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Working Group on the Black Sea (WGBS)

Subregional Group on Stock Assessment for the Black Sea (SGSABS)

Benchmark session for the assessment of sprat in GSA 29

Constanta, Romania, 27–28 November 2018

REPORT

EXECUTIVE SUMMARY

The Subregional Group on Stock Assessment for the Black Sea (SGSABS) benchmark session for the assessment of sprat in GSA 29 was held at in Constanta, Romania, on 27–28 November 2018. The objective of the meeting was to perform a full analysis and review of the information and methods used to provide advice on the status of the stock, focusing on the consideration of old and new data sources as well as old and new (or improved) assessment models and assumptions. The session was attended by a total of 36 experts, including experts from the region, experts on the species and/or stock assessment models discussed, as well as an external reviewer.

The session investigated all available input data and carried out an analysis of the performance of three different stock assessment models: state-space assessment model (SAM), Integrated Catch-at-age Analysis (ICA) and Extended survivor analysis (XSA), all were tested with different assumptions and/or input data series. ICA with fully selected age of two and all XSA models run produced very similar results overall, especially for the more recent part of the time series. SAM provided a lower perception of spawning stock biomass (SSB) and a higher perception of F, although the final year of XSA was within the confidence bounds of the SAM. The historical part of the quantities estimated by SAM was very different from ICA and XSA; this discrepancy is ascribable to the different modeling approach. All models showed a cyclical pattern in both recruitment and SSB. XSA and ICA also showed overall decreasing trends in these quantities, coupled with an increasing trend in F, which SAM did not show.

For practical reasons related to operational constraints making the running of ICA models virtually impossible, it was agreed not to use ICA in the future. Pending further work and, given the expert perception on the stock (i.e. a decrease in SSB and length-structure of the stock), the Group agreed with the overall results of XSA towards providing precautionary advice of not increasing fishing effort for the Black Sea sprat stock, temporarily considering its status as uncertain, while further investigating methodological and data-related issues.

Considering the trend in the past years, the partial reduction in stock size and catches may be a consequence not only of fishing mortality but also of the environment and the cyclical nature of the stock.

CONTENTS

1. TERMS OF REFERENCE OF THE MEETING

The meeting of the Subregional Group on Stock Assessment for the Black Sea (SGSABS) benchmark session for the assessment of sprat in geographical subarea (GSA 29) was held at in Constanta, Romania, on 27–28 November 2018.

The objective of the meeting was to perform a full analysis and review of the information and methods used to provide advice on the status of the stock, focusing on the consideration of old and new data sources as well as old and new (or improved) assessment models and assumptions. In particular, the benchmark meeting addressed the following Terms of Reference (ToRs) proposed by the Working Group on the Black Sea (WGBS) at its seventh session and approved by the forty-second session of the General Fisheries Commission for the Mediterranean (GFCM):

- the identification of all problems and issues associated to the data, assumptions and methodologies used for the current assessment;
- the identification and provision of extra data required to address the above problems;
- the identification of appropriate alternative methodologies to be tested on top of existing ones;
- final revision and agreement of data, assumptions (including all biological parameters) and assessment methods proposed;
- the performance of the assessments;
- comparison of the outcomes and selection of the most appropriate one for the provision of advice, in light of respective shortcomings and advantages;
- the estimation of adequate reference points and analysis of their robustness; and
- the provision of advice on the status of the stock based on the outcomes of the chosen model with respect to the estimated reference points.

In line with the adopted ToRs and in order to ensure the best quality advice is provided, the benchmark session was attended by stock and methodological experts, both from the area/subregion and outside (see list of participants in Appendix 2. In order to support Black Sea experts in analysing data and to provide assistance to the participants in running the sprat stock assessment models during the meeting, the GFCM Secretariat invited Ms Piera Carpi (stock assessment scientist) to participate in the meeting as independent expert. In addition, Mr Mikael van Deurs (sprat assessment expert from the National Institute of Aquatic Resources of the Technical University of Denmark [DTU Aqua]) was invited to participate as external reviewer of the benchmark session.

Following the benchmark assessment, all historical data, assumptions and models will be fixed for the successive 3–4 years and assessments presented in this time period are expected to provide updates incorporating data from the most recent year(s).

2. PREVIOUS ADVICE AND IDENTIFIED UNCERTAINTIES

2.1. Advice in the context of the GFCM

The GFCM has carried out assessments of European sprat in the Black Sea since 2012 (data year), using Integrated Catch-at-age Analysis (ICA; Patterson and Melvin, 1996). Since 2012, this has been done within the remit of the SGSABS. The assessment outcomes in terms exploitation rate (E) and E relative to its reference point (E=0.4) are summarized in Table 1. In 2016, the ICA model performed at the Scientific, Technical and Economic Commission for Fisheries (STECF) (EWG 17–14) was reviewed and it was noted that the fits at age of some of the main indices were overestimated possibly providing an over-optimistic view of the stock. A state-space assessment model (SAM) was attempted with a reduced set of indices excluding those with bad internal consistency diagnostics. The outcomes of the SAM model, in terms of exploitation rate, included the outcomes of the ICA within their confidence intervals but on the lower (more optimistic) bounds. SAM highlighted a risk that the stock was fished above maximum sustainable yield (MSY). A range of estimates of exploitation rates was provided and a benchmark assessment to decide between models was been planned for 2018.

Table 1. Summary of GFCM assessments of European sprat in the Black Sea from 2012 to 2016 (data/reference year)

Data year	Model	Fcurr/ *Ecurr	$F_{0.1}$/ *Eref	Ratio	Comments
2012	ICA	0.38*	0.4*	0.95	Further information on biological parameters and environmental relationships from analysis of catches is desirable
2013	ICA	0.45	0.64	0.72	Hydro-acoustic survey covering at least western and north-western part of the Black Sea desirable. Egg and larvae survey could also be included.
2014	ICA	0.32*	0.4*	0.8	Model is run with the same configuration as last year, incorporating one more year of data. Results confirmed by two exercises with ASPIC and CMSY. Stock advice is consistent within years and changes in stock status reflect fluctuations in stock biomass due to recruitment peaks.
2015	ICA	0.36*	0.4*	0.9	The model was run with the same configuration as last year, incorporating one more year of data. Stock advice has been consistent over the years and changes in stock status reflect fluctuations in stock biomass due to recruitment peaks.
2016	SAM	0.37 – 0.59*	0.4*	0.93 – 1.48	The ICA model performed at the STECF (EWG 17-14) was reviewed and it was noted that the fits at age of some of the main indices were overestimated possibly providing an over-optimistic view of the stock. A SAM model was attempted with a reduced set of indices excluding those with bad internal consistency diagnostics. The outcomes of the SAM model, in terms of exploitation rate, include the outcomes of the ICA within their confidence intervals but on the lower (more optimistic) bounds. SAM highlights a risk that the stock is fished above MSY. A range of estimates of exploitation rates is provided and a benchmark assessment to decide between models has been planned for 2018.

2.2. Advice in the context of the STECF

The STECF has provided advice on the status of the European sprat resource from 2007 to 2016 (data year) through working groups dedicated specifically to Black Sea assessments (SGMED-09-01; STECF-OWP-11-06; STECF-12-15; STECF 13-20; STECF 14-14; STECF 15-16; STECF 17-14). The accepted assessments were all carried out using ICA and provided, until 2016, the basis for GFCM assessments of stock status. In 2016, for the first time, the SGSABS proposed an alternative model to the original STECF ICA. The request for a benchmark assessment stemmed from the differences encountered between the STECF ICA assessment and the alternative SAM accepted and validated by the GFCM.

3. REVIEW OF AVAILABLE FISHERIES DEPENDENT AND FISHERIES INDEPENDENT INFORMATION

Two data preparation meetings were organized, within the context of the BlackSea4Fish project, in preparation for the sprat benchmark session:

i. For Turkish data: Trabzon (Turkey), 27–29 September 2018

From the very beginning of the SGSABS, the poor quality of the tuning data was underlined and the importance of estimation of sprat abundance and biomass from the Turkish hydro-acoustic survey for anchovy was underlined. The standardization of the Turkish commercial catch per unit effort (CPUE) index was also pointed out as a significant deficiency. The data preparation meeting in Trabzon was held to go over these deficiencies in the Turkish data, and to discuss the potential data sources, which were not considered in the past. The meeting was attended by the lead fisheries institutes on the Black Sea coast of Turkey, the Central Fisheries Research Institute of Turkey (SUMAE) and the fisheries statistics department.

In this context, it was decided to use the Turkish Statistical Institute (TURKSTAT) records, fleet registries in the Turkish Fisheries Information System (SUBIS) and the landing transport authorization documents that have to be issued by the fishing cooperatives. In this way, it seemed possible to statistically model the relationship between the landings of a boat and its engine power and the period of the fishing season. Thus, standardization of CPUE, with regards to the engine power and the time, was targeted.

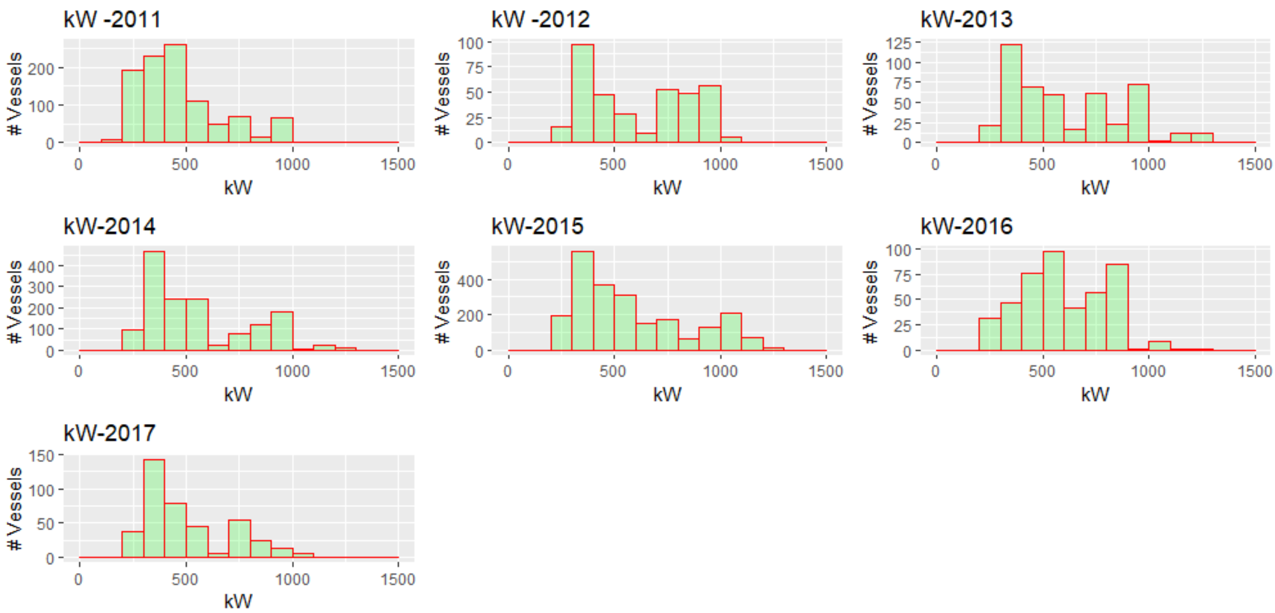


Figure 1. Turkish CPUE data: kW of Turkish vessels in 2011–2017

This meeting and the work stemming from it resulted in the standardization of the Turkish CPUE data using information on vessel characteristics (kW and tonnage– Figure 1) and the estimation of sprat biomass and abundance based on hydro-acoustic surveys (Table 9 below). Vessel charchteristics and time are also likely to be important for the standardization of data from other countries.

ii. For Bulgarian and Romanian data: Burgas (Bulgaria), 13–15 November 2018

Participants included five experts from Bulgaria the (Institute of Oceanology at the Bulgarian Academy of Science (IO BAS), the Institute of Bioversity and Ecosystem Research at the Bulgarian Academy of Science (IBER BAS) and the Institute for Field Research (IFR), four experts from Romania (National Institute for Marine Research and Development "Grigore Antipa" – NIMRD) and the the BS4Fish project coordinator. It was chaired by Mr. Simion Nicolaev, and moderated by Violin Raykov and the BS4Fish project coordinator.

These meetings allowed to identify and evaluate the data available and to formulate roadmaps for the work to be done in preparation for the benchmark session (Tables 2 and 3).

The data available and used in the assessments are reported below.

Table 2. Available data by country

	Available data (catch only, catch-at-length, catch-at-age, abundance index)					
Type of data	Bulgaria	Georgia	Turkey	Romania	Russian Federation*	Ukraine
Landings	1970 - 2017	1988-2003	1993-2017	1960 – 2017	1970-2017	1988 - 2017
Catch length frequency distribution	2003 - 2017	/	2009-2017	2008 – 2017	/	2014 - 2017
Survey index	Spring: 2007-2017 with gaps	/	Autumn: 2012-2016 with gaps; 2018 April and July surveys	Spring: 2008-2017 with gaps Autumn: 2008-2017 with gaps	/	/
Survey length frequency distribution	/	/	/	/	/	/
Commercial CPUE			Standardised: 2011-2017; Nominal: 1993-2017	Nominal: 2009-2017		Nominal: 1996-2012 (NW), 2015-2017
Growth models	2016	/	2017	2017	2017	2017
Sex ratio	/	2002-2017	2009-2017	/	/	/
Maturity at length/age	Cumulative for all years	Cumulative for all years	Cumulative for all years	Cumulative for all years	Cumulative for all years	Cumulative for all years
Weight length relationship	2007 - 2016	/	2009-2017	Cumulative for all years	Cumulative for all years	Cumulative for all years
M at age	Gislason	/	Gislason	Gislason	/	Gislason

3.1. Landings data

The opportunities of for marine fishing are limited by the specific characteristics of the Black Sea. The exploitation of the fish resources is limited in the shelf area. The water below 100–150 m is anoxic and contains hydrogen sulphide. In Bulgarian, Romanian, Russian and Ukrainian waters the most intensive fishery for Black Sea sprat is conducted between April and October with mid-water trawls on vessels larger than 40 m, while in Turkey the most intensive fishery for Black Sea sprat is conducted between January and April with mid-water trawls mostly on vessels between 15-40 m. Beyond the twelve-mile zone a special permission is needed for fishing. Harvesting of Black Sea sprat is conducted during the day, when the sprat aggregations become denser and are successfully fished with mid-water trawls. Information on the fleets targeting sprat in the different riparian countries can be found in the Stock Assessment Form.

Landings by country can be found in Table 3.

Table 3. Sprat catches by country

	UKRAINE	**BULGARIA**	**USSR/RUS.FED***	**TURKEY**	**GEORGIA**	**ROMANIA**	**TOTAL**
1960						1377	1377
1961						2779	2779
1962						2144	2144
1963						2193	2193
1964						3045	3045
1965						4372	4372
1966						476	476
1967						701	701
1968						1015	1015
1969						914	914
1970		1407	400			1337	3144
1971		2473	800			1346	4619
1972		2962	900			2262	6124
1973		3383	900			2201	6484
1974		4468	500			1245	6213
1975		5565	830			731	7126
1976		7199	1610			1610	10419
1977		8754	6700			1463	16917
1978		10596	22807			1490	34893

	UKRAINE	BULGARIA	USSR/RUS.FED*	TURKEY	GEORGIA	ROMANIA	TOTAL
1979		13541	57923			2269	73733
1980		16568	66893			989	84450
1981		1888	75121			2360	79369
1982		16524	56348			3002	75874
1983		12023	25484			3364	40871
1984		13921	24138			4456	42515
1985		15924	28839			6836	51599
1986		1169	43096			8965	53230
1987		10979	45341			9474	65794
1988	39800	6199	7157		7207	6454	66817
1989	63239	7403	16045		9708	8911	105306
1990	33174	2651	6955		7918	3198	53896
1991	11094	1909	2675		1268	729	17675
1992	11492	2353	3221		830	2074	19970
1993	9154	2174	694	940	232	2439	15633
1994	12615	2200	1013	933	308	2203	19272
1995	15218	2874	1263	1639	292	2421	23707
1996	20720	3535	1537	1608	185	2001	29586
1997	20208	3646	706	500	85	3318	28463
1998	30282	3275	1243	1500	24	3293	39617
1999	29238	3595	4473	695	45	1933	39979
2000	32644	1737	5543	7000	42	1803	48769
2001	48938	695	11122	1000	30	1792	63577
2002	45430	11595	11218	2050	43	1618	71954
2003	31366	9155	20410	6025	2	1218	68176
2004	30891	2889	14324	5411	4	1350	54869

	UKRAINE	BULGARIA	USSR/RUS.FED*	TURKEY	GEORGIA	ROMANIA	TOTAL
2005	35707	2575	13247	5500		1487	58516
2006	21309	2655	8157	7311		1142	40574
2007	18013	2559	6077	11921		521	39091
2008	21111	4304	7814	39303		234	72766
2009	24604	4551	8744	53385		92	91376
2010	24652	4041	5911	57023		39	91666
2011	24379	3958	5097	87141		131	120706
2012	15751	3157	3937	12092		88	35025
2013	12866	3784	3132	9764		99	29645
2014	2114	2279	10319	41648		85	56445
2015	2237	3287	26119	76996		110	108749
2016	1745	2295	25766	50225		49	80080
2017	2160	3189	13203	33950		29	52531

These were combined and the total was used in the assessment from 1997 to 2017 (Figure 2)

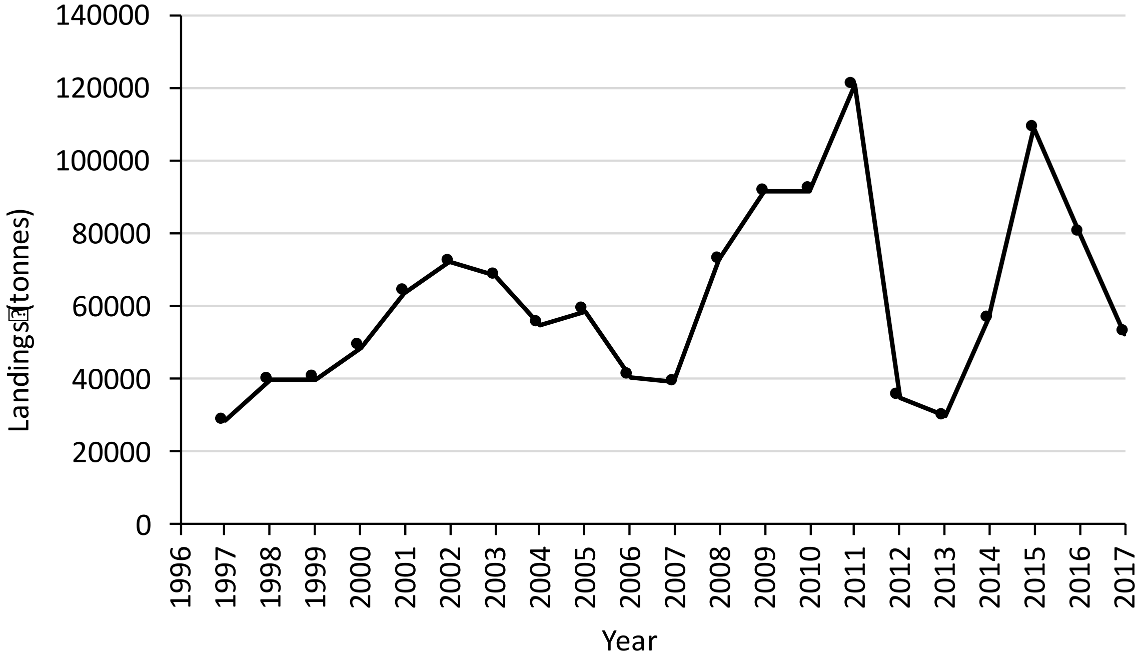


Figure 2. Total landings of Black Sea sprat, 1997–2017

3.2. Catch length frequency distribution

Length frequency distributions of catches were provided by Bulgaria, Romania, Turkey and Ukraine for a variable number of years (Table 3, Figures 6 and 7). All countries provided information at half cm, with the exception of Romania. Ukraine provided fork length instead of total length, hence the data were converted using a conversion factor. The minimum length observed was 5 cm, while the maximum size was 12 cm. Bulgaria seems to catch slightly bigger sizes compare to the other countries (Figures 6, 7 and 8).

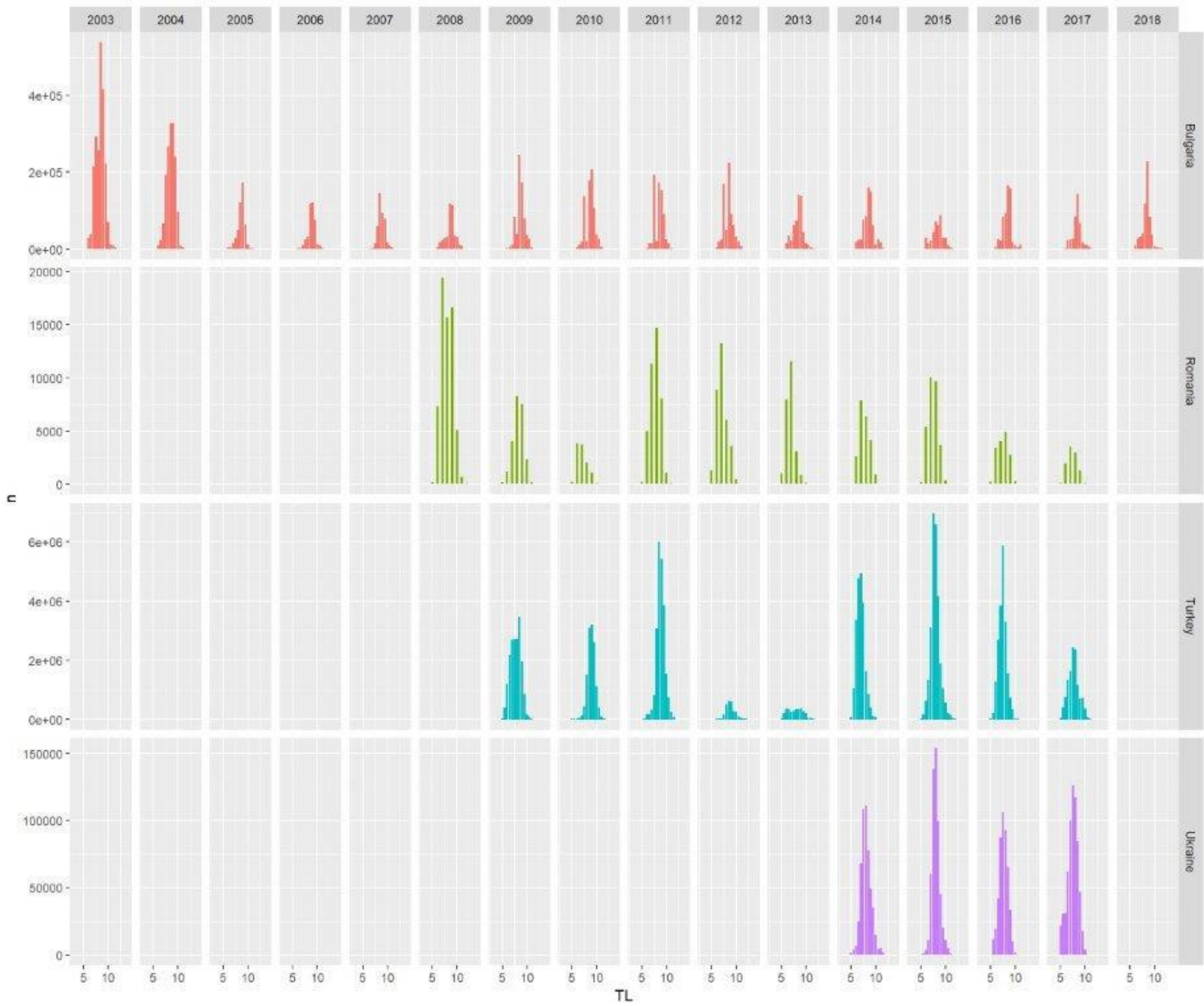


Figure 3. Length frequency distributions of sprat landings by country and year

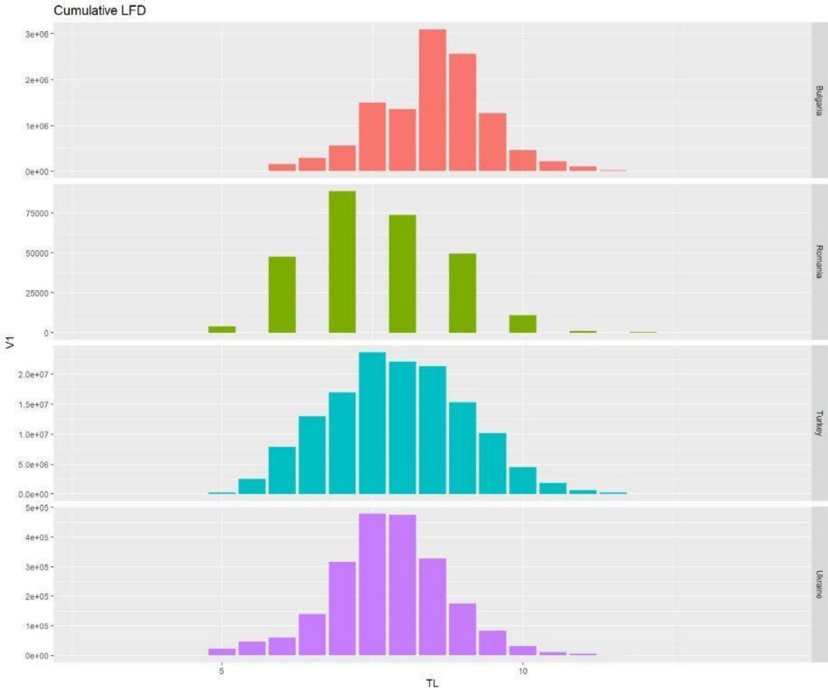


Figure 4. Cumulative length frequency distribution of sprat landings by country

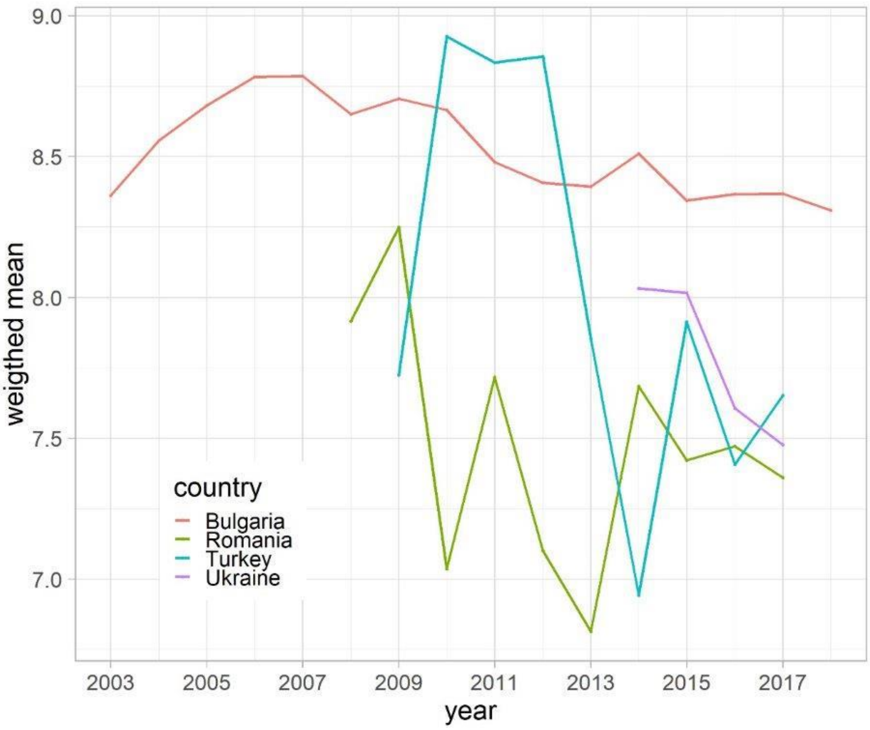


Figure 5. Weighted mean length of sprat in landings by country

3.3. Catch age compositions

For Turkish landings, the 2017 age-length-key was used for 2009–2017. It was checked the Bulgarian age-distribution could be used back in time to distribute landings onto age-groups (light area in table). However, this was not a good idea, so instead the average age-distribution from 2009–2017 was applied back in time (Table 4, Figure 6).

For all other countries, a Bulgarian age-distribution was applied to the total landings. Between 1997 and 2008 the number-at-age were constructed using the method used in STECF EWG 17-11, while from 2009 to 2017, the numbers at age were constructed using a common weight-at-age (Table 5) and this resulted in the final numbers at age displayed in Table 6.

Table 4. Sprat landings at age for Turkey

ALK (2017) [2009–2017]

age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0	35116.56	11961.22	176861.3	28638.75	55828.51	164076.1	147341.8	149756.8	189816.9	333124.3	1133702	1230053.409	47739.74	148574.4	9205.724	474257.4	3403907	627981.6	1105364	984819
1	216321.8	73682.41	1089485	176417.8	343909.6	1010727	907641.3	922517.8	1169293	2052082	6983728	12406054.44	4151874	8256852	1098905	1525549	16363757	19452619	16177987	8277498
2	72327.73	24635.9	364271.9	58985.72	114987	337939	303472.2	308446.2	390955.9	686118.6	2335027	4339119.924	6377713	10658908	1087965	764256.5	1387481	5627909	2514101	2208791
3	14283.16	4865.056	71935.8	11648.4	22707.45	66735.62	59929.17	60911.42	77205.31	135493.5	461117.1	514214.2804	1905036	2861347	390408.5	306622.8	123691.4	945653.2	163186.9	542072.7
4	2858.52	973.6546	14396.67	2331.22	4544.492	13355.95	11993.76	12190.34	15451.27	27116.63	92284.41	54965.49732	345418.7	655836.9	126726.9	95965.27	10595.91	322389.2	10493.47	76835.37
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

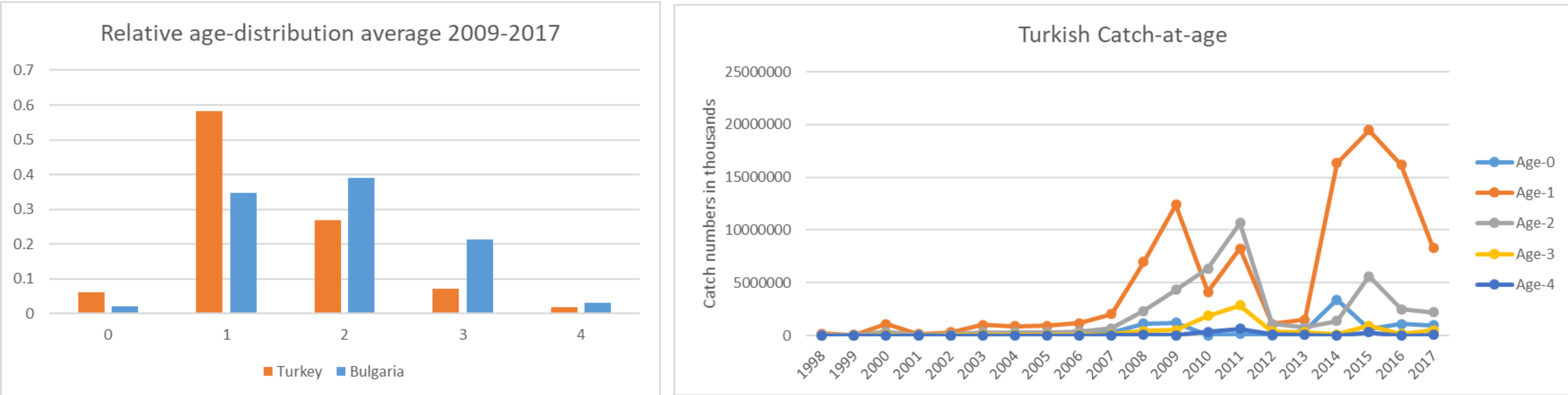


Figure 6. Turkish relative age distribution (2009–2017) and landigs at age

Table 5. Common weight-at-age based on all countries except Turkey

age-0	age-1	age-2	age-3	age-4
2.15	3.32	4.61	6.13	7.46

Table 6. Sprat number-at-age in landings for all countries

Age/Year	0	1	2	3	4
1997	278487	2741443	2600143	829539	42904
1998	235863	2278185	2830524	1740582	82350
1999	1009438	3838268	3085718	1302166	120608
2000	405525	4877453	3340121	1313377	109537
2001	809489	10352371	6646461	1268796	108793
2002	415385	6828731	7655154	3089580	182212
2003	1315819	6188471	5970581	3309605	737421
2004	444744	6878143	3579996	2666271	278459
2005	528326	6023749	4651599	1602439	371915
2006	1157538	5976467	2704547	785481	91525
2007	3180140	5350500	1875506	801512	113131
2008	1299013	7773549	3248220	1326810	168349
2009	1979332	14238341	7530960	1729513	532871
2010	891685	6602043	9721570	3229173	819631
2011	782402	9424607	12525931	3764540	1058941
2012	465300	2531245	3347988	1312284	469487
2013	768479	2763507	2519506	926117	332365
2014	4562112	18059495	3005799	449541	86327
2015	2037239	20063128	8134946	3380907	576390
2016	4201526	16420618	6259962	2113295	451917
2017	1734411	9550165	3444792	1129819	183765

Cohorts in the catches are shown in Figure 7. Fully recruited age seems to be age one in most years, with few exceptions where age two is the first age fully recruited by the fishery.

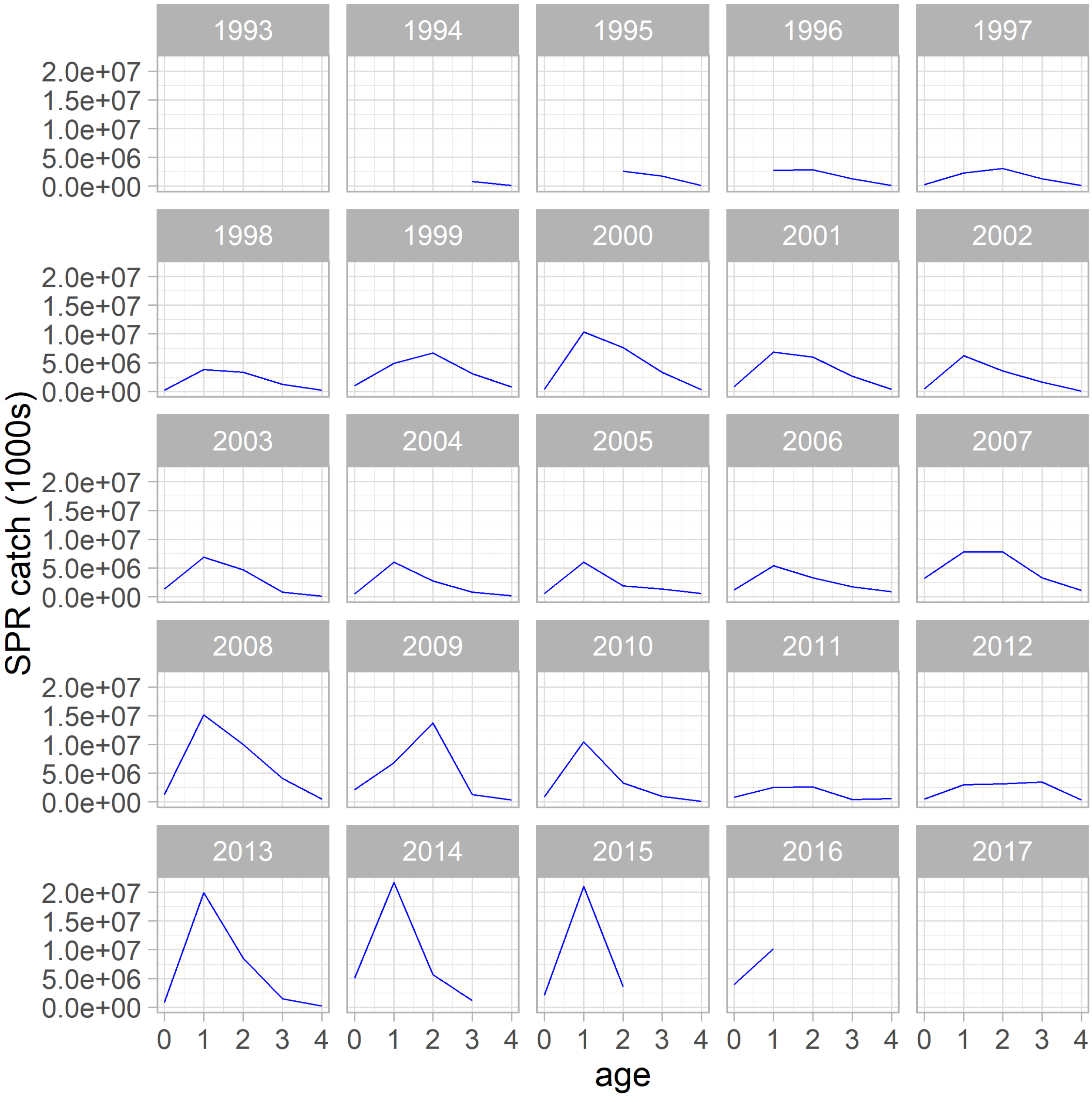


Figure 7. Sprat in GSA 29. Cohorts in the catches for the overall catch at age matrix.

Internal consistency in the catch-at-age matrix is shown in Figure 8. Catch-at-age data show a decent internal consistency.

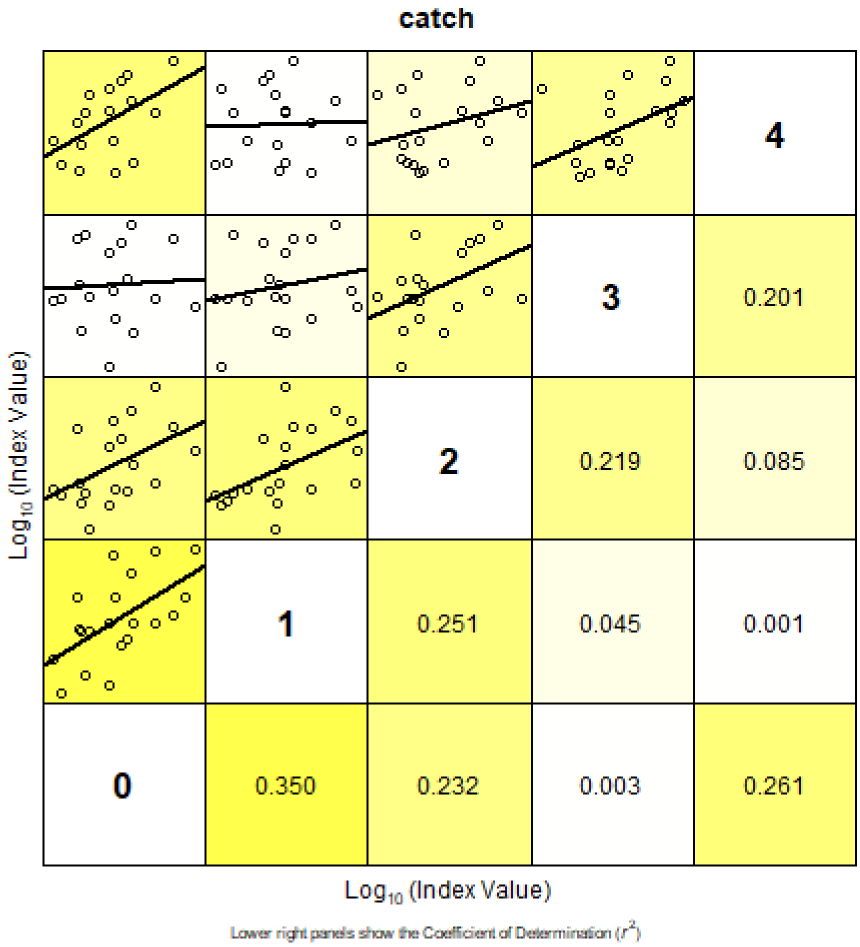


Figure 8. Sprat in GSA 29. Internal consistency in the catch-at-age data.

3.4. Surveys and tuning indices

3.4.1. Turkish pelagic (hydro-acoustic) survey

Within the scope of the project of pelagic survey, the hydro-acoustic survey at the beginning and end (Figures 12 and 13) of the fishing season is carried out with SIMRAD EK-60 scientific echo sounder (38 kHz). The survey was planned in the Turkish Exclusive Economic Zone (EEZ). In addition to acoustic scans, mid-trawl sampling and water parameters are taken with CTD. Analysis of the data was done with the Echoview program and the stock containing the period of small pelagic (anchovy, horse mackerel and sprat) in the region was estimated. The total estimated biomass was 78323 tonnes in October-November 2016 and 87406 tonnes in July 2018 (Table 7).

Table 7. Turkish acoustic survey

Year	Oct-Nov surveys	July Surveys	April Survey	Oct-Nov surveys	July Surveys	April Survey
	Abundance (thousands)	Abundance (thousands)	Abundance (thousands)	Biomass (tonnes)	Biomass (tonnes)	Biomass (tonnes)
2012	17100			16500		
2013		691392			344576	
2014	13065			21526		
2015		450718			225630	
2016	33394			78323		
2017						
2018		170451	1619378		87406	5647,994

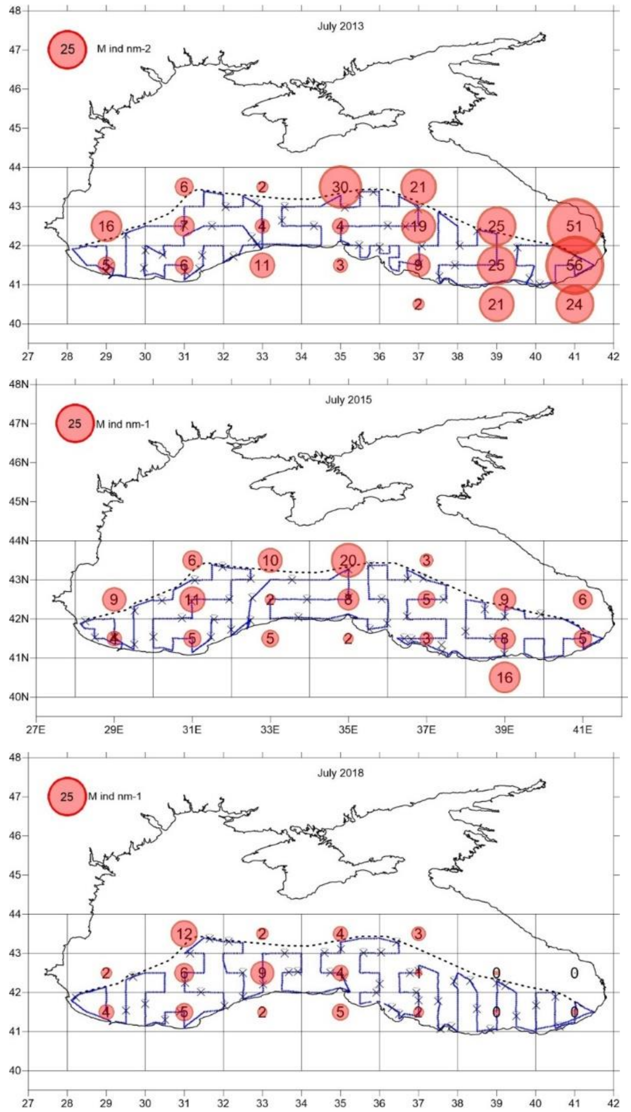


Figure 9. Turkish acoustic summer surveys

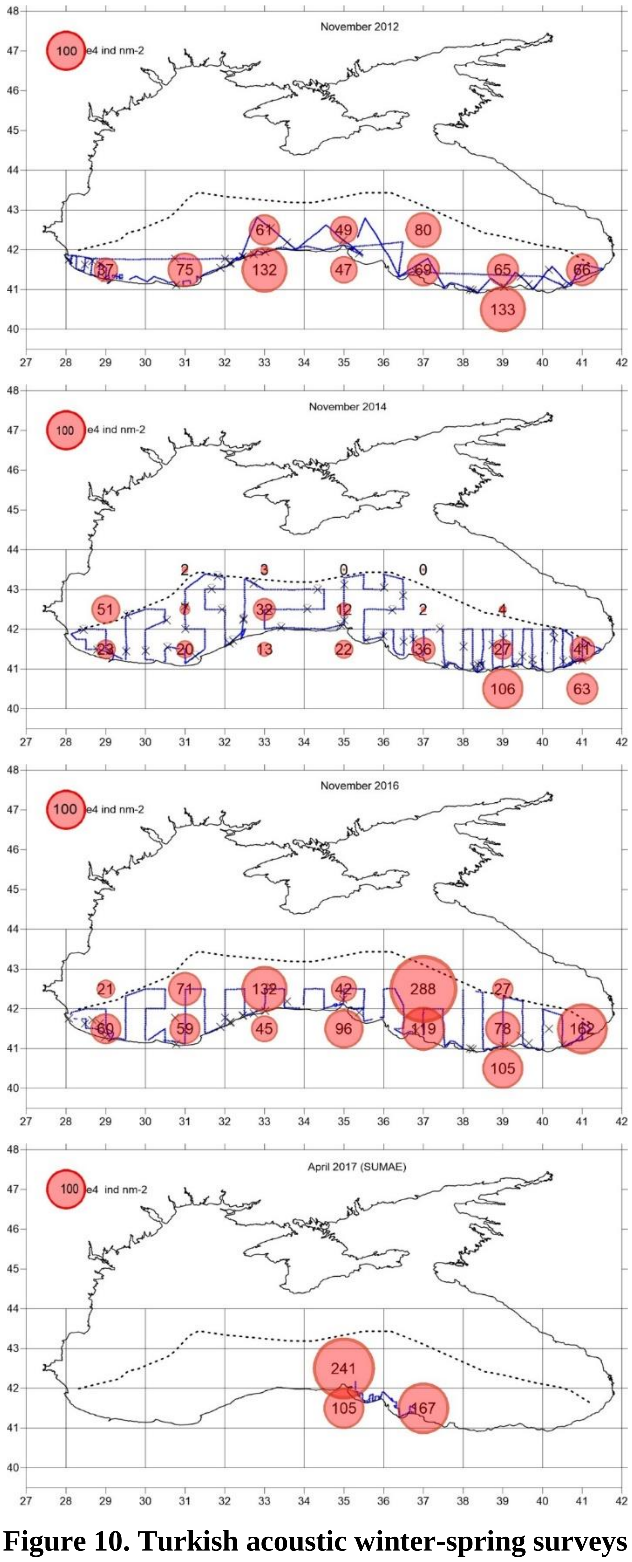


Figure 10. Turkish acoustic winter-spring surveys

3.4.2. Bulgarian hydro acoustic survey

The pelagic trawl survey was accomplished in August – September and December 2016 in the Bulgarian Black Sea area. To establish the abundance of the reference species (*Sprattus sprattus*) in front of the Bulgarian coast a standard methodology for stratified sampling was employed (Gulland, 1966). To address the research objectives the region was divided in four strata according to depth – Stratum 1 (15 – 35 m) Stratum 2 (35 – 50 m), Stratum 3 (50 – 75 m) and Stratum 4 (75 – 100 m). The study area in Bulgarian waters was partitioned into 128 equal in size not overlying fields, situated at depth between 10 – 100 m. The total surveyed area in Bulgarian part was 9136.7 km^2 and total estimated biomass was 21 090.35 tonnes in August-September 2016. The total surveyed area in Bulgarian part in December was 9136.7 km^2 and total estimated biomass was 32 279.9 tonnes. The total surveyed area in Bulgarian part was 6633.5 km^2 and total estimated biomass was 1529.1 tonnes in August-September 2017. The total surveyed area in Bulgarian part in December was 6633.5 km^2 and total estimated biomass was 1466.4 tonnes.

Table 8. Estimated abundance indices, CPUA (catch per unit area, kg/km^2) and relative sprat biomass (kg) during the Bulgarian Black Sea scientific survey (2016)

Spring 2016

CPUA (mean)		B (kg)	Ax	№ Fields
1471.931	15-30	3039.744	2065.14	33
1519.404	30-50	2757.445	1814.82	29
2070.384	50-75	5700.844	2753.52	44
3832.021	75-100	9592.315	2503.2	40
		21090.35	9136.68	146

Autumn 2016

CPUA (mean)		B (kg)	Ax	№ Fields
1851.279	15-30	3823.15	2065.14	33
2460.126	30-50	4464.686	1814.82	29
4637.265	50-75	12768.8	2753.52	44
4483.566	75-100	11223.26	2503.2	40
		32279.9	9136.68	146

Spring 2017

CPUA (mean)		B (kg)	Ax	№ Fields
141,7682	15-30	292,7712	2065,14	33
315,4774	30-50	572,5347	1814,82	29
241,0763	50-75	663,8084	2753,52	44
		1529,114	6633,48	106

Autumn 2017

CPUA (mean)		B (kg)	Ax	№ Fields
95,39138	15-30	196,9966	2065,14	33
333,7065	30-50	605,6172	1814,82	29
241,0763	50-75	663,8084	2753,52	44
		1466,422	6633,48	106

3.4.3. Romanian pelagic survey

The Romanian fishing fleet is operating in the area of competence of GSA 29. The Romanian fishing area is included between Sulina and Vama Veche; the coastline extends for over 240 km, which can be divided into two main geographical and geomorphologic sectors: the northern sector (about 158 km in length) lies between the secondary delta of the Chilia branch and Constantza, and the southern sector (about 85 km in length) lies between Constantza and Vama Veche. Traditionally, the fishing in the Romanian Black Sea area was carried out in two ways:

Fishing practiced along of the coastline in about twelve fishing points between Sulina - Vama Veche, in the coastal area with small depth (3.0 - 11.0 m) (Figure 11).

Coastal trawlers, equipped with pelagic trawls and turbot gillnets, activating at depths greater than 20 m (Figure 12).

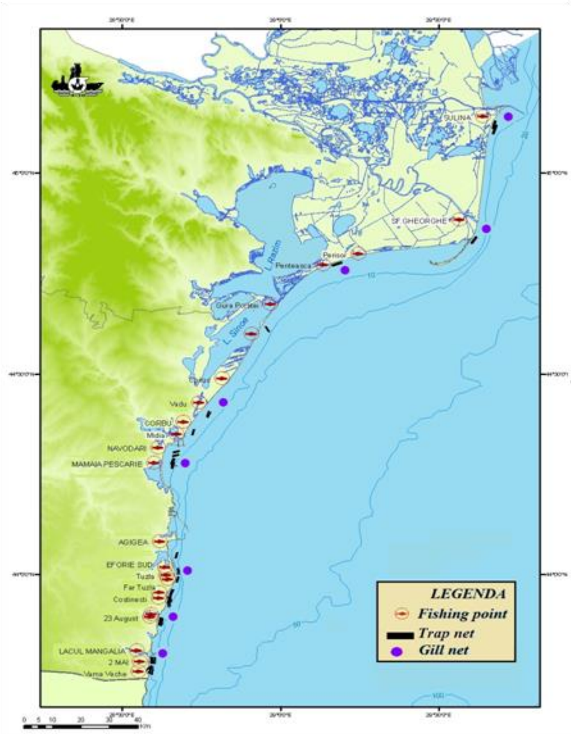


Figure 11. Fishery ports and distribution area for stationary fishing gear

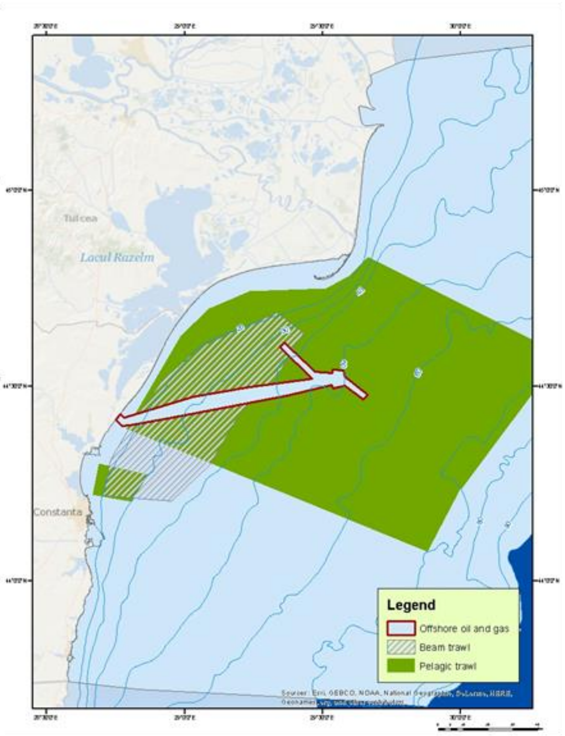


Figure 12. Distribution of trawling zones for active fishing gear

Structure analysis by length classes of commercial catches of sprat, has highlighted the presence of mature specimens and a high homogeneity of cards. The length of sprat individuals are within the limits of classes of length 50,0-110,0 mm / 1.117 – 8.525 g. The dominant classes are those of 70.0 - 95.0 mm / 2.417 – 4.964 g (Figure 13). The dominant females 65.15 percent, males (34.85 percent). The average body length was 80.720 mm and the average mass of 3.199 g.

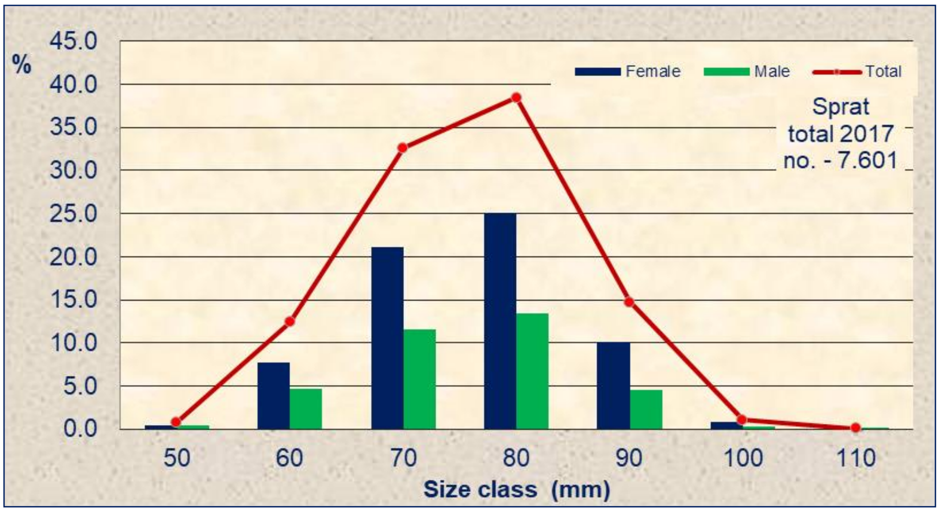


Figure 13. Structure by lengths of sprat in 2017

Age composition of sprat catches indicates the presence of individuals from one to three years. Most of the individuals caught are one year old (68.8 percent of all specimens analyzed), followed closely by those of two years (27.2 percent) and three years (4.0 percent) (Figure 17).

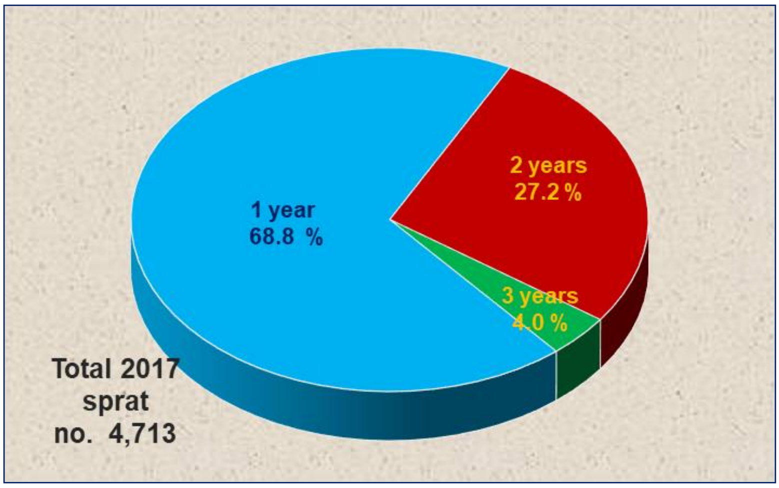


Figure 14. Structure by age composition of sprat in 2017

Pelagic survey 2017:

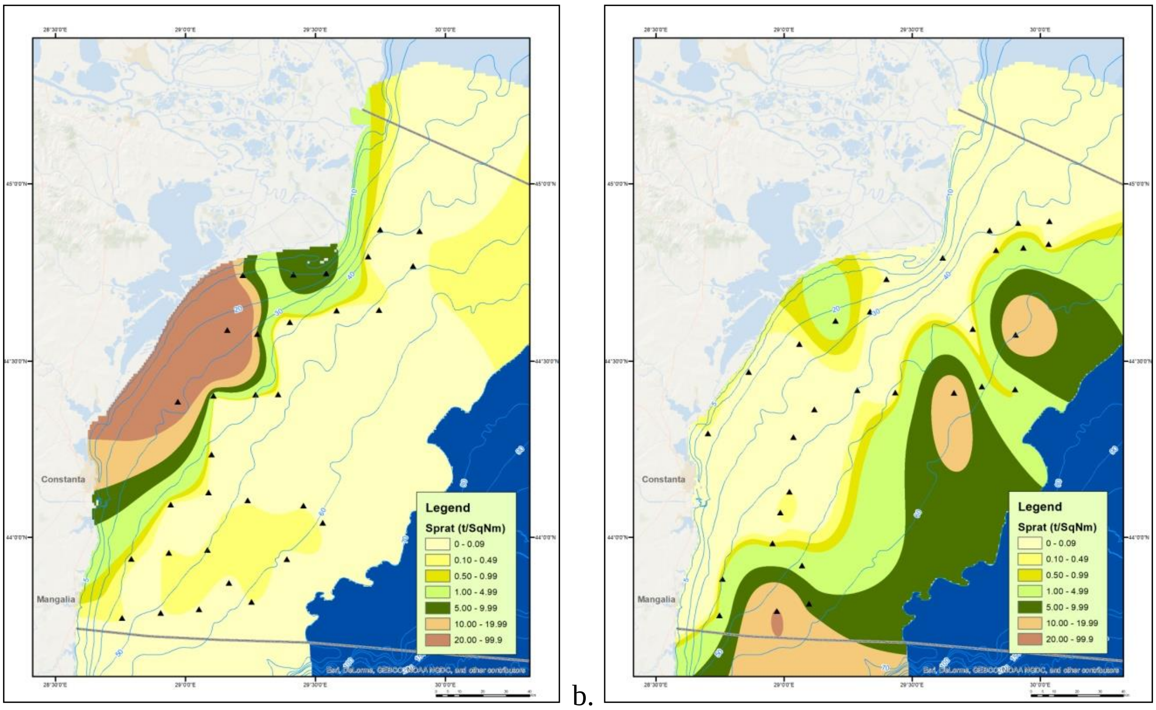
Period: 06 – 13 June and 10 - 19 October 2017

Type of fishing vessel: B-410 (STEAUA DE MARE 1);

Characteristics: pelagic trawls: 36/26–59 m; horizontal trawl opening - 20 m; vertical trawl opening 11–12 m; no. trawls: 42 + 30; depth 20.1–66.4 m; trawl speed 3.2 knots; time trawling 30 min; catch 50 – 1.650 kg.

Estimated total biomass: European sprat:

Spring - in the 31 sample trawlings made with the pelagic trawl, on a surface of 1.800 Nm², the average values of the catches were of about 0.02 – 30.97 t/Nm². The maximum value was recorded in the Sf. Gheorghe - Constanta sectors (0–50 m) (Figure 15). The estimated biomass for sprat crowds, in the research area, was of about 23.268 tonnes.



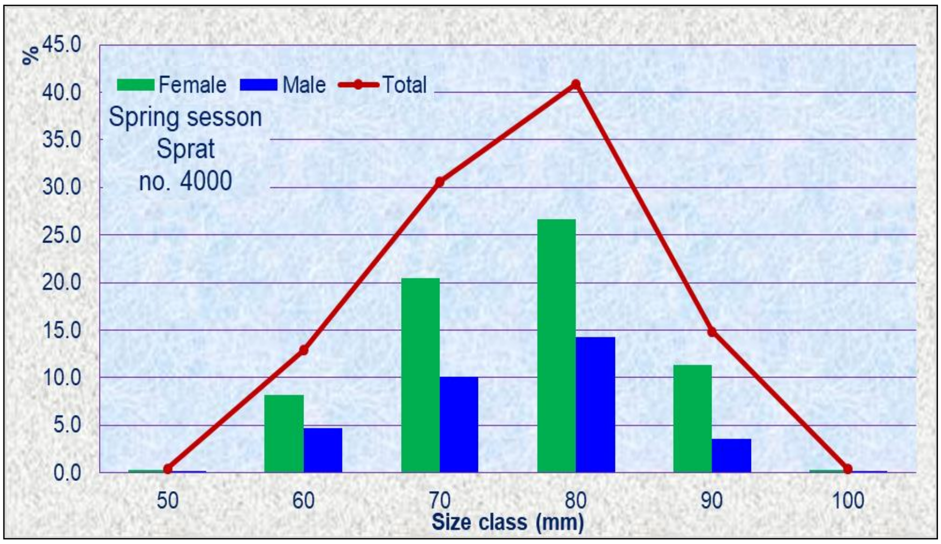
a. b.

Figure 15. Distribution of whiting agglomerations in spring (a) and autumn (b), pelagic trawl survey, in the Romanian area

Table 9. Assessment of sprat agglomerations (tonnes), in June 2017

Depth range (m)	0 – 30 m	30 – 50 m	50 - 70 m	Total
Investigated area (Nm^2)	325	1050	425	1800
Variation of the catches (t/ Nm^2)	6.60 - 78.37	0 - 31.67	0 - 0.04	0 - 78.37
Average catch (t/ Nm^2)	30.971	3.002	0.0244	4.653
Biomass of the fishing agglomerations (t)	10070.817	3152.23	10.376	8376.73
Biomass extrapolated the Romanian shelf (t)				23268.7

The analysis of structure by lengths and mass cards of sprat during survey has highlighted the presence of mature specimens and a high homogeneity of cards. The length of sprat individuals are within the limits of classes of length 55.0–105.0 mm / 1.05–6.43 g. The dominant classes are those of 65.0–90.0 mm / 1.7 – 4.72 g (Figure 16a). The dominant females 67.18 percent, males (32.83 percent). The average body length was 80.83 mm and the average mass of 3.177 g. Age composition of sprat catches indicates the presence of individuals from one to three years. Most of the individuals caught are one year old (72.0 percent of all specimens analyzed), followed closely by those of two years (25.5 percent) and three years (2.6 percent) (Figure 16b).

a. 

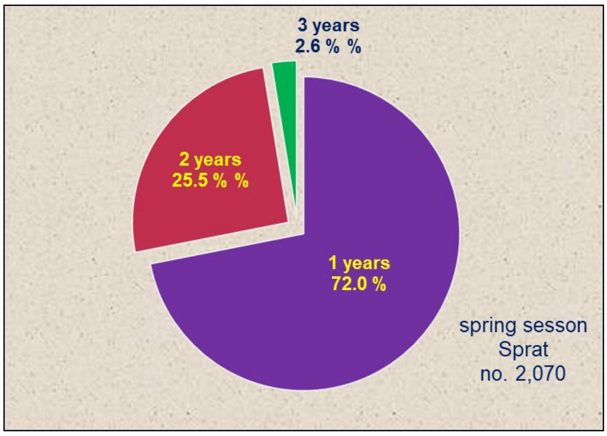
b. 

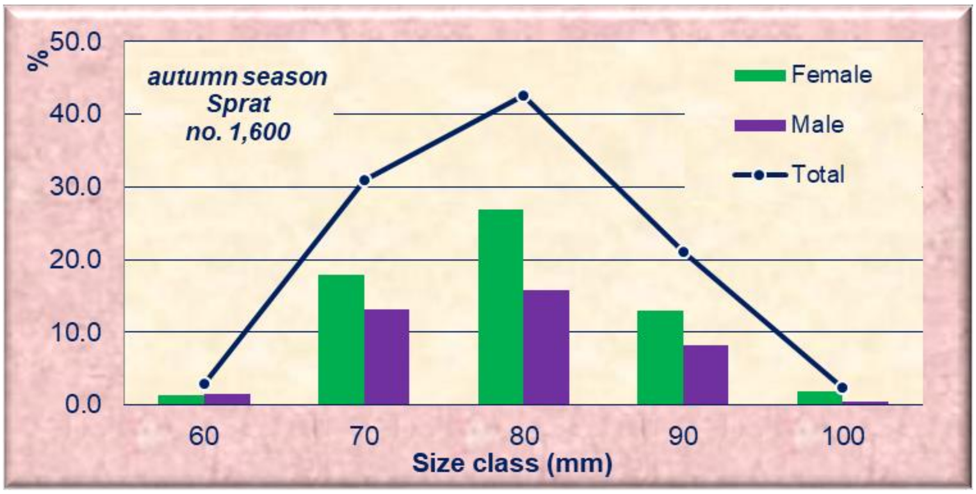
Figure 16. Structure by lengths (a) and age (b) of sprat during the spring survey

Autumn - in the 30 sample trawlings made with the pelagic trawl, on a surface of 2.050 Nm², the average values of the catches were of about 2.39–8.051 t/Nm². The maximum value was recorded in the Sf. Gheorghe - Cap Tuzla (50–70 m) sectors (Figure 16). The estimated biomass was of about 11.960 tonnes.

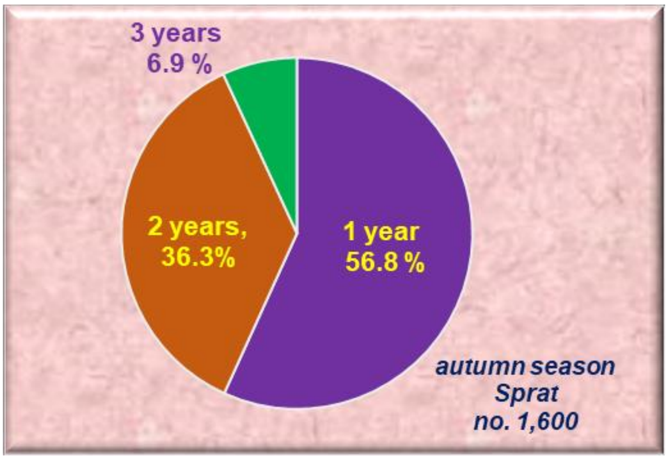
Table 10. Assessment of sprat agglomerations (tonnes) in Octomber 2017

Depth range (m)	0 – 30 m	30 – 50 m	50 - 70 m	Total
Investigated area (Nm^2)	450	1150	450	2050
Variation of the catches (t/ Nm^2)	0 - 1.55	0 - 2.14	0 - 15.54	0 - 15.54
Average catch (t/ Nm^2)	0.222	0.371	7.223	2.392
Biomass of the fishing agglomerations (t)	100.027	426.5	3250.776	4903.925
Biomass extrapolated the Romanian shelf (t)				11,960

The length of sprat individuals are within the limits of classes of length 65.0–110.0 mm / 1.8–7.35 g. The dominant classes are those of 75.0 - 95.0 mm / 2.2 – 4.92 g (Figure 17a). The dominant females 60.94 percent, males (39.06 percent). The average body length was 83.82 mm and the average mass of 3.667 g. Age composition of sprat catches indicates the presence of individuals from one to three years. Most of the individuals caught are one year old (56.8 percent of all specimens analyzed), followed closely by those of two years (36.3 percent) and three years (6.9 percent) (Figure 17b).



a.



b.

Figure 17. Structure by lengths (a) and age composition (b) of sprat during the autumn survey

The agglomeration biomass of the main species from Romanian littoral

The swept area method is used for assessment of the biomass of fishing agglomerations of sprat, whiting and picked dogfish based on the statistic processing of productivity data obtained in sampling trawling and industrial trawling. The calculated biomasses by swept area for main species at the Romanian littoral ranged between: sprat (30.917 tonnes and 68.887 tonnes) (Figure 18).

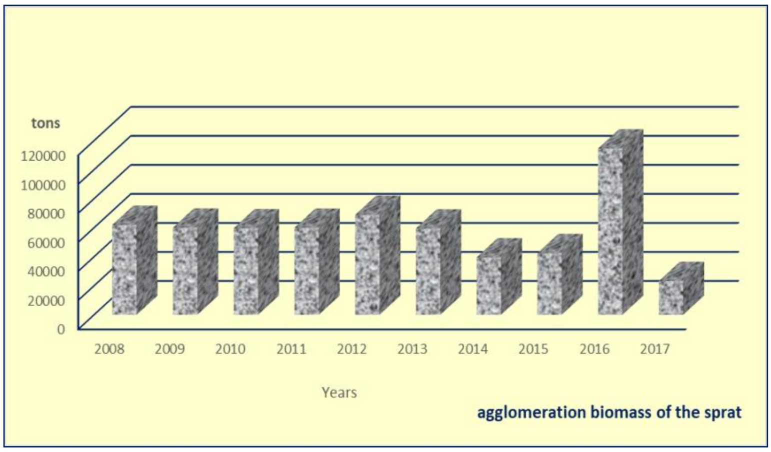


Figure 18. Agglomeration biomass of sprat on the Romanian littoral

3.4.4. Final survey data used in the assessments

The final survey data used in the benchmark assessment are summarized in Tables 13 and 14.

Table 11. Fisheries independent indices of abundance used in the assessments (base-case SAM)

ROMANIA SPRING					
	0	1	2	3	4
2008	-1	9881984	5611011	1555178	-1
2009	-1	5089936	2889177	800881.6	-1
2010	-1	-1	-1	-1	-1
2011	-1	6538941	7877695	2155310	-1
2012	-1	6570406	7915665	2165685	-1
2013	-1	15070855	6613688	1036769	-1
2014	-1	8000718	3332732	1360382	-1
2015	-1	9524358	4198231	827479.7	-1
2016	-1	21585755	11904074	3297779	-1
2017	-1	4578088	2035989	309726.8	-1
ROMANIA AUTUMN					
	0	1	2	3	4
2008	-1	4935724	2802514	776759.8	-1

2009	-1	1611215	8522738	1843946	-1
2010	-1	15452217	3794207	578887.6	-1
2011	-1	-1	-1	-1	-1
2012	-1	19086789	6243709	1772872	-1
2013	-1	-1	-1	-1	-1
2014	-1	-1	-1	-1	-1
2015	-1	1874169	2855318	394890.8	-1
2016	-1	476849.6	2517682	1057193	-1
2017	-1	2071960	1019102	170515.6	-1

TURKEY STANDARDIZED CPUE

	0	1	2	3	4
2011	18875.75	1078385	1402334	378758.6	87236.58
2012	2727.278	336748.2	336471.6	121868	39800.06
2013	321716.1	1066212	545249.4	220699.7	69495.29
2014	1225728	6028587	520280.9	47032.12	4040.443
2015	130359	4151140	1213429	206049.4	70682.09
2016	317621	2753069	746928.8	185306.5	26371.03
2017	433666.9	3758930	1019827	253010.1	36005.95

Table 12. Fisheries independent indices of abundance (used in SAM sensitivity runs, models 2 and 3)

BULGARIA SPRING

	0	1	2	3	4
2007	194	12978	14272	1736	0
2008	325	13705	9633	5201	3854
2009	655	15558	25149	321	78
2010	4202	31605	38889	322	62
2011	-1	-1	-1	-1	-1

2012	-1	-1	-1	-1	-1
2013	-1	-1	-1	-1	-1
2014	-1	-1	-1	-1	-1
2015	628	28980	10916	3221	537
2016	321	19614	880	218	56
2017	0	62	655	912	122

TURKEY ACUSTIC AUTUMN					
	0	1	2	3	4
2012	14227.23	2711.468	154.5544	6.044388	0.775273
2013	-1	-1	-1	-1	-1
2014	4569.22	8261.329	233.6955	0.479624	0.028168
2015	-1	-1	-1	-1	-1
2016	7564.06	20802.89	4647.164	344.3355	35.5651

3.5. Biological parameters

The biological parameters used in the assessments are summarized in Tables 14 – 16

Table 12. Growth and length weight parameters

Length-weight data and sex ratio from Turkey

Length-weight relationship	a	b	sex ratio (% females/total)	Data source
2009	0.0046	3.1025	55.86	Zengin et al. (Kartrıp)
2010	0.0061	2.9826	55.41	Zengin et al. (Kartrıp)
2011	0.0046	3.0946	57.87	Zengin et al. (Kartrıp)
2012	0.0054	3.0298	61.62	Zengin et al. (Kartrıp)
2013	0.0037	3.2364	61.42	Zengin et al. (Kartrıp)
2014	0.0034	3.2541	61.36	Zengin et al. (Kartrıp)
2015	0.0082	2.8131	60.52	İlhan et al. (Pelagic)
2016	0.0048	3.0769	67.78	İlhan et al. (Pelagic)
2017	0.003	3.3076	65.07	İlhan et al. (Pelagic)

Length-weight data from Bulgaria

Years	a	b	sex ratio (% females/total)	Data source
2007	0.0009	2.88		Raykov et al.,2007
2008	0.007	2.78		Raykov et al., 2008
2009	0.0008	2.76		Raykov et al., 2009
2010	0.009	2.77		Raykov et al., 2010
2011	0.009	2.9		
2012	0.0008	2.66		
2013				
2014				
2015	0.0008	2.79		
2016	0.0009	2.88		

Growth parameters by country

Country/ Parameter	Max TL	a	b	L∞	K	t0	age mat	asym wt	Year
Bulgaria	12.5	0.0009	2.88	12.7	0.45	-0.88	0.5	1.298205	2016
Russia		0.0085	2.97	12.08*	0.27	-1.51			2016
Turkey	12.8	0.003	3.3076	11.94963	0.464066	-1.26624	1	13.78253	2017
Ukraine	12	0.0084	2.8798	11.1	0.44	-0.81	0	10.76727	2017
Romania	12	0.043763	2.05	12.01	0.477	-0.35	0	7.135569	2017

Fork length [1]

Table 13. M Vector (Gislason 2010) by country

Age	Turkey		Bulgaria		Romania		Ukraine	
	Mean Length	Gislason	Mean Length	Gislason	Mean Length	Gislason	Mean Length	Gislason
0.5	6.684806	1.6	5.874934	1.75	4.003212	3.18	4.862714	1.95
1.5	8.639519	1.01	8.348146	0.995	7.040647	1.28	7.082961	1.06
2.5	9.868489	0.718	9.925135	0.753	8.925808	0.874	8.51288	0.777
3.5	10.64117	0.636	10.93067	0.645	10.09582	0.717	9.433801	0.71
4.5	11.12697	0.603	11.57182	0.638	10.82198	0.641	10.02691	0.597
5.5	11.43241	0.566	11.98064	0.556	11.27266	0.6	10.40889	0.562

Table 14. Mean solution parameters used in the assessments

AGE	**0**	**1**	**2**	**3**	**4**
WEIGHT (KG)	0.0013	0.0031	0.0043	0.0057	0.007
M	1.77	1.02	0.75	0.66	0.61

[1] Information provided by the Russian Federation. Includes statistical data for the Autonomous Republic of Crimea and the city of Sevastopol, Ukraine, temporarily occupied by the Russian Federation

MATURITY	0	1	1	1	1

Using a common weight at age.

3.6. Stock assessment

This section shows the assumptions, assessment results and model diagnosis of the three different models used in the benchmark: i) Integrated Catch at age Analysis (ICA; Patterson and Melvin, 1996); ii) an Extended Survivorship Analysis (XSA; Shepherd, 1999); and iii) a State-space Assessment model (SAM; Nielsen and Berg, 2014).

Input data for the three assessment models tested were the same: the only difference concerned the length of the time series used and the number of indices included. The choice was dictated by the possibility of the method used to handle or not gaps in the data. Thus, for example, SAM -being a fully statistical catch at age model- can accept missing data in the time series, hence in SAM all the data available for the longest most reliable period were used. On the other hand, ICA and XSA do not accept gaps, therefore the longest complete time series was used for catches, and only indices with at least five years of data were chosen.

3.7. Integrated catch-at-age analysis (ICA)

3.7.1.Model assumptions

Catch-at-age Analysis (ICA; Patterson and Melvin. 1996) was used to assess the stock of sprat in GSA 29. ICA is a statistical catch-at-age method based on the Fournier and Deriso models (Deriso *et. al.*, 1985). It applies a statistical optimization procedure to calculate population numbers and fishing mortality coefficients-at-age from data of catch numbers-at-age and natural mortality. The dynamics of a cohort (generation) in the stock are expressed by two non-linear equations referred to as a survival equation (exponential decay) and a catch equation:

$N_{a+1.y+1} = N_{a.y} * \exp(-F_{a.y} - M)$.

$C_{a.y} = N_{a.y} * [1 - \exp(-F_{a.y} - M)] * F_{a.y} / (F_{a.y} + M)$

where C, N, M and F are catch, abundance, natural mortality, and fishing mortality, while a and y are subscript indices for age and year.

The ICA algorithm minimizes the weighted sum of squared residuals (SSR) of observed and modelled CPUE assuming Gaussian distribution of the log residuals.

Weights associated with catches and different indices are usually set by the user on the basis of some information about the reliability of different indices and current experience with modelling the stock.

ICA has been used to assess the sprat stock in the Black Sea since 2010. The software used to run ICA is not implemented for Windows 7 and above, and the R-FLR package commonly used was dismissed years ago. During the Working Group, the assessor managed to run the software in a Windows 1995 virtual machine. However, given the availability of more powerful and up to date assessment models, and the impossibility of running the software with modern operative systems, it was decided to only present the results for sake of comparison, but to reject the assessment on the overall. The group agreed to move on to more sophisticated and accessible assessment methods.

3.7.2. Input data and parameters

Catch and weight at age, natural mortality, and two age structured fish abundance indices were used to run ICA. Total catch at age data were compiled by summing catch at age matrices from Bulgaria, Romania, Russia, Turkey and Ukraine. The two age structured indices used were the Turkish standardized CPUE and the Bulgarian spring survey. Fraction of harvest and M before spawning were set equal to 0.1. ICA was run assuming a constant selection pattern in 2011–2017, i.e. six years separable constraint as used in last year settings; reference F at was set at age 2 and Selection at the last "real" age was set equal to one.

3.7.3. Results

As mentioned previously, results from ICA were not used to provide advice, and the results presented here were disregarded from further analysis. The results of the ICA show a reasonable fit to catch data (Figure 19), while the fitting to the survey data presents strong year trends (Figure 20, Figure 21).Analyses of the main population parameters (Figure 22) indicate a strong decreasing trend of the spawning stock biomass (SSB) from the higher levels at the beginning of the time series. The estimates for the last three years remain stable on an average to low level. Recruitment in the last year is estimated to be at high levels. F has been constantly increasing from the very low levels at the beginning of the time series. The highest value is reported for 2015, while in 2016–2017 the F drop to quite low values. The stock dynamic shows a cyclic pattern, with years of strong recruitment followed by years of low to medium recruitment, which leads to corresponding changes in the SSB.

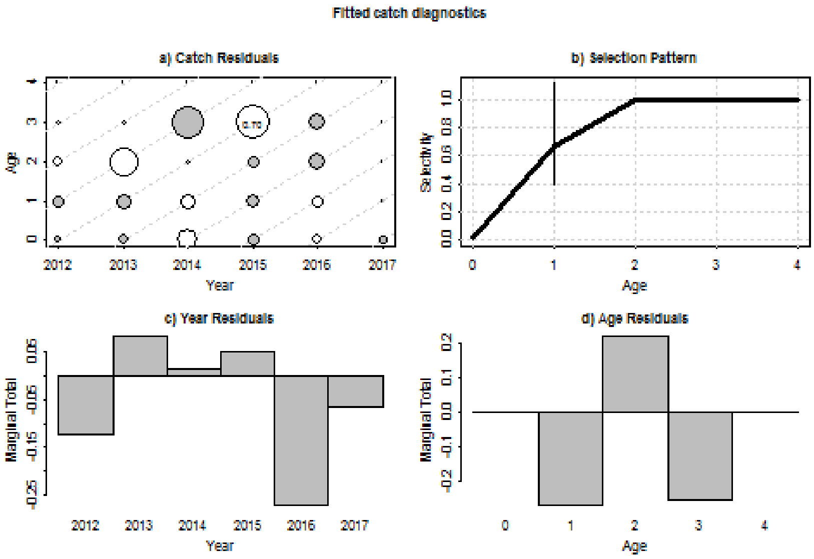


Figure 19. Sprat in GSA 29. Main diagnostics for the ICA model. Top left: overall catch residuals by age and year; top right: selection curve; bottom left: marginal total residuals by year; bottom right: marginal total residuals by age.

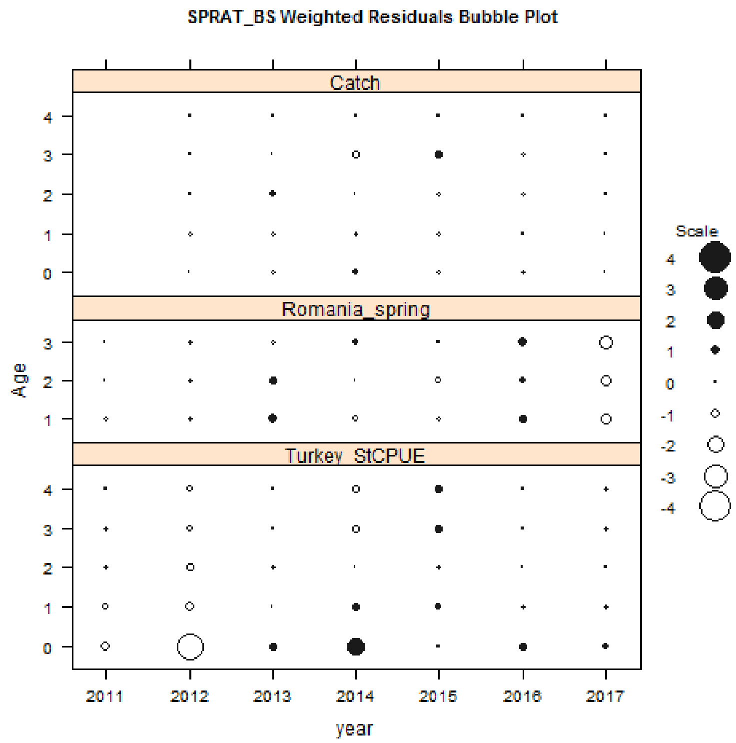


Figure 20. Sprat in GSA 29. Fitting of the ICA model to respectively the catch data (top), the Romanian spring survey (middle) and the Turkish standardized CPUE (bottom).

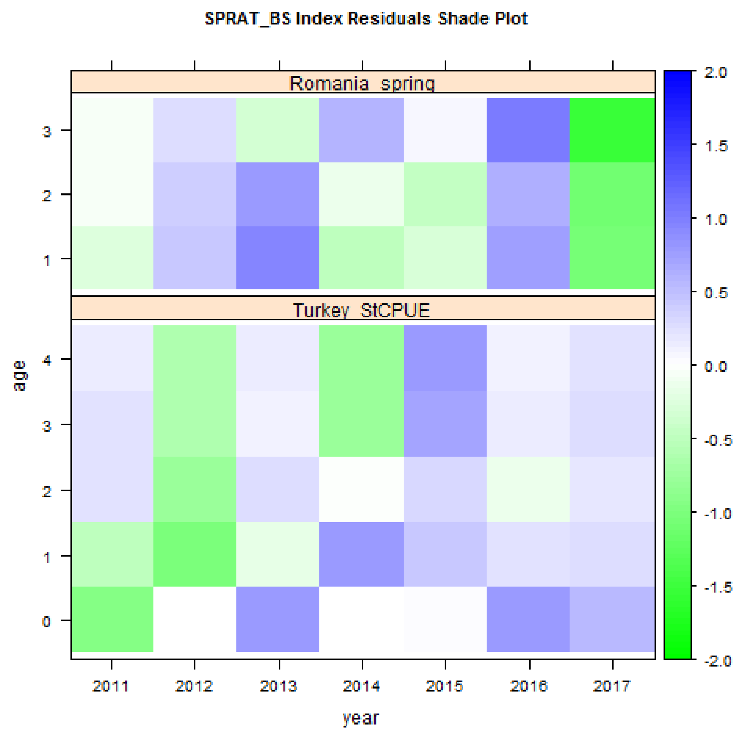


Figure 21. Sprat in GSA 29. Overall residuals for the Romanian spring survey (middle) and the Turkish standardized CPUE (bottom). The colors help visualizing pattern in the residuals.

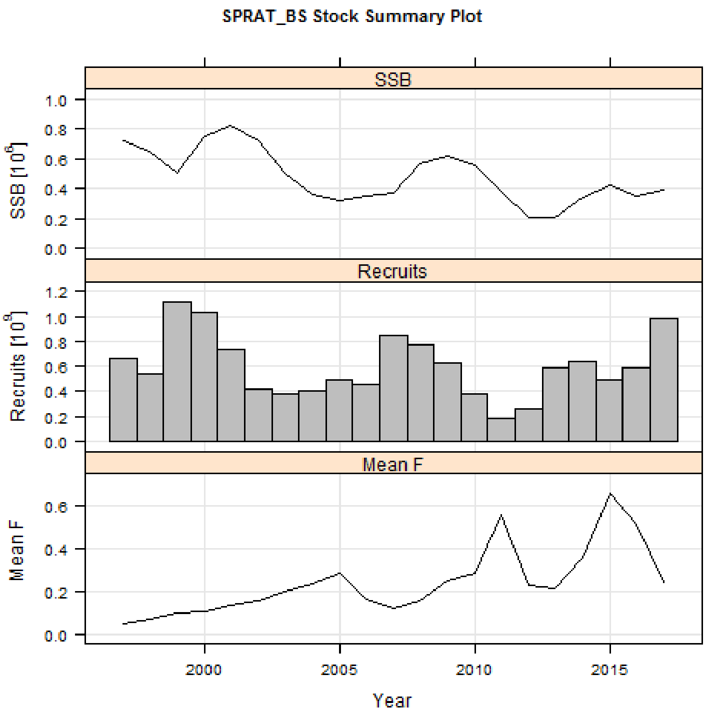


Figure 22. Sprat in GSA 29. ICA results for SSB, recruitment and F.

3.8. Extended Survivor Analysis (XSA)

3.8.1. Model assumptions

The XSA was performed using the FLR library in R. XSA assessment method uses virtual population Extended Survivor Analysis (XSA; Shepherd 1999), an extension of Survivors Analysis (Doubleday 1981), and focuses on the relationship between catch-per-unit-effort (CPUE) and population abundance, allowing the use of a more complicated model for the relationship between CPUE and year-class strength at the youngest ages. The detailed algorithm is presented in Darby and Flatman (1994).

3.8.2. Input data and parameters

Catch and weight at age, natural mortality, and two age-structured indices of abundance were used to run XSA (see tables in section 2). Total catch at age data were compiled by summing catch at age matrices from Bulgaria, Romania, Russia, Turkey and Ukraine. The 2 age structured indices used were the Turkish standardized CPUE and the Bulgarian spring survey. Fraction of harvest and m before spawning were set equal to 0.1. Several combinations for catchability independent of year class strength, catchability independent on age and f standard error were tested. The settings that produced the best diagnostics (good residuals and low standard error; Table 15) were chosen for the final run.

Table 15. Sprat in GSA 29. Final XSA settings

XSA SETTINGS	
FSE	0.5
RAGE	1
QAGE	2
SHK.YRS	5
SHK.AGES	1

3.8.3.Results

The results of XSA show a reasonable fit to fishery independent indices (Figure 23): the residuals per age and year of the tuning fleet were relatively low, ranging from 2 to -2, and did not show any tendency with time or age.

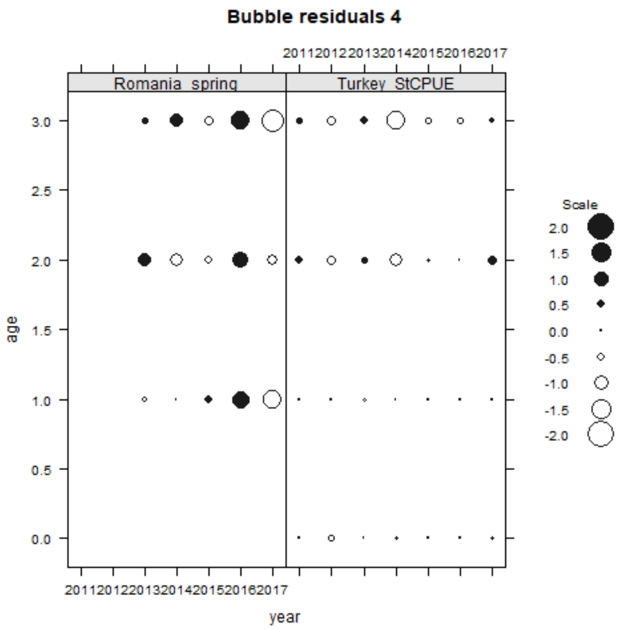


Figure 23. Sprat in GSA 29. Log residuals for the two tuning fleets of the final XSA run.

Results of XSA (Figure 24, Table 16, Table 17, and Table 18) showed an overall decreasing trend in the SSB. The stock dynamic shows a cyclic pattern, with years of strong recruitment followed by years of low to medium recruitment, which leads to corresponding changes in the SSB; the peaks of both recruitment and SSB are much lower in the recent years. The fishing mortality increases from low levels at the beginning of the time series to high values. The average F of the last ten years is equal to 0.5.

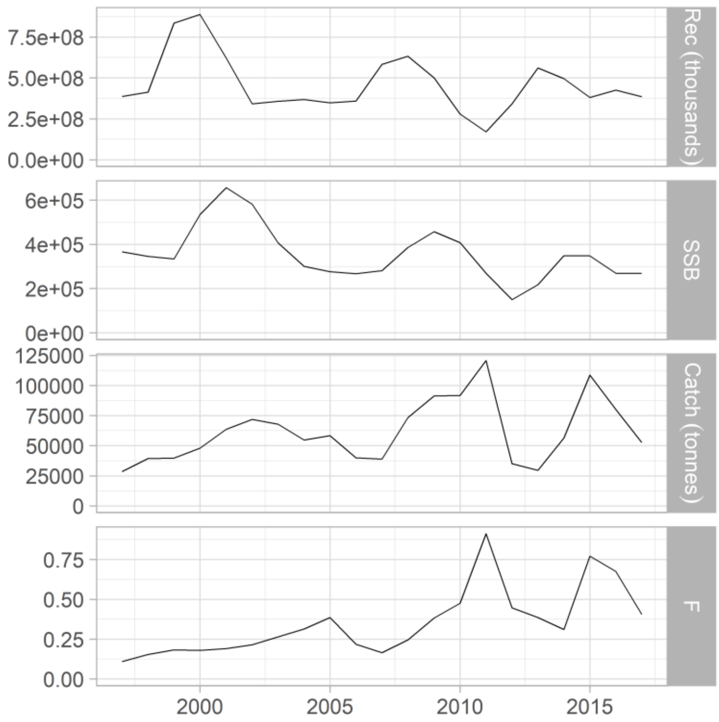


Figure 24. Sprat in GSA 29. XSA summary results. SSB and catch are in tonnes, recruitment in 1000s individuals.

Table 16. Sprat in GSA 29. XSA summary results

	SSB	**Recruitment**	**fbar(1-3)**
1997	366363.2	3.88E+08	0.109201
1998	345950.5	4.13E+08	0.153934
1999	334320.9	8.34E+08	0.182537
2000	534144.9	8.88E+08	0.179387
2001	657054.4	6.21E+08	0.191363
2002	582197.2	3.41E+08	0.214876
2003	406505.2	3.57E+08	0.26472
2004	301314	3.68E+08	0.313996
2005	276512.3	3.49E+08	0.385652
2006	267681.7	3.58E+08	0.218214
2007	280669.2	5.83E+08	0.165395

2008	386010.4	6.33E+08	0.24478
2009	456885.7	5.01E+08	0.381927
2010	407637.3	2.8E+08	0.47569
2011	269385.3	1.7E+08	0.911998
2012	150383.2	3.42E+08	0.44618
2013	217333.9	5.62E+08	0.385718
2014	348574.5	4.95E+08	0.310064
2015	348239.6	3.8E+08	0.771169
2016	270138.5	4.25E+08	0.675735
2017	268813.2	3.86E+08	0.405085

Table 17. Sprat in GSA 29. XSA Fishing mortality at age resulting from XSA.

	0	**1**	**2**	**3**	**4**
2008	0.005	0.141	0.292	0.301	0.301
2009	0.01	0.249	0.441	0.456	0.456
2010	0.008	0.139	0.632	0.656	0.656
2011	0.011	0.402	1.159	1.175	1.175
2012	0.003	0.159	0.556	0.624	0.624
2013	0.003	0.082	0.535	0.539	0.539
2014	0.023	0.378	0.257	0.296	0.296
2015	0.013	0.517	0.695	1.101	1.101
2016	0.024	0.557	0.718	0.752	0.752
2017	0.011	0.254	0.476	0.485	0.485

Table 18. Sprat in GSA 29. Numbers at age resulting from XSA.

	0	**1**	**2**	**3**	**4**
2008	6.33E+08	98327586	18649676	7115150	871998
2009	5.01E+08	1.08E+08	30733292	6582147	1942539
2010	2.8E+08	84762131	30197909	9349387	2249007
2011	1.7E+08	47426354	26552702	7590237	1970517
2012	3.42E+08	28776260	11418504	3939164	1337894
2013	5.62E+08	58231930	8840559	3095513	1059380
2014	4.95E+08	95702303	19305080	2446562	453925
2015	3.8E+08	82792716	23616684	7058613	1114715
2016	4.25E+08	64119788	17767134	5570246	1123245
2017	3.86E+08	70978957	13230473	4094358	636884

FLR XSA Diagnostics

CPUE data from indices

Catch data for 21 years 1997 to 2017. Ages 0 to 4.

Fleet	first age	last age	first yr	last yr	alpha	beta
1 Romania_spring	1	3	2013	2017	<NA>	<NA>
2 Turkey_StCPUE	0	3	2011	2017	<NA>	<NA>

Time series weights Tapered time weighting applied - Power = 3 over 20 years

Catchability analysis:

Catchability independent of size for ages > 1

Catchability independent of age for ages > 2

S.E. of the mean to which the estimates are shrunk = 0.5

Minimum standard error for population estimates derived from each fleet = 0.3

Regression weights

year

age	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
all	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fleet: Romania_spring

Log catchability residuals.

year

age	2013	2014	2015	2016	2017
1	-0.233	-0.020	0.380	0.960	-1.092
2	0.755	-0.691	-0.411	0.922	-0.565
3	0.292	0.713	-0.474	1.029	-1.262

Regression statistics

Ages with q dependent on year class strength

[1] "-1.20314432653973" "31.0871379411744"

Fleet: Turkey_StCPUE

Log catchability residuals.

year

age	2011	2012	2013	2014	2015	2016	2017
0	0.070	-0.297	-0.037	0.114	0.000	0.043	0.098
1	0.008	0.011	-0.093	-0.005	0.003	0.042	0.032
2	0.339	-0.469	0.262	-0.679	0.141	-0.050	0.461
3	0.258	-0.427	0.374	-1.037	-0.305	-0.304	0.209

Regression statistics

Ages with q dependent on year class strength

[1] "0.291156485338748" "0.39052345596339" "16.1067783471098" "12.0253847993405"

Terminal year survivor and F summaries:

Age 0 Year class =2017

	scaledWts	survivors	yrcls
Turkey_StCPUE	0.206	91313541	2017
Fshk	0.280	47185442	2017
Nshk	0.515	68007477	2017

Age 1 Year class =2016

scaledWts	survivors	yrcls	
Romania_spring	0.065	49126834	2016
Turkey_StCPUE	0.639	21533640	2016
Fshk	0.296	13247606	2016

Age 2 Year class =2015

scaledWts	survivors	yrcls	
Romania_spring	0.111	2207360	2015
Turkey_StCPUE	0.377	6161732	2015
Fshk	0.512	3034397	2015

Age 3 Year class =2014

scaledWts	survivors	yrcls	
Romania_spring	0.091	367494	2014
Turkey_StCPUE	0.291	1599819	2014
Fshk	0.618	1272706	2014

3.8.4. Retrospective analysis, comparison between model runs, sensitivity analysis, etc.

Retrospective results show quite a strong pattern for all variables, with an overestimation of the stock status and underestimation of the fishing mortality for the last three years (Figure 25).

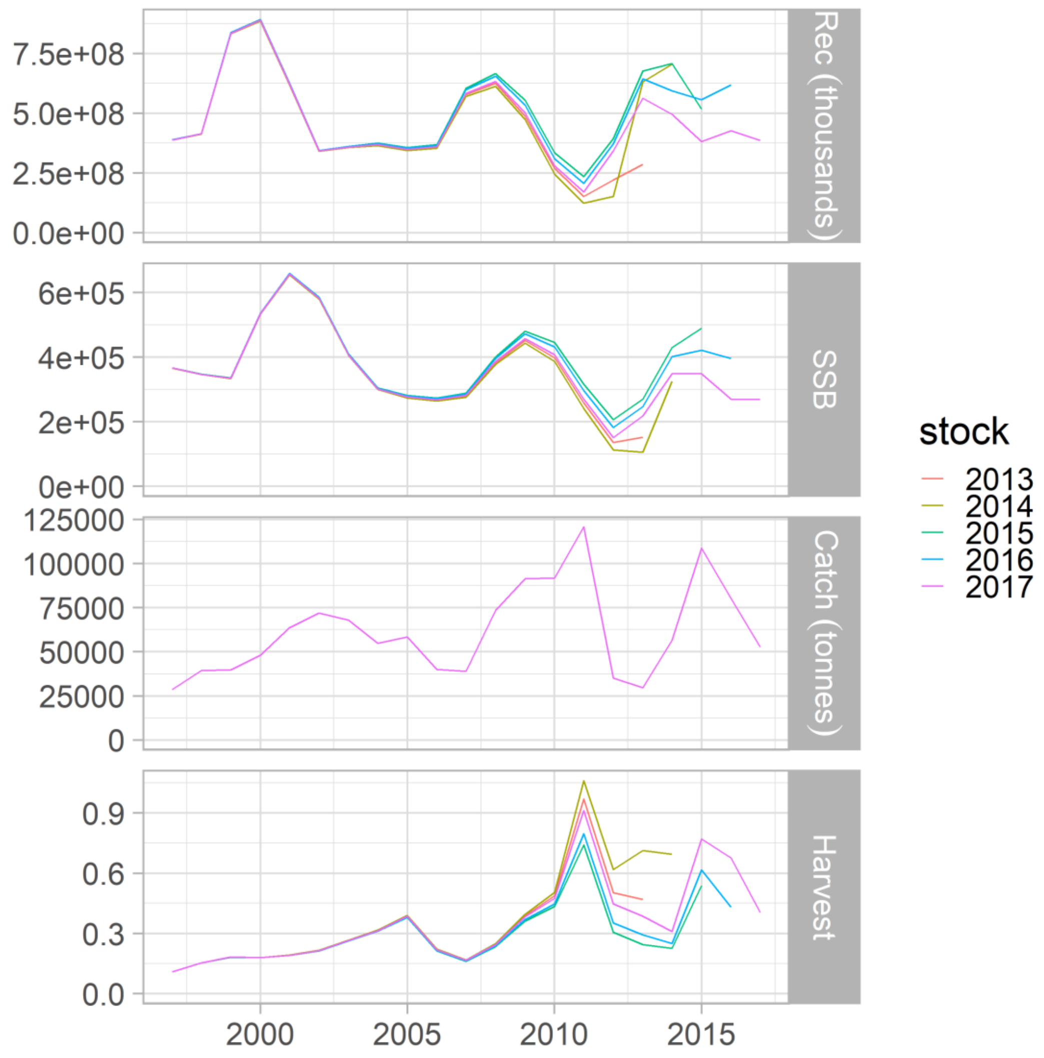


Figure 25. Sprat in GSA 29. XSA retrospective analyses

3.9. State-Space Assessment Model (SAM)

3.9.1. Model assumptions

The basic state-space assessment model (SAM) is described in Nielsen & Berg (2014). The method was implemented using the online webpage interface on **www.stokassessment.org** and is accessible by logging in as guest and using the stock name: SPR_BS_sur1.

3.9.2. Input data and parameters

Base case scenario

Catch and weight at age, natural mortality, and three age-structured indices of abundance were used to run SAM (see tables in section 2). Total catch at age data were compiled by summing catch at age matrices from Bulgaria, Romania, Russia, Turkey and Ukraine. The three age structured indices used were the Turkish standardized CPUE, the Bulgarian spring survey and the Bulgarian autumn survey: this was possible because SAM can handle data gaps, so the more informative time series of survey were used.

Starting from the base case, the influence of each index was evaluated by removing them sequentially from the assessment one at a time ("leave-one-out").

The base case had the following settings:

```
$minAge
# The minimum age class in the assessment: 0
$maxAge
# The maximum age class in the assessment: 4
$maxAgePlusGroup
# Is last age group considered a plus group (1 yes, or 0 no): 1
$keyLogFsta
# Coupling of the fishing mortality states (normally only first row is used).
  0   1   2   3   3
 -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1
$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry, or 2 AR [1])
 2
$keyLogFpar
# Coupling of the survey catchability parameters (normally first row is not used, as that is covered by fishing mortality).
 -1  -1  -1  -1  -1
 -1   0   1   1  -1
 -1   2   3   4  -1
  5   6   7   8   8
$keyQpow
# Density dependent catchability power parameters (if any).
 -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1
$keyVarF
# Coupling of process variance parameters for log(F)-process (normally only first row is used)
  0   0   1   1   1
 -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1
```

-1 -1 -1 -1 -1

$keyVarLogN

Coupling of process variance parameters for log(N)-process

0 1 1 1 1

$keyVarObs

Coupling of the variance parameters for the observations.

```
  0   0   1   1   1
 -1   2   2   2  -1
 -1   3   3   3  -1
  4   5   6   6   6
```

$obsCorStruct

Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstructured). | Possible values are: "ID" "AR" "US"

"ID" "ID" "ID" "ID"

$keyCorObs

Coupling of correlation parameters can only be specified if the AR(1) structure is chosen above.

NA's indicate where correlation parameters can be specified (-1 where they cannot).

#0-1 1-2 2-3 3-4

```
 NA  NA  NA  NA
 -1  NA  NA  -1
 -1  NA  NA  -1
 NA  NA  NA  NA
```

$stockRecruitmentModelCode

Stock recruitment code (0 for plain random walk, 1 for Ricker, and 2 for Beverton-Holt).

0

$noScaledYears

Number of years where catch scaling is applied.

0

$keyScaledYears

A vector of the years where catch scaling is applied.

$keyParScaledYA

A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols = no ages).

$fbarRange

lowest and higest age included in Fbar

1 3

$keyBiomassTreat

To be defined only if a biomass survey is used (0 SSB index, 1 catch index, and 2 FSB index).

-1 -1 -1 -1

$obsLikelihoodFlag

Option for observational likelihood | Possible values are: "LN" "ALN"

"LN" "LN" "LN" "LN"

$fixVarToWeight

If weight attribute is supplied for observations this option sets the treatment (0 relative weight, 1 fix variance to weight).

0

$fracMixF

The fraction of t(3) distribution used in logF increment distribution

0

$fracMixN

The fraction of t(3) distribution used in logN increment distribution

0

$fracMixObs

A vector with same length as number of fleets, where each element is the fraction of t(3) distribution used in the distribution of that fleet

0 0 0 0

Sensitivity analyses:

In addition, several sensitivity analyses were carried out:

Model 2: base case + Bulgarian spring survey

Model 3: Model 2 + Turkish acoustic autumn survey

Model 4: base case with fishery data starting from 2009

3.9.3. Results

The base case showed the best fitting to the residuals, and was chosen as the final model – the results reported below are thus pertinent to the base case only. The sensitivity to the exclusion of each one of the survey is shown in the sensitivity section of this report. The inclusion of the two other tuning indices available on top of those used in the base case had little effect on the results due to the fragmented nature of these time series. The only effect was on the perception of the last year in the assessment (2017) for both recruitment and SSB, which showed a more negative trend. On the other hand, the use of the short time series had, as expected, a bigger effect: despite the overall trend remaining the same, the absolute value for SSB and recruitment increased, while the one for F decreased. Also, the uncertainty for all estimates increased and the fitting to the tuning series worsened.

The results of SAM show a reasonable fit to fishery independent indices (Figure 26) and to catch data: some trends are visible especially for the survey data, while residuals for the catch data don’t show any particular pattern.

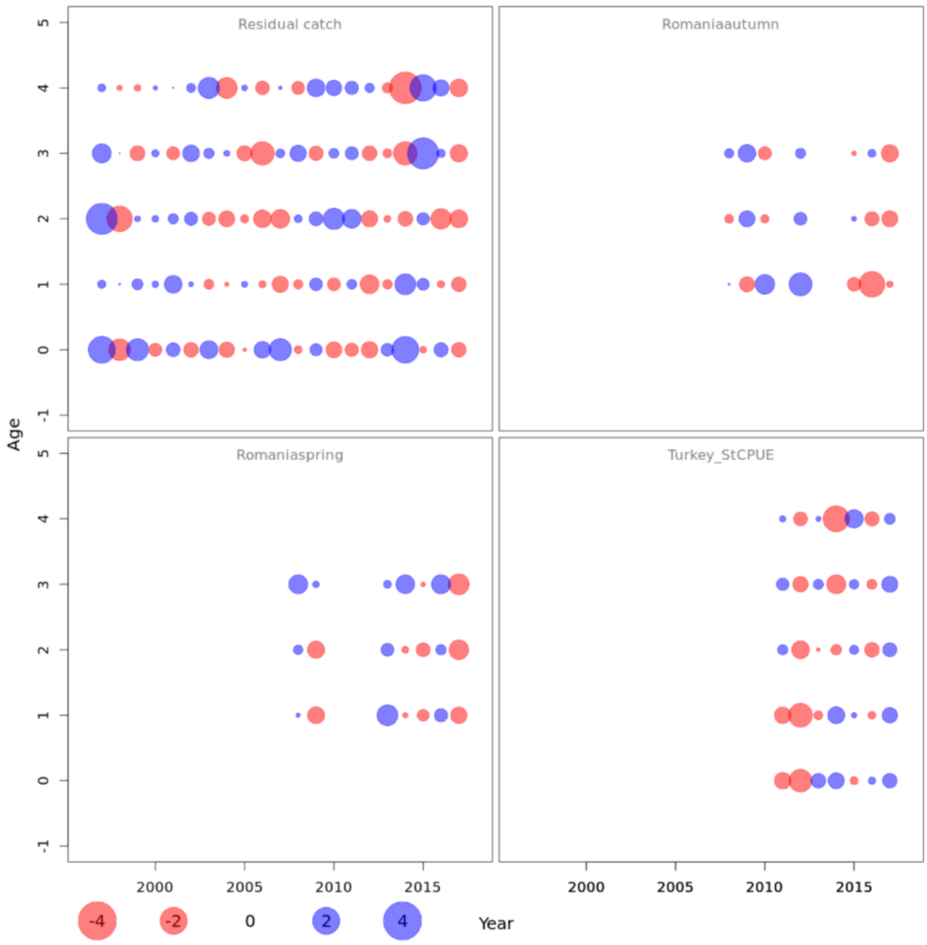


Figure 26. Sprat in GSA 29. Log residuals of the final SAM run

The stock dynamics (both SSB and recruitment) show a cyclic pattern, with years of strong recruitment followed by years of low recruitment which leads to corresponding changes in the SSB; in particular, three peaks are visible from 1997, with the last years of the time series heading towards a low level (Figure 27). The fishing mortality shows less marked cycles, with the beginning and the end of the times series at high levels. Estimated parameters are summarised in Table 20.

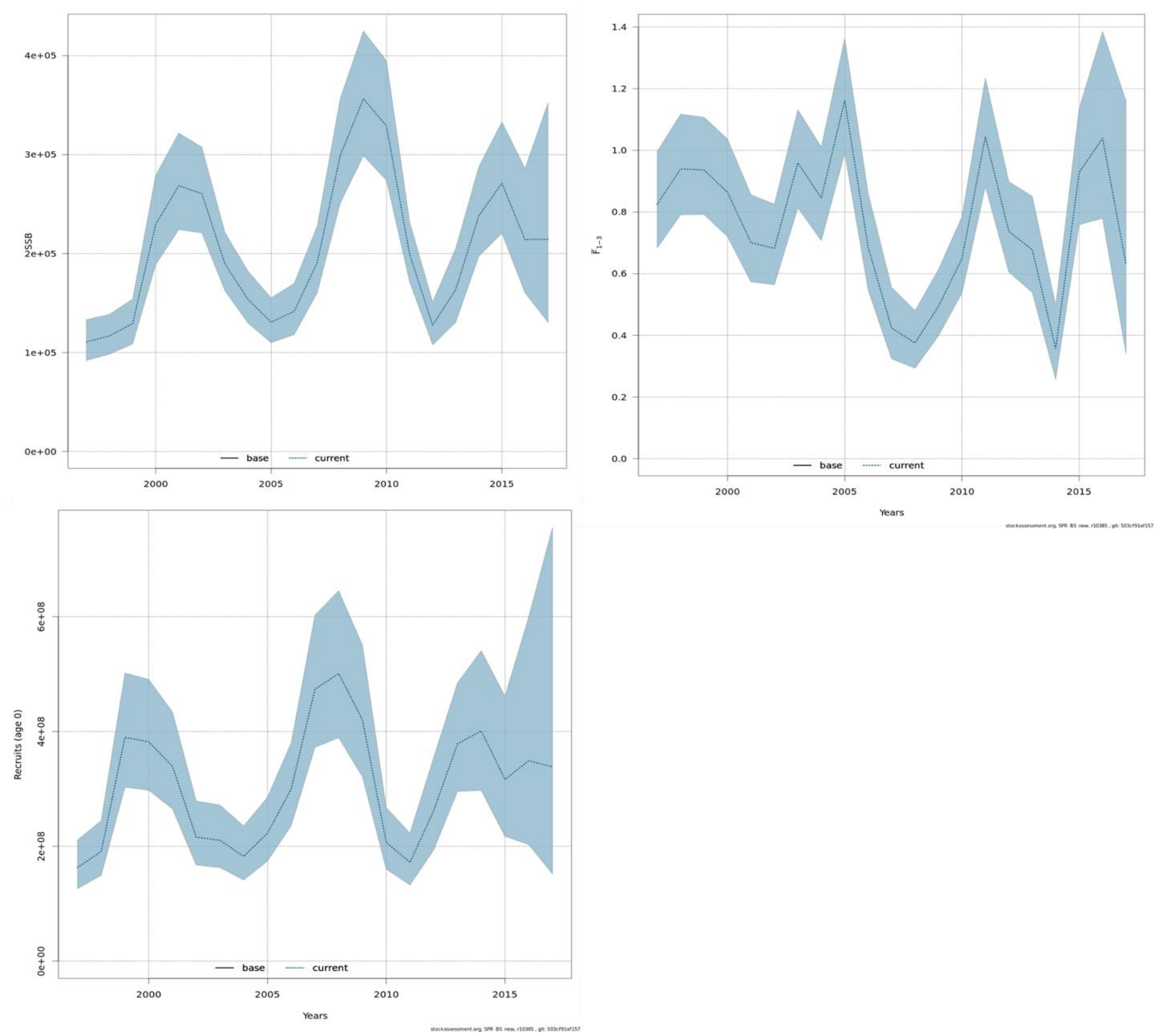


Figure 27. Sprat in GSA 29. SAM summary results. SSB and harvest on the top row and recruitment in thousands of individuals on the bottom row

Table 19. Sprat in GSA 29. Results of the final base case SAM run.

Year	R(age 0)	Low	High	SSB	Low	High	Fbar(1-3)	Low	High	TSB	Low	High
1997	163091205	126111372	210914691	110726	92026	133224	0.825	0.684	0.996	338018	283498	403023
1998	191275303	149587461	244580937	116835	98430	138680	0.94	0.791	1.117	383024	320928	457136
1999	389843424	302898873	501744672	129336	108650	153960	0.936	0.792	1.107	655236	536162	800755
2000	382125761	297578299	490694711	229483	188748	279009	0.864	0.72	1.036	757938	628894	913461
2001	339314626	265291258	433992495	268598	224251	321714	0.7	0.573	0.856	746330	628498	886254
2002	216084832	167334526	279037778	260604	220813	307565	0.683	0.564	0.825	578843	495369	676382
2003	210409220	162858562	271843491	189621	162461	221321	0.96	0.814	1.132	494917	419301	584171
2004	182417657	141411205	235315169	153775	129755	182242	0.846	0.707	1.011	415058	349275	493232
2005	222952958	174217871	285321024	130692	110055	155200	1.162	0.99	1.362	443441	370736	530405
2006	299749962	236152861	380474069	141664	118093	169939	0.686	0.547	0.86	551567	459750	661721
2007	473870547	372613571	602643899	191245	160520	227851	0.424	0.324	0.555	831786	689913	1002834
2008	501024680	389102503	645140364	299440	251204	356937	0.375	0.294	0.48	988747	820634	1191299
2009	420122487	320766260	550253958	356345	298894	424837	0.495	0.399	0.614	950789	788277	1146804
2010	206926628	160145878	267372659	328835	273908	394775	0.649	0.537	0.785	646489	551661	757618

2011	171967958	132660890	222921606	199508	171431	232183	1.044	0.883	1.234	461083	393673	540037
2012	262279479	193812254	354933828	127647	107866	151055	0.738	0.606	0.898	488286	390390	610730
2013	378535163	295690860	484590121	163761	130657	205253	0.677	0.539	0.851	679501	559106	825822
2014	400933454	297238007	540804443	238222	197275	287668	0.358	0.257	0.497	790497	633883	985805
2015	316610325	217345128	461211618	271033	220653	332915	0.928	0.759	1.136	729232	563562	943604
2016	349002683	203066137	599818733	214149	160318	286055	1.039	0.779	1.386	706772	472644	1056878
2017	338542320	151749993	755261334	214423	130537	352216	0.629	0.341	1.16	686754	363215	1298489

Table 20. Sprat in GSA 29. Results of the final base case SAM run: model parameters.

Parameter name	par	sd(par)	exp(par)	Low	High
logFpar_0	-7.3	0.283	0.001	0	0.001
logFpar_1	-5.798	0.21	0.003	0.002	0.005
logFpar_2	-7.711	0.364	0	0	0.001
logFpar_3	-5.801	0.366	0.003	0.001	0.006
logFpar_4	-5.467	0.374	0.004	0.002	0.009
logFpar_5	-6.964	0.68	0.001	0	0.004
logFpar_6	-2.533	0.275	0.079	0.046	0.138
logFpar_7	-2.068	0.263	0.126	0.075	0.214
logFpar_8	-2.029	0.217	0.131	0.085	0.203
logSdLogFsta_0	-1.245	0.335	0.288	0.147	0.563
logSdLogFsta_1	-0.834	0.195	0.434	0.294	0.641
logSdLogN_0	-1.007	0.19	0.365	0.25	0.535
logSdLogObs_0	-0.734	0.168	0.48	0.343	0.672
logSdLogObs_1	-1.668	0.34	0.189	0.096	0.372
logSdLogObs_2	-0.341	0.16	0.711	0.516	0.98

logSdLogObs_3	-0.072	0.169	0.931	0.664	1.305
logSdLogObs_4	0.572	0.271	1.771	1.031	3.043
logSdLogObs_5	-0.372	0.282	0.69	0.392	1.213
logSdLogObs_6	-0.422	0.164	0.656	0.473	0.91
itrans_rho_0	1.359	0.443	3.893	1.605	9.444

3.9.4. Retrospective analysis, comparison between model runs, sensitivity analysis

Retrospective results for the SAM model show quite a strong bias for all variables, however, there is no trend in the direction of the bias for any of the variable (Figure 28).

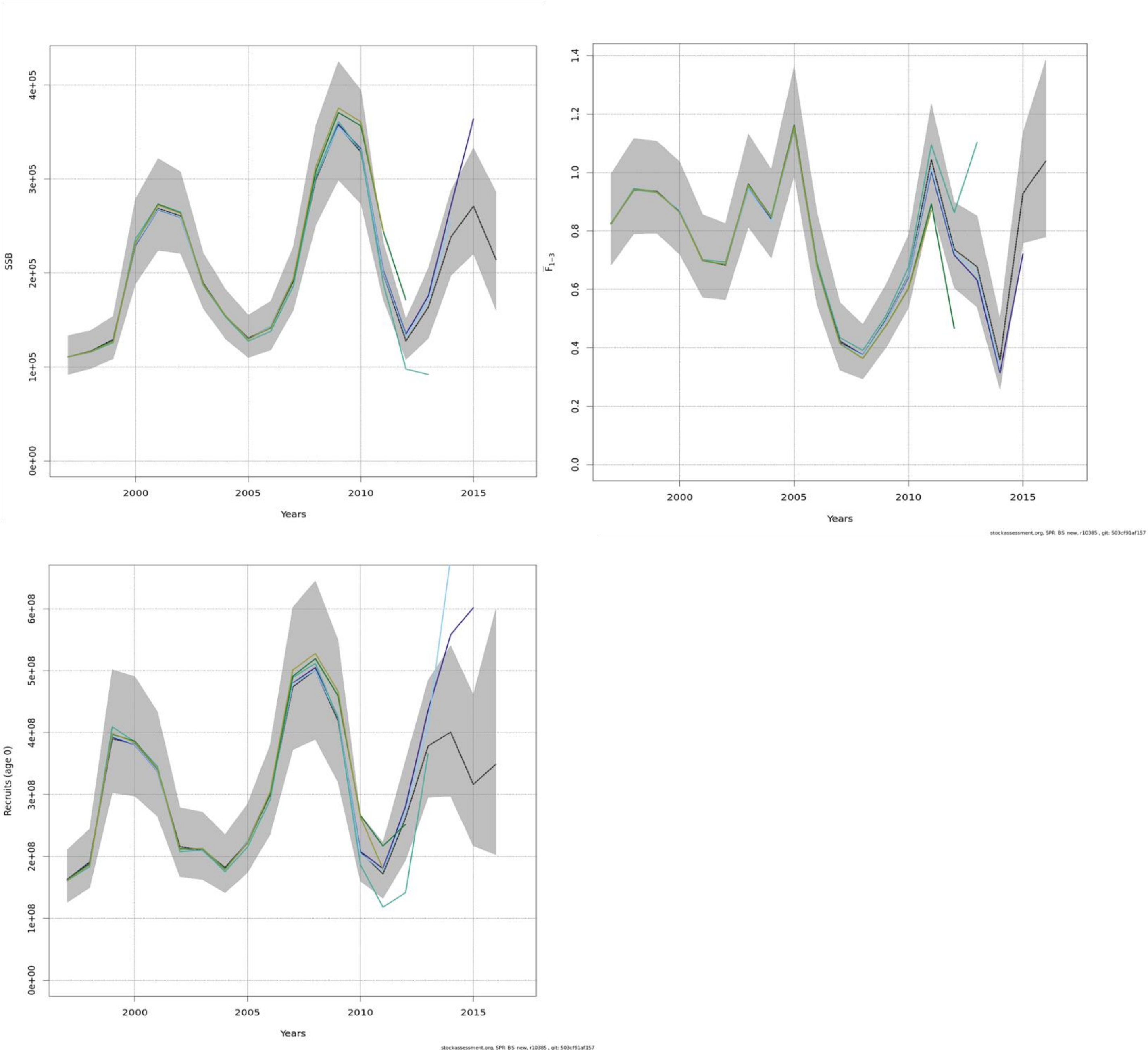


Figure 28. Sprat in GSA 29. SAM retrospective analyses

To assess the influence of the inclusion of each one of the indices of abundance, a leave one out run was performed, removing the indices used one at the time. In particular, the inclusion of the Turkish standardised CPUE contributes to lower the SSB and the recruitment, while both the Romanian survey provide the perception of a higher stock size (Figure 29).

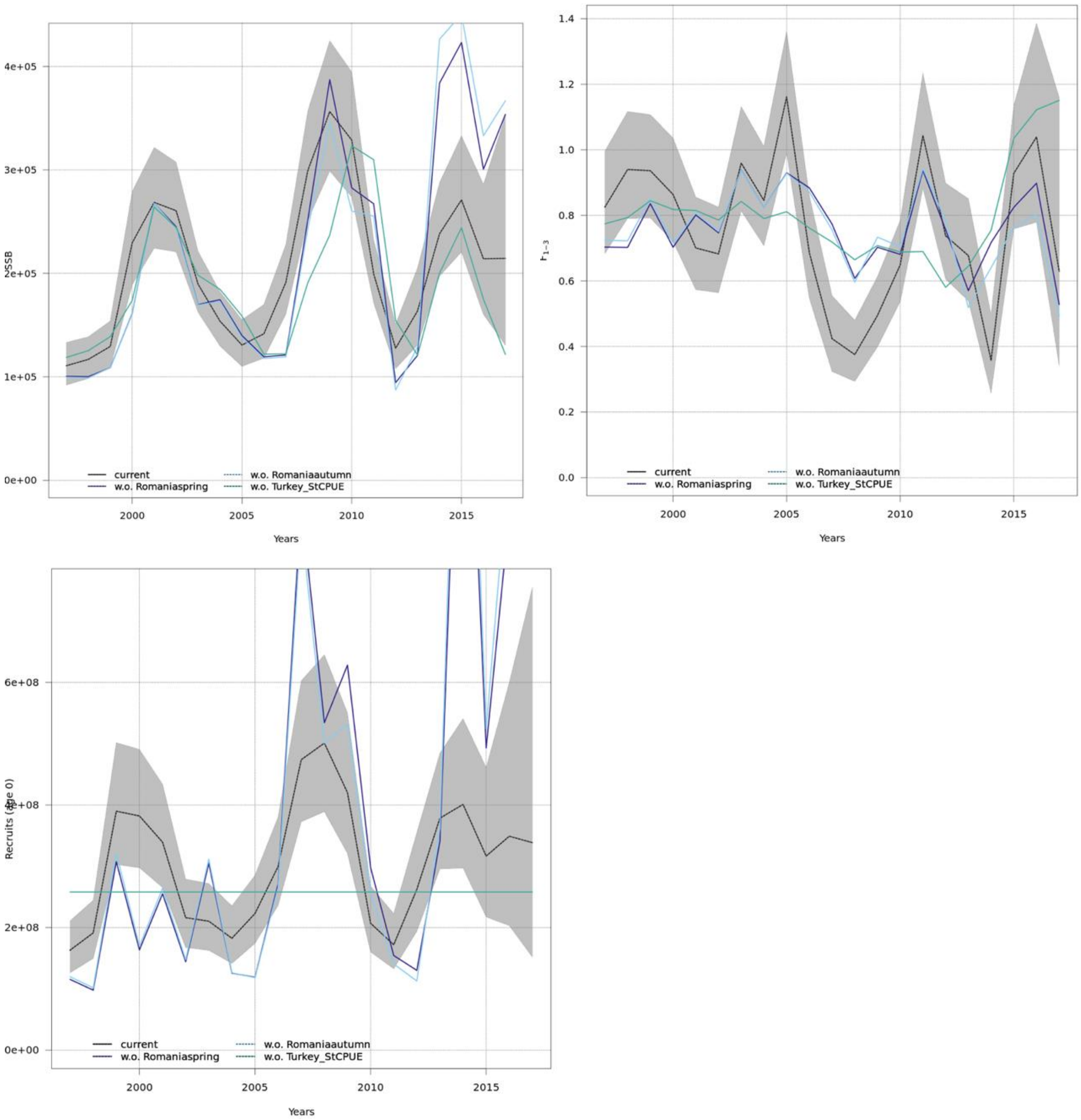


Figure 29. Sprat in GSA 29. Leave one out analysis. SSB and F(1–3) on top row, recruitment on the bottom row

3.10. Comparison between model outcomes

The SSB comparison between the three models show that SAM provides a different perspective compared to the Virtual Population Analysis (VPA)-like models (Figure 30). While ICA and XSA show a decreasing trend from the high levels of the late nineties, SAM show an alternation between high and low SSB levels. The confidence intervals from SAM for the most recent year contain both the ICA and XSA result.

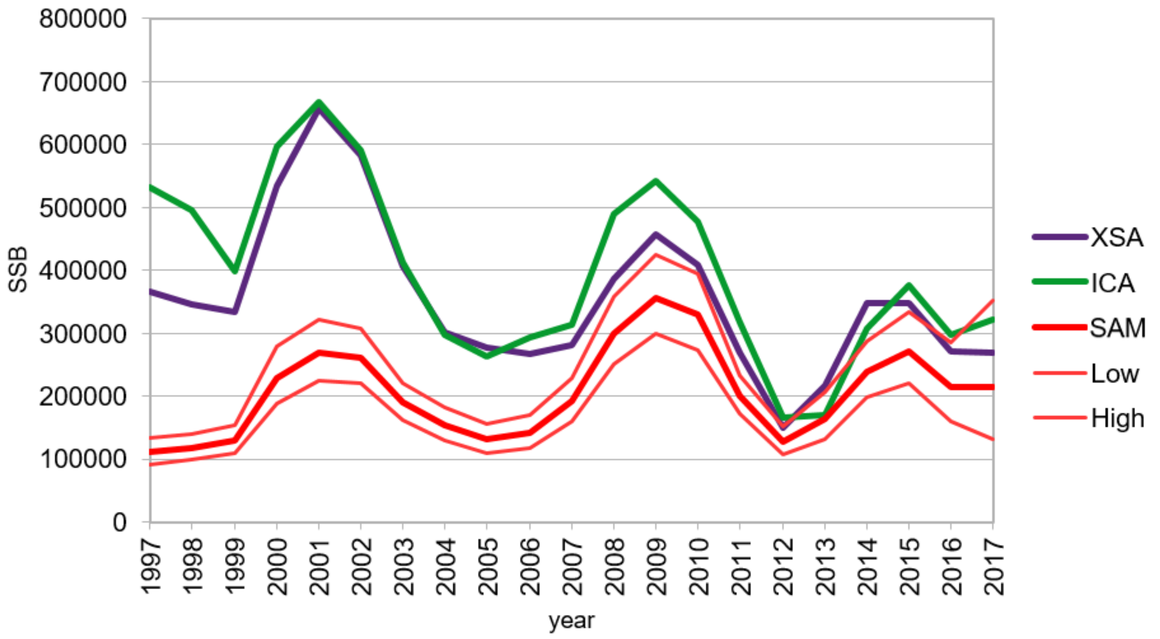


Figure 30. Sprat in GSA 29. SSB results for ICA, XSA and SAM

In terms of F, SAM results are higher throughout the whole time series (Figure 31). However, the gap between the F values from the three models is lower for the most recent part of the time series.

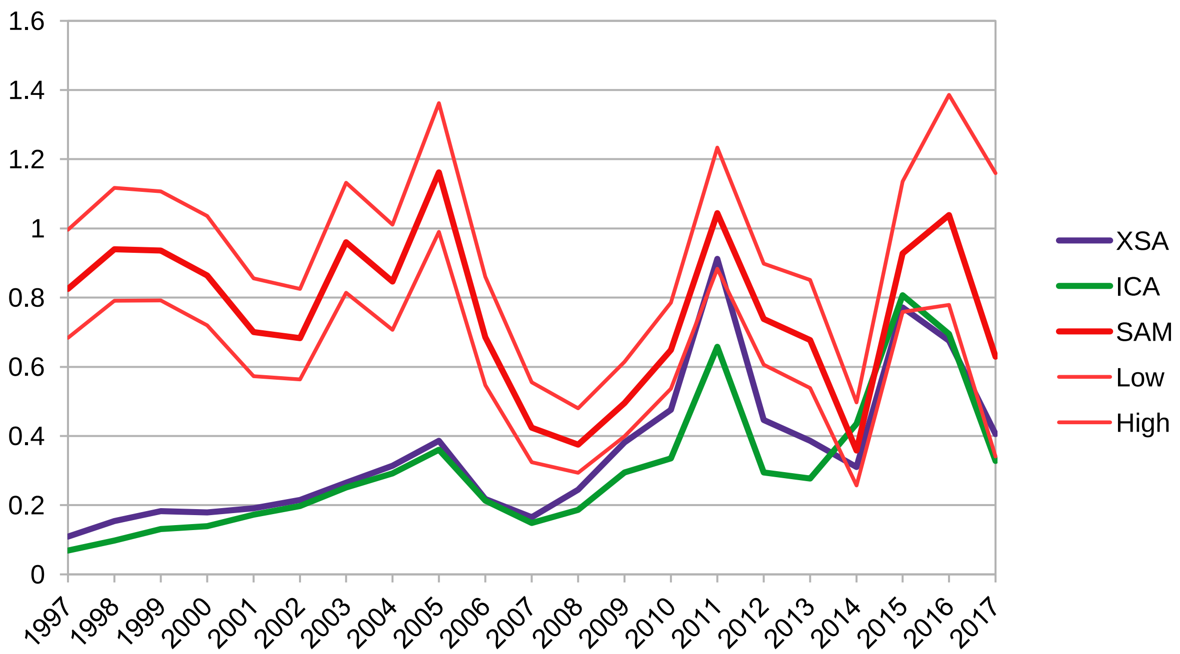


Figure 31. Sprat in GSA 29. Fbar results for ICA, XSA and SAM

Results for recruitment are much more consistent between the three models, showing a similar cyclic pattern, with ICA and XSA rescaled higher than SAM (Figure 32). For several years along the time series the confidence intervals from the SAM estimates contain the other two models results.

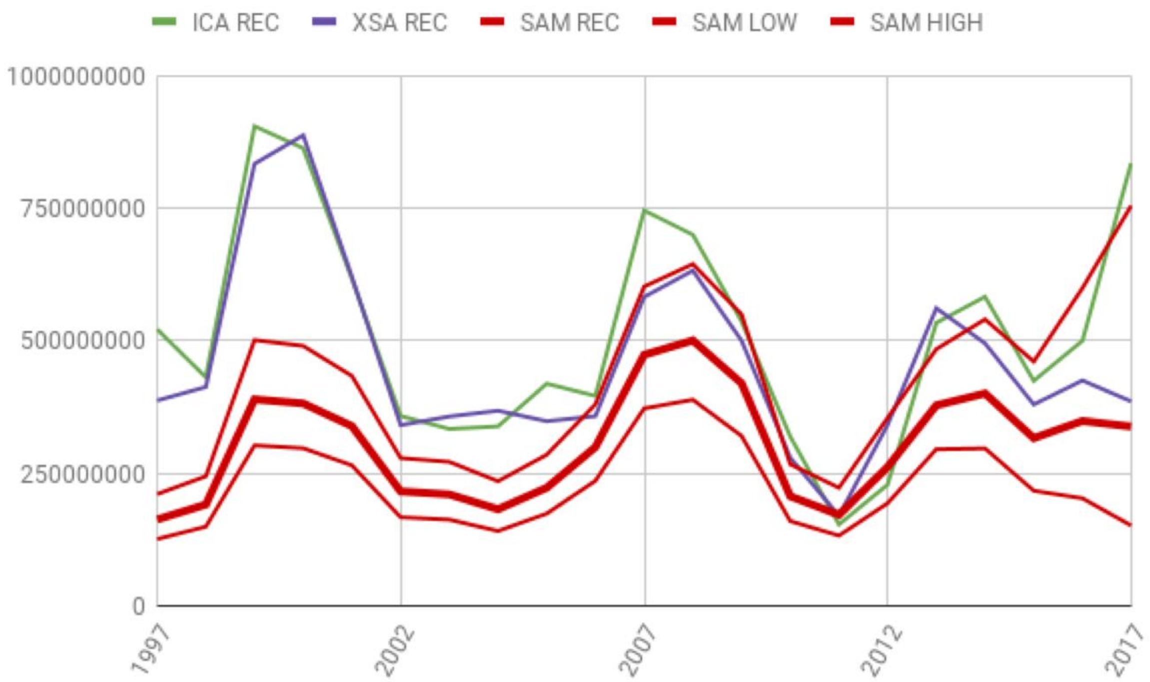


Figure 32. Sprat in GSA 29. Recruitment results for ICA, XSA and SAM

Exploitation rates for the two accepted models (XSA and SAM) are shown in Figure 33.

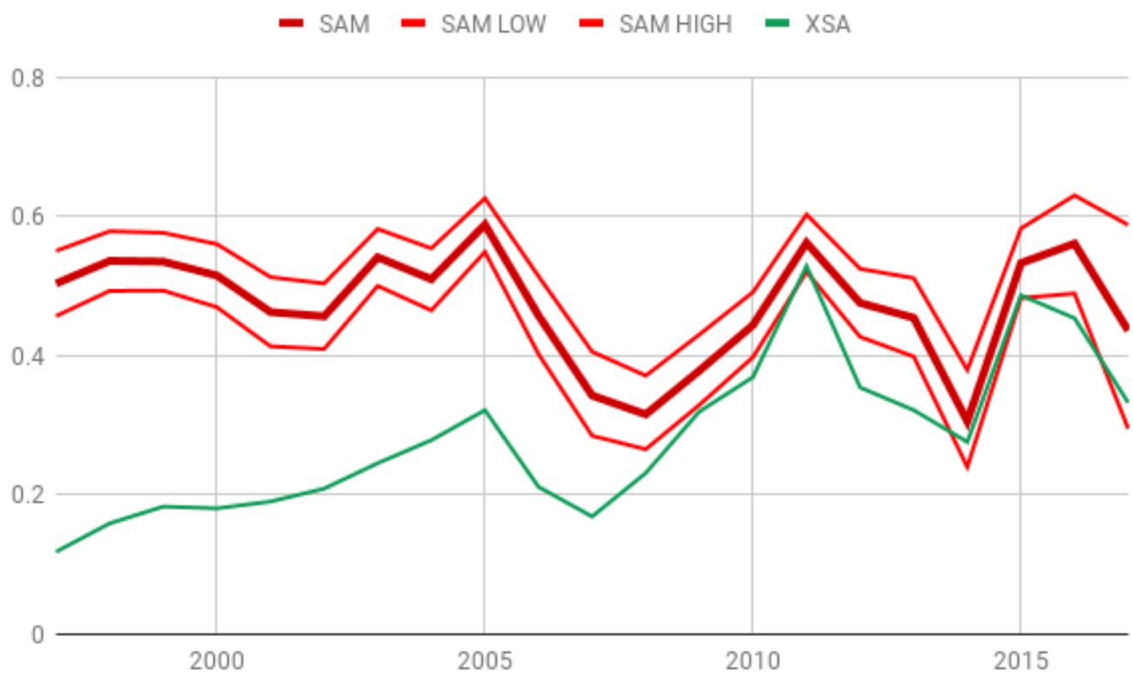


Figure 33. Sprat in GSA 29. Exploitation rate for XSA and SAM based on ages 1-3

Table 21. Sprat in GSA 29. Exploitation rates (E) from SAM (based on Fbar (1–3) for 2017 and including high and low confidence intervals) and XSA (based on Fbar (1–3) for the average of 2015–2017 and for 2017 only in brackets)

SAM	SAM low	SAM high	XSA	Reference
0.44	0.30	0.59	0.42 (0.33)	0.4

Biomass reference points were calculated using ICES guidelines for Blim and Bpa:

SAM:

Blim = the minimum of the SSB time series above which recovery is observed

Bpa = Blim * exp(1.645 * sdSSB) (see Table 20 for sdSSBexp(1.645*

XSA (no uncertainty):

Blim = the minimum of the SSB time series above which recovery is observed

Bpa = Blim * 2

From the SAM base case:

sdSSB = 0.282

Blim = 130692 tonnes

Bpa = 207832.7 tonnes

Current SSB = 214423 tonnes

From XSA:

Blim = 150383.2 tonnes

Bpa = 300766.4 tonnes

Current SSB = 295730.4 tonnes (average of 2015-2017; 2017: 268813.2 tonnes)

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. Data

The benchmark was preceded by dedicated data preparation meetings for Romanian, Bulgarian and Turkish data, carried out within the framework of the BlackSea4Fish project. These meetings allowed to discuss the data and experts were able to provide the appropriate information by country to start the benchmark. The datasets available for the benchmark were significantly enhanced compared to those available in 2017.

The Group acknowledged that the work done by experts within the BlackSea4Fish project towards the provision of data for the benchmark was outstanding. The significant improvements contributed towards fulfilling the terms of reference for the benchmark and included:

- time series of length frequency distributions
- several surveys to tune the models, including an attempt to analyze the Turkish anchovy acoustic survey data for sprat, as well as mid water trawl surveys in different seasons for Bulgaria and Romania,
- a standardized CPUE time series for the Turkish fleet

The group noted the difference in length distributions among countries with Bulgaria having consistently larger fish in their catches, and Romania and Turkey having smaller ones with a greater variability around mean length.

Weight-at-age data were not provided because not requested by the GFCM input data template. Data were provided by the experts of some countries during the meeting but owing to the difference between countries, years and ages, the group decided to fix a weight-at-age vector for all years. It was recommended weight-at-age be included in the input data template.

A vector-at-age of natural mortality was estimated by taking an average of Gislason estimates by country.

The time-series of catch-at-age were provided by experts from 2009 to 2017 and recovered from previous STECF assessments prior to 2009.

4.2. Assessments

Based on the common dataset compiled by the group, a number of different runs were performed using four different assessment models. ICA and SAM were used, as requested by the terms of reference of the session, as well as XSA and separable VPA, as requested by the group in course of action:

- ICA: ICA was run using FLR (FLICA) based on the same overall settings of STECF EWG 17-11 (2017) and trialing two assumptions on the fully selected ages: 1 and 2. Owing to the requirement of the model to have complete time series, only two tuning series were used (Romanian spring survey and Turkish standardized CPUE).
- SAM: different configurations of a base case model were tested as follows:
    - Base case: fishery data from 1997 to 2017 and the three longest-running tuning series (Romanian autumn and spring surveys and Turkish standardized CPUE).
    - Model 2: base case + Bulgarian spring survey
    - Model 3: Model 2 + Turkish acoustic autumn survey
    - Model4: base case with fishery data starting from 2009
- XSA: owing to the requirement of the model to have complete time series, XSA was run on fishery data from 1997 to 2017 and only two tuning series (Romanian spring survey and Turkish standardized CPUE). Sensitivity analyses on different combinations of rage, qage, fse and shrinkage were performed.
- Separable VPA: using fishery data from 1997 to 2017.

4.3. General results

ICA with fully selected age of two and all XSA models run produced very similar results overall, especially for the more recent part of the time series.

SAM provided a lower perception of SSB and a higher perception of F, although the final year of XSA was within the confidence bounds of the SAM. The historical part of the quantities estimated by SAM was very different from ICA and XSA; this discrepancy is ascribable to the different modeling approach.

All models showed a cyclical pattern in both recruitment and SSB. XSA and ICA also showed overall decreasing trends in these quantities, coupled with an increasing trend in F, which SAM did not show.

Estimated quantities of F were converted in exploitation rate (E = F/Z) and compared to Patterson's E = 0.4. The final perception of the exploitation generated by SAM was in contrast with that provided by XSA (Table 20). Furthermore, biomass reference points were calculated using ICES guidelines for Blim and Bpa. Both XSA and SAM estimated SSB above Bpa.

4.4. Conclusions, recommendations and advice

The group reviewed the methodologies used and, for practical reasons related to operational constraints making the running of ICA models virtually impossible, agreed not to use ICA in the future. The group also expressed difficulties in formulating a decision regarding the model to be adopted and discussed the pros and contra of XSA and SAM. These are included in Table 22 along with the identification of the data required for running each of the two models. Pros of XSA related mainly to the relative simplicity of the method while pros of SAM included the possibility of using fragmented time series and the fact it includes a framework to account for and estimate uncertainty. The groups recognized the fact that SAM is used worldwide to assess small pelagic stocks (e.g. Adriatic anchovy and sardine, northeast Atlantic mackerel). Pending further work and, given the expert perception on the stock (i.e. a decrease in SSB and length-structure of the stock), the Group agreed with the overall results of XSA.

In this context, the group recommended the benchmark session be extended into the next intersession, during which time work would be done towards resolving the identified issues within the context of the BlackSea4Fish project. Irrespective of the model used to assess the stock, the group underlined a number of points to be investigated, in the short and medium term, towards gaining a better understanding of the status and dynamics of the sprat stock in the Black Sea:

- Investigate the use of time-variable weight-at-age (short-term)
- Explore the possibility of developing a multispecies model also taking into account environmental drivers (e.g. North Sea sprat is assessed using multispecies options from the Stochastic MultiSpecies [SMS] model, Lewy and Vinther, 2004) (medium-term)
- Further investigate the issue of stock distribution/identification (medium-term)

Based on the experience of this first benchmark assessment, the group recommended that all benchmarks be preceded by intense data preparation in order to evaluate data availability, data gaps and data quality before aggregating country data into a single Black Sea data set. This data preparation should start well in advance of the benchmark in order to have time for the resolution of any emerging issues. In this context, the importance of cooperation among experts was stressed and the crucial future role of the BlackSea4Fish project was underlined.

The group strongly advocated the creation a Black Sea subregional database, as included in the workplan of the BlackSea4Fish project. This database should be applicable to all species, not only sprat, and represent a crucial step towards harmonizing data manipulation and applying data quality controls.

In light of the discussions, the group agreed to provide precautionary advice of not increasing fishing effort for the Black Sea sprat stock, temporarily considering its status as uncertain, while further investigating methodological and data-related issues.

Table 22. Pros and contra of XSA and SAM models as well as lists of input data required

XSA	SAM
Pros	
Simpler to use	it accounts uncertainty allows inclusion of time series with gaps (i.e. use of surveys) forward methodology (more precise for recent year estimates) allows performance of MSE - framework for MSE already in place more diagnostic tools (likelihood, AIC, uncertainty) does not assume catches without error web interface for immediate output view and sharing of results can include aggregate biomass indices
Contra	
XSA not suitable for short lived species Deterministic model, providing no uncertainty around estimates Applies a backward estimation, so recent years are the most uncertain Assumes catch without error Cannot deal with gaps in the time series	More complicated to use
Data requirements	
Catch-at-age with no gaps in the time series Tuning indices with no gaps in the time series Estimates of natural mortality Weight-at-age Maturity-at-age	Catch-at-age Tuning indices Estimates of natural mortality Weight-at-age Maturity-at-age

References

Lewy, P. and Vinther, M. 2004. A stochastic age-length-structured multispecies model applied to North Sea stocks. ICES CM 2004/ FF:20.

5. EXTERNAL REVIEWERS' REPORT

Reviewer: Mikael van Deurs, senior scientist, DTU Aqua Denmark

I participated in the Black Sea sprat (sprat in GSA 29) benchmark meeting as external reviewer. The meeting took place in Constanta, Romania, 27–28 November 2018. With the exception of Russia all countries, with a part in the sprat fishery, was represented at the meeting. Each country arrived with data ready to be shared with the group (also catch data from Russia was made available to the group). The meeting progressed according to Terms of Reference, and the process was constructive and productive. After Power Points presentations of data in plenum (in particular from surveys held by different countries), the group coordinated data and compiled the necessary input for the stock assessment models.

Three different stock assessment models were applied to the data: ICA, XSA, and SAM. ICA and XSA were providing a rather similar perception of the stock, whereas, the SAM model provided a slightly different perception of the stock, which sparked a discussion on how to select model. The final plenum decision was to put most emphasize on the XSA results. This decision was based mainly on the following two arguments: (i) the ICA model suffers from severe operational limitations (i.e. outdated software); and (ii) the SAM model is more complex, which has advantages (also highlighted in the report), but also the disadvantage that very few of the group members (if any) fully comprehend how the SAM model estimate stock numbers and fishing mortality (F), using mixed effect modeling and hidden Marchov chains to reduce model parameters and include the so-called "process error". The main challenges related to the data-input for the models were (i) the lack of age distributions to be applied to the catches of the individual years (in particular prior to 2009); (ii) lack of information on weight-at-age for the individual years; and (iii) lack of longer survey time-series and fisheries independent information about recruitment. As discussed at the meeting, these challenges can obviously not be overcome in the historic data, but coordinated effort should be made (between benchmarks) to improve on these aspect with respect to future data. I will return to these matters below.

The ICA and XSA model produced slightly decreasing trends in SSB and increasing time-series of F, whereas, there were no time-trends in the SSB and F time-series produced by the SAM model. Furthermore, SAM gave the impression of relative lower SSB and higher F, compared to ICA and SAM. The SAM model include more survey time-series, since it is flexible toward missing years in data. However, a "leave one out" analysis on the surveys used in the SAM showed that the differences between models is not likely to be driven by the inclusion of different surveys.

I made a quick cohort analysis of the catch numbers at age used as input for the stock assessment models and found no temporal trend. The natural mortality (M) is assumed to be constant and catches increase substantially over time. If recruitment is not increasing over time (which it was not in ICA and XSA outputs), it is not surprising that SSB will decline over time and F increase (as we see it in ICA and XSA). In contrast to ICA and XSA, the SAM model produced recruitment time-series with a slightly increasing trend, which may be countering the increase in catches, resulting in stable SSB and F over time. It should also be noted that SAM assumes that M and age-distributions are not known without error (accounted for by the so-called "process-error"), which could potentially explain why SAM arrives at a different results (incl. slightly increasing recruitment). However, it should here be noted that a constant age-distribution was applied to the catches before 2009 (and after 2009 an age-length key based on Bulgarian data was extrapolated to data from other countries). This could potentially be introducing a large bias to the cohort development in the catch numbers at age. For example, large incoming year classes may not be visible in the data, biasing the estimates of recruitment, which in the first two thirds of the time series is informed only by catches (i.e. no survey available). Mainly for this reason, interpretation of long-term trends produced by the models should be made with caution.

Looking at the most recent parts of the time-series, the stock perception only varies slightly between models (i.e. lower F and higher SSB in ICA and XSA; and higher F and lower SSB in SAM). However, it is SSB viewed against the biomass reference-point (Blim and Bpa, in this case) that is important in a management context (the same account for F, which needs to be viewed against Fmsy), and in this respect both the SAM and XSA model gives the impression of a stock that is generally not overexploited, and only twice within the last ten years (2012 and 2013) has SSB been in close contact with Blim.

Other comments

It is not clear to me how the Turkish standardized CPUE was calculated. Since this tuning time-series is an important input to all assessment models, I suggest elaborating and refining the method description before the next benchmark.

Unreported catches were not discussed and/or mentioned in the report. I assume this means that the group agrees that unreported catches are negligible. I therefore suggest including a statement about this in the next benchmark report.

Forecasting of catch opportunities were not discussed at the meeting. I recommend that the next meeting should initiate discussions on choice of forecast methods and how to produce the best possible recruitment estimate. A good recruitment estimate should not only be accurate, but the timing should also be right before it can be used in a short-term forecast.

There are some indications (Figure 8) that the size of fish is decreasing. I recommend to look further into this matter, since decreasing weight at age will influence SSB and should preferentially be accounted for in the stock assessment. On the other hand, if it is not weight-at-age that is decreasing, but the numbers of older fish, this could indicate increasing total mortality (which we may have missed by applying a constant M and constant age-distribution). Would it possible to begin an international Black Sea sprat age-reading program?

For a future meeting, I recommend producing internal and external consistency plots for all surveys. Such plots produce useful information about the surveys.

There is quite a bit of retrospective pattern in both the XSA and SAM model. This indicates that the model produces a quite uncertain prediction of SSB and recruitment in the terminal year, which could challenge forecasting. However, as long as the retrospective pattern is not showing a bias (i.e. constantly down-scaling recruitment as more years is added), it is not a major problem. However, it is a bit difficult to determine if there is a bias or not. I therefore recommend that Mohn´s Rho is calculated (see ICES guidelines) and presented as well (for next time), as this parameter is a good indicator of the magnitude of the bias.

A sensitivity analysis of the effect of selected shrinkage parameters used in the XSA model would have been useful (Table 17).

As also stated in the conclusion of the report, it could be worthwhile to investigate if the current stock identity is the most appropriate (one stock unit as opposed to two or more stock units). For example, the substantial differences in growth parameters found between areas (Table 14) could indicate the need for considering a different stock identity/identities.

If age-0 sprat has not recruited to the fishery (see Figure 22), it should be considered if age-0 should be removed from the Turkish standardized CPUE time-series used as input for the assessment models.

In several places the report lack a bit of explanation: for example what is "Ax" in table on page 20? Why is it saying "whiting agglomeration" in Figure 18? What is the difference between the survey reported in Figure 17 and Figure 19 and 20? What is it that is shown in Figure 21 and how is this so-called "agglomeration biomass" produced? On page 28 there is reference to table 5.1, but I cannot find table 5.1 anywhere in the report. Is Figure 23 and 24 showing the same residuals? The FLR XSA Diagnostics on page 33 are a bit difficult to follow, since they are basically unformatted flr-outputs.

Since the SAM model belong to a class of models that are fundamentally different from more conventional models in its estimation process, it could perhaps be useful to invite a scientist with expertise in the SAM model to the next meeting. This may facilitate a more informed discussion regarding the choice of assessment model.

Thanks for inviting me as reviewer to the Black Sea sprat benchmark. It was by all means a very positive experience, and I wish all the best to the group (and the sprat stock) in the future

Kind regards

Mikael van Deurs

Appendix 1

AGENDA

1. Opening of the meeting
2. Review of available fisheries dependent and fisheries independent information
3. Analysis of potential assessment models, including detected issues with previous assessment models, and identification of candidate models and assumptions
4. Practical session; assessment runs and compilation of tentative results
5. General discussion on assessment outcomes
6. Simulations and reference points
7. Conclusions and preparation of draft advice

Appendix 2

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