3 Bay of Biscay anchovy

3.1 ACOM advice, STECF advice and political decisions

In 2013 and 2014, the STECF evaluated a set of harvest control rules for the management of the Bay of Biscay anchovy stock (STECF, 2013, 2014). The European Commission, EU Member States and stakeholders chose the harvest control rule named G4 with a harvest rate of 0.45. ICES reviewed this harvest control rule in 2015 and concluded that it was precautionary (Annex 5 in ICES (2015)). Subsequently, in December 2015, ICES advised that "when the management plan is applied, catches in 2016 should be no more than 25 000 tonnes". In January 2016 the Council established the TAC in 2016 for the Bay of Biscay anchovy stock at 25 000 tonnes (Council Regulation No 72/2016).

In May 2016, based on the good state of the stock, the Southwest Waters Advisory Council (SWWAC) asked for a change in the harvest control rule used for management to rule G3 with a rate of exploitation of 0.4 and an increase of the fishing opportunities for 2016 from 25 000 to 33 000 t (SWWAC Advice 101 released on 05/05/2016). In June, the Council increased the 2016 TAC to 33 000 t (Council Regulation No 891/2016), on the basis that "The stock biomass and recruitment of anchovy in the Bay of Biscay are among the highest in the historical time-series, thus allowing a higher precautionary TAC in 2016 in accordance with the management strategy assessed by the Scientific, Technical and Economic Committee for Fisheries (STECF) in 2014".

This new harvest control rule has formed the basis of the ICES advice and the TAC subsequently established by the Council from 2017 onwards.

In January 2022 the Council established a provisional TAC of 24 000 tonnes for the Bay of Biscay anchovy stock for the period from 1 January to 30 June 2022 (Council Regulation No 2022/109). The final TAC was set in March at 33 000 tonnes (Council Regulation No 2022/515) from which 90% corresponded to Spain and 10% to France. However, these percentages might be modified due to bilateral agreements between countries.

According to the European Commission Regulation No. 185/2013, the deductions from the anchovy fishing quota allocated to Spain because of overfishing of mackerel quota in 2009 shall be applied from 2016 to 2023. This supposes a reduction of 3696 tonnes in the 2022 Spanish quota of Bay of Biscay anchovy.

Regarding the landing obligation regulation that aims at progressively eliminate discards in all Union fisheries, in October 2014 the European Commission established a discard plan for certain pelagic species in southwestern waters (No. 1394/2014). This includes an exemption from the landing obligation for anchovy caught in artisanal purse-seine fisheries based on evidence of high survivability and de minimis exemptions both in the pelagic trawl fishery and the purse-seine fishery from 2015 to 2017. These exemptions have been extended until 2023 through various regulations (Commission Delegated Regulation 2018/188, Commission Delegated Regulation 2020/2015, Commission Delegated Regulation 2020/2015).

3.2 The fishery in 2021 and 2022

3.2.1 Fishing fleets

Two fleets operate on anchovy in the Bay of Biscay: Spanish purse-seines (operating mainly during spring) and the French fleet constituted of purse-seiners (the Basque ones operating mainly in spring and the Breton ones in autumn) and pelagic trawlers (operating mainly during the second half of the year but with decreasing catches along years).

Since the reopening of the fishery in 2010 the number of fishing licences for anchovy in Spain have been oscillating between 149 and 175. For France, the number of purse-seiners able to catch anchovy since 2016 is around 28. The exact number of vessels is not fixed, due to important movements in this fleet. Most of them are based in Brittany. The number of Basque purse-seiners has decreased progressively and some of them joined the North of the Bay of Biscay in the last years. The real target species of these vessels is sardine, and anchovy is more opportunistic in summer or autumn.

The number of French pelagic trawlers decreased drastically during the closure of anchovy fishery (2005–2009) because they were targeting mainly anchovy and tuna. Currently around 12 pairs of trawlers (~24 vessels) are able to target anchovy. In the last years a shift has occurred on the French anchovy fishery. Pair pelagic trawlers mainly targeted tuna between July and October, and single pelagic trawlers didn't catch anchovy. In 2021, there were very low catches by the French fisheries. Only 64 tons were caught by the French fleet in 2021, 83% by purse-seiners and 17% by pelagic trawlers. According to the very low price (anchovies were too small for the market), vessels have dedicated their fishing effort to other species, particularly tuna and sardine.

A more complete description of the fisheries is available in the stock annex.

3.2.2 Catches

Historical catches are presented in Table 3.2.2.1 and Figure 3.2.2.1. Total catches in 2021 were 27 982 tonnes, from which 27 918 corresponded to Spain and 64 to France. In 2021, the French landings of anchovy drastically decreased because vessels found only small or medium-size individuals, and the price was very low, so vessels stopped targeting anchovy. From the Spanish catches, 1 tonne corresponded to anchovy used as live bait for tuna fishing. Discards are less than 1% of the total catch and they are considered negligible for this stock.

The series of monthly catches are shown in Table 3.2.2.2. In 2021, most of the catches occurred between March and May, where the bulk of the Spanish fishery occur. Although catches were recorded in all the months.

The quarterly catches by division in 2021 are given in Table 3.2.2.3. Most of the catches took place in the second quarter (58.0%), followed by the first quarter (26.4%) and with lower catches in third and fourth quarters (15.5% and 0.2% respectively). The major fishing activity of the Spanish fleet occurred in the second quarter (58.1%) followed by the first quarter (26.5%), whereas the French fleet operated mainly in the third and fourth quarters (51.6 and 41.9% respectively). Regarding fishing areas, most of the Spanish catches in the first and second semesters corresponded to ICES division 8.c East, whereas in the third semester catches occurred in division 8.c East and West. All the French catches corresponded to ICES divisions 8.a and 8.b.

In previous years, non-negligible catches originated in divisions 7.h and 7.e (statistical rectangles 25E5 and 25E4) were reallocated to Division 8.a due to their very concentrated location at the boundary between 8.a, 7.h and 7.e in the same period. In 2021 only 6.6 tons have been declared in 25E5 and 25E4 and these catches have been reallocated to 8.a.

Table 3.2.2.1: Bay of Biscay anchovy: Annual catches (in tonnes) as estimated by the Working Group members.

COUNTRY	FRANCE	SPAIN	SPAIN	UNALLOCATED	OTHER COUNTRIES	INTERNATIONAL
YEAR	VIIIab	VIIIbc	Live Bait Catches			VIII
1960	1 085	57 000	n/a			58 085
1961	1 494	74 000	n/a			75 494
1962	1 123	58 000	n/a			59 123
1963	652	48 000	n/a			48 652
1964	1 973	75 000	n/a			76 973
1965	2 615	81 000	n/a			83 615
1966	839	47 519	n/a			48 358
1967	1 812	39 363	n/a			41 175
1968	1 190	38 429	n/a			39 619
1969	2 991	33 092	n/a			36 083
1970	3 665	19 820	n/a			23 485
1971	4 825	23 787	n/a			28 612
1972	6 150	26 917	n/a			33 067
1973	4 395	23 614	n/a			28 009
1974	3 835	27 282	n/a			31 117
1975	2 913	23 389	n/a			26 302
1976	1 095	36 166	n/a			37 261
1977	3 807	44 384	n/a			48 191
1978	3 683	41 536	n/a			45 219
1979	1 349	25 000	n/a			26 349
1980	1 564	20 538	n/a			22 102
1981	1 021	9 794	n/a			10 815
1982	381	4 610	n/a			4 991
1983	1 911	12 242	n/a			14 153
1984	1 711	33 468	n/a			35 179
1985	3 005	8 481	n/a			11 486
1986	2 311	5 612	n/a			7 923
1987	4 899	9 863	546			15 308
1988	6 822	8 266	493			15 581
1989	2 255	8 174	185			10 614
1990	10 598	23 258	416			34 272
1991	9 708	9 573	353			19 634
1992	15 217	22 468	200			37 885
1993	20 914	19 173	306			40 393
1994	16 934	17 554	143			34 631
1995	10 892	18 950	273			30 115
1996	15 238	18 937	198			34 373
1997	12 020	9 939	378			22 337
1998	22 987	8 455	176			31 617
1999	13 649	13 145	465			27 259
2000	17 765	19 230	n/a			36 994
2001	17 097	23 052	n/a			40 149
2002	10 988	6 519	n/a			17 507
2003	7 593	3 002	n/a			10 595
2004	8 781	7 580	n/a			16 361
2005	952	176	0			1 128
2006	913	840	0			1 753
2007**	140	1	0			141
2008	0	0	0			0
2009	0	0	0			0
2010	4 573	5 744	n/a			10 317
2011	3 615	10 916	n/a			14 530
2012	5 975	7 896	n/a	531		14 402
2013	2 392	11 801	n/a			14 192
2014	4 012	16 114	n/a			20 126
2015	4 261	23 992	n/a		5	28 258
2016	2 300	18 060	310			20 670
2017	3 153	22 955	332	9		26 450
2018	3 151	27 607	15			30 773
2019	2 048	24 802	7			26 857
2020	138	25 661	24			25 823
2021	64	27 917	1			27 982
2022 (Up to end of Octo	264	24 619				24 883
AVERAGE (1960-2004)	6 394	26 337				32 824
AVERAGE (2010-2021)	2 973	18 622				21 698

** : Experimental fishery

Table 3.2.2.2: Bay of Biscay anchovy: Monthly catches by country (Subarea 8; without live bait catches).

YEAR\MONTH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
1987	0	0	454	5246	5237	782	229	636	707	812	309	352	14763
1988	6	0	42	1657	4317	3979	584	1253	2423	445	136	246	15088
1989	706	73	36	588	4943	806	132	566	186	472	1619	301	10429
1990	80	6	2101	2658	11459	3083	1471	5132	5553	1570	652	92	33856
1991	1418	2175	626	2036	6913	1858	215	479	1621	822	238	882	19282
1992	2422	1864	1282	4241	13125	3448	719	1488	3291	3228	2489	89	37685
1993	1738	1864	3362	3260	7906	5927	2110	2979	4254	3342	3273	70	40086
1994	1972	1917	1591	5741	4761	7231	1796	2306	3382	3295	421	74	34487
1995	620	958	842	5967	12329	2764	439	1098	2155	1382	903	387	29843
1996	1132	647	752	1834	9763	6897	2449	2675	3617	2818	1575	17	34176
1997	2278	688	105	2782	2762	1985	1895	2400	3578	2381	921	185	21961
1998	1558	2363	1276	371	4839	2510	3943	5039	4298	2640	2500	104	31442
1999	2088	1360	626	4681	4282	2345	2052	948	4049	2130	2207	27	26794
2000	2219	948	925	1957	11922	4565	3148	3063	4043	2995	1210	0	36994
2001	960	565	479	2249	14428	4413	2514	3403	4435	3850	2852	1	40149
2002	1436	2561	1573	915	2506	2098	673	1034	2970	1152	578	0	17497
2003	39	2	0	1740	890	1403	294	2297	1602	1322	986	20	10595
2004	210	106	3	2377	3247	3241	902	2017	2886	557	813	2	16360
2005	363	17	35	4	183	525	0	0	0	0	0	0	1127
2006	1	0	33	124	630	870	95	0	0	0	0	0	1753
2007	0	0	0	39	57	45	0	0	0	0	0	0	141
2008	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	299	1324	2955	1532	75	632	2425	863	213	0	10317
2011	0	0	1586	4483	4492	351	2	176	815	1319	1258	47	14530
2012	0	0	68	1060	5663	1809	354	868	2352	1940	288	0	14402
2013	0	3	272	2226	5166	3269	312	316	1375	1069	185	1	14192
2014	0	0	0	3739	8604	1950	180	2081	2025	1188	357	0	20125
2015	0	0	1011	6089	4482	7833	505	1305	6331	590	106	0	28253
2016	41	11	1432	8746	3811	1339	657	1760	687	58	1758	62	20360
2017	21	16	1915	5854	9839	5118	559	937	1307	289	238	15	26108
2018	10	10	1498	8895	12956	2131	1736	1831	1166	508	9	8	30758
2019	7	8	2800	9743	8924	717	1863	1295	866	452	171	4	26850
2020	19	20	220	4090	9896	626	2670	3878	3729	224	405	24	25800
2021	1	1	7384	8512	7209	499	2632	1680	18	32	7	6	27981

Table 3.2.2.3: Bay of Biscay anchovy: Catches in the Bay of Biscay by country and divisions in 2021 (without live bait catches).

		QUARTERS				CATCH (t)	
COUNTRIES	DIVISIONS	1	2	3	4	ANNUAL	%
SPAIN	8abd	70	0	5	18	93	0.3%
	8cE	6690	15620	2362	0	24672	88.4%
	8cW	626	596	1930	0	3152	11.3%
	TOTAL	7386	16216	4297	18	27917	100.0%
	%	26.5%	58.1%	15.4%	0.1%	100.0%	
FRANCE	8abd	0	4	33	27	64	100.0%
	8cE					0	0.0%
	8cW					0	0.0%
	TOTAL	0	4	33	27	64	100.0%
	%	0.0%	6.5%	51.6%	41.9%	100.0%	
INTERNATIONAL	8abd	70	4	38	45	158	0.6%
	8cE	6690	15620	2362	0	24672	88.2%
	8cW	626	596	1930	0	3152	11.3%
	TOTAL	7386	16220	4330	45	27981	100.0%
	%	26.4%	58.0%	15.5%	0.2%	100.0%	

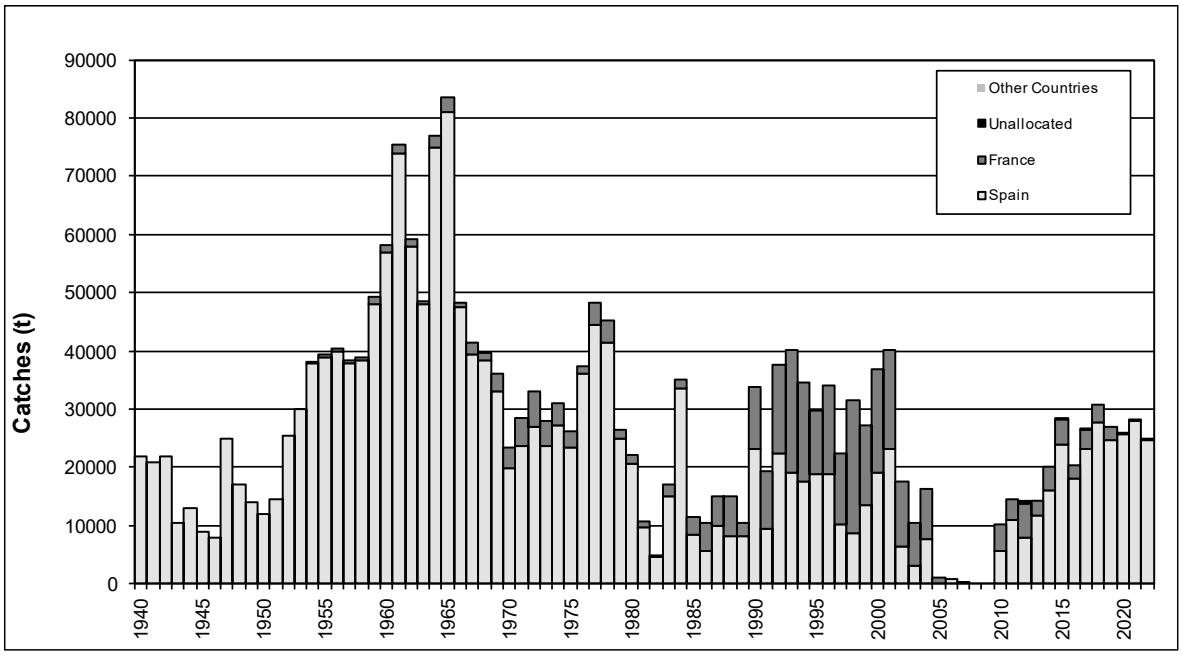


Figure 3.2.2.1: Bay of Biscay anchovy: Historical evolution of catches in Subarea 8 by countries. 2022 data are preliminary.

3.2.3 Catch numbers-at-age and length

In 2021 there were no length and age samples available from the French fishery due to the low level of catches. Catch numbers-at-age of the French catches were estimated assuming that the percentage of numbers-at-age per quarter were equal to the percentage of numbers-at-age of the Spanish catches in divisions 8.a and 8.b, where the French fishery occurs.

Catch numbers-at-age by quarter in 2021 for Spain and France are given in Table 3.2.3.1. Age 1 individuals were predominant in the second and third quarters representing the 51.6% and 70.5% of total catches each quarter respectively while age 2 individuals were predominant in the first quarter with a 48.5% of total catches in that quarter. Age 0 individuals appeared in third and fourth quarters, representing the 0.4% and 88.2% of the total of each quarter respectively.

Table 3.2.3.2 records the age composition of the international catches since 1987, on a half-yearly basis. In 2021, the one-year-old anchovies dominated in the catches in both semesters, representing the 51.1% in the first semester and the 69.6% in the second semester.

See the stock annex for methodological issues.

Table 3.2.3.1: Bay of Biscay anchovy: Catch-at-age in thousands for 2021 by quarter (without the catches from the live bait tuna fishing boats).

	QUARTERS	1	2	3	4	Annual total
	AGE	VIIIabc	VIIIabc	VIIIabc	VIIIabc	VIIIabc
TOTAL Sub-area 8	0	0	0	1 001	2 743	3 744
	1	173 121	383 130	148 122	250	704 623
	2	178 205	336 469	60 662	117	575 453
	3	15 723	21 690	167	0	37 580
	4	311	551	0	0	862
	5	0	0	0	0	0
	TOTAL(n)	367 360	741 839	209 951	3 111	1 322 261
	W MED.	20.10	21.86	20.62	14.45	21.16
	CATCH. (t)	7386	16220	4330	45	27981
	SOP	7385	16219	4330	45	27979
	VAR. %	99.99%	99.99%	100.01%	100.02%	99.99%

Table 3.2.3.2: Bay of Biscay anchovy: Catches-at-age of anchovy of the fishery in the Bay of Biscay on half-year basis (including live bait catches up to 1999 and from 2016 onwards). Units: Thousands.

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	38 140	0	150 338	0	180 085	0	16 984	0	86 647	0	38 434	0	63 499	0	59 934	0	49 771
1	218 670	120 098	318 181	190 113	152 612	27 085	847 627	517 690	323 877	116 290	1 001 551	440 134	794 055	611 047	494 610	355 663	522 361	189 081
2	157 665	13 534	92 621	13 334	123 683	10 771	59 482	75 999	310 620	12 581	193 137	31 446	439 655	91 977	493 437	54 867	282 301	21 771
3	31 362	1 664	9 954	596	18 096	1 986	8 175	4 999	29 179	61	16 960	1	5 336	0	61 667	1 325	76 525	90
4	14 831	58	1 356	0	54	0	0	0	0	0	0	0	0	0	0	0	4 096	7
5	8 920	0	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	431 448	173 494	398 971	529 130	294 445	219 927	915 283	615 671	663 677	215 579	1 211 647	510 015	1 239 046	766 523	1 049 714	471 789	885 283	260 719

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	109 173	0	133 232	0	4 075	0	54 357	0	5 298	0	749	0	267	0	7 530	0	11 184
1	683 009	456 164	471 370	439 888	443 818	598 139	220 067	243 306	559 934	396 961	460 346	507 678	103 210	129 392	50 327	133 083	254 504	252 887
2	233 095	53 156	138 183	40 014	128 854	123 225	380 012	142 904	268 354	64 712	374 424	98 117	217 218	77 128	44 546	87 142	85 679	20 072
3	31 092	499	5 580	195	5 596	3 398	17 761	525	84 437	18 613	19 698	5 095	37 886	3 045	34 133	11 459	12 444	1 153
4	2 213	42	0	0	155	0	108	0	0	0	4 948	0	76	0	887	1 152	4 598	16
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total #	949 408	619 034	615 133	613 329	578 423	728 837	617 948	441 092	912 725	485 584	859 417	611 639	358 390	209 832	129 893	240 366	357 225	285 312

YEAR	2005		2006		2007		2008		2009		2010		2011		2012		2013	
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
0	0	0	0	0	0	0	0	0	0	0	0	16 287	0	4 656	0	3 761	0	10 343
1	7 818	0	48 718	3 894	0	0	0	0	0	0	125 198	135 570	164 061	159 675	56 013	167 935	84 863	81 392
2	32 911	0	17 172	991	0	0	0	0	0	0	77 342	13 864	214 454	11 080	254 863	69 396	223 958	45 177
3	6 935	0	6 465	320	0	0	0	0	0	0	10 897	815	7 161	503	5 055	1 115	87 493	5 559
4	586	0	49	2	0	0	0	0	0	0	1 711	189	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Total #	48 250	0	72 405	5 207	0	0	0	0	0	0	215 149	166 725	385 677	175 914	315 932	242 207	396 315	142 471

YEAR	2014		2015		2016		2017		2018		2019		2020		2021			
Age	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half		
0	0	37 068	0	443	0	74 571	0	23 725	0	1 770	0	373	0	62 514	0	3 744		
1	228 729	187 159	560 920	251 508	261 072	136 044	469 609	82 487	682 918	178 348	305 170	87 158	527 627	544 756	556 251	148 372		
2	336 224	12 181	357 044	128 579	363 465	58 740	425 906	48 549	399 932	37 574	543 415	77 355	235 637	51 618	514 673	60 779		
3	53 703	3 035	27 236	6 914	45 212	2 287	92 731	7 660	39 483	1 210	52 579	6 673	30 559	1 601	37 413	167		
4	4 271	0	173	0	231	0	2 339	0	292	0	440	0	171	3	862	0		
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Total #	622 927	239 443	945 373	387 443	669 979	271 642	990 585	162 421	1 122 624	218 902	901 605	171 559	793 994	660 492	1 109 199	213 062		

3.2.4 Weights and lengths-at-age in the catch

The series of mean weight-at-age in the fishery by half year, from 1987 to 2021, is shown in Table 3.2.4.1. See the stock annex for methodological issues.

Table 3.2.4.1: Bay of Biscay anchovy: Mean weight-at-age (grammes) in the international catches on half-year basis. Units: grammes.

INTERNATIONAL

YEAR	1987		1988		1989		1990		1991		1992		1993		1994		1995	
Sources	Anon. (1989 & 1991)		Anon. (1989)		Anon. (1991)		Anon. (1991)		Anon. (1992)		Anon. (1993)		Anon. (1995)		Anon. (1996)		Anon. (1997)	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	11.7	na	5.1	na	12.7	na	7.4	na	14.4	na	12.6	na	12.3	na	14.7	na	15.1
1	21.0	21.9	20.8	23.6	19.5	24.9	20.6	23.8	18.5	25.1	19.6	23.0	15.5	20.9	16.8	25.3	22.5	26.9
2	32.0	34.2	30.3	30.4	28.5	35.2	28.5	27.7	25.2	29.0	30.9	28.8	27.0	29.4	26.8	28.1	32.3	31.3
3	37.7	39.2	34.5	44.5	29.7	42.7	44.8	40.8	28.2	39.0	37.7	27.4	30.5	na	30.7	30.0	36.4	36.4
4	41.0	40.0	37.6	na	27.1	na	na	na	na	na	na	na	na	na	na	na	37.3	29.1
5	42.0	0.0	48.5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	27.3	20.8	24.6	10.7	23.9	15.6	21.3	24.0	22.1	21.1	21.7	22.5	19.6	21.2	22.3	24.3	26.9	25.0

YEAR	1996		1997		1998		1999		2000		2001		2002		2003		2004	
Sources:	Anon. (1998)		Anon. (1999)		Anon (2000)		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	12.0	na	11.6	na	10.2	na	15.7	na	19.3	na	14.3	na	9.5	na	15.4	na	15.5
1	19.1	23.2	14.4	20.3	21.8	23.7	17.1	27.0	21.7	28.2	22.7	27.5	25.0	28.8	21.0	25.4	21.7	24.9
2	29.3	27.7	26.9	30.1	24.3	27.7	29.8	33.5	29.1	33.0	31.8	31.1	31.6	33.4	36.2	29.5	35.7	33.5
3	35.0	35.7	32.0	29.7	31.9	28.7	34.7	38.9	32.8	36.9	36.3	38.6	42.8	36.5	40.3	36.4	39.3	40.7
4	46.1	39.7	na	na	31.9	na	55.9	na	na	na	40.7	na	45.6	na	36.9	37.9	44.0	42.8
5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Total	22.2	21.6	17.3	19.1	22.5	24.3	25.4	27.7	24.9	29.0	27.1	28.2	30.9	30.6	31.4	27.1	26.0	25.2

YEAR	2005		2006		2007		2008		2009		2010		2011		2012		2013	
Sources:	WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data	
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Age 0	na	na	na	na	na	na	na	na	na	na	na	14.4	na	8.9	na	12.6	na	12.0
1	19.3	na	20.3	17.8	na	na	na	na	na	na	25.0	25.9	22.5	20.5	16.7	22.3	20.8	21.9
2	24.5	na	27.7	19.7	na	na	na	na	na	na	32.1	27.4	32.4	27.3	28.9	25.9	28.8	28.7
3	27.6	na	31.3	19.7	na	na	na	na	na	na	43.7	43.2	36.4	34.8	38.7	26.5	31.5	31.6
4	24.5	na	37.3	34.3	na	na	na	na	na	na	43.0	44.4	na	na	na	na	na	na
5	na	na	na	na	na	na	na	na	na	na	55.7	na	na	na	na	na	na	na
Total	24.1	na	23.0	18.2	na	na	na	na	na	na	28.6	25.0	28.3	20.6	26.9	23.2	27.7	23.7

YEAR	2014		2015		2016		2017		2018		2019		2020		2021			
Sources:	WG data		WG data		WG data		WG data		WG data		WG data		WG data		WG data			
Periods	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half		
Age 0	na	16.1	0.0	9.4	na	14.3	na	8.5	na	12.5	na	11.9	na	9.3	na	13.7		
1	18.3	26.3	17.0	19.9	19.3	20.0	19.8	23.3	20.7	22.1	20.2	21.0	16.5	16.8	19.9	20.0		
2	25.1	33.3	25.5	28.1	24.5	24.1	25.1	26.8	25.0	28.3	27.4	26.0	21.6	21.9	22.3	22.2		
3	28.9	45.8	28.7	38.5	31.7	32.8	28.8	30.7	33.7	28.8	32.2	33.6	28.4	28.7	27.6	36.3		
4	26.0	na	25.5	na	32.6	na	29.9	na	27.8	na	27.7	na	29.3	29.4	32.4	0.0		
5	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na		
Total	22.9	25.3	20.5	22.9	23.0	19.4	23.0	22.6	22.7	23.2	25.3	23.7	18.5	16.5	21.3	20.5		

3.2.5 Preliminary fishery data in 2022

The provisional catches during the first semester of 2022 were 21 163 t, from which 21 149 t corresponded to Spain and 14 t to France. 23% of the catches (in mass) during the first semester were age 1. During the second semester provisional catches until the end of October were 3721 t, from which 3470 t corresponded to Spain and 250 t to France. Overall, the total catches in 2022 from France were very low (264 t).

It must be emphasised that 2022 fishery data are preliminary. No age structure was available yet for the French catches in the first half of the year, and they were assumed to have the same age composition as the Spanish catches in June, when most of the French catches of the first semester take place. For the assessment, 2022 November and December catches were assumed to be 612 t (2.4% of the total annual catch which is the average percentage of the total catches in November and December in 2010–2021, after the reopening of the fishery). Therefore, the total catch in November and December was estimated at 612 t, resulting in 4333 tonnes for the second semester 2022.

3.3 Fishery-independent data

3.3.1 BIOMAN DEPM survey 2022

All the methodology for the survey and the estimates performance are described in detail in the stock annex. A detailed report of the 2022 survey and the corresponding results is attached as a working document in ICES WGACEGG 2022 in annex 3 (Santos Mokoroa. M et al. BIOMAN 2022).

3.3.1.1 Survey description

The 2022 anchovy DEPM survey was carried out in the Bay of Biscay from the 5th to the 27th of May, covering the whole spawning area of the species, following the procedures described in the stock annex. Two research vessels were used at the same time and place: the RV Vizconde de Eza to collect the plankton samples and the RV Emma Bardán to collect the adult samples. Some specifications of the sampling are given in Table 3.3.1.1.1.

Total number of PairoVET samples (vertical sampling) obtained was 757. From those, 596 had anchovy eggs (79%) with an average of 310 eggs m-2 per station in the positive stations, and a maximum of 3,380 eggs m-2 in a station. A total of 23,523 anchovy eggs were encountered and classified in the PairoVET stations. The number of CUFES samples (horizontal sampling) obtained was 1,700. Frome those 1,302 (77%) stations had anchovy eggs with an average of 41 eggs m-3 per station and a maximum of 677 eggs m-3 in a station.

This year 17% of the anchovy eggs were found in the Cantabrian Sea, where the western spawning limit was found at 6º20'W. There were eggs all over the platform up to the northern limit of ICES Subarea 8. The eggs passed the 200 m depth isoline almost in all the area except from 47 º 30' to 48ºN that arrived until 180m approximately (Figure 3.3.1.1.1). The total area covered was 115,118Km2 and the spawning area for anchovy was 92,290Km2, representing 80% of the total.

Regarding the adult samples, 47 pelagic trawls were selected for the analysis. The spatial distribution of the samples and their species composition is shown in Figure 3.3.1.1.2. The most abundant species in the trawls were anchovy, sardine, mackerel and horse mackerel. Anchovy adults were found in the same places where the anchovy eggs were found. This year the biggest anchovies were found at

the West of the Cantabrian Sea as well as in the Northwest of the French platform. The smallest anchovies were found around the mouth of the Gironde River and at the East of the Cantabrian Sea and Southeast of the French platform. Spatial distribution of mean length and mean weight is shown in Figure 3.3.1.1.3.

This year the mean sea surface temperature of the survey(16.7°C) was higher than last year (14.0 °C), the minimum was 12.97°C and the maximum 19.3°C. The mean sea surface salinity (34.8) was lower than last year (35.4) with a minimum of 30.5 and a maximum of 36.8. Figure 3.3.1.1.4 shows the maps of sea surface salinity and temperature found during the survey. There were atypical weather conditions this year during May, it was the warmest of this century and the second driest in the historical series. in addition, from the surface buoys results, a NE-SW drifting trend was observed, which is contrary to the typical NW-SE drift. The buoys reflected the anticyclonic conditions that prevailed in March-April-May.

3.3.1.2 Total daily egg production estimate

The estimates of daily egg production(P_0), daily egg mortality rates (z) and total egg production (P_{tot}) are given in Table 3.3.1.2.1 and the mortality curve model adjusted is shown in Figure 3.3.1.2.1. Total egg production in 2022 was estimated at 1.61 E+13 with a CV of 0.0824, higher than last year and the second highest of the historical series since 1987. Figure 3.3.1.2.2 shows the historical series of P_0, z, spawning area and P_{tot}.

3.3.1.3 Daily fecundity and total biomass

To estimate the total Biomass following the DEPM a daily fecundity (*DF*) estimate is necessary. To estimate the *DF* the sex ratio (*R*), the female mean weight (W_f), the batch fecundity (*F*) and the spawning fraction (*S*) estimates are required. The anchovy adults from the survey were used to estimate those parameters. This year there were no problems in estimating these parameters. The results of all these parameters for 2022 are showed in table (Table 3.3.1.3.1) and the historical series in Figure 3.3.1.3.1. The final total biomass obtained as the quotient between P_{tot} and *DF* was 198,741t with a CV of 0.1057, lower than the last two years and the third highest of the historical series.

3.3.1.4 Population at age

In order to estimate the numbers-at-age, the age readings based on 3,002 otoliths from 47 samples, well distributed over the spawning area, were available. Six strata were defined based on the egg abundance, the adult distribution and the mean size, mean weight and age of adult anchovy: West Cantabrian (WC), Central Cantabrian (CC), East Cantabrian (EC), East (E), Garonne (G) and North (N; Figure 3.3.1.4.1). 56% of the anchovy in numbers were estimated as individuals of age 1 (42% in mass), 39% of the individuals in numbers were of age 2 (50% in mass) and 4% of the individuals in numbers were of age 3 (8% in mass; Table 3.3.1.4.1). This was a medium year recruitment in relation to the historical series. The anchovy age composition by haul 2022 is showed in Figure 3.3.1.4.2. The time-series of the numbers-at-age is shown in Figure 3.3.1.4.3. The historical series of the total biomass at age and weight at age are showed in Figure 3.3.1.4.4.

Table 3.3.1.1.1: Bay of Biscay anchovy: Details of the DEPM survey BIOMAN 2022.

Parameters	Anchovy DEPM survey
Surveyed area	(43º19' to 47º53'N and 6º 20' to 1º14' W)
RV	*Vizconde de Eza* and *Emma Bardán*
Date	05-27/05/2022
Eggs	RV VIZCONDE DE EZA
PairoVET stations (plankton)	757
% st with anchovy eggs	79%
Anchovy egg average by st	310 eggs/m^2
Max. anchovy eggs in a St	3,380 eggs/m^2
Total ANE egg collected&staged	23,523 eggs
North spawning limit	47º'52'N
West spawning limit (Cantabrian)	6º20'W
Total area surveyed	115,118 Km^2
Spawning area for anchovy	92,290 Km^2
CUFES stations (plankton)	1,700
Adults	RV EMMA BARDAN& Purse-seines
Pelagic trawls Emma Bardán	42+4 from RV Thalassa
Pelagic trawls with anchovy	46
Selected for analysis	46
Hauls from purse-seines	1
Total adult samples for analysis	47

Table 3.3.1.2.1: Bay of Biscay anchovy: 2022 estimates for daily egg production (P0; egg/m2/day), daily mortality rates (z) and total daily egg production (Ptot)(eggs/day) with its Standard error (S.e) and Coefficient of variation (CV).

Parameter	Value	S.e.	CV
P_0	174.37	14.38	0.0824
z	0.32	0.051	0.1615
Ptot	1.61E+13	1.3E+12	0.0824

Table 3.3.1.3.1: Bay of Biscay anchovy: estimates of adult parameters for applying the DEPM for anchovy in the Bay of Biscay (ICES 8abcd): sex ratio (R) (% of females), spawning fraction (S) (% of females spawning per day), batch fecundity (*F*) (eggs/batch/mature female), female mean weight (Wf)(g) and daily fecundity (*DF*) (eggs/g/day) for the application of the DEPM and total biomass (*B*)(tons) with their standard error (S.e) and coefficient of variation (CV). Total egg production (P_{tot})(eggs) estimate is showed as well.

Parameter	estimate	S.e.	CV
P_{tot} (eggs)	1.61E+13	1.33E+12	0.0824
R'(% of females)	0.53	0.0048	0.0090
S (% fem. spawning/day)	0.34	0.0143	0.0424
F (eggs/batch/mature fem.)	7,340	591	0.0805
W_f (g)	16.18	0.92	0.0569
DF (eggs/g/day)	81.36	5.38	0.0661
B (tons)	198,741	21,008	0.1057

Table: 3.3.1.4.1: Bay of Biscay anchovy: Anchovy total biomass (B), percentage at age, numbers-at-age, mean weight at age, mean length-at-age, total biomass at age in mass and percentage at age in mass with the corresponding standard error (S.e.) and coefficient of variation (CV) from BIOMAN 2022. As well as the biological features mean weight at age (g) and mean length-at-age (mm).

Parameter	estimate	S.e.	CV
BIOMASS (tons)	198,741	21,008	0.1057
total mean Weight (g)	13.4	0.71	0.0528
Population (millions)	14,835	1903	0.1283
Percentage at age 1	0.56	0.047	0.0838
Percentage at age 2	0.39	0.040	0.1025
Percentage at age 3+	0.04	0.010	0.2189
Numbers-at-age 1	8,396	1,497.2	0.1783
Numbers-at-age 2	5,780	758.6	0.1313
Numbers-at-age 3+	660	139.6	0.2117
Percent. at age 1 in mass	0.42	0.048	0.1144
Percent. at age 2 in mass	0.50	0.038	0.0760

Parameter	estimate	S.e.	CV
Percent. at age 3+ in mass	0.08	0.015	0.1886
Biomass at age 1 (tons)	84,315	14,440	0.1713
Biomass at age 2 (tons)	98,389	11,558	0.1175
Biomass at age 3+ (tons)	16,037	3,193	0.1991

Biological Features	estimate	S.e.	CV
Weight at age 1 (g)	10.03	0.32	0.0314
Weight at age 2 (g)	17.04	0.69	0.0407
Weight at age 3 (g)	24.15	0.89	0.0369
Length-at-age 1 (mm)	122.1	1.13	0.0092
Length-at-age 2 (mm)	141.7	1.52	0.0107
Length-at-age 3 (mm)	157.3	1.81	0.0115

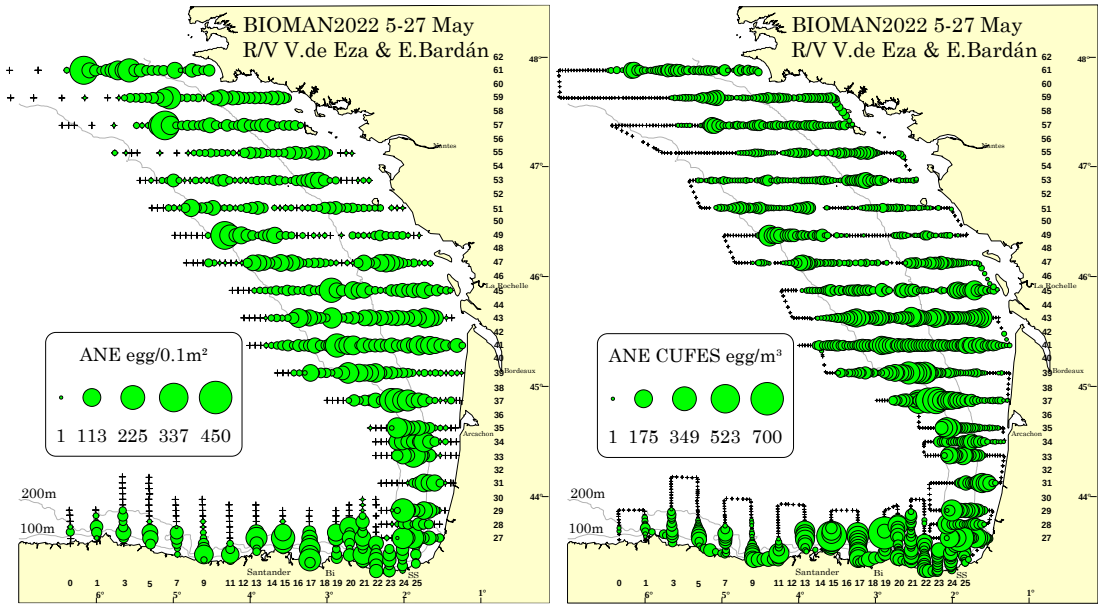


Figure 3.3.1.1.1: Bay of Biscay anchovy: Spatial distribution and abundance of anchovy egg obtained with PairoVET (vertical sampling net) (eggs per 0.1 m2) on the left and CUFES (horizontal sampling net; egg/m³) on the right obtained during the DEPM survey BIOMAN2022.

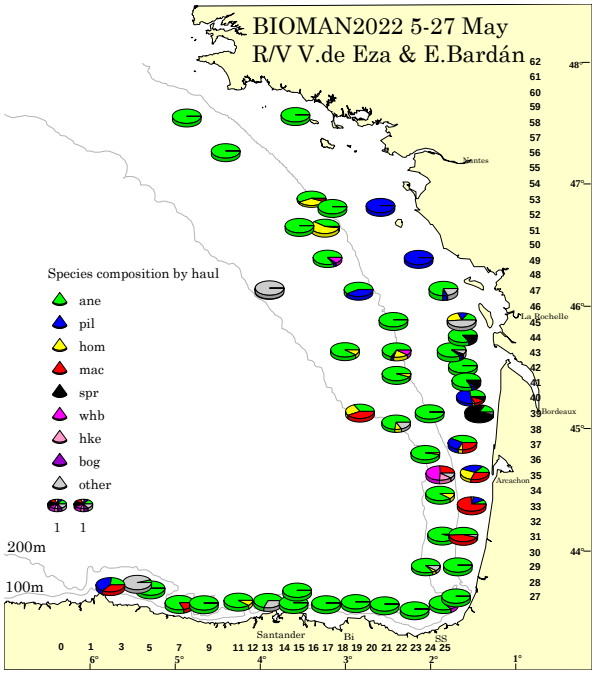


Figure 3.3.1.1.2: Bay of Biscay anchovy: Species composition of the 47 hauls obtained for the anchovy adult parameters analysis for the application of the DEPM.

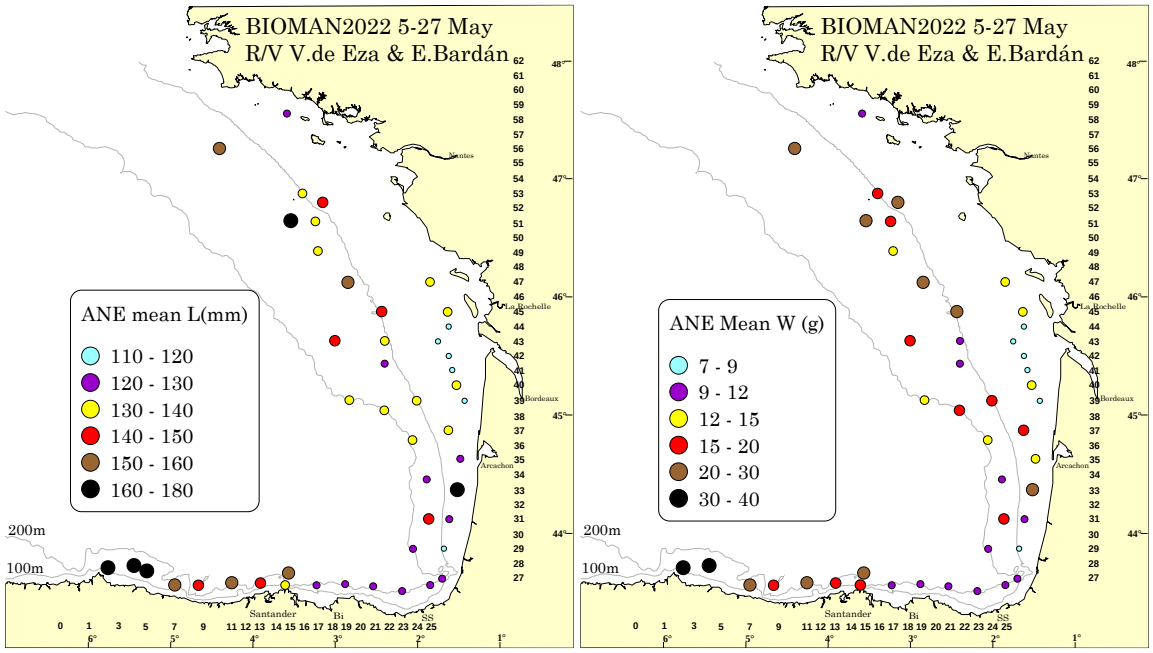


Figure 3.3.1.1.3: Bay of Biscay anchovy: Spatial distribution of anchovy mean length (left) and mean weight (right) (males and females) by haul during BIOMAN2022.

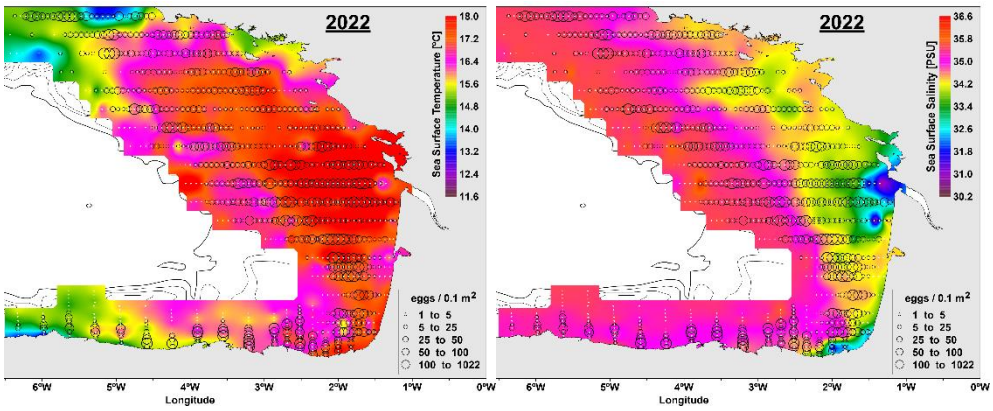


Figure 3.3.1.1.4: Bay of Biscay anchovy: Spatial distribution of sea surface temperature (left) and sea surface salinity (right) during BIOMAN 2022 with the anchovy egg abundances spatial distribution.

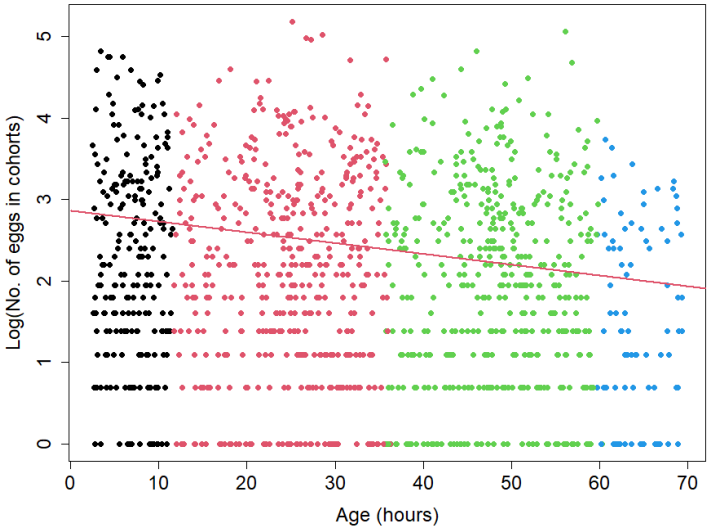


Figure 3.3.1.2.1: Bay of Biscay anchovy: Exponential mortality model in log scale adjusted applying a GLM to the data obtained in the Bayesian egg ageing (spawning peak at 23:00h GMT). The red line is the adjusted line. The coloured dots represent the different cohorts.

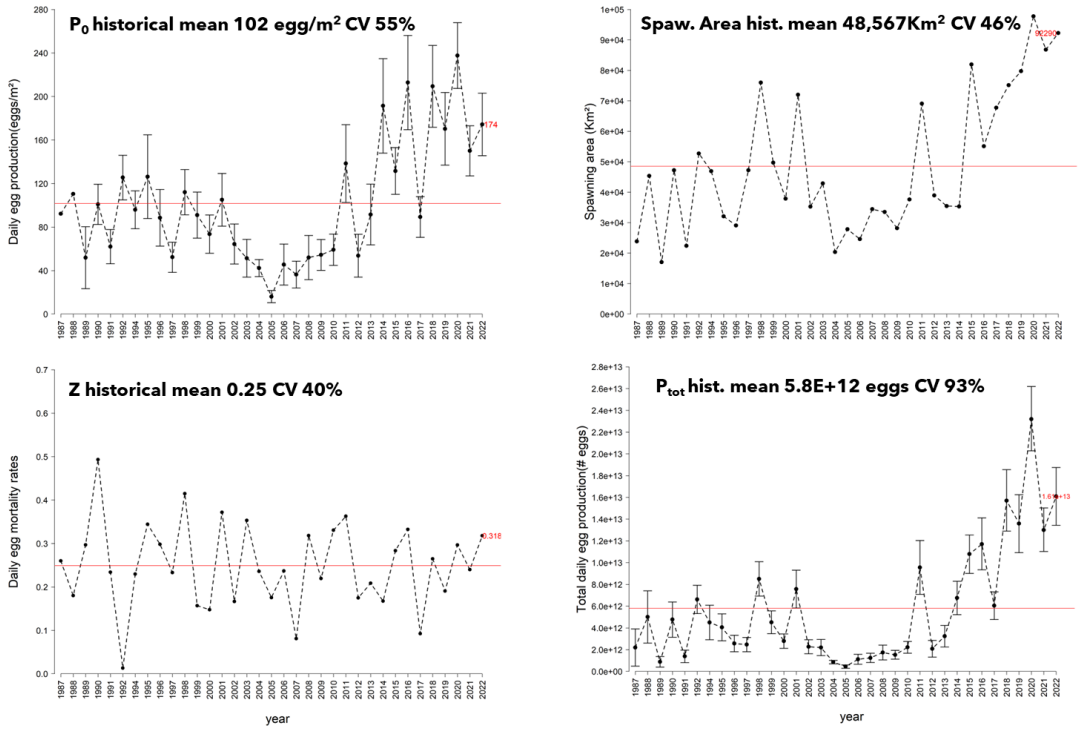


Figure 3.3.1.2.2: Bay of Biscay anchovy: historical series including 2022 estimates for daily egg production (P0) (egg/m2/day), spawning area (Km2), daily mortality rates (z) and total daily egg production (Ptot)(eggs/day) for anchovy in the Bay of Biscay. The red line is the historical mean, the values showed in bold are the historical mean and the CV (coefficient of variation) over time for each parameter.

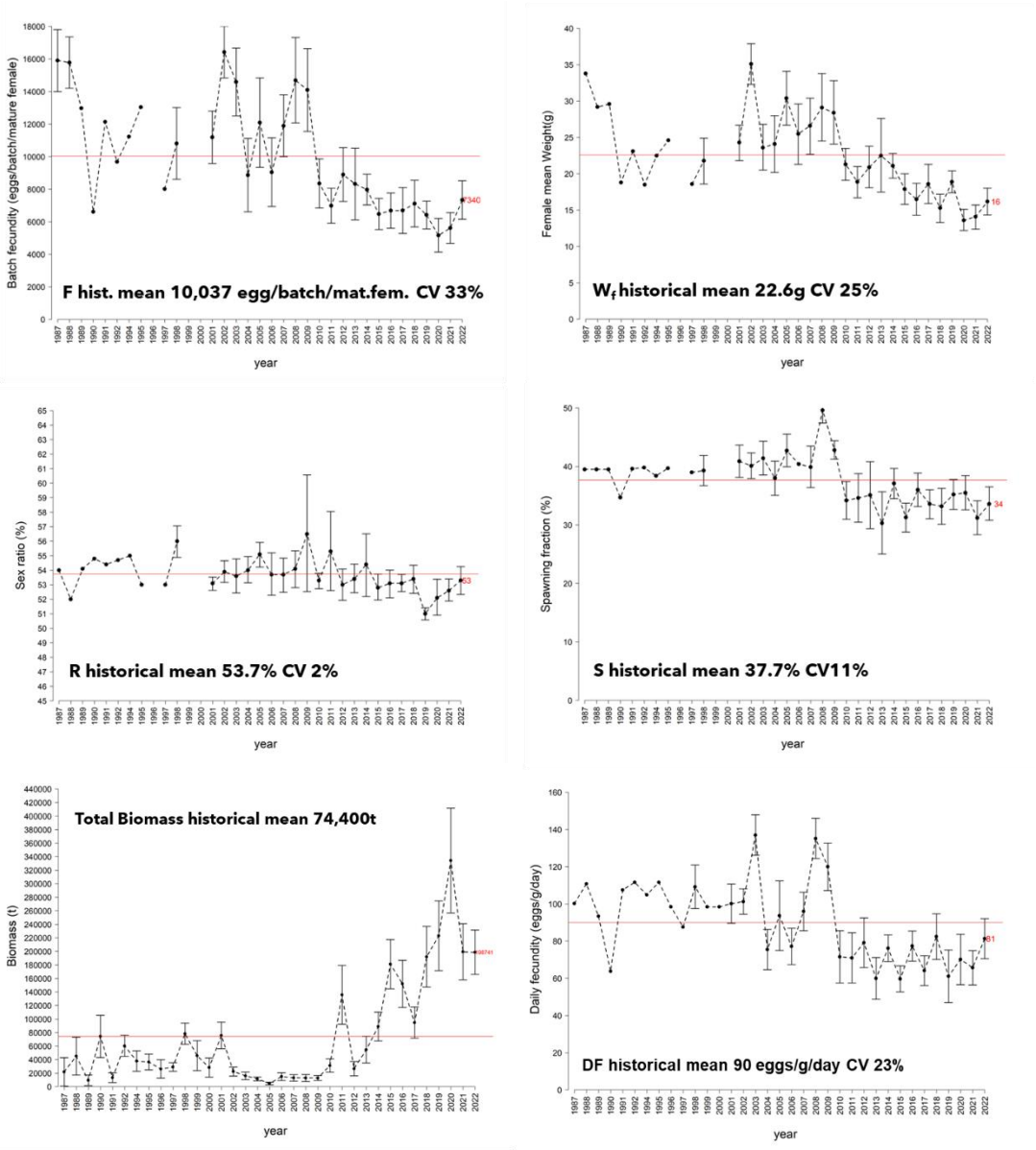


Figure 3.3.1.3.1: Bay of Biscay anchovy: historical series including 2022 estimates of the adult parameters for anchovy in the Bay of Biscay: batch fecundity (F) (eggs/batch/mature female), female mean weight (Wf)(g), sex ratio (R) (% of females), spawning fraction (S) (% of females spawning per day), daily fecundity (DF) (eggs/g/day) for the application of the DEPM and the total biomass (B)(tons). The red line is the historical mean, the values showed in bold are the historical mean and the CV (coefficient of variation) over time for each parameter.

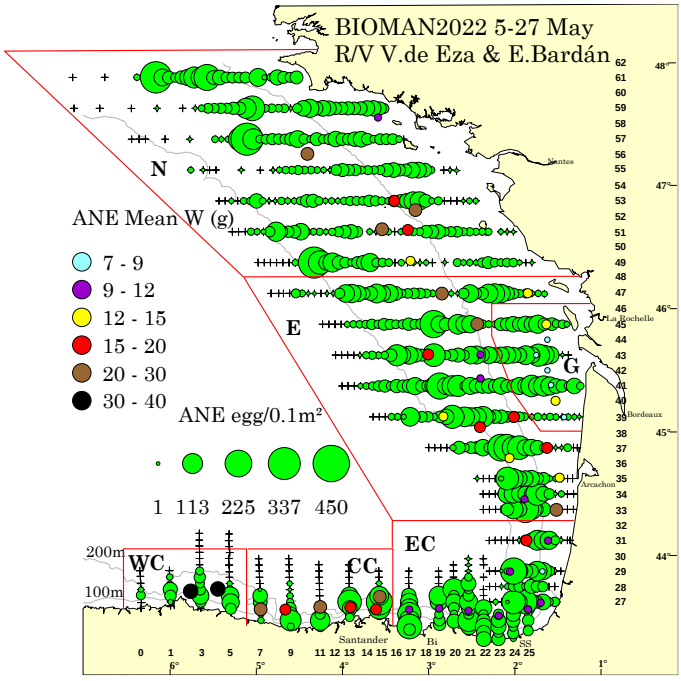


Figure 3.3.1.4.1: Bay of Biscay anchovy: Six regions were defined to weight the adult samples to estimate anchovy numbers-at-age in 2022: West Cantabrian (WC), Central Cantabrian (CC), East Cantabrian (EC), East (E), Garonne (G) and North (N). The red lines represent the border of the regions, the green bubbles the abundance of anchovy eggs (egg/0.1m2) in each station and the small colour bubbles represent the mean weight (g) of individuals within each haul.

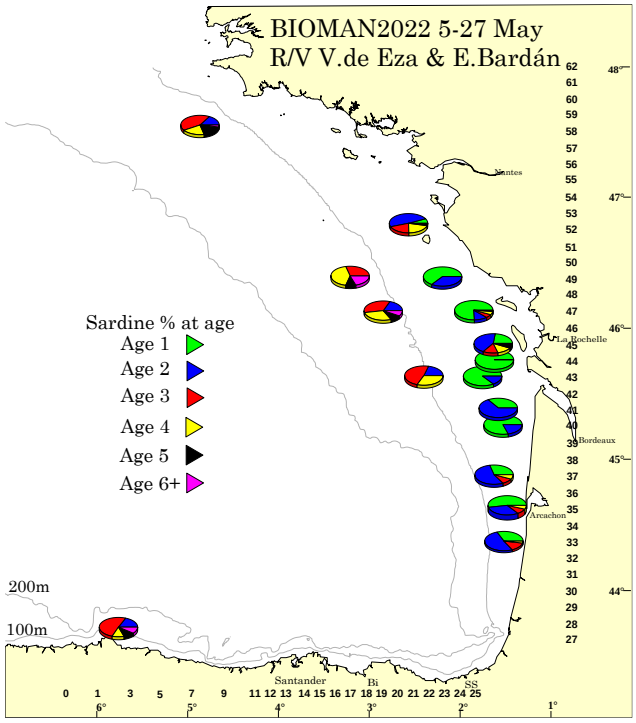


Figure 3.3.1.4.2: Bay of Biscay anchovy: Anchovy age composition by haul during BIOMAN2022.

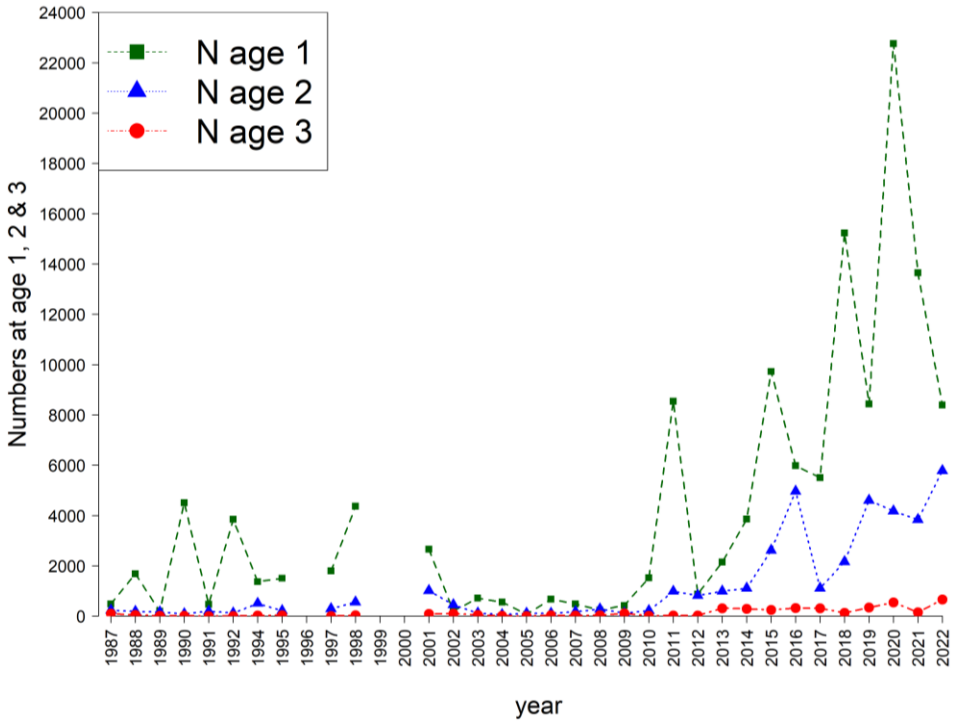


Figure 3.3.1.4.3: Bay of Biscay anchovy: Anchovy historical series of numbers-at-age from 1987 to 2022 from BIOMAN surveys.

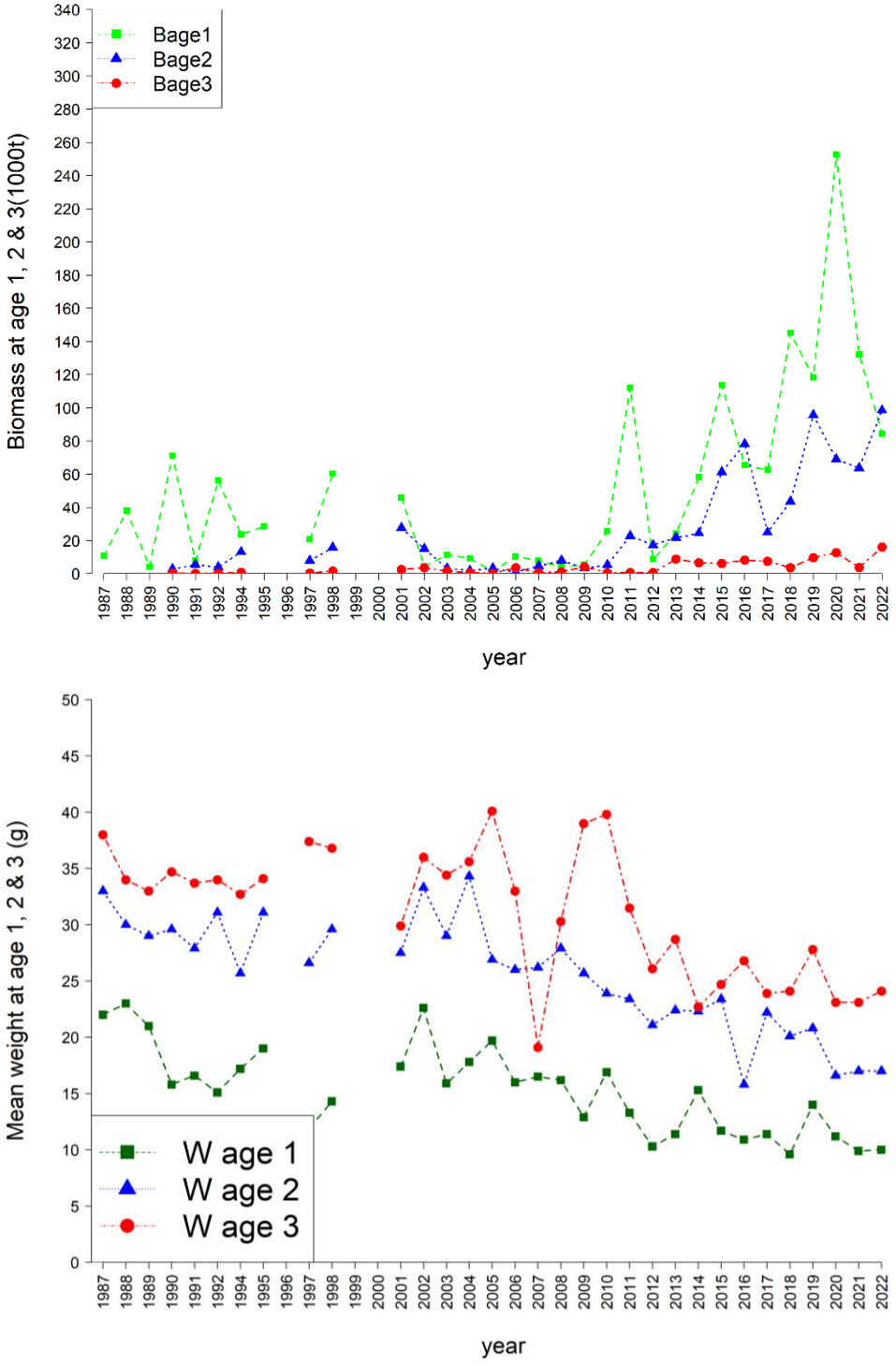


Figure 3.3.1.4.4: Bay of Biscay anchovy: Anchovy historical series (1987-2022) of total biomass at age and mean weight at age in the BIOMAN surveys.

3.3.2 PELGAS spring acoustic survey 2022

An acoustic survey (PELGAS) is carried out every year in the Bay of Biscay in spring onboard the French research vessel Thalassa. All the methodology is described in detail in the stock annex and a detailed report with the 2022 results is presented as a working document to ICES WGACEGG 2022. The objective of PELGAS survey is to study the abundance and distribution of pelagic fish in the Bay of Biscay. The main target species are anchovy and sardine, but they are considered in a multispecific context and within an ecosystemic approach as they are located in the centre of the pelagic ecosystem.

A consort survey is routinely organized since 2007 with French commercial vessels during 18 days. This approach is identical with previous year's surveys, using the commercial vessel's hauls for echoes identification and biological parameters to complement the hauls made by the RV Thalassa. Four commercial vessels (two pairs of pelagic trawlers) participated to PELGAS22 survey: A total of 110 hauls (including not valid) were carried out during the consort survey including 53 hauls by the RV Thalassa and 46 hauls by commercial vessels.

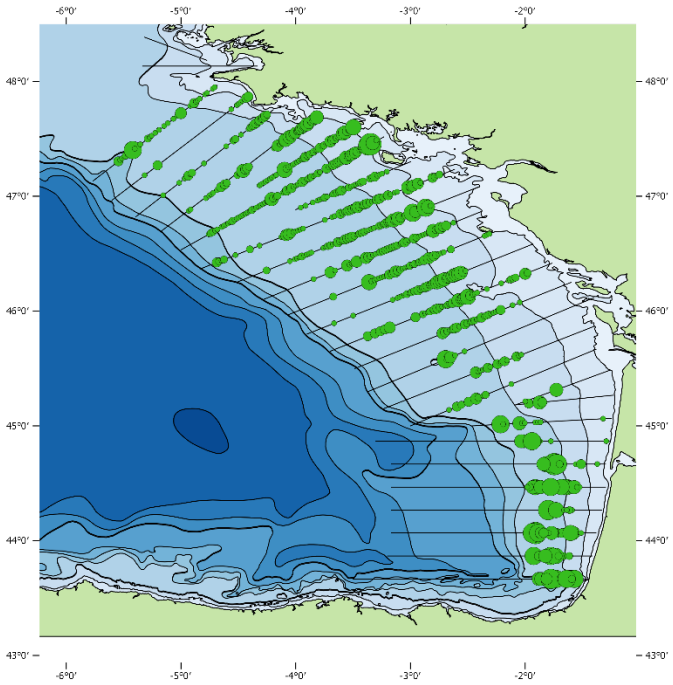


Figure 3.3.2.1: Bay of Biscay anchovy: Total abundance of anchovy per ESDU in 2022.

The biomass estimate of anchovy observed during PELGAS2022 is 180 750 tons, which is above the average of the series, but far away the strong maximum observed in 2021.

In the Gironde area, the configuration was very unusual in terms of energy compared to what is usually observed, with a very low energy attributed to anchovy (Figure 3.3.2.1). It may be linked with absence of river discharge this year.

The one-year-old anchovies were present in more coastal areas than older fishes (in terms of energy and, as well, biomass) and they were sometimes mixed. The average size of one year old fish was comparable the average size in recent years (two years really differed from the average: 2012 and

particularly 2015 where fishes were much smaller) but shows a clear decreasing trend, year after year. Bigger (and older) fish appeared close to the surface or in midwater from the central part to the North of the Bay of Biscay.

The other picture of anchovy we can have in 2022 is the massive schools in subsurface in the South, sometimes longer than one nautical mile.

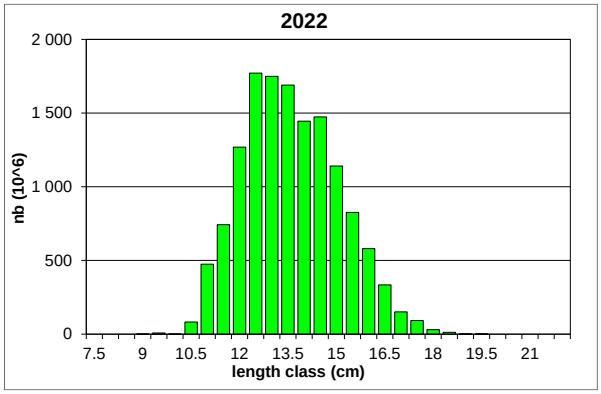


Figure 3.3.2.2: Bay of Biscay anchovy: Length distribution of global anchovy as observed during PELGAS22 survey.

Globally we observe that length structure shows a classic distribution, with fish from 10 to 18 centimetres (Figure 3.3.2.2). It must be noticed that even if some individuals were small (less than 12 cm), almost all fishes were mature and in their spawning period. This observation on maturity contrasted with the 2015 observation where a large proportion of the population was not spawning at the period of the survey.

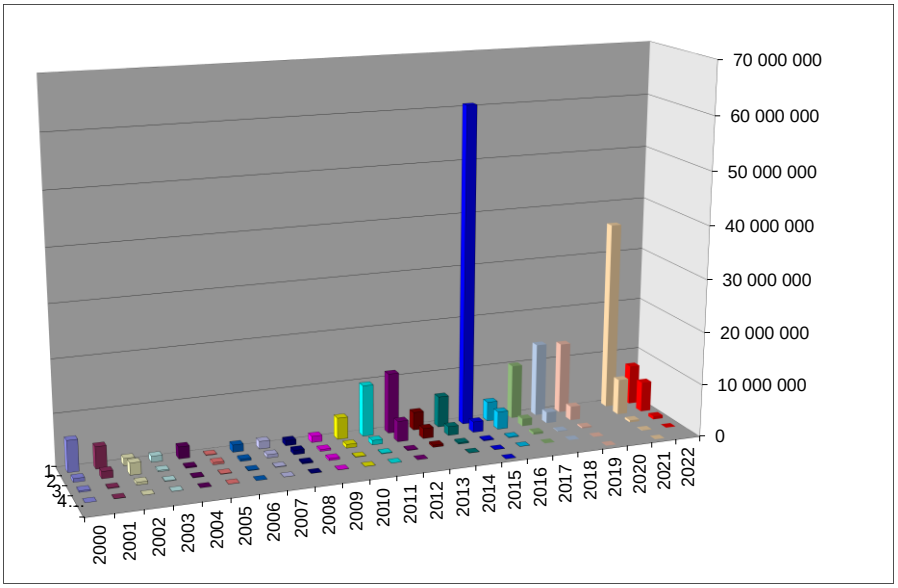


Figure 3.3.2.3: Bay of Biscay anchovy: Anchovy numbers-at-age as observed during PELGAS surveys since 2000.

Looking at the numbers-at-age since 2000, the proportion of 1 year old anchovies (54%) is lower than the exceptional recruitment observed last year (Figure 3.3.2.3). This 2020 cohort (1 year old in 2021) seems to be not tracked this year.

The huge 2015 age-class is not followed in 2016 and in 2017 as well. Once again, it could indicate that an overestimation occurred on the recruitment in 2015. Several investigations have been done to explain, without results for the time being.

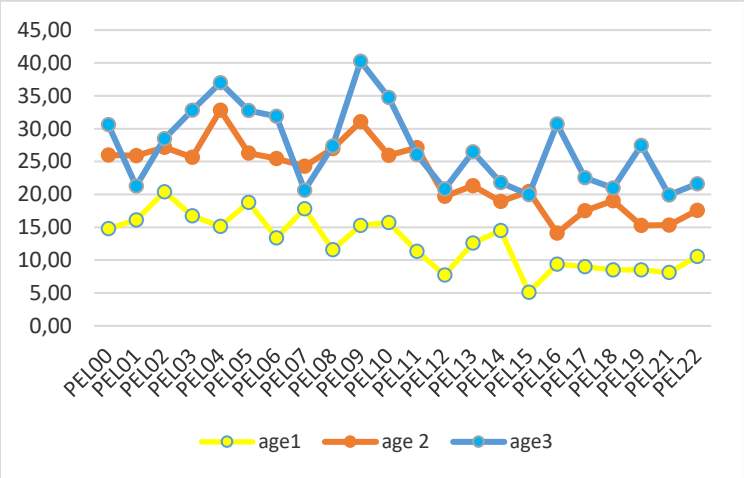


Figure 3.3.2.4: Bay of Biscay anchovy: Evolution of mean weight at age (g) of anchovy along PELGAS series.

As previous years, we observe that globally the trend of the mean weight at age is decreasing (Figure 3.3.2.4). This trend is almost the same for sardine in the Bay of Biscay, even this trend seems to stop since 2016. Further investigations should be done to test some initial hypothesis (maybe an effect of density-dependence or a change in planktonic composition), but there is no real explanation for the time being.

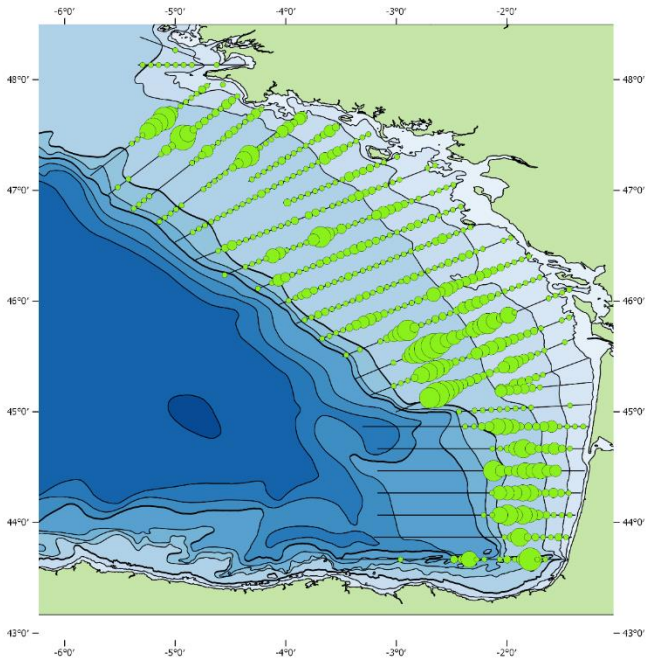


Figure 3.3.2.5: Bay of Biscay anchovy: Distribution of anchovy eggs observed with CUFES during PELGAS22.

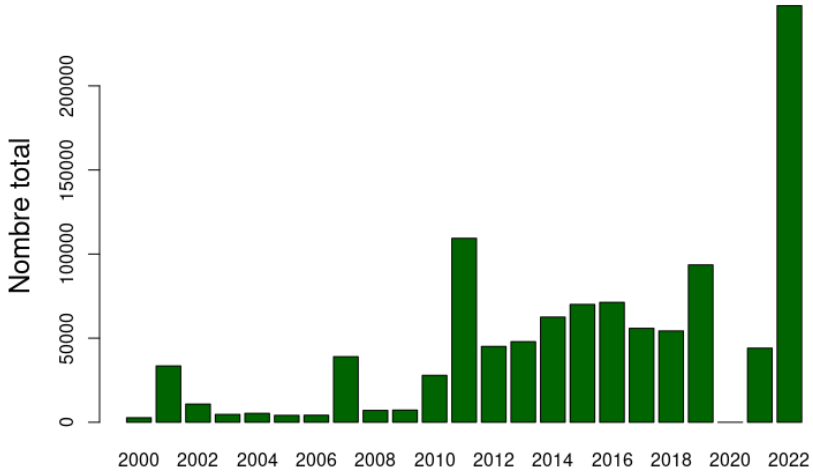


Figure 3.3.2.6: Bay of Biscay anchovy: Number of eggs observed during PELGAS surveys from 2000 to 2022.

During this survey, in addition of acoustic transects and pelagic trawl hauls, 748 CUFES samples were collected and counted, 69 vertical plankton hauls and vertical profiles with CTD were carried out. Eggs were sorted and counted automatically with the zoocam system and staged during the survey.

Between 2011 and 2021, the Bay of Biscay was marked by a large quantity of collected and counted anchovy eggs (Figure 3.3.2.6), with the same magnitude over the values, reaching the maximum in 2011.The strong maximum appears this year. Their spatial pattern of distribution was quite usual,

with major part of the abundance South of 46°N. However, eggs are present almost everywhere in the Bay of Biscay, according to the high level of adults biomass. Eggs are particularly abundant on the platform and were not present in front of the Gironde. Spawning occurred over the mid-shelf in the North, an area where eggs are observed rarely.

Globally, the total number of eggs seems to be the strong maximum of the series, about two times of the previous higher level in 2019. According to the high level of biomass, the huge number of eggs suggests this year an exceptional fecundity of anchovy in the Bay of Biscay at the period of the PELGAS survey.

3.3.3 Autumn juvenile acoustic survey 2022 (JUVENA 2022)

The methodology of the autumn juvenile acoustic survey JUVENA is described in detail in the stock annex. The results of the last survey in autumn 2022 were reported and discussed in ICES WGACEGG 2022 (Boyra et al., 2022, WD WGACEGG2022, ICES, 2022). Therefore, in this section only a short summary is provided, highlighting some issues of relevance for this assessment input.

The main objective of the JUVENA survey is estimating the abundance of the anchovy juvenile population and their growth condition at the end of summer in the Bay of Biscay. In 2022, as in previous years, the survey was coordinated by AZTI and IEO. AZTI led the assessment studies whereas IEO led the ecological studies. The survey JUVENA 2022 took place between the 17th of August and 3rd of October on board the chartered RV Ramón Margalef and the RV Emma Bardán, both equipped with scientific echosounders (Boyra et al., 2022; WD to WGACEGG). This year, the sampling strategy was modified by increasing the inter-transect distance from 15 to 18 nm. This was done to reduce the risk of underestimation bias due to coverage issues because of bad weather, allowing also to increase the time devoted to fishing. With this change, the sampling design is intended to be more systematic, returning to the design that was acquired during the first three years of the JUVENA campaign. It assumes ~4% uncertainty (Boyra et al., 2013) in exchange for avoiding a potential underestimate of biomass. Geostatistical simulations are currently underway to estimate the uncertainty in the acoustic interpolation using the entire time-series. The survey covered from 7º22′ W in the Cantabrian area to 47º65′ N in the French coast, with a total of 98 hauls to identify the species detected by the acoustic equipment, 69 of which were positive of anchovy (Figure 3.3.3.1). As usual, most of the biomass of juveniles was located off-the-shelf or in the outer part of the shelf in the first layers of the water column (Figure 3.3.3.2). The area of distribution of juvenile anchovy this year was among the highest in the temporal series, which represents a high estimation (Figure 3.3.3.3). The mean size of anchovy was 8.6 cm long, above the average of the time-series.

The biomass of juveniles estimated for this year was around 481 000 tonnes (Table 3.3.3.1). This value represents a high estimation in the time-series.

Table 3.3.3.1 Bay of Biscay anchovy. Summary of the estimates obtained in JUVENA autumn acoustic surveys from 2003 to 2022.

Year	Area+ (nm^2)	Size juv (cm)	Juveniles age 0
2003	3476	7.9	98601
2004	1907	10.6	2406
2005	7790	6.7	134131
2006	7063	8.1	78298
2007	5677	5.4	13121
2008	6895	7.5	20879
2009	12984	9.1	178028
2010	21110	8.3	599990
2011	21063	6	207625
2012	14271	6.4	142083
2013	18189	7.4	105271
2014	37169	5.9	723946
2015	21845	6.8	462340
2016	16933	7.3	371563
2017	19808	6.6	725403
2018	26787	6.3	489708
2019	20298	6.1	114074
2020	29849	6.1	228879
2021	26723	5.3	208241
2022	24354	8.6	481893

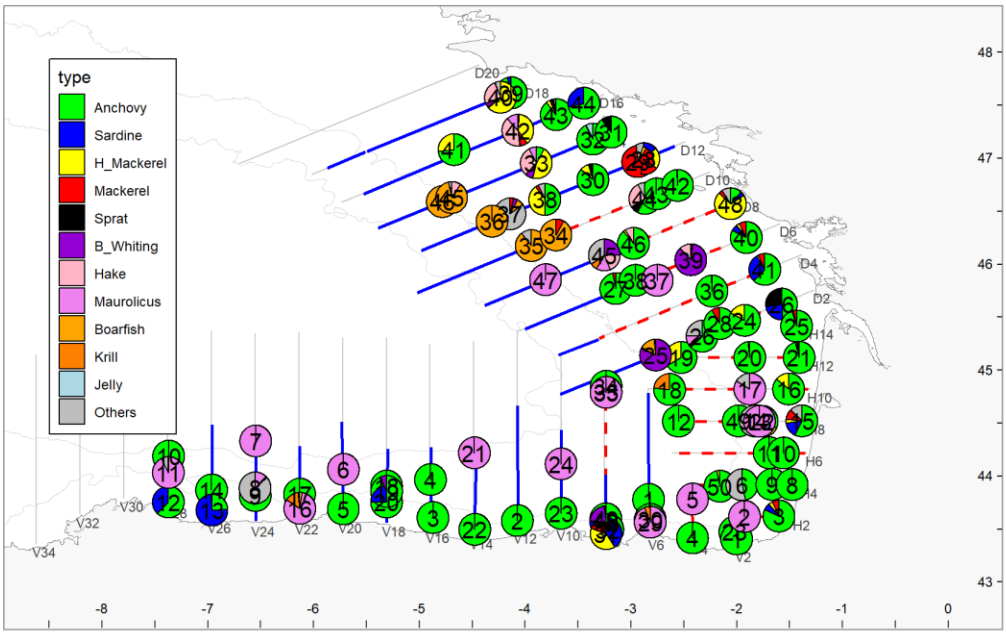


Figure 3.3.3.1: Bay of Biscay anchovy: Survey transects and species composition of the pelagic hauls in JUVENA 2022.

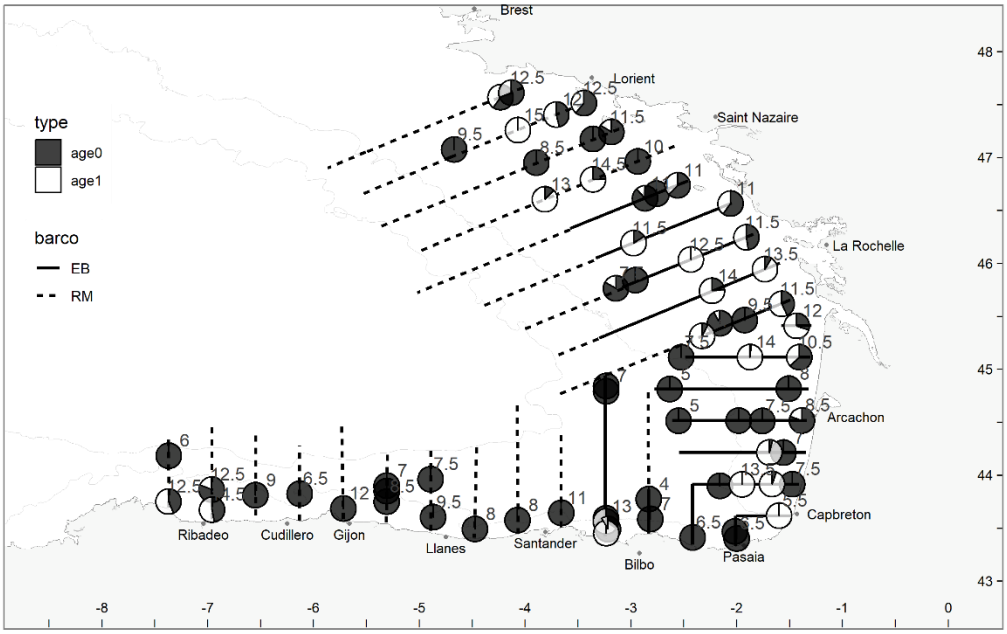


Figure 3.3.3.2: Bay of Biscay anchovy: Positive area of anchovy in JUVENA 2022. The pie charts show the percentage of juveniles (white) and adults (black) in the fishing hauls.

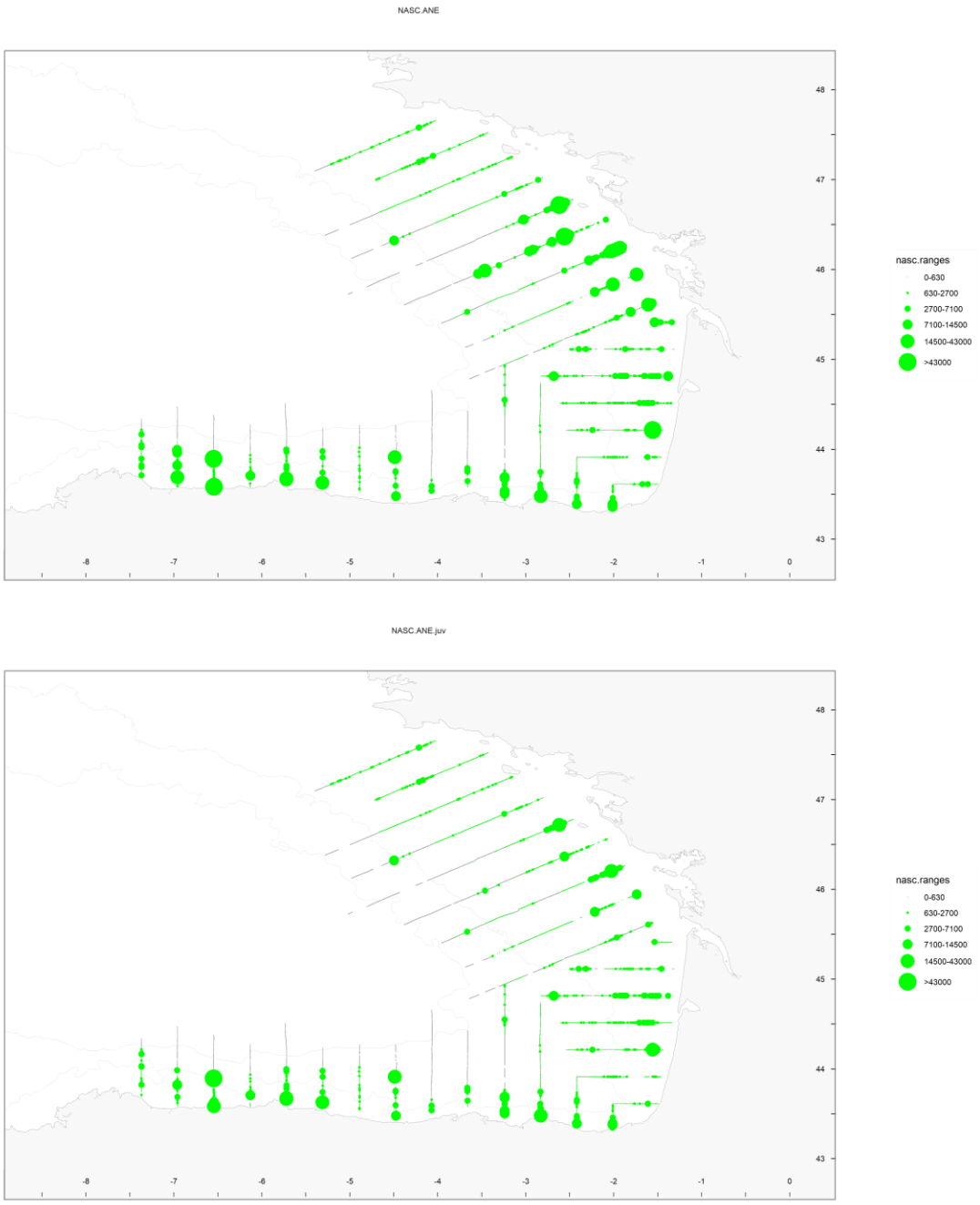


Figure 3.3.3.3: Bay of Biscay anchovy: Bubble maps representing acoustic backscattering by ESDU of 0.1 nm for total anchovy (top) and age 0 anchovy (bottom) in JUVENA 2022.

3.4 Biological data

3.4.1 Maturity-at-age

As reported in previous year reports, anchovies are fully mature as soon as they reach their first year of life, in spring the year after the hatch. See stock annex - Bay of Biscay Anchovy (Subarea 8) for details.

3.4.2 Natural mortality and weight-at-age in the stock

Natural mortality is fixed at 0.8 for age 1 and 1.2 for older individuals (age 2+).

In the CBBM assessment model the parameters G1 and G2+ representing the annual intrinsic growth of the population by age class are assumed constant along years and are estimated based on the weight-at-age data from the surveys.

See stock annex - Bay of Biscay Anchovy (Subarea 8) for further information.

3.5 State of the stock

According to the stock annex, the assessment of the Bay of Biscay anchovy can be conducted in June or November. The management plan currently in place is based on the November assessment. This year the final assessment of the stock was conducted in November 2022 and followed the methodology described in the stock annex.

3.5.1 Stock assessment

The input data entering into the assessment of the anchovy stock consist of:

- total biomass estimated by DEPM and acoustic surveys (BIOMAN and PELGAS) with their corresponding coefficients of variation;
- proportion of the biomass at-age 1 estimated by the DEPM and acoustic surveys (BIOMAN and PELGAS);
- juvenile abundance index from JUVENA;
- total catch by semester;
- proportion (in mass) of age 1 in the catch by semester (in 2022 only for the first semester);
- growth rates by age estimated from the weights-at-age of the stock.

The historical series of spawning–stock biomass (SSB) from the DEPM and acoustic surveys are shown in Figure 3.5.1.1. The trends in biomass from both surveys are similar. From 2003 to 2018, a parallel trend but with larger biomass estimates from the acoustic surveys is apparent, except in 2016 and 2018 that the DEPM biomass estimate was larger than the acoustic biomass. In 2020, the DEPM SSB estimate (around 334 300 t) was the largest of the historical time-series, well above the second highest value (223 200t) observed in 2019. The acoustic survey provided the largest SSB estimate of the historical time-series in 2021 (451 660 t) with a much higher value than the DEPM SSB estimate for 2021 (199 490 t). In 2022 both the DEPM and the acoustic surveys provided similar SSB estimates

(198 741 and 180 749 t respectively). The largest discrepancy between the SSB estimates from the DEPM and acoustic surveys occurred in 1991, 2000, 2002, 2012, 2015 and 2021.

The agreement between both surveys is usually higher when estimating the relative age composition of the population. In 2022 the DEPM survey age 1 biomass proportion was around 0.42 and the acoustic age 1 biomass proportion was around 0.41 (Figure 3.5.1.2).

The historical series of the juvenile abundance index from the autumn acoustic survey JUVENA is shown in Figure 3.5.1.3. The 2022 survey index is well above the average value of the temporal time-series, with a higher value than the 2019, 2020 and 2021 index values that were slightly below the average.

In 2019 due to the bad weather conditions the JUVENA survey could not cover the region to the north of 46.6ºN. The 2019 juvenile abundance index was considered likely underestimated. This has been confirmed in next years by the BIOMAN and PELGAS surveys. Besides being among the largest SSB estimates of the BIOMAN and PELGAS surveys time-series, the age 1 proportion estimates were above the average indicating large recruitments.

Due to the low total French landing in 2021 (64 t), length sampling was not available and age structure from Spanish catches in divisions 8.a and 8.b was used for catch-at-age calculations (see Section 3.2.3). Figure 3.5.1.4 shows the historical series of total catches by semester. In general, catches in the first semester are larger than in the second semester. The absence of catches from 2005 to 2009 corresponds to various consecutive fishery closures due to the low level of the population. The fishery was reopened in March 2010. In 2022, the preliminary total catch was around 21 163 t in the first half of the year and 4333 t in the second half. The latter was under the assumption that the November and December catches were 612t (2.4% of the total catch which is the average % of November and December French catches in 2010–2021). Definitive 2022 catch estimates will be provided in WGHANSA 2023. Regarding the age structure of the catches, age 1 proportion in the catches in the first semester in 2022 was 0.23, which is below the average age 1 proportion in the time-series (Figure 3.5.1.5).

Historical series of intrinsic growth rates by age (computed from the weights-at-age of the stock) suggest a larger growth at-age 1 than at-age 2+ (Figure 3.5.1.6).

The data used for the November assessment are given in Table 3.5.1.1.

Figure 3.5.1.7 compares prior and posterior distribution of some of the parameters estimated. Summary statistics (median and 90% probability intervals) of the posterior distributions of the parameters estimated are given in Tables 3.5.1.2 and 3.5.1.3. Recruitment (age 1 in mass at the beginning of the year), SSB (at spawning time which is assumed to be 15th May), fishing mortality by semester and harvest rates (catch/biomass) from the final assessment are shown in Figure 3.5.1.8. The estimated level of SSB in 2022 is approximately 137 278t, which is among the three highest in the time-series, and the 90% probability interval is around 94 268t and 194 166t. This probability interval is among the widest in the time-series, accounting for the lack of PELGAS 2020 and the discrepancies observed in the surveys of the last years. The posterior median of recruitment in 2022 is around 82 388t and the 90% probability interval is between 30 964t and 206 732t. The posterior distribution of recruitment in 2022 is wide because only the JUVENA 2022 survey provides direct information about that recruitment (age 1 biomass) level. Assuming no fishing takes place in 2022, the SSB in 2022 is estimated around 135 608t with a 90% probability interval around 82 692t and 254 490t (Figure 3.5.1.9).

Overall, the Pearson residuals for all the observations used in the assessment are within -2 and 2, showing no major discrepancies between the observed and modelled quantities (Figure 3.5.1.10) and indicating that the model estimates are a compromise between all surveys inputs and catch estimates

and all along the time-series. Since 2013, the time-series of biomass from the DEPM has positive residuals, and for some years (i.e. 2020 and 2021) large negative residuals are observed for JUVENA recruitment index, which should be further investigated in next years.

The final estimates are compared with last year's November assessment (ICES, WGHANSA 2021) in Figure 3.5.1.11. In general, the results from both assessments are similar except to small changes in the perception of the last three years. Recruitment in 2022 has been revised upwards, while recruitment in 2020 and 2021 slightly downwards. Fishing mortalities in the first semester of 2020 and 2021 are slightly larger than in last year's assessment. As a result, biomasses in 2020 and 2021 are smaller than in last year's assessment.

Table 3.5.1.1: Bay of Biscay anchovy: Input data for CBBM.

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
	DEPM survey			Acoustic survey			Acoustic survey	Semester 1		Semester 2		G1	G2+
Year	Age 1 (tonnes)	Total (tonnes)	cv	Age 1 (tonnes)	Total (tonnes)	cv	Age 0 previous year (tonnes)	Age 1 (tonnes)	Total (tonnes)	Age 1 (tonnes)	Total (tonnes)	Age 1	Age 2+
1,987	10,637	21,943	0.480	NA	NA	NA	NA	4,561	11,719	2,219	2,666	0.405	0.141
1,988	37,813	45,230	0.310	NA	NA	NA	NA	6,739	10,002	4,018	4,404	0.266	0.125
1,989	4,128	9,477	0.410	6,476	15,500	NA	NA	3,026	7,153	643	1,086	0.323	0.129
1,990	71,142	74,371	0.208	NA	NA	NA	NA	17,337	19,386	12,080	14,347	0.566	0.130
1,991	7,821	13,295	0.271	28,322	64,000	NA	NA	6,150	15,025	2,743	3,087	0.626	0.198
1,992	56,202	60,332	0.125	84,439	89,000	NA	NA	19,737	26,381	9,939	10,829	NA	NA
1,993	NA	NA	NA	NA	NA	NA	NA	12,152	24,058	12,589	15,255	NA	NA
1,994	23,739	37,777	0.204	NA	35,000	NA	NA	8,236	23,214	8,849	10,408	0.594	0.283
1,995	28,416	36,432	0.159	NA	NA	NA	NA	11,600	23,479	4,961	5,629	NA	NA
1,996	NA	26,148	0.260	NA	NA	NA	NA	13,007	21,024	10,397	11,864	NA	NA
1,997	21,098	29,022	0.110	38,498	63,000	NA	NA	6,730	10,600	8,675	9,852	0.911	0.324
1,998	68,015	78,277	0.101	NA	57,000	NA	NA	9,620	12,918	14,811	18,481	NA	NA
1,999	NA	45,932	0.244	NA	NA	NA	NA	3,681	15,381	6,136	10,617	NA	NA
2,000	NA	28,321	0.245	89,363	113,120	0.064	NA	12,036	22,536	11,463	14,354	NA	NA

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
2,001	45,779	75,826	0.126	67,110	105,801	0.141	NA	10,379	23,095	13,828	17,043	0.649	0.266
2,002	4,330	22,462	0.147	27,642	110,566	0.113	NA	2,585	11,089	3,720	6,405	0.249	0.032
2,003	11,401	16,109	0.173	18,687	30,632	0.132	NA	1,055	4,074	3,376	6,405	0.769	0.206
2,004	9,042	11,496	0.117	33,995	45,965	0.167	98,601	5,467	9,183	6,285	7,004	0.410	0.157
2,005	1,441	4,832	0.202	2,467	14,643	0.171	2,406	146	1,127	NA	0	0.277	0.205
2,006	10,085	15,113	0.238	18,282	30,877	0.136	134,131	982	1,659	69	95	0.493	-0.307
2,007	7,946	13,060	0.178	26,230	40,876	0.100	78,298	42	141	NA	0	0.524	0.146
2,008	3,940	12,898	0.200	10,400	37,574	0.162	13,121	NA	0	NA	0	0.458	0.333
2,009	5,460	12,832	0.140	11,429	34,855	0.112	20,879	NA	0	NA	0	0.618	0.439
2,010	25,543	31,277	0.159	64,564	86,355	0.147	178,028	3,099	6,111	3,544	3,971	0.325	0.276
2,011	112,202	135,732	0.160	115,379	142,601	0.077	599,990	3,701	10,913	3,256	3,576	0.465	-0.123
2,012	8,936	26,663	0.202	73,843	186,865	0.046	207,625	948	8,600	3,869	5,753	0.777	0.307
2,013	24,090	54,686	0.179	42,508	93,854	0.128	142,083	1,759	10,928	1,722	3,144	0.670	0.013
2,014	59,283	91,299	0.125	86,670	125,427	0.063	105,271	4,188	14,274	4,752	5,278	0.427	0.101
2,015	113,677	181,063	0.101	313,249	372,916	0.074	723,946	9,524	19,416	4,976	8,838	0.257	0.143
2,016	65,312	152,049	0.114	35,604	89,727	0.130	462,340	5,024	15,380	2,501	3,991	0.765	0.456
2,017	62,488	94,759	0.122	83,713	134,500	0.154	371,563	9,316	22,763	1,705	3,248	0.567	0.079
2,018	145,159	192,088	0.116	136,397	185,524	0.070	725,403	14,138	25,499	4,095	5,236	0.773	0.325
2,019	118,102	223,210	0.115	129,269	183,166	0.053	489,708	6,164	22,760	1,842	4,085	0.167	0.105

	BIOMAN			PELGAS			JUVENA	CATCH				GROWTH	
2,020	252,547	334,283	0.116	NA	NA	NA	114,072	8,831	14,870	9,173	10,350	0.424	0.332
2,021	132,182	199,490	0.104	327,454	451,660	0.097	228,879	11,081	23,606	2,970	4,323	0.546	0.348
2,022	84,315	198,741	0.106	73,926	180,749	0.098	208,241	4,794	21,163	NA	4,333	NA	NA
2,023	NA	NA	NA	NA	NA	NA	481,893	NA	0	NA	0	NA	NA

Table 3.5.1.2: Bay of Biscay anchovy: Median and 90% probability intervals for some of the parameters estimated in the CBBM.

Notation	5%	Median	95%	Meaning of parameter
qdepm	0.684	0.831	1.007	Catchability of the DEPM B index
qac	1.223	1.452	1.722	Catchability of the Acoustic B index
qrobs	0.027	0.480	8.440	Parameter of the observation equation for the juvenile index
krobs	0.919	1.185	1.453	Parameter of the observation equation for the juvenile index
psidepm	2.325	4.013	6.836	Precision (inverse of variance) of the observation equation of DEPM B index
psiac	4.582	7.985	13.310	Precision (inverse of variance) of the observation equation of Acoustic B index
psirobs	0.962	1.801	3.139	Precision (inverse of variance) of the observation equation of juvenile index
xidepm	3.407	4.075	4.791	Variance-related parameter for the observation equation of DEPM age 1 proportion
xiac	2.816	3.393	3.945	Variance-related parameter for the observation equation of Acoustic age 1 proportion
xicatch	2.354	2.693	3.015	Variance-related parameter for the observation equation of age 1 proportion in the catch
B0	16,046	20,858	26,452	Initial biomass
mur	10.329	10.613	10.884	Median (in log scale) of the recruitment process
psir	0.759	1.155	1.679	Precision (in log scale) of the recruitment process
sage1sem1	0.393	0.462	0.540	Age 1 selectivity during the 1st semester
sage1sem2	0.852	1.027	1.239	Age 1 selectivity during the second semester
G1	0.487	0.541	0.599	Intrinsic growth at age 1
G2	0.175	0.227	0.285	Intrinsic growth at age 2+
psig	20.434	28.282	38.333	Precision of the observation equations for intrinsic growth at ages 1 and 2+

Table 3.5.1.3: Bay of Biscay anchovy: Median and 90% probability intervals for recruitment, spawning–stock biomass, fishing mortalities by semester and harvest rates (Catch/SSB) as resulted from CBBM.

	R (tonnes)			SSB (tonnes)			fsem1			fsem2			Harvest rate		
Year	5%	Median	95%	5%	Median	95%	5%	Median	95%	5%	Median	95%	5%	Median	95%
1,987	11,942	15,676	20,599	15,706	20,468	26,455	0.978	1.267	1.641	0.275	0.380	0.543	0.544	0.703	0.916
1,988	25,736	30,749	37,612	23,346	28,281	35,121	0.836	1.068	1.337	0.308	0.415	0.552	0.410	0.509	0.617
1,989	6,406	8,929	12,363	10,556	14,917	20,746	0.733	1.004	1.364	0.141	0.208	0.313	0.397	0.552	0.780
1,990	58,961	67,249	77,841	45,566	52,683	62,267	1.025	1.268	1.542	0.584	0.773	1.012	0.542	0.640	0.740
1,991	17,576	23,016	30,221	21,943	29,241	38,440	0.902	1.184	1.536	0.211	0.300	0.432	0.471	0.619	0.825
1,992	67,709	86,090	108,999	52,822	70,402	91,931	0.928	1.241	1.658	0.281	0.407	0.598	0.405	0.529	0.704
1,993	51,772	65,183	80,184	60,386	72,428	86,753	0.710	0.890	1.120	0.463	0.603	0.784	0.453	0.543	0.651
1,994	33,205	41,119	50,723	38,354	47,111	58,246	0.957	1.196	1.491	0.493	0.665	0.906	0.577	0.714	0.877
1,995	34,129	44,812	58,304	28,453	39,486	53,966	1.185	1.605	2.171	0.266	0.398	0.619	0.539	0.737	1.023
1,996	40,583	50,333	62,070	38,354	46,426	57,136	0.995	1.281	1.631	0.554	0.757	1.030	0.576	0.708	0.857
1,997	30,542	39,429	50,969	33,931	44,010	57,461	0.513	0.676	0.884	0.442	0.627	0.914	0.356	0.465	0.603
1,998	70,165	90,601	116,758	69,088	89,497	115,198	0.362	0.479	0.638	0.376	0.541	0.795	0.273	0.351	0.454
1,999	30,158	44,550	63,205	50,539	66,799	87,168	0.419	0.553	0.744	0.318	0.446	0.636	0.298	0.389	0.514
2,000	74,036	90,611	109,498	75,924	91,838	109,575	0.590	0.738	0.926	0.315	0.410	0.544	0.337	0.402	0.486
2,001	62,514	73,370	86,889	77,598	89,242	103,113	0.565	0.680	0.822	0.425	0.531	0.662	0.389	0.450	0.517
2,002	9,190	12,763	17,723	31,278	37,719	45,892	0.464	0.567	0.690	0.413	0.533	0.680	0.381	0.464	0.559

	R (tonnes)			SSB (tonnes)			fsem1			fsem2			Harvest rate		
2,003	15,397	19,580	24,294	22,059	26,910	32,871	0.314	0.396	0.494	0.521	0.682	0.910	0.319	0.389	0.475
2,004	24,548	29,988	37,350	24,186	29,990	37,974	0.693	0.891	1.136	0.474	0.660	0.904	0.426	0.540	0.669
2,005	2,699	4,152	6,156	10,159	14,022	19,334	0.118	0.163	0.228	0.000	0.000	0.000	0.058	0.080	0.111
2,006	11,409	15,691	21,235	14,105	19,130	25,388	0.187	0.253	0.345	0.008	0.012	0.017	0.069	0.092	0.124
2,007	15,154	20,809	28,124	21,872	28,812	37,510	0.011	0.014	0.019	0.000	0.000	0.000	0.004	0.005	0.006
2,008	6,036	8,754	12,694	17,641	22,959	29,614	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2,009	6,768	9,625	13,674	14,806	19,163	24,750	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2,010	35,771	46,659	61,153	36,619	47,259	61,102	0.322	0.423	0.543	0.145	0.204	0.286	0.165	0.213	0.275
2,011	87,995	110,485	140,126	92,737	116,009	145,188	0.239	0.307	0.391	0.054	0.072	0.097	0.100	0.125	0.156
2,012	34,158	44,839	58,040	77,500	95,732	118,687	0.161	0.202	0.254	0.124	0.160	0.206	0.121	0.150	0.185
2,013	28,597	37,721	49,476	53,566	67,375	84,313	0.296	0.375	0.475	0.094	0.123	0.162	0.167	0.209	0.263
2,014	55,374	71,460	92,058	66,318	84,623	106,780	0.373	0.475	0.607	0.116	0.155	0.211	0.183	0.231	0.295
2,015	87,748	109,804	140,167	102,765	126,223	157,264	0.351	0.446	0.558	0.131	0.173	0.229	0.180	0.224	0.275
2,016	39,156	51,350	69,062	76,434	96,296	122,448	0.283	0.365	0.460	0.083	0.109	0.143	0.158	0.201	0.253
2,017	51,814	66,575	86,259	67,758	86,851	112,038	0.515	0.667	0.857	0.071	0.096	0.130	0.232	0.299	0.384
2,018	86,140	109,836	142,234	95,440	122,060	158,569	0.459	0.602	0.779	0.077	0.106	0.145	0.194	0.252	0.322
2,019	51,488	69,984	94,918	80,052	107,430	142,885	0.381	0.511	0.685	0.071	0.099	0.138	0.188	0.250	0.335
2,020	94,602	128,389	175,558	115,953	155,351	206,898	0.208	0.281	0.379	0.117	0.164	0.230	0.122	0.162	0.218
2,021	103,540	141,682	192,774	135,599	187,017	253,399	0.252	0.343	0.479	0.040	0.057	0.081	0.110	0.149	0.206

	R (tonnes)			SSB (tonnes)			fsem1			fsem2			Harvest rate		
2,022	43,476	65,158	98,865	94,268	137,278	194,166	0.243	0.342	0.491	0.057	0.084	0.126	0.131	0.186	0.270
2,023	30,964	82,389	206,732	82,692	135,608	254,490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

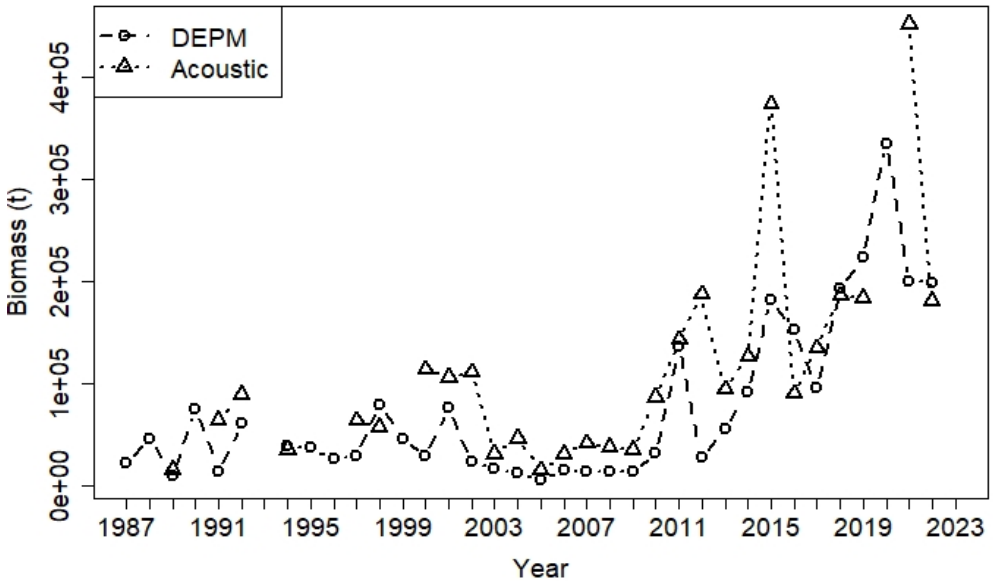


Figure 3.5.1.1: Bay of Biscay anchovy: Historical series of spawning–stock biomass estimates and the corresponding confidence intervals from DEPM (solid line and circles) and acoustics (dashed line and triangles).

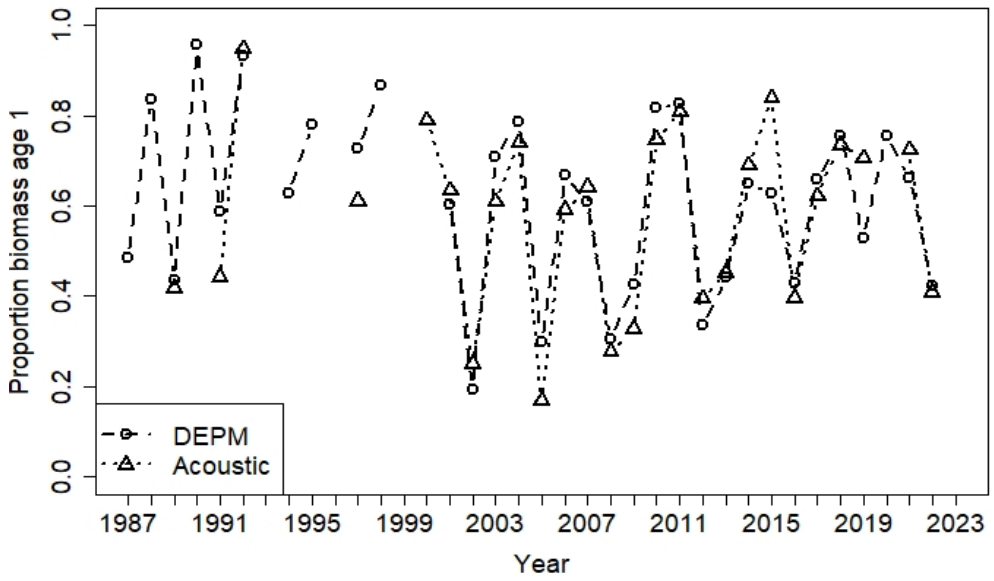


Figure 3.5.1.2: Bay of Biscay anchovy: Historical series of age 1 biomass proportion estimates from DEPM (dashed line and circles) and acoustics (dotted line and triangles).

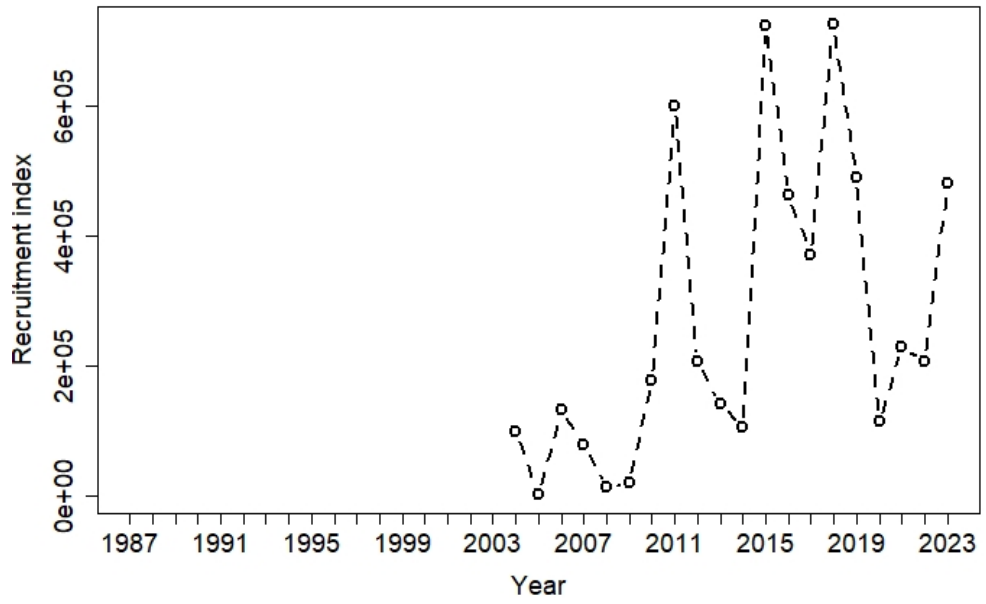


Figure 3.5.1.3: Bay of Biscay anchovy: Historical series of the juvenile abundance index from the autumn acoustic survey JUVENA that is related to recruitment (age 1) next year.

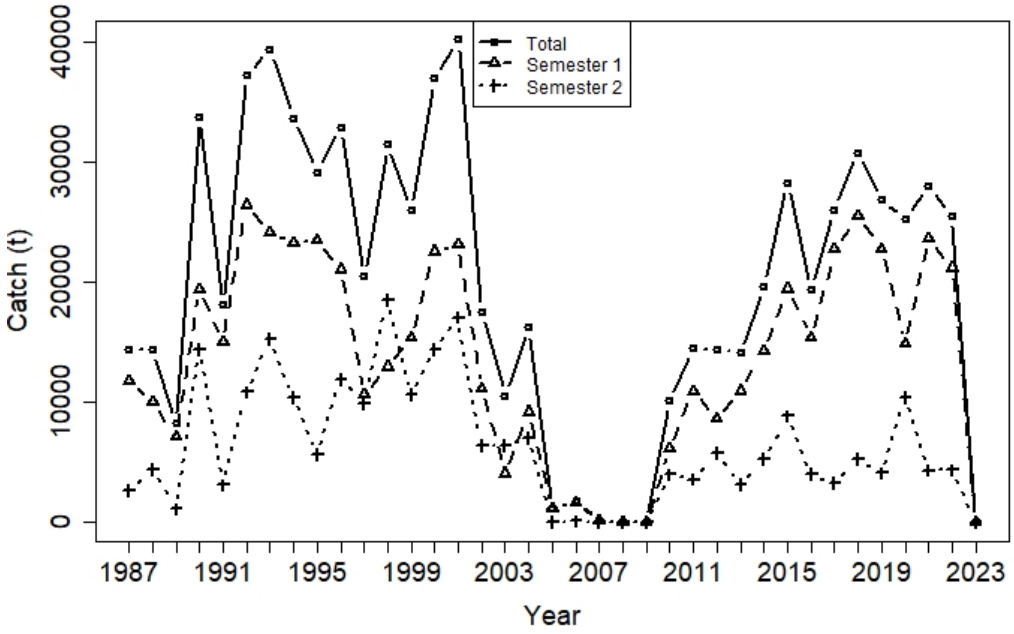


Figure 3.5.1.4: Bay of Biscay anchovy: Historical series of total catch (solid line) and catch by semesters (dashed and dotted lines for the first and second semester respectively). Note that the catch in 2022 is provisional and the catch in 2023 is set at zero.

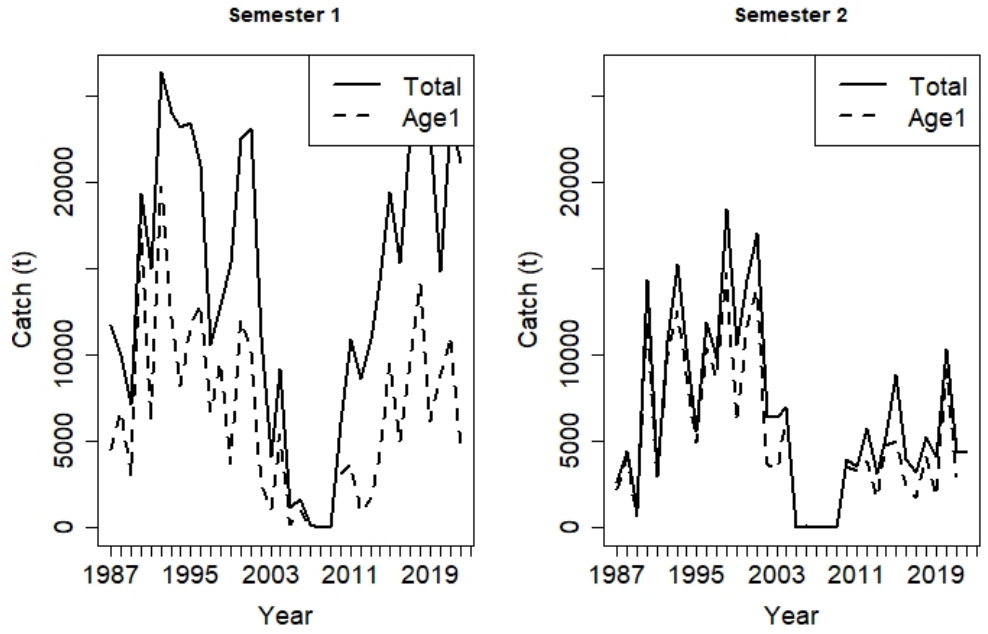


Figure 3.5.1.5: Bay of Biscay anchovy: Historical series of total (solid line) and age 1 (dashed line) catch (in tonnes). The left panel corresponds to the first semester and the right panel to the second semester. Note that the catch in 2022 is provisional.

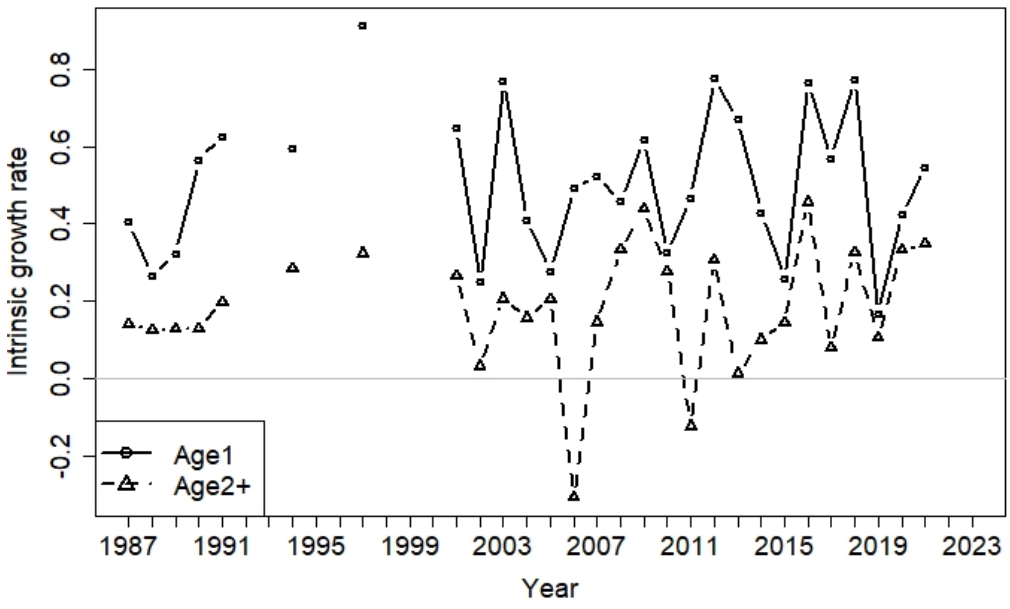


Figure 3.5.1.6: Bay of Biscay anchovy: Historical series of intrinsic growth rates by age as estimated from the mean weights-at-age of the stock.

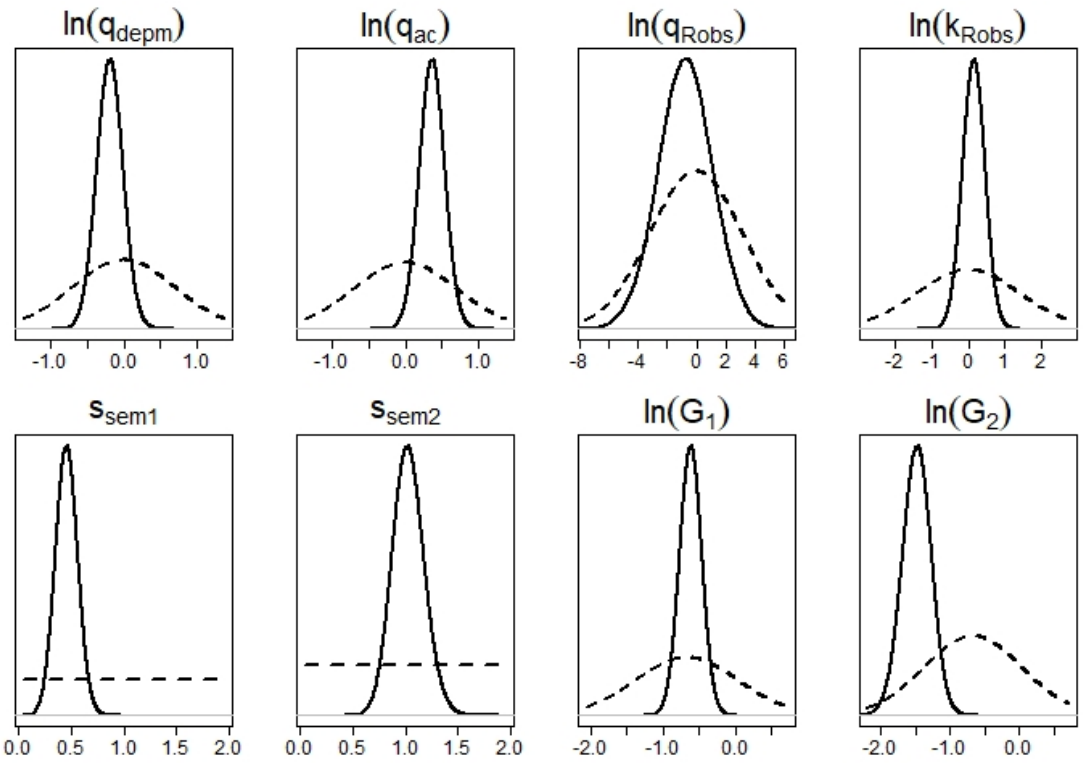
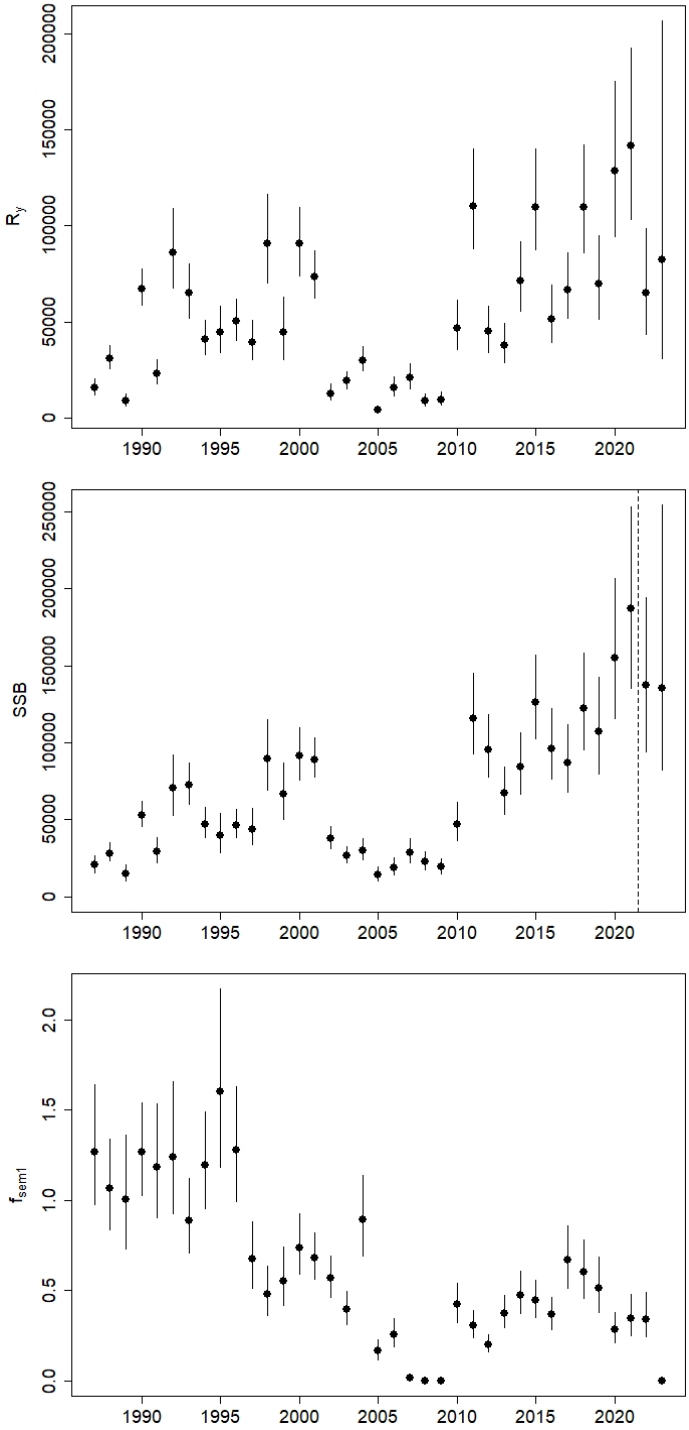


Figure 3.5.1.7: Bay of Biscay anchovy: Comparison between the prior (dotted line) and posterior distribution (solid line) for some of the parameters of CBBM.


R_y
0
50000
100000
150000
200000
1990
1995
2000
2005
2010
2015
2020
SSB
0
50000
100000
150000
200000
250000
1990
1995
2000
2005
2010
2015
2020
f_{sem1}
0.0
0.5
1.0
1.5
2.0
1990
1995
2000
2005
2010
2015
2020

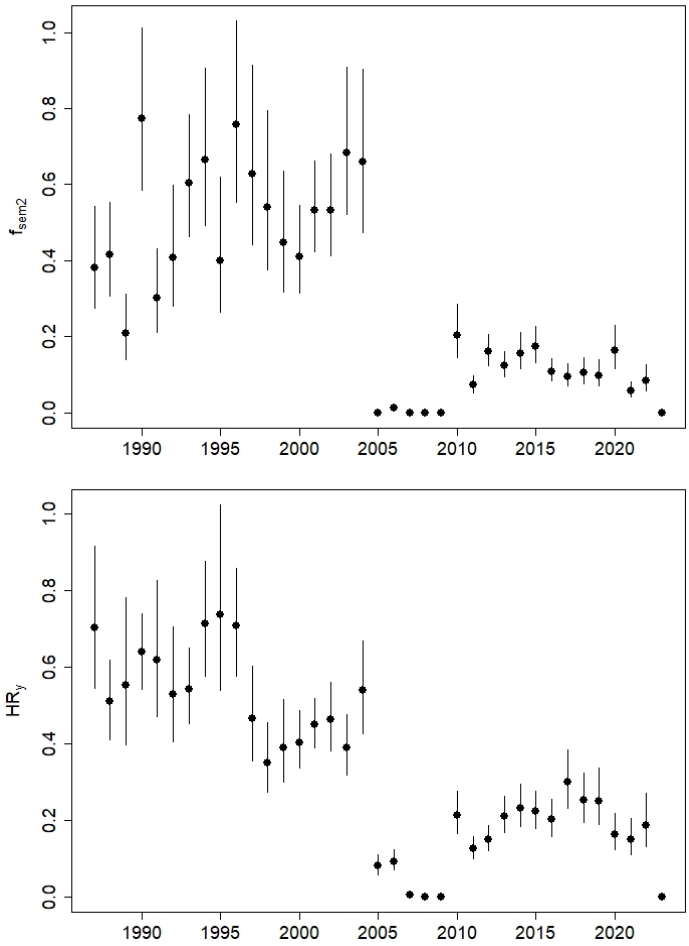


Figure 3.5.1.8: Bay of Biscay anchovy: Posterior median (bullet points) and 90% probability intervals (solid lines) for the recruitment (age 1 in mass in January), the spawning–stock biomass, the fishing mortality for the first and second semesters and the harvest rates (catch/biomass) from the CBBM. It must be taken into account that the fishing mortalities in 2022 are fixed at zero and SSB in 2022 results from no fishing in 2022.

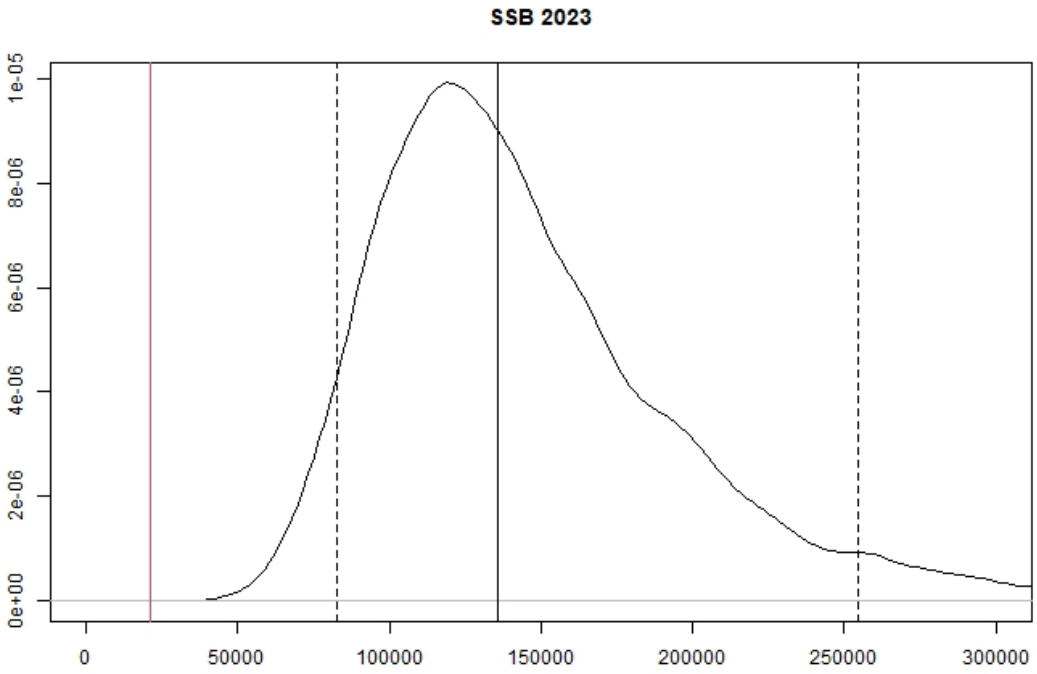


Figure 3.5.1.9: Bay of Biscay anchovy: Posterior distribution of SSB in 2022, under the assumption of no fishing during 2022. The red vertical line represents B_{lim} at 21 000 tonnes.

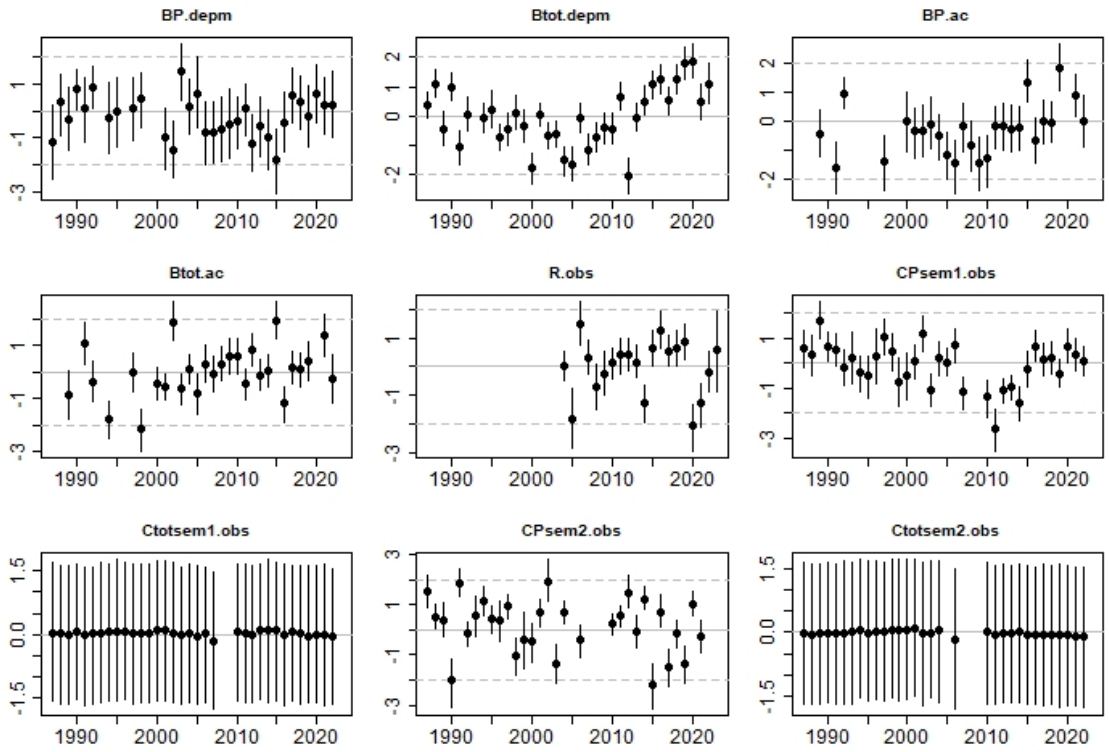
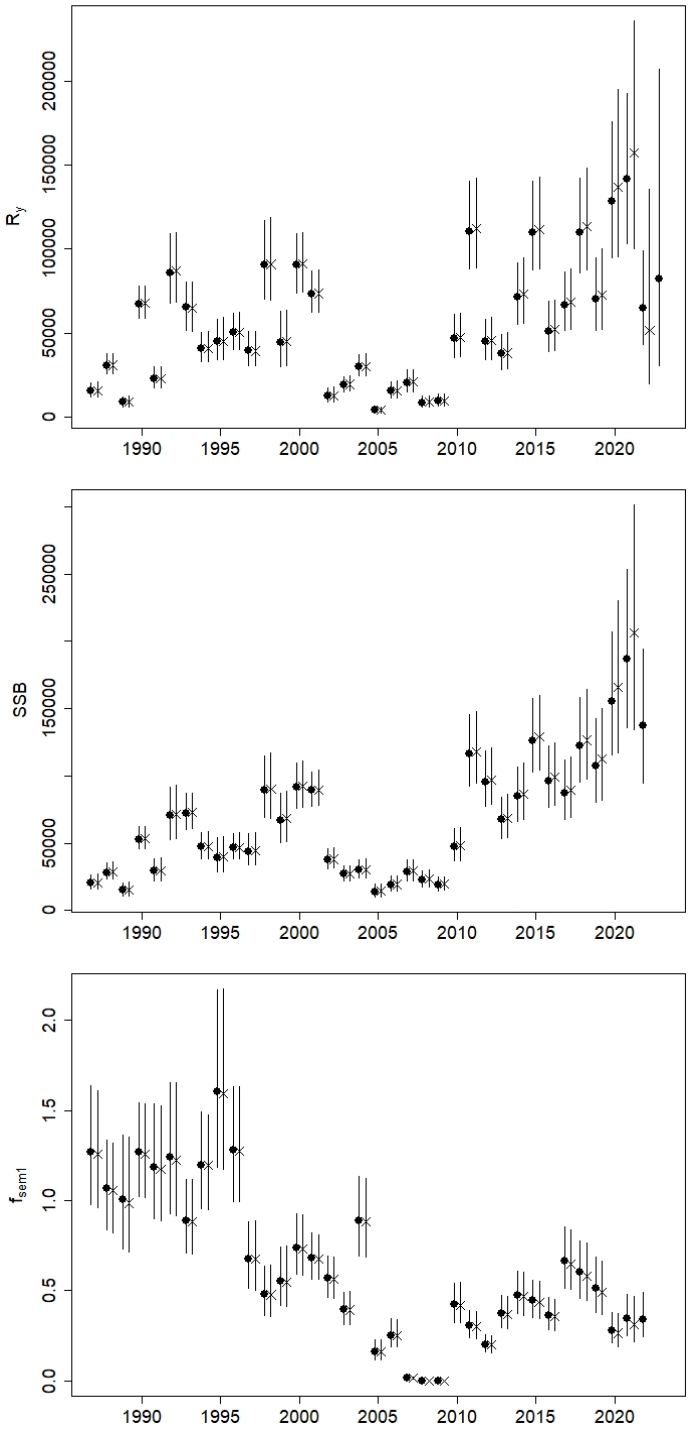


Figure 3.5.1.10: Bay of Biscay anchovy: Pearson residual medians and 90% probability intervals to the survey and catch observations used in the CBBM. From top to bottom and from left to right, residuals of the age 1 biomass proportion from the DEPM, total biomass from the DEPM, age 1 biomass proportion from the acoustic, total biomass from the acoustic, recruitment index, age 1 proportion in mass in the 1st semester catch, total catch in the 1st semester, age 1 proportion in mass in the second semester catch and total catch in the second semester.


R_y
0
50000
100000
150000
200000
1990
1995
2000
2005
2010
2015
2020
SSB
0
50000
150000
250000
1990
1995
2000
2005
2010
2015
2020
f_{sem1}
0.0
0.5
1.0
1.5
2.0
1990
1995
2000
2005
2010
2015
2020

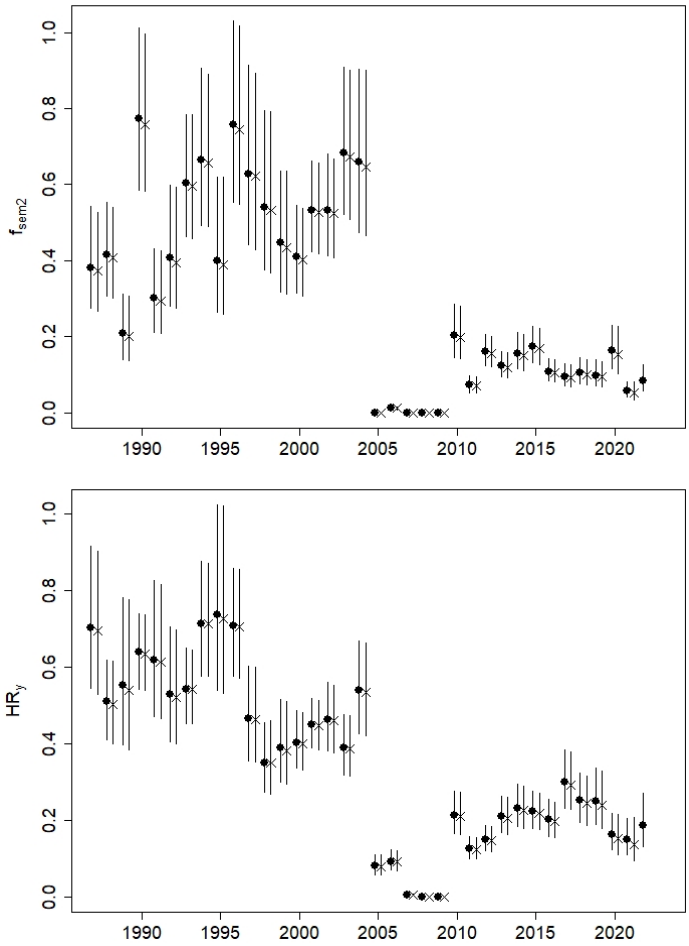


Figure 3.5.1.11: Bay of Biscay anchovy: From top to bottom comparison of the posterior median (points) and 90% probability intervals (solid lines) of the recruitment (age 1 in mass in January), the spawning–stock biomass, the fishing mortality in the first and in the second semester and the harvest rate assessed in WGHANSA 2021 (cross) and in WGHANSA 2022 (bullet).

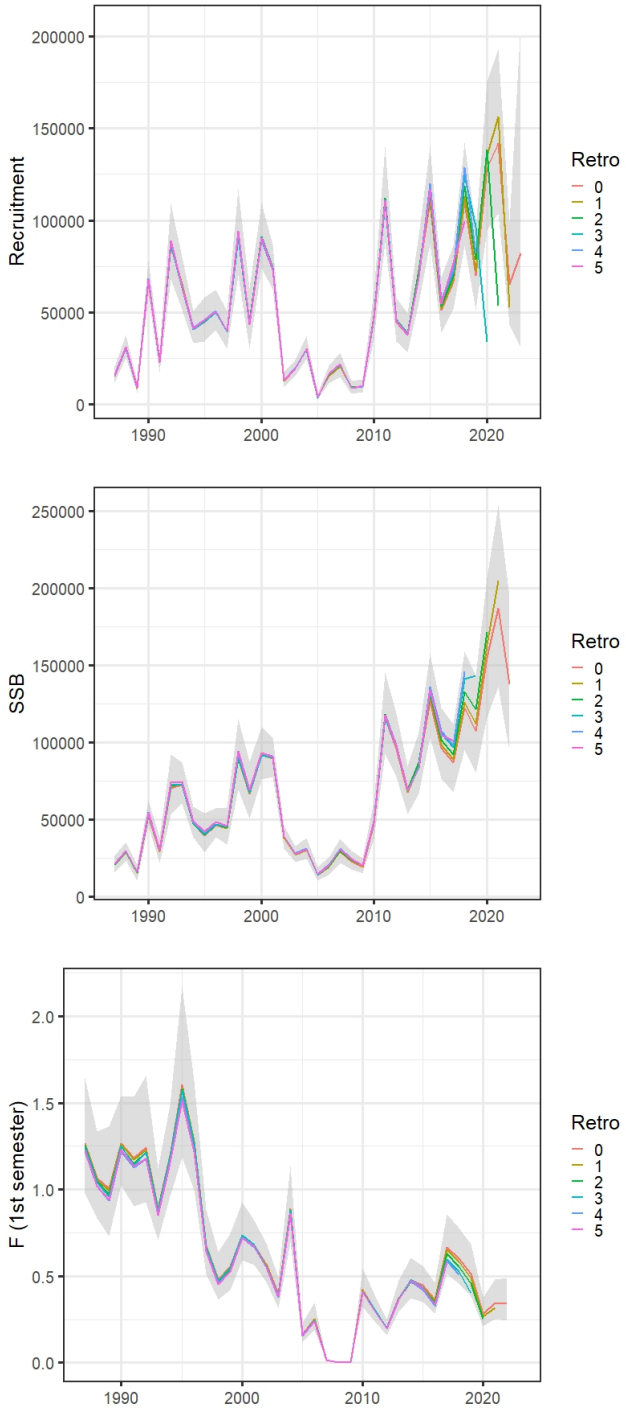
3.5.2 Retrospective pattern

A five-year retrospective analysis of SSB, recruitment, fishing mortality by semester and harvest rate was conducted. For each run, assessment was conducted using DEPM and acoustic surveys data until the terminal year and recruitment survey data until the intermediate year. Catch data for the intermediate year were assumed to be zero, so that SSB and fishing mortality by semester for the intermediate year were not considered reliable, i.e. only estimates of recruitment in the intermediate year were analysed.

The trends for SSB, recruitment and fishing mortality by semester in the retrospective analysis are similar. Furthermore, the estimates from the retrospective analysis are in general within the 90% probability interval of last year's assessment (Figure 3.5.2.1). The only exceptions are recruitments in 2020 and 2021 that have been strongly revised upwards in the following year's assessments.

Retrospective bias was measured in terms of the Mohn's rho (Mohn, 1999) using the function mohn() in the R package icesAdvice (https://CRAN.R-project.org/package=icesAdvice). The relative bias for recruitment in the intermediate year was positive in 2019, and negative in the other years, with high

absolute values for 2020 and 2021 (Figure 3.5.2.2). It ranged between -0.75 and 0.12 and the Mohn's rho was calculated at -0.29. The relative bias for SSB in the terminal year was always positive (Figure 3.5.2.2). The relative bias for SSB ranged between 0.1 and 0.33, and the Mohn's rho was 0.18. Mohn's rho for the fishing mortality by semester and annual harvest rate was -0.14, -0.19 and -0.15 respectively. The relative bias for the three time-series was negative in all the years (Figure 3.5.2.2).



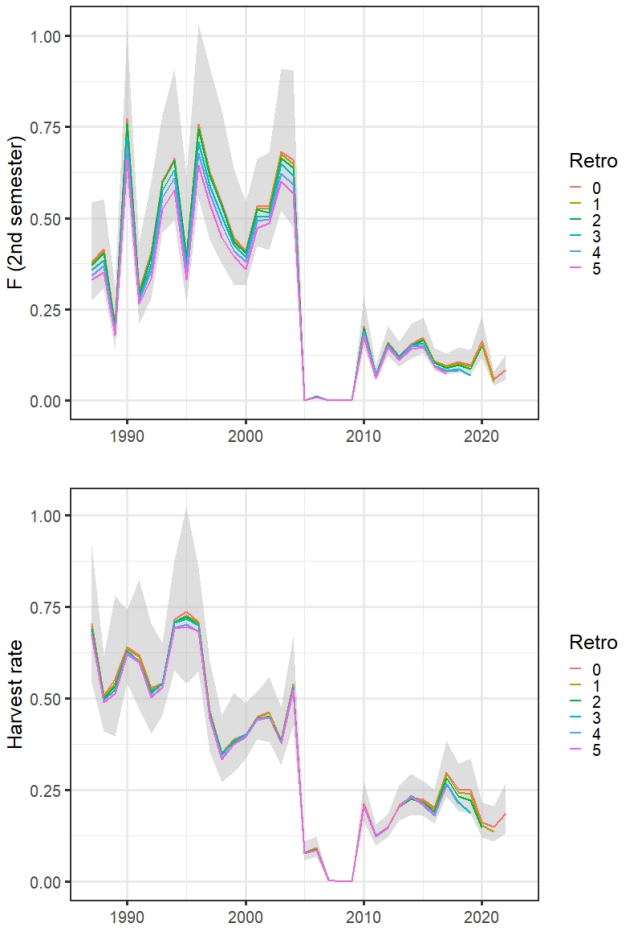


Figure 3.5.2.1: Bay of Biscay anchovy: From top to bottom retrospective pattern of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and second semesters and harvest rate. The shaded are represents the 90% probability intervals from this year's assessment.

Figure 3.5.2.2: Bay of Biscay anchovy: From top to bottom and from left to right relative bias of recruitment (age 1 in tonnes on 1st January), SSB, fishing mortality on 1st and second semesters and harvest rate. The horizontal dashed lines represent the Mohn's rho statistic for each time-series.

3.5.3 Reliability of the assessment

Compared to commonly used assessment methods in ICES, the Bayesian two-stage biomass-based model (CBBM) entails changes in both the methodology used for projecting the population forward and establishing catch options and in the terminology in which the assessment and consequent advice is given. The state of the stock is given in terms of spawning biomass, recruitment is understood as biomass at-age 1 at the beginning of the year and management options may be given in terms of catches. Due to the Bayesian framework, all the results are given in stochastic terms and deterministic

point estimates are replaced by summary statistics of the posterior distributions of the parameters, such as medians and percentiles.

The Pearson residuals for all the observations used in the assessment show no major discrepancies between the observed and modelled quantities (residuals within -2 and 2). However, the residuals of the age 1 proportion (in mass) in the catch of the first semester have been negative from 2010 (fishery reopening) to 2015, and the residuals of biomass from the DEPM have been positive since 2013. The former can be related to changes in the selection pattern of the fishery, while the later can be related to interannual changes in the percentage of biomass in the Cantabrian coast, which is not covered by the acoustic survey. All these patterns should be further investigated in next years.

The catch data for 2022 are preliminary and the definite data will be available for WGHANSA 2023. As a result, the fishing mortality estimates in 2022 must also be considered as preliminary.

In 2015, the WG tested the sensitivity of the assessment to the reallocation of the French catches near the border of Subarea 8, and it was demonstrated that the influence was low. This should be further investigated in the next coming years, especially if the reallocated catches exceed the limits of the historical series.

The assessment scale is given by the survey catchability estimates. It therefore must be emphasized and admitted explicitly that the assessment should always be examined in relative terms, exploring the trends in biomass or harvest rates.

3.6 Short-term predictions

As the assessment, the short-term forecast for this stock can be conducted in June or in November. In June, there is no indication on next year recruitment, so the forecast has usually been based on an assumed undetermined recruitment scenario in which all the past recruitments were equally likely. In November, the forecast can be based on the next year recruitment distribution derived from the November assessment. The short-term prediction presented here, is based on the results from the final assessment conducted in November described in the previous section.

Recruitment in 2023 is estimated in the assessment and it is mainly informed by the latest JUVENA juvenile abundance index and the parameters of the JUVENA observation equations. Figure 3.6.1 shows the posterior distribution of recruitment in 2023 from the assessment in November. The median recruitment (age 1 biomass on 1st January) in 2023 for the November projections is around 82 389t.

The method for the short-term projections based on the November assessment is described in the stock annex approved in October 2013.

The European Commission requested ICES to provide advice based on the harvest control rule (HCR) named G3 with a harvest rate of 0.4 (STECF, 2013, 2014).

The full formulation of this HCR is as follows:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & if \widehat{SSB}_y \leq 24000 \\ -2600 + 0.4\widehat{SSB}_y & if 24000 < \widehat{SSB}_y \leq 89000 \\ 33000 & if \widehat{SSB}_y > 89000 \end{cases}$$

where $\widehat{SSB}_y$ is the expected spawning–stock biomass in year y. See also Figure 3.6.2 for a graphical representation.

In this rule, the TAC from January to December is based on the spawning biomass $\widehat{SSB}_y$ that will occur during the management year, which at the same time depends on the catches taken during the first semester of the management year. So, both parameters (catches and SSB) are inter-dependent and vary together. This leads to seek the value of fishing mortality during the first semester solving the system for the median values of recruitment 2022, biomass at-age 2+ at the beginning of 2022, the growth rates at-age 1 and 2+ and the selectivity at-age 1 in the first semester. The % of annual catches taken in the first semester was assumed to be 60% following STECF (2013; 2014). The simulations done by STECF for similar HCR suggested that the performance of the HCR was not dependent on the assumed split of the catches by semesters.

According to HCR G3 with harvest rate of 0.4, the TAC for the fishing season running from 1 January to 31 December 2023 should be established at 33 000 t. Under the assumption that 60% of the annual catches are taken in the first semester, the deterministic SSB in 2023 is 120 428 t (Table 3.6.3). When the projection is stochastic, the median SSB in 2022 is around 121 860 t with a 90% probability interval between 69 110t and 240 614t (Figure 3.6.3). The probability of SSB in 2022 being below B_{lim} is below 0.001.

Starting from the posterior distribution of recruitment (age 1 biomass) and biomass at-age 2+ on the 1st January 2023, the population was projected forward for one year. Total allowable catch during 2023 were explored from 0 (fishery closure) to 70 000 tonnes with a step of 5000 tonnes for a range of percentages of catches being taken in the first semester from 0 to 1 with a step of 0.1. Probability distributions of SSB in 2023 were derived for each of the catch options. For all cases, the probability of SSB in 2023 being below B_{lim} is below 0.03 (Table 3.6.1 and Figure 3.6.4) and the corresponding median SSB values in 2023 are above 85 000t (Table 3.6.2 and Figure 3.6.4).

Under the assumption that 60% of the annual catches are taken in the first semester, the probability of SSB in 2023 being below B_{lim} is lower than 0.05 for total catches up to 138 113 t (Table 3.6.3 and Figure 3.6.5). The harvest rate in 2022 was equal to 0.186. The same harvest rate in 2023 would lead to catches around 23 136 t and SSB around 124 568 t, with probability of SSB being below Blim lower than 0.001.

The final catch options table for 2023 is given in Table 3.6.3.

Following the stock annex, the usual underlying assumption for the short-term projections is that 60% of the catches are taken in the first semester. This value corresponds to the average of the percentages of catches in the first semester from 1987 to 2004 before the fishery closure and it was also used in the evaluation of the management plan (STECF, 2013, 2014). However, the percentage of the catches taken in the first semester since the reopening of the fishery has been 0.75. In 2020 a sensitivity analysis was carried out to test the potential influence of this assumption. In general, given the current high levels of biomass, the impact in the final catch option table was low.

Table 3.6.1: Bay of Biscay anchovy: Probability of SSB in 2022 of being below Blim under different catch options for 2023 and alternative catch allocation by semesters.

P(SSB < Blim)			% CATCHES IN THE FIRST SEMESTER 2023										
			0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2023	0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		10000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		15000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		20000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		25000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		30000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		35000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		40000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
		45000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0011
		50000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0011	0.0020
		55000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0020	0.0033
		60000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0015	0.0029	0.0069
		65000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.0024	0.0053	0.0131
		70000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0018	0.0036	0.0109	0.0202

Table 3.6.2: Bay of Biscay anchovy: Median SSB in 2022 under different catch options for 2023 and alternative catch allocation by semesters.

P(SSB < Blim)		% CATCHES IN THE FIRST SEMESTER 2023										
		0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
R estimated	TOTAL CATCH 2023											
	0	135,608	135,608	135,608	135,608	135,608	135,608	135,608	135,608	135,608	135,608	135,608
	5000	135,608	135,268	134,927	134,584	134,241	133,898	133,556	133,212	132,870	132,528	132,185
	10000	135,608	134,927	134,241	133,556	132,870	132,185	131,495	130,801	130,104	129,406	128,717
	15000	135,608	134,584	133,556	132,528	131,495	130,453	129,406	128,373	127,336	126,297	125,251
	20000	135,608	134,241	132,870	131,495	130,104	128,717	127,336	125,950	124,552	123,132	121,718
	25000	135,608	133,898	132,185	130,453	128,717	126,986	125,251	123,488	121,718	119,960	118,206
	30000	135,608	133,556	131,495	129,406	127,336	125,251	123,132	121,012	118,908	116,798	114,663
	35000	135,608	133,212	130,801	128,373	125,950	123,488	121,012	118,557	116,091	113,592	111,084
	40000	135,608	132,870	130,104	127,336	124,552	121,718	118,908	116,091	113,235	110,363	107,456
	45000	135,608	132,528	129,406	126,297	123,132	119,960	116,798	113,592	110,363	107,095	103,839
	50000	135,608	132,185	128,717	125,251	121,718	118,206	114,663	111,084	107,456	103,839	100,131
	55000	135,608	131,841	128,028	124,198	120,311	116,446	112,521	108,551	104,564	100,501	96,387
	60000	135,608	131,495	127,336	123,132	118,908	114,663	110,363	106,011	101,610	97,140	92,623
	65000	135,608	131,148	126,642	122,072	117,503	112,878	108,186	103,471	98,641	93,760	88,793
	70000	135,608	130,801	125,950	121,012	116,091	111,084	106,011	100,871	95,638	90,322	85,025

Table 3.6.3: Bay of Biscay anchovy: Catch options for 2023 under the assumption that 60% of the catches were taken in the first semester.

		STOCHASTIC	DETERMINISTIC	
Basis	Catch 2023	P(SSB 2023<Blim)	SSB 2023	Harvest rate 2023
G3 with hr=0.4	33,000	0.000	120,428	0.274
Zero catches	0	0.000	134,125	0.000
Same deterministic harvest rate as 2022	23,136	0.000	124,568	0.186
P(SSB2023<Blim)=0.05	138,113	0.050	73,291	1.884
Other options	10,000	0.000	130,020	0.077
Other options	20,000	0.000	125,876	0.159
Other options	30,000	0.000	121,692	0.247
Other options	40,000	0.000	117,465	0.341
Other options	50,000	0.000	113,195	0.442

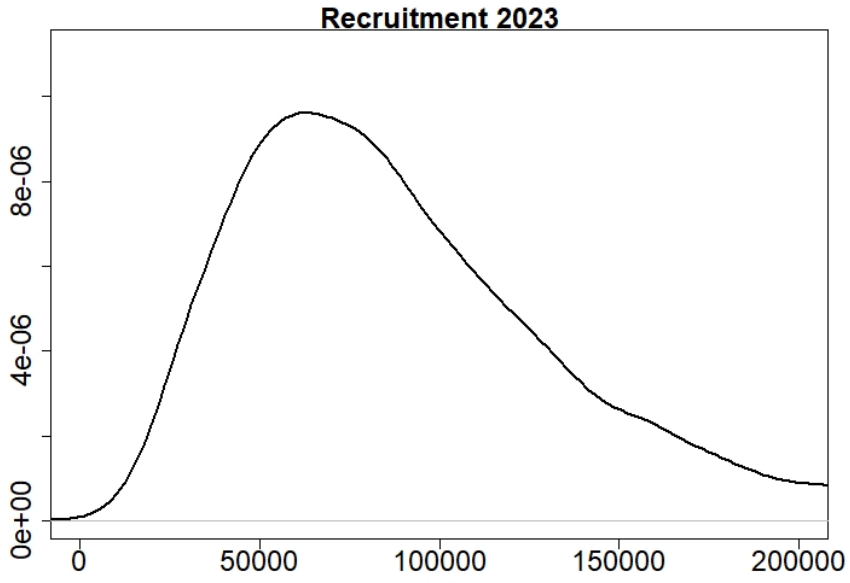


Figure 3.6.1: Bay of Biscay anchovy: Posterior distribution of recruitment (age 1 biomass at the beginning of the year) in 2023.

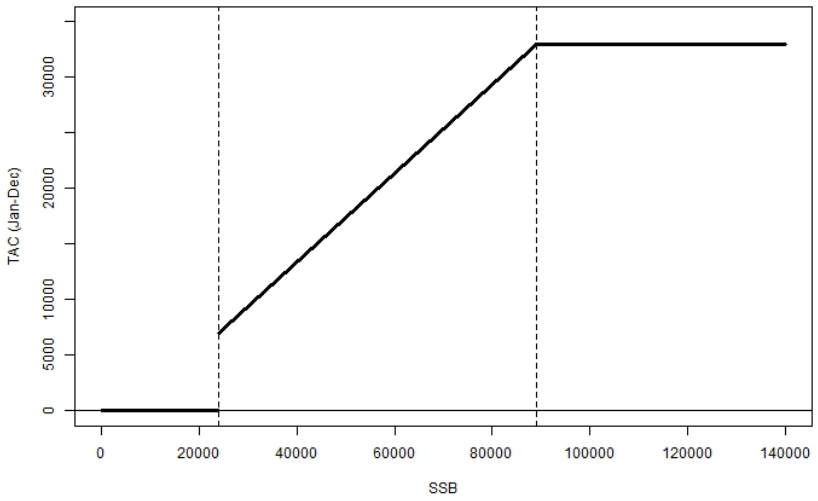


Figure 3.6.2: Bay of Biscay anchovy: Harvest control rule G3 with harvest rate of 0.4 according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

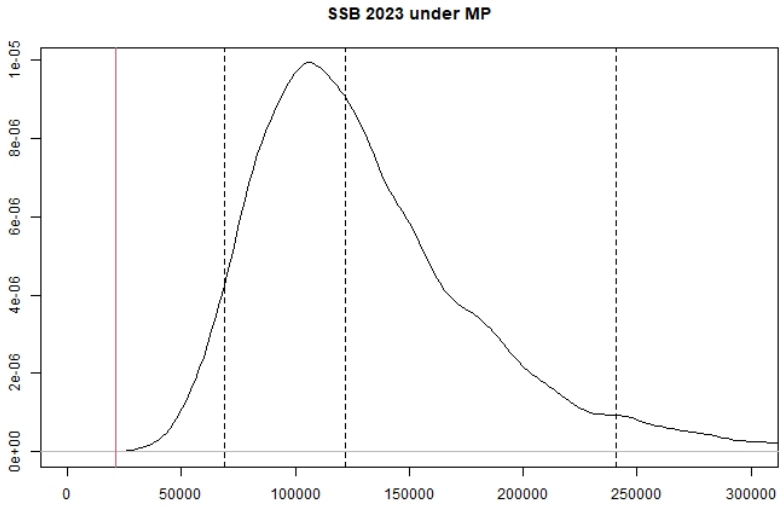


Figure 3.6.3: Bay of Biscay anchovy: Posterior distribution of SSB in 2023 if the annual catch is set according to the LTMP at 33 000 t and 60% of the catch is taken during the first semester. Vertical black dashed lines represent the 5, 50 and 95 posterior quantiles, whereas the red vertical line is Blim (21 000 t).

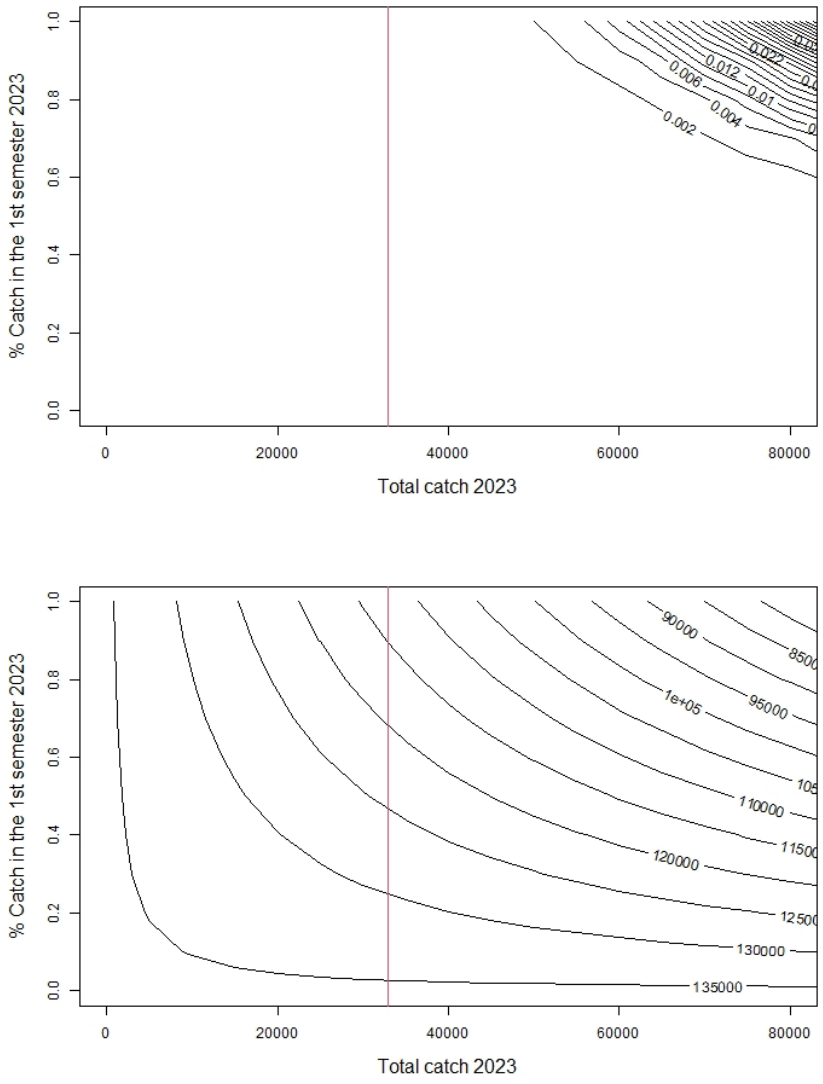


Figure 3.6.4: Bay of Biscay anchovy: Contour plots of probability of SSB in 2023 being below Blim (on the top) and median SSB in 2023 (on the bottom) depending on the total catch in 2023 (x-axis) and the % of the catch in the first semester (y-axis). The vertical red line is set at 33 000 t.

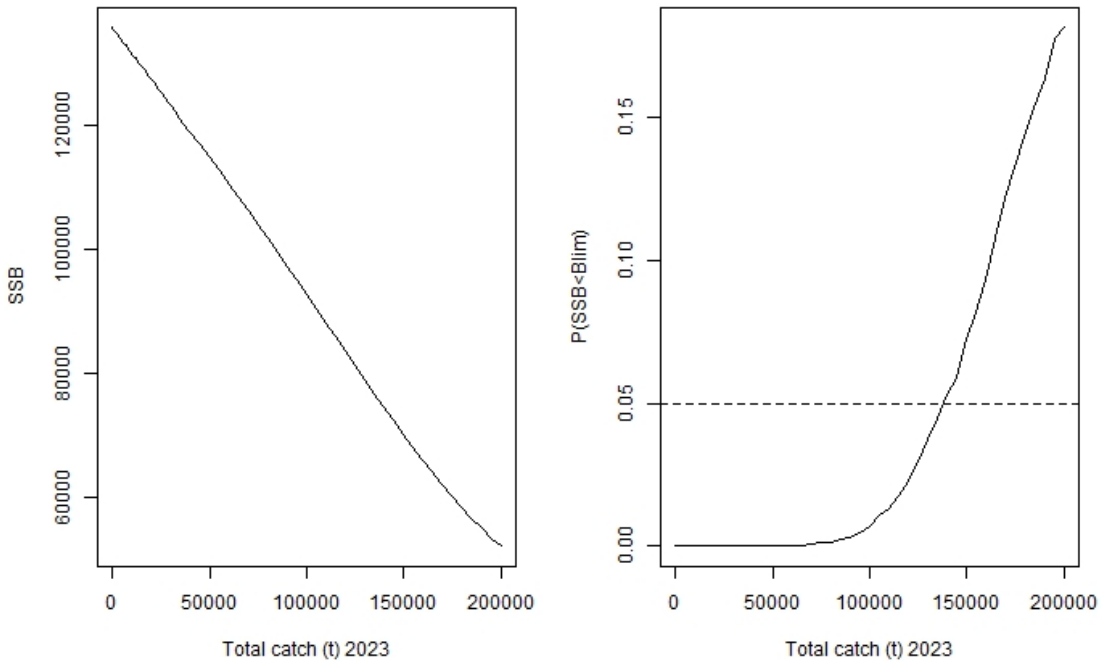


Figure 3.6.5: Bay of Biscay anchovy: SSB in 2023 (on the left) and probability of SSB in 2023 been below Blim (on the right) depending on the total catch taken in 2023 when 60% of the catch is taken during the first semester.

3.7 Reference points and management considerations

3.7.1 Reference points

The reference points and their definitions are found in the stock annex for this stock, which was approved in October 2013.

Bay of Biscay anchovy is a short-lived species classified in category 1. According to the guidelines, the classification of status of stock for short-lived species should be based directly on the distribution of SSB at spawning time relative to B_{lim}. B_{lim} is set at 21 000 tonnes. Given that the current assessment provides the probability distributions for SSB, the probability of SSB being below B_{lim} can be directly estimated and the definition of B_{pa} becomes irrelevant. Alternatively, F precautionary approach (PA) reference points don't need to be defined, since ICES does not use F reference points to determine exploitation status for short-lived species.

According to the recent advisory practice (ICES Advice 2019, Book1, Section 1.2 General context of ICES advice), the ICES MSY approach for short-lived stocks is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn), which is more robust against low SSB and recruitment failure than a fishing mortality approach. In addition, fishing mortality is not allowed to be higher than F_{cap}, a limit fishing mortality that constraints the exploitation rate when biomass is high. This applies to the Bay of Biscay anchovy. Hence, defining an F_{MSY} is irrelevant, and advice aiming at MSY is equivalent to the precautionary approach advice. ICES advice for this stock is based on a management plan and MSY $B_{escapement}$ and F_{cap} have not been defined for this stock.

3.7.2 Short-term advice

Providing a risk adverse advice according to the precautionary approach in the short-term per-spective translates into recommending a TAC, which implies a low risk of leading below B_{lim}, for selected scenario(s) of recruitment.

The Bayesian assessment model provides estimates of the uncertainty, which are expressed as posterior distributions of the interest parameters. The posterior distributions express the uncer-tainty of the results given the uncertainty of the data and the prior assumptions, and presumably represent more realistic estimates of the uncertainty than the assumptions underlying the distance between B_{lim} and B_{pa} in the common deterministic framework.

According to the current stock annex, the assessment of this stock can be conducted at two points in time: in June when SSB is estimated based on the most recent spring surveys information and in November when the assessment can incorporate the most recent juvenile abundance index from JUVENA and any other updated data.

Similarly, the forecast can be given based either on the June or November assessment. In the former, the assessment goes up to June, and given that there is no indication on the strength of the incoming year class, an undetermined scenario is assumed based on a mixture distribution of all the past recruitments. In the latter, the assessment covers the whole year up to December and the next year recruitment distribution is derived from the assessment which includes the latest juvenile abundance index.

3.7.3 Management plans

A draft management plan was proposed by the EC in 2009 in cooperation between science (STECF) and stakeholders (Southwestern Waters AC). This plan was not formally adopted by the EU, but it was used from 2010 to 2014 for establishing the TAC for the period between 1st July and 30th June next year.

In February 2013, the Bay of Biscay anchovy stock was benchmarked in the Benchmark Workshop on Pelagic Stocks (WKPELA). The new stock annex for this stock was approved in October 2013 after further discussions held during WGHANSA 2013 and afterwards by correspondence.

Given that the 2009 long-term management plan proposal for the stock was based on the methods described in the previous stock annex (approved by WKSHORT 2009), STECF was requested to assess the harvest control rule and possible alternatives scoped with the stakeholders, and provide advice taking into account the long-term biological and economic objectives established in the plan. The STECF expert group met from 14 to 18 October 2013 and concluded that the change in the assessment methodology did not affect the usefulness of the LTMP proposal and that the HCR remained within the precautionary limits of risk.

In addition, the STECF expert group advised on a possible revision of the HCR (including changes regarding the HCR and the management calendar) and set the basis for conducting an impact assessment for the Bay of Biscay anchovy long-term management regulation (STECF, 2013).

The data analysis for support of the impact assessment for the management plan of Bay of Biscay anchovy was carried out by an STECF expert group that met from 10 to 14 March 2014 (STECF, 2014). A range of alternative HCR formulations were tested and they were considered to provide a sound base for developing options for fisheries management. In particular, for all the HCRs tested, the

STECF noted that changing the management period to January–December reduced the risks of the stock falling below B_{lim}, and leaded to a small increase in quantity and stability of catches compared with the management period July–June.

During the two expert group meetings, the STECF concluded that the HCR in the 2009 LTMP proposal remained appropriate as a basis for advising on TACs. Therefore, in July 2014, the TAC from July 2014 to June 2015 was set according to this draft plan.

In the second semester of 2014, managers and stakeholders agreed on adopting the HCR named G4 in the STECF report with a harvest rate of 0.45 (Figure **3.7.3.1**). According to this rule, the TAC for the management period from January to December is set as:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & if \widehat{SSB}_y \leq 24000 \\ -3800 + 0.45\widehat{SSB}_y & if 24000 < \widehat{SSB}_y \leq 64000 \\ 33000 & if \widehat{SSB}_y > 64000 \end{cases}$$

where is the expected spawning–stock biomass in year. In this rule, the TAC from January to December is based on the spawning biomass that will occur during the management year, which at the same time depends on the catches taken during the first semester of the management year. So, both parameters (catches and SSB) are interdependent and vary together. This leads to seek the value of fishing mortality during the first semester solving the system for the median values of incoming recruitment, biomass at-age 2+ at the beginning of the year, the growth rates at-age 1 and 2+ and the selectivity at-age 1 in the first semester. The % of annual catches taken in the first semester is assumed to be 0.6 according to STECF (2013; 2014).

Subsequently, the European Commission requested ICES to provide advice in December 2014 based on this new HCR, which was used to set a new TAC from January to December 2015. In 2015, ICES reviewed the selected harvest control rule and concluded that it was precautionary (Annex 5 in ICES, 2015a). Subsequently, ICES advice for year 2016 was again provided in accordance with this HCR. In May 2016, the SWWAC recommended to modify the management framework (SWW Opinion 101). Based on the good state of the stock, they asked to use the harvest control rule G3 with a rate of exploitation of 0.4 (Figure **3.7.3.1**), which sets the TAC for the management period from January to December as:

$$TAC_{Jan_y-Dec_y} = \begin{cases} 0 & if \widehat{SSB}_y \leq 24000 \\ -2600 + 0.4\widehat{SSB}_y & if 24000 < \widehat{SSB}_y \leq 89000 \\ 33000 & if \widehat{SSB}_y > 89000\,. \end{cases}$$

This rule complies with the probability of risk of 5% as evaluated by STECF (2014) and has been assessed to conform to the ICES criteria for management plans (ICES, 2016, Annex 9). The SWWAC recommended an immediate application of this HCR and in June 2016 the European Commission increased the fishing opportunities for 2016 from 25 000 to 33 000 tonnes. The European Commission requested that this rule was used as the basis of the ICES advice from 2017 onwards.

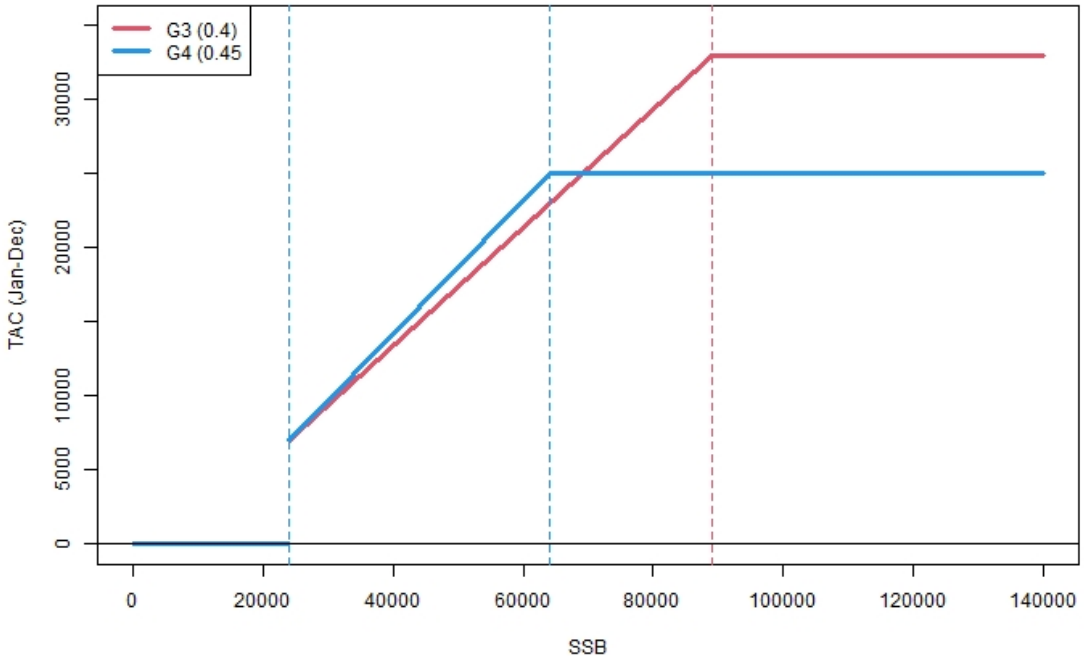


Figure 3.7.3.1: Bay of Biscay anchovy: Harvest control rules G4 with harvest rate of 0.45 (in red) and G3 with harvest rate of 0.4 (in blue) according to which the TAC from January to December is set as a function of the expected spawning–stock biomass (on 15th May) in the management year.

3.7.4 Species interactions effects and ecosystem drivers

Anchovy is a prey species for other pelagic and demersal species, and also for cetaceans and birds. Recruitment depends strongly on environmental factors, and several recruitment predictions have been proposed in the past based on environmental variables. However, their prediction capacity is still being tested.

3.7.5 Ecosystem effects of fisheries

These effects are not quantified.

3.8 References

Boyra, G., Martínez, U., Cotano, U., Santos, M., Irigoien, X., and Uriarte, A. 2013. Acoustic surveys for juvenile anchovy in the Bay of Biscay: abundance estimate as an indicator of the next year's recruitment and spatial distribution patterns. ICES Journal of Marine Science, 70: 1354–1368.

STECF. 2013. Advice on the harvest control rule and evaluation of the anchovy plan COM(2009) 399 final (EWG 13-20). Publications Office of the European Union, Luxembourg, 2013, ISBN 978-92-79-34619-4.

STECF. 2014. Evaluation /scoping of management plans - data analysis for support of the impact assessment for the management plan of bay of biscay anchovy (COM(2009)399 final) (EWG 14-03). Publications Office of the European Union, Luxembourg, 2014, ISBN 978-92-79-37843-0.

ICES. 2015. Report of the working group on southern horse mackerel, anchovy and sardine (WGHANSA), 24-29 june 2015, Lisbon, Portugal. ICES CM 2015/ACOM:16. 612 pp.

ICES. 2020. Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.5977

ICES. 2021. Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.8138

ICES. 2022. Working Group on Acoustic and Egg Surveys for small pelagic fish in Northeast Atlantic (WGACEGG). ICES Scientific Reports.