

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

Advice for 2013

ICES advises on the basis of precautionary considerations, and taking into account the current low biomass that catches in 2014 should be no more than 17 000 tonnes. Discards are considered to be negligible and all catches are assumed to be landed.

Stock status

F (Fishing Mortality)			
	2010	2011	2012
Quality considerations			Above average
SSB (Spawning-Stock Biomass)			
	2011	2012	2013
Quality considerations			64% below average

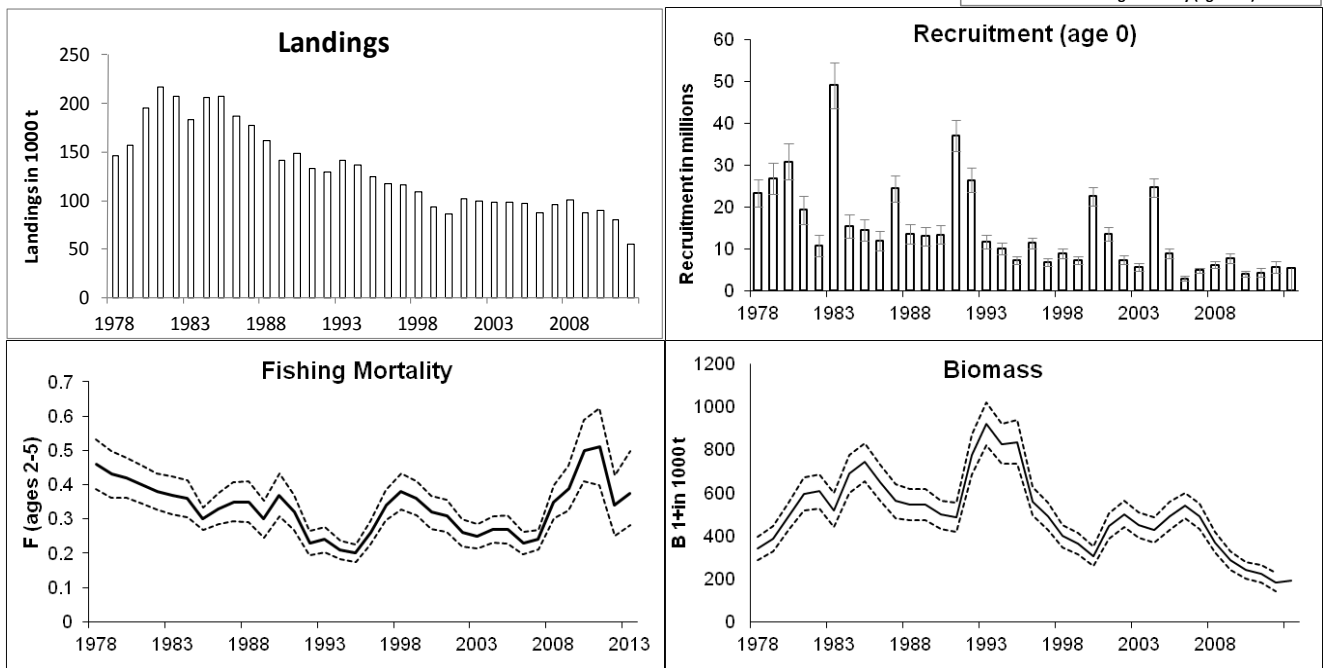
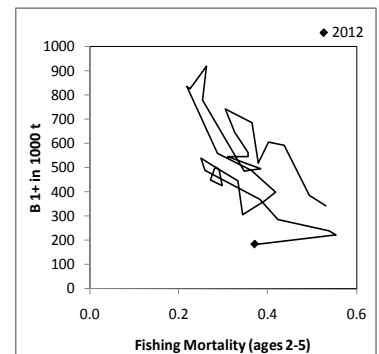


Figure 7.4.19.1 Sardine in Divisions VIIIc and IXa. Summary of stock assessment (weights in thousand tonnes, biomass expressed in weight-at-age 1 and older fish; Biomass 1+). Top right: Biomass 1+ and F over the years. Assumed recruitment values are shaded.

The biomass of age 1 and older fish has decreased since 2006. In 2012, the biomass was 64% below the long-term average. Recruitment has been below the long-term average since 2005. Fishing mortality fluctuated without a clear trend. In 2010–2011 fishing mortality was well above the long-term average, but it decreased 33% from 2011 to 2012.

Management plans

ICES has evaluated a proposed management plan developed by Portugal and Spain (ICES, 2013a). 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 concentrated to southern Galician and Cantabrian waters. 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 catches (2012) = 55 kt (100% landings: 99% purse-seine and 1% other gear types).

Effects of the fisheries on the ecosystem

Purse-seines have a low bycatch of non-target species: when targeting sardine, the catches are virtually 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. The basis of the model was changed in 2012, which explains the shift in subsequent assessments.

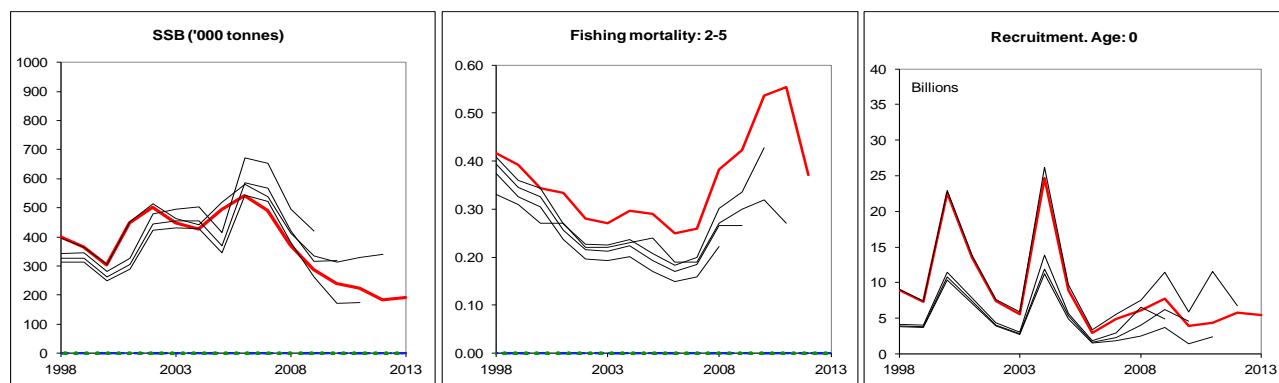


Figure 7.4.19.2 Sardine in Divisions VIIIc and IXa. Historical assessment results (final-year recruitment and biomass estimates included). The 2012 F values were incorrectly presented in the advice.

Scientific basis

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

Discards were not included and are considered negligible.

Indicators

None.

Other information

Benchmarked in February 2012 ([WKPELA](#); ICES, 2012).

Working group report

[WGHANSA](#) (ICES, 2013b).

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Reference points

No reference points are defined for this stock.

Outlook for 2014

Basis: $F(2013) = \text{average } F(2010-2012) \text{ unscaled} = 0.45$; $B_{1+}(2013) = 192$; $B_{1+}(2014) = 181$; Catches (2013) = 56; $R(2013)$ and $R(2014) = GM(2008-2012) = 5446$ million.

Rationale	Catches (2014)	Basis	F (2014)	B ₁₊ (2015)	%B ₁₊ change ¹⁾
Precautionary considerations	17	$F_{2002-2007} \times (B_{1+2013} / B_{1+2002-2007})$	0.10	212	+17%
Proposed management plan	20.520	$(0.36 \times (B_{1+2013} - \text{lower trigger level}))$	0.13	210	+16%
Zero catch	0	$F = 0$	0	224	+24%
Other options	15	$F_{2013} \times 0.2$	0.09	214	+18%
	28	$F_{2013} \times 0.4$	0.18	204	+13%
	39	$F = \text{average } 2002-2007$	0.25	197	+9%
	41	$F_{2013} \times 0.6$	0.27	195	+8%
	54	$F_{2013} \times 0.8$	0.36	187	+3%
	65	F_{2013}	0.45	179	-1%

Weights in thousand tonnes.

¹⁾ B₁₊ 2015 relative to B₁₊ 2014.

Management plan

ICES has evaluated a management plan as requested by the EC (ICES, 2013a). The management plan description can be found in Annex 7.4.19. 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 $0.36 \times (B_{1+}(2013) - \text{lower trigger level}) = (0.36 \times (192 - 135))$ because the biomass is currently between the two trigger points in the harvest rule, resulting in catches of no more than 20 520 t in 2014. Discards are considered to be negligible and all catches are assumed to be landed.

Precautionary considerations

Fishing mortality has increased and SSB decreased in the most recent years, despite advice since 2002 not to increase F. F should be brought back to where it was before the start of this increase, i.e. the 2002–2007 average. However, taking into account the low biomass, below previous B_{loss} and the below-average recruitment, fishing mortality F should be reduced further. For F to be reduced to zero at zero biomass the reduction should be the ratio between the current biomass ($B_{1+(2013)} = 192$ kt) and the average biomass in this period (484 kt, ratio of 40%) to $F = 0.10$. This results in catches of no more than 17 000 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. Given the available data, ICES was unable to define a B_{lim} 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 Spanish and Portuguese purse-seiners in a directed human consumption fishery. The fisheries are managed by Portugal and Spain through minimum landing size, maximum daily catch, days fishing limitations, and closed areas.

In Portugal, management measures since 1997 include an overall limitation in the number of fishing days (180 days per year and a weekend ban). Since 2010, annual catch limits are set for the Portuguese fishery by the Portuguese authorities. In 2012, the catch limit was 36 thousand t and was set in two steps: 9 thousand t for 1 January–31 May and 27 thousand t for 1 June–31 December. In 2013, limits of 12 thousand t and 15 thousand t were set for 1 January–31 May and 1 June–31 August, respectively. Fishing for sardine was banned for 45 days during the first quarter of the year, with different regional periods.

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

The effects of these fishery regulations are uncertain but may have contributed to the decline in fishing mortality observed between 1998 and 2007. The catch limits regulated in Portugal since 2010 and particularly in 2012 may have contributed to avoid further increases in fishing mortality.

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 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. The lack of an acoustic index for 2012 and the triennial modus for the DEPM survey (last survey 2011) caused large fluctuations in the assessment between 2012 and 2013. The 2011 and 2013 acoustic observations are the lowest in the time-series.

Uncertainties in the assessment relating to the extent of sardine movement across the northern stock boundary still apply. The high abundance of age 1 sardine in the Bay of Biscay in 2012 (together with the low abundance in the Iberian area) and the increase in Spanish catches in the eastern part of the Cantabrian Sea suggest that mixing between sardine from the two stocks may have been higher this year.

Comparison with previous assessment and advice

Compared to last year's assessment, B_{1+} in 2012 is revised downwards by 46%, F_{2011} is revised upwards by around 65%, and R_{2011} is revised downwards by 62%.

The basis for the advice is the same as last year, precautionary considerations, but this year modified to take account of the low biomass.

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.

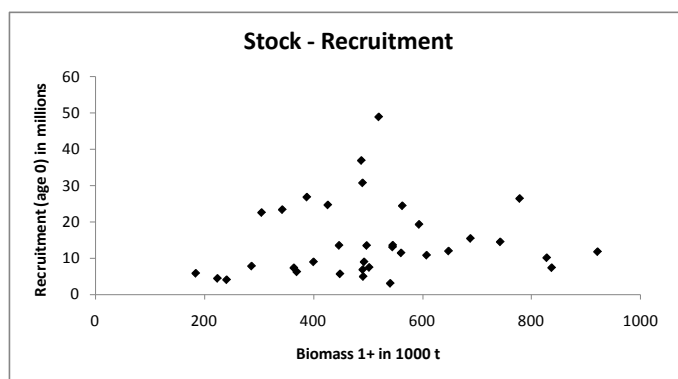


Figure 7.4.19.3 Sardine in Divisions VIIIc and IXa: Stock–recruitment plot.

Table 7.4.19.1 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 ²
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 ²	-	150	149
1991	Precautionary TAC	176	-	135	133
1992	No advice	-	-	139	130
1993	Precautionary TAC	135	-	153	142
1994	No advice	118 ¹	-	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			
2014	Reduce F to the 2002–2007 level adjusted to low biomass	< 17			

Weights in thousand tonnes.

n/a = not available.

¹Estimated catch at *status quo* F.

²Includes only Divisions VIIIc and IXa.

Table 7.4.19.2

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

Year	Sub-area						All sub-areas	Div. IXa	Portugal	Spain (excl.Cadiz)	Spain (incl.Cadiz)
	VIIIc	IXa North	IXa Central North	IXa Central South	IXa South Algarve	IXa South Cadiz					
1940	66816		42132	33275	23724		165947	99131	99131	66816	66816
1941	27801		26599	34423	9391		98214	70413	70413	27801	27801
1942	47208		40969	31957	8739		128873	81665	81665	47208	47208
1943	46348		85692	31362	15871		179273	132925	132925	46348	46348
1944	76147		88643	31135	8450		204375	128228	128228	76147	76147
1945	67998		64313	37289	7426		177026	109028	109028	67998	67998
1946	32280		68787	26430	12237		139734	107454	107454	32280	32280
1947	43459	21855	55407	25003	15667		161391	117932	96077	65314	65314
1948	10945	17320	50288	17060	10674		106287	95342	78022	28265	28265
1949	11519	19504	37868	12077	8952		89920	78401	58897	31023	31023
1950	13201	27121	47388	17025	17963		122698	109497	82376	40322	40322
1951	12713	27959	43906	15056	19269		118903	106190	78231	40672	40672
1952	7765	30485	40938	22687	25331		127206	119441	88956	38250	38250
1953	4969	27569	68145	16969	12051		129703	124734	97165	32538	32538
1954	8836	28816	62467	25736	24084		149939	141103	112287	37652	37652
1955	6851	30804	55618	15191	21150		129614	122763	91959	37655	37655
1956	12074	29614	58128	24069	14475		138360	126286	96672	41688	41688
1957	15624	37170	75896	20231	15010		163931	148307	111137	52794	52794
1958	29743	41143	92790	33937	12554		210167	180424	139281	70886	70886
1959	42005	36055	87845	23754	11680		201339	159334	123279	78060	78060
1960	38244	60713	83331	24384	24062		230734	192490	131777	98957	98957
1961	51212	59570	96105	22872	16528		246287	195075	135505	110782	110782
1962	28891	46381	77701	29643	23528		206144	177253	130872	75272	75272
1963	33796	51979	86859	17595	12397		202626	168830	116851	85775	85775
1964	36390	40897	108065	27636	22035		235023	198633	157736	77287	77287
1965	31732	47036	82354	35003	18797		214922	183190	136154	78768	78768
1966	32196	44154	66929	34153	20855		198287	166091	121937	76350	76350
1967	23480	45595	64210	31576	16635		181496	158016	112421	69075	69075
1968	24690	51828	46215	16671	14993		154397	129707	77879	76518	76518
1969	38254	40732	37782	13852	9350		139970	101716	60984	78986	78986
1970	28934	32306	37608	12989	14257		126094	97160	64854	61240	61240
1971	41691	48637	36728	16917	16534		160507	118816	70179	90328	90328
1972	33800	45275	34889	18007	19200		151171	117371	72096	79075	79075
1973	44768	18523	46984	27688	19570		157533	112765	94242	63291	63291
1974	34536	13894	36339	18717	14244		117730	83194	69300	48430	48430
1975	50260	12236	54819	19295	16714		153324	103064	90828	62496	62496
1976	51901	10140	43435	16548	12538		134562	82661	72521	62041	62041
1977	36149	9782	37064	17496	20745		121236	85087	75305	45931	45931
1978	43522	12915	34246	25974	23333	5619	145609	102087	83553	56437	62056
1979	18271	43876	39651	27532	24111	3800	157241	138970	91294	62147	65947
1980	35787	49593	59290	29433	17579	3120	194802	159015	106302	85380	88500
1981	35550	65330	61150	37054	15048	2384	216517	180967	113253	100880	103264
1982	31756	71889	45865	38082	16912	2442	206946	175190	100859	103645	106087
1983	32374	62843	33163	31163	21607	2688	183837	151463	85932	95217	97905
1984	27970	79606	42798	35032	17280	3319	206005	178035	95110	107576	110895
1985	25907	66491	61755	31535	18418	4333	208439	182532	111709	92398	96731
1986	39195	37960	57360	31737	14354	6757	187363	148168	103451	77155	83912
1987	36377	42234	44806	27795	17613	8870	177696	141319	90214	78611	87481
1988	40944	24005	52779	27420	13393	2990	161531	120587	93591	64949	67939
1989	29856	16179	52585	26783	11723	3835	140961	111105	91091	46035	49870
1990	27500	19253	52212	24723	19238	6503	149429	121929	96173	46753	53256
1991	20735	14383	44379	26150	22106	4834	132587	111852	92635	35118	39952
1992	26160	16579	41681	29968	11666	4196	130250	104090	83315	42739	46935
1993	24486	23905	47284	29995	13160	3664	142495	118009	90440	48391	52055
1994	22181	16151	49136	30390	14942	3782	136582	114401	94468	38332	42114
1995	19538	13928	41444	27270	19104	3996	125280	105742	87818	33466	37462
1996	14423	11251	34761	31117	19880	5304	116736	102313	85758	25674	30978
1997	15587	12291	34156	25863	21137	6780	115814	100227	81156	27878	34658
1998	16177	3263	32584	29564	20743	6594	108924	92747	82890	19440	26034
1999	11862	2563	31574	21747	18499	7846	94091	82229	71820	14425	22271
2000	11697	2866	23311	23701	19129	5081	85786	74089	66141	14563	19644
2001	16798	8398	32726	25619	13350	5066	101957	85159	71695	25196	30262
2002	15885	4562	33585	22969	10982	11689	99673	83787	67536	20448	32136
2003	16436	6383	33293	24635	8600	8484	97831	81395	66528	22819	31303
2004	18306	8573	29488	24370	8107	9176	98020	79714	61965	26879	36055
2005	19800	11663	25696	24619	7175	8391	97345	77545	57490	31464	39855
2006	15377	10856	30152	19061	5798	5779	87023	71646	55011	26233	32012
2007	13380	12402	41090	19142	4266	6188	96469	83088	64499	25782	31970
2008	13636	9409	45210	20858	4928	7423	101464	87828	70997	23045	30468
2009	11963	7226	36212	20838	4785	6716	87740	75777	61835	19189	25905
2010	13772	7409	40923	17623	5181	4662	89571	75798	63727	21181	25843
2011	8536	5621	37152	13685	6387	9023	80403	71867	57223	14157	23180
2012	13090	4154	19647	9045	2891	6031	54857	41768	31583	17244	23275

Div. IXa = IXa North + IXa Central-North + IXa Central-South + IXa South-Algarve + IXa South-Cadiz

Table 7.4.19.3 Sardine in Divisions VIIIc and IXa. Summary of stock assessment. CV: coefficient of variation.

Year	Recruits	CV R	Biomass 1+	CV Biomass 1+	SSB	Catch	F (2–5)	CV F(2–5)
	Thousand	%	Thousand tonnes	%	Thousand tonnes	Thousand tonnes	Year–1	%
1978	23382	14	343	16	328	146	0.46	16
1979	26854	14	388	15	358	157	0.43	16
1980	30787	14	490	13	456	195	0.42	14
1981	19297	17	594	13	554	217	0.40	14
1982	10774	23	608	13	583	207	0.38	14
1983	49046	11	520	15	506	184	0.37	15
1984	15414	18	688	13	624	206	0.36	15
1985	14463	18	743	12	723	208	0.30	11
1986	11927	19	648	13	629	187	0.33	14
1987	24451	13	563	14	548	178	0.35	16
1988	13546	17	546	13	514	162	0.35	17
1989	13037	17	545	13	528	141	0.30	18
1990	13457	17	498	13	481	149	0.37	17
1991	36980	10	488	14	465	133	0.32	16
1992	26458	11	778	12	699	130	0.23	15
1993	11741	14	921	11	875	142	0.24	15
1994	10068	13	828	11	797	137	0.21	13
1995	7311	14	837	12	811	125	0.20	13
1996	11409	11	561	12	548	117	0.26	13
1997	6788	13	491	13	466	116	0.34	13
1998	8929	12	400	13	383	109	0.38	14
1999	7289	14	364	14	345	94	0.36	14
2000	22573	10	305	15	296	86	0.32	15
2001	13487	12	447	13	408	102	0.31	15
2002	7390	14	502	12	462	100	0.26	15
2003	5609	17	449	13	436	98	0.25	14
2004	24684	9	427	14	417	98	0.27	14
2005	8931	12	493	13	386	97	0.27	15
2006	2991	17	541	11	518	87	0.23	14
2007	4877	13	491	12	481	96	0.24	12
2008	6166	13	370	13	364	101	0.35	14
2009	7762	14	287	15	276	87	0.39	17
2010	3980	18	241	16	228	90	0.50	18
2011	4361	24	224	18	224	80	0.51	22
2012	5769	24	185	23	175	55	0.34	26
2013	5446*		192					

*Geometric mean (2008–2012).

Annex 7.4.19 Proposed management plan

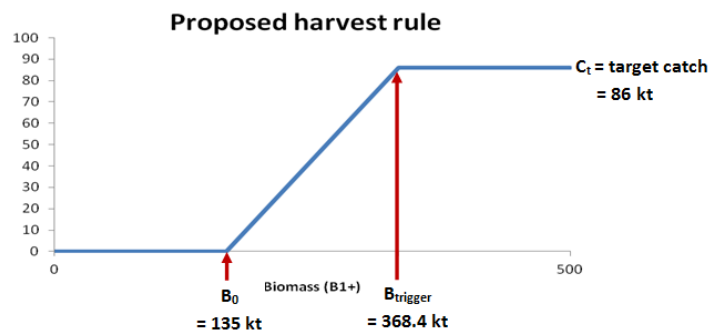
In the document referred to in the plan (*Plan de gestion sardina*), the harvest rule is stated as:

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

where

$$\begin{aligned} B_{1+} &= \text{the biomass of the ages 1 and older, in kt}^1 \\ C_{\text{MAX}} &= \text{maximum catch in kt} \\ B_{\text{trigger}} &= 368.4 \text{ kt (1.2 } B_{\text{lim}}) \\ d &= 0.36 \\ B_0 &= 135 \text{ kt} \\ C_t &= \text{target catch} = 86 \text{ kt.} \end{aligned}$$

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.