ages and length frequencies from catch sampling), survey indices (PELAGO&PELACUS-Q2, PT-DEPM&SP-DEPM). Annual maturity data from DEPM survey, and natural mortalities from Gislason formula.
Discards and bycatch	Not included and are considered negligible.
Indicators	None
Other information	Benchmarked in February 2012 (WKPELA ; ICES, 2012).
Working group	Working Group on Anchovy and Sardine (WGHANSA)

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Reference points

No reference points are defined for this stock.

Outlook for 2015

Basis: $F(2014) = \text{average } F(2011-2013) \text{ scaled to } F_{2013}=0.44$; $B_{1+}(2014) = 188$; $B_{1+}(2015) = 169$; Catches (2014) = 51; $R(2014)$ and $R(2015) = GM(2009-2013) = 4384$ million.

Rationale	Catches (2015)	Basis	F (2015)	B ₁₊ (2016)	%B ₁₊ change ¹⁾
Precautionary considerations	16	$F_{2002-2007} \times (B_{1+2014} / B_{1+2002-2007})$	0.11	193	14
Proposed management plan	19.095	Catch 2015 is $(0.36 \times (B_{1+2014} - \text{lower trigger level}))$	0.13	191	13
Zero catch	0	$F = 0$	0	205	21
Other options	12	$F_{2014} \times 0.2$	0.09	196	16
	24	$F_{2014} \times 0.4$	0.17	187	11
	35	$F_{2014} \times 0.6$	0.26	179	6
	36	$F = \text{average } 2002-2007$	0.27	179	6
	45	$F_{2014} \times 0.8$	0.35	172	2
	55	F_{2014}	0.44	165	-2

Weights in thousand tonnes.

¹⁾ B₁₊ 2016 relative to B₁₊ 2015.

Management plan

ICES has evaluated a management plan as requested by the EC (ICES, 2013a). The management plan description can be found in Annex 7.3.19. ICES concluded that the plan is provisionally precautionary, causing low probabilities of unsustainable fishing mortality, when the biomass used for comparison in the harvest control rule is the B₁₊ in the beginning of the intermediate year.

Following the proposed EC management plan implies that the TAC is set by the formula $0.36 \times (B_{1+}(2014) - \text{lower trigger level}) = (0.36 \times (188 - 135))$ because the biomass is currently between the two trigger points in the harvest rule, which implies catches of no more than 19 095 t in 2015. Discards are considered to be negligible and all catches are assumed to be landed.

Precautionary considerations

The stock biomass is at a historically low level and fishing mortality peaked in 2010–2011. It has decreased since then but it is still above the long-term average. F should be brought back to where it was before the start of this increase, i.e. the 2002–2007 average (0.27). However, taking into account the low biomass, below previous B_{loss} and the below-average recruitment, ICES considers fishing mortality F should be reduced further. This reduction is based on the ratio between the current biomass ($B_{1+(2014)} = 188\ 000$ t) and the average biomass in the period before high fishing mortality occurred (average $B_{1+(2002-2007)} = 406\ 000$ t, ratio of 41%) to $F = 0.11$. This results in catches of no more than 16 000 t. Discards are considered negligible and all catches are assumed to be landed.

Additional considerations

Management plan evaluations

ICES has evaluated a proposed management plan developed by Portugal and Spain (ICES, 2013a). Given the available data, ICES was unable to define reference points to use for the evaluation. ICES concludes the plan is provisionally precautionary, because it gives low probabilities of exceeding F_{loss} or driving B₁₊ below B_{loss} and a high probability of rapid recovery when B₁₊ declines to below trigger values. The proposed plan implies a relatively modest exploitation

rate with mean $F = 0.22$, which is 70% of the natural mortality. As an F slightly lower than the natural mortality is a potential proxy for F_{MSY} (Deriso, 1982), the plan results in exploitation in the lower range of candidate F_{MSY} values.

Further exploration of sardine stock dynamics is required; for example it may be possible to draw inferences from studies of other sardine stock dynamics at low biomass. This will provide a better informed basis for determining precautionary criteria which may improve the evaluation of the current proposed plan. Additionally, alternative settings (lower target catch, higher trigger points) and catch stabilizers could be tested to improve the performance of the plan and make it more precautionary.

Regulations and their effects

There is no international TAC. Almost all catches are taken by purse-seiners in a directed human consumption fishery. Until 2014, the fisheries are managed by Portugal and Spain through minimum landing size, maximum daily catch, days fishing limitations, and closed areas.

Since 2010, annual catch limits are set for the Portuguese fishery by the Portuguese authorities. In 2013, the catch limit was 36 000 t, following the multiannual management plan.

In Spain, management measures include a maximum allowable catch of 7000 kg per fishing day and a 5-fishing-days week limitation since 1997.

In both countries, fishing for sardine was banned for 45 days during the first quarter of the year, with different regional periods.

Biology

Sardine is distributed in the Iberian region, to the north in Subareas VII and VIII and in the North Sea, and to the south on the Moroccan shelf. The information presented here assumes that sardine in Divisions VIIIc and IXa is a unit stock, based on biological characteristics. However, some movement of fish between Divisions VIIIb and VIIIc is known to occur. The effect of this movement is uncertain but is presently considered to have little influence on the estimation of the stock in the assessed area (Divisions VIIIc and IXa).

The environment

Sardine recruitment is considered to be influenced at both the local and the global scale by environmental variables that may reduce the transportation of eggs and larvae offshore which are critical to ensuring egg and larval survival. Indirect effects, e.g. on growth and condition through variations in food supply or water temperature have been given less attention. Results from such studies show that environmental effects, although present, are often weak and in some cases findings have been contradictory. For example, upwelling intensity has been found to affect recruitment both positively and negatively.

The Iberian sardine is considered a forage fish, i.e. a fish that provides food for predatory fish as well as marine mammals and birds. Sardine is one of the most abundant small pelagic species in western Iberian waters and has been found to be important in the diet of several species of fish and marine mammals. Forage fish such as sardine may exert bottom-up control of their predators or top-down control on their zooplanktonic prey, or they may control both prey and predators (wasp-waist control).

Uncertainties in assessment and forecast

The assessment shows a retrospective pattern overestimating SSB and underestimating F is observed in the last 3 years.

The DEPM and the acoustic surveys show discrepant signals in the stock trajectory. The assessment tends to accommodate the signals from the two surveys by providing a broad average perspective but follows the acoustic survey in the years when the DEPM is not available.

Some unresolved technical issues in the software code prevented the inclusion of confidence interval in fishing mortality. Hence confidence intervals are not shown.

Comparison of the basis of previous assessment and advice

The basis for the assessment has not changed from last year, but the forecast has been amended to account for changes in F in recent years (the intermediate year F was scaled to 2013). The basis for the advice is the same as last year: precautionary considerations.

Sources

- Deriso, R. B. 1982. Relationship of fishing mortality to natural mortality and growth at the level of maximum sustainable yield. *Canadian Journal of Fisheries and Aquatic Sciences*, 39: 1054–1058.
- ICES. 2012. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA 2012), 13–17 February 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:47. 572 pp.
- ICES. 2013a. Management plan evaluation for sardine in Divisions VIIIc and IXa. *In* Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 7, Section 7.3.5.1.
- ICES. 2013b. Report of the Working Group on Southern Horse Mackerel, Anchovy, and Sardine (WGHANSA), 21–26 June 2013, Bilbao, Spain. ICES CM 2013/ACOM:16.
- ICES. 2014a. Advice basis. *In* Report of the ICES Advisory Committee, 2014. ICES Advice 2014, Book 1, Section 1.2.
- ICES. 2014b Report of the Working Group on Southern Horse Mackerel, Anchovy, and Sardine (WGHANSA), 20–25 June 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:16.

Table 7.3.19.1 Sardine in Divisions VIIIc and IXa. Single-stock exploitation boundaries (advice), management, and catch.

Year	ICES Advice	Predicted catch corresp. to advice	Agreed TAC	Official landings VIII & IX	ICES catch ^a
1987	No increase in F; TAC	140	-		178
1988	No increase in F; TAC	150	-	167	162
1989	No increase in F; TAC	212	-	146	141
1990	Room for increased F	227 ^a	-	150	149
1991	Precautionary TAC	176	-	135	133
1992	No advice	-	-	139	130
1993	Precautionary TAC	135	-	153	142
1994	No advice	118 ^b	-	147	137
1995	No advice; apparently stable stock	-	-	137	125
1996	Lowest possible level	-	-	134	117
1997	Lowest possible level	-	-	n/a	116
1998	Significant reduction	-	-	n/a	109
1999	Reduce F to 0.2	38	-	n/a	94
2000	F below 0.2	< 81	-	n/a	86
2001	F below 0.2	< 88	-	n/a	102
2002	F below 0.25	< 95	-	n/a	100
2003	No increase in F	100	-	n/a	98
2004	No increase in F	128	-	n/a	98
2005	No increase in F	106	-	n/a	97
2006	No increase in F	96	-	n/a	87
2007	No increase in F	114	-	n/a	96
2008	No increase in F	92	-	n/a	101
2009	No increase in F	71	-	n/a	88
2010	No increase in F	75	-	n/a	90
2011	Maintain F at 2002–2007 level	75	-	77	80
2012	Reduce F to the 2002–2007 level	36	-	52	55
2013	Reduce F to the 2002–2007 level	< 55	-	46	46
2014	Reduce F to the 2002–2007 level adjusted to low biomass	< 17	-		
2015	Reduce F to the 2002–2007 level adjusted to low biomass	< 16			

Weights in thousand tonnes.

n/a = not available.

^aIncludes only Divisions VIIIc and IXa.

^bEstimated catch at *status quo* F.

Table 7.3.19.2

Sardine in Divisions VIIIc and IXa. ICES estimates of catch (tonnes) by subarea.

Year	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz	All sub-areas	Div. IXa
1940	66816		42132	33275	23724		165947	99131
1941	27801		26599	34423	9391		98214	70413
1942	47208		40969	31957	8739		128873	81665
1943	46348		85692	31362	15871		179273	132925
1944	76147		88643	31135	8450		204375	128228
1945	67998		64313	37289	7426		177026	109028
1946	32280		68787	26430	12237		139734	107454
1947	43459	21855	55407	25003	15667		161391	117932
1948	10945	17320	50288	17060	10674		106287	95342
1949	11519	19504	37868	12077	8952		89920	78401
1950	13201	27121	47388	17025	17963		122698	109497
1951	12713	27959	43906	15056	19269		118903	106190
1952	7765	30485	40938	22687	25331		127206	119441
1953	4969	27569	68145	16969	12051		129703	124734
1954	8836	28816	62467	25736	24084		149939	141103
1955	6851	30804	55618	15191	21150		129614	122763
1956	12074	29614	58128	24069	14475		138360	126286
1957	15624	37170	75896	20231	15010		163931	148307
1958	29743	41143	92790	33937	12554		210167	180424
1959	42005	36055	87845	23754	11680		201339	159334
1960	38244	60713	83331	24384	24062		230734	192490
1961	51212	59570	96105	22872	16528		246287	195075
1962	28891	46381	77701	29643	23528		206144	177253
1963	33796	51979	86859	17595	12397		202626	168830
1964	36390	40897	108065	27636	22035		235023	198633
1965	31732	47036	82354	35003	18797		214922	183190
1966	32196	44154	66929	34153	20855		198287	166091
1967	23480	45595	64210	31576	16635		181496	158016
1968	24690	51828	46215	16671	14993		154397	129707
1969	38254	40732	37782	13852	9350		139970	101716
1970	28934	32306	37608	12989	14257		126094	97160
1971	41691	48637	36728	16917	16534		160507	118816
1972	33800	45275	34889	18007	19200		151171	117371
1973	44768	18523	46984	27688	19570		157533	112765
1974	34536	13894	36339	18717	14244		117730	83194
1975	50260	12236	54819	19295	16714		153324	103064
1976	51901	10140	43435	16548	12538		134562	82661
1977	36149	9782	37064	17496	20745		121236	85087
1978	43522	12915	34246	25974	23333	5619	145609	102087
1979	18271	43876	39651	27532	24111	3800	157241	138970
1980	35787	49593	59290	29433	17579	3120	194802	159015
1981	35550	65330	61150	37054	15048	2384	216517	180967
1982	31756	71889	45865	38082	16912	2442	206946	175190
1983	32374	62843	33163	31163	21607	2688	183837	151463
1984	27970	79606	42798	35032	17280	3319	206005	178035
1985	25907	66491	61755	31535	18418	4333	208439	182532
1986	39195	37960	57360	31737	14354	6757	187363	148168
1987	36377	42234	44806	27795	17613	8870	177696	141319
1988	40944	24005	52779	27420	13393	2990	161531	120587
1989	29856	16179	52585	26783	11723	3835	140961	111105
1990	27500	19253	52212	24723	19238	6503	149429	121929
1991	20735	14383	44379	26150	22106	4834	132587	111852
1992	26160	16579	41681	29968	11666	4196	130250	104090
1993	24486	23905	47284	29995	13160	3664	142495	118009
1994	22181	16151	49136	30390	14942	3782	136582	114401
1995	19538	13928	41444	27270	19104	3996	125280	105742
1996	14423	11251	34761	31117	19880	5304	116736	102313
1997	15587	12291	34156	25863	21137	6780	115814	100227
1998	16177	3263	32584	29564	20743	6594	108924	92747
1999	11862	2563	31574	21747	18499	7846	94091	82229
2000	11697	2866	23311	23701	19129	5081	85786	74089
2001	16798	8398	32726	25619	13350	5066	101957	85159
2002	15885	4562	33585	22969	10982	11689	99673	83787
2003	16436	6383	33293	24635	8600	8484	97831	81395
2004	18306	8573	29488	24370	8107	9176	98020	79714
2005	19800	11663	25696	24619	7175	8391	97345	77545
2006	15377	10856	30152	19061	5798	5779	87023	71646
2007	13380	12402	41090	19142	4266	6188	96469	83088
2008	13636	9409	45210	20858	4928	7423	101464	87828
2009	11963	7226	36212	20838	4785	6716	87740	75777
2010	13772	7409	40923	17623	5181	4662	89571	75798
2011	8536	5621	37152	13685	6387	9023	80403	71867
2012	13090	4154	19647	9045	2891	6031	54857	41768
2013	5272	2128	15065	9084	4112	10157	45818	40546

Table 7.3.19.3

Sardine in Divisions VIIIc and IXa. Summary of stock assessment.

Year	Recruitment	Biomass 1+	Landings	Mean F
	Age 0	Tonnes	Tonnes	Ages 2-5
	thousands	tonnes	tonnes	
1978	23313500	294134	146000	0.544
1979	26550000	343568	157000	0.51
1980	30285900	450693	195000	0.471
1981	18960200	556295	217000	0.444
1982	10642300	571954	207000	0.417
1983	48373200	487789	184000	0.396
1984	15330800	655710	206000	0.379
1985	14560900	712052	208000	0.315
1986	12031500	622478	187000	0.332
1987	24643900	543282	178000	0.359
1988	13625600	532279	162000	0.353
1989	13067400	536293	141000	0.293
1990	13450900	492039	149000	0.359
1991	36815500	484998	133000	0.318
1992	26263000	774800	130000	0.233
1993	11628100	916842	142000	0.243
1994	9952300	822745	137000	0.209
1995	7193820	830272	125000	0.203
1996	11217800	555005	117000	0.268
1997	6660780	483536	116000	0.343
1998	8735370	392693	109000	0.396
1999	7115880	355411	94000	0.375
2000	22021700	295942	86000	0.329
2001	13111700	433069	102000	0.319
2002	7163760	485050	100000	0.269
2003	5425150	431469	98000	0.261
2004	23600100	407352	98000	0.289
2005	8461540	467955	97000	0.284
2006	2808970	509794	87000	0.245
2007	4500140	458709	96000	0.259
2008	5536170	339881	101000	0.391
2009	6511940	256338	87000	0.449
2010	3186420	205491	90000	0.604
2011	3159520	178372	80001	0.683
2012	3953520	131407	55000	0.515
2013	6247200	149172	46000	0.437
2014	4383901*	188000		
Average	13797037	444107	129528	0.364

* Geometric mean (2009–2013).

Annex 7.3.19 Proposed management plan

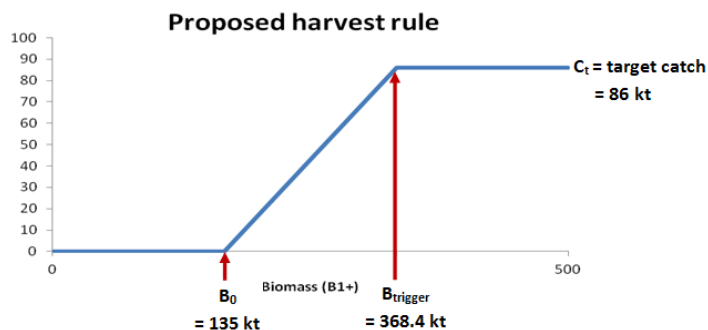
In the document referred to in the plan (*Plan de gestion sardina*), the harvest rule is stated as:

$$\begin{aligned}
 B_{1+} > B_{\text{trigger}} &\rightarrow C_{\text{MAX}} = C_t \text{ kt} \\
 B_0 < B_{1+} < B_{\text{trigger}} &\rightarrow C_{\text{MAX}} = d(B_{1+} - B_0) \text{ kt} \\
 B_{1+} < B_0 &\rightarrow C_{\text{MAX}} = 0
 \end{aligned}$$

where

- B_{1+} = the biomass of the ages 1 and older, in kt ¹⁾
- C_{MAX} = maximum catch in kt
- B_{trigger} = 368.4 kt (1.2 B_{lim})
- d = 0.36
- B_0 = 135 kt
- C_t = target catch = 86 kt.

The harvest rule is illustrated in the figure below:



The harvest rule sets a TAC directly according to an estimate of the biomass of fish aged 1 and older (B_{1+}). The TAC is fixed at C_t when B_{1+} is above B_{trigger} , and reduced if it is below.

ICES has not defined a B_{lim} for this stock, but for the purposes of the formulation of this plan the value is taken as B_{loss} in 2000 according to the 2012 assessment.

¹ For the purpose of this evaluation the B_{1+} in the beginning of the intermediate year is used.