10 Sprat in Division 3.a and Subarea 4 (Skagerrak, Kattegat and North Sea)

10.1 The Fishery

10.1.1 ACOM advice applicable to 2019 and 2020

There have never been any explicit management objectives for this stock. Last year, the advised TAC (July 2019 to June 2020) was set to 138 726 t for sprat in Subarea 4 and Division 3.a. The 2019 herring bycatch quotas were 13 190 t for the North Sea and 6659 t for Division 3.a. During the WKSPRAT benchmark meeting in 2018, sprat in Subarea 4 and Division 3.a were merged into one stock assessment model. Also a number of other modifications were made to the configurations of the assessment model (see (WKSPRAT: ICES, 2018) for further details).

10.1.2 Catches in 2019

Catch statistics for 1996–2019 for sprat in the North Sea by area and country are presented in Table 10.1.1. Catch data prior to 1996 are considered less reliable (see Stock Annex). The small catches of sprat from the fjords of Norway are not included in the catch tables (Table 10.1.1–10.1.2). The WG estimate of total catches for the North Sea and Division 3.a in 2019 were 147 793 t (total official catches amounted to 147 919 t). This is a 23% decrease compared to 2018, but not far from the average for the time-series. The Danish catches represent 83% of the total catches.

The spatial distribution of landings was similar to 2018 (Figure 10.1.1). As in previous years, a low percentage (10% in 2019) of the catches were landed in the first and second quarter of 2019 (Table 10.1.2).

10.1.3 Regulations and their effects

The Norwegian vessels have a maximum vessel quota of 550 t when fishing in the North Sea. A herring bycatch of up to 10% in biomass is allowed in Norwegian sprat catches.

Most sprat catches are taken in an industrial fishery where catches are limited by herring bycatch quantities. Bycatches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. Bycatch is especially considered to be a problem in area 4.c. This led to the introduction of a closed area (sprat box) to ensure that sprat catches were not taken close to the Danish west coast where large bycatches were expected.

ICES evaluated the effectiveness of the sprat box in 2017 (ICES, 2017). The evaluation showed that fishing inside the sprat box would be expected to reduce unwanted catches of herring by weight but not in number and concluded that other management measures are sufficient to control herring bycatch. The sprat box was removed in 2017.

10.1.4 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported. From about 2000, Norwegian pelagic trawlers were licensed to take part in the sprat fishery in the North Sea. In the first years, the Norwegian catches were mainly taken

by purse-seine, and the catches taken by trawl were low. In recent years, the share of the total Norwegian catches taken by trawl has increased (2019: 90% taken by trawl).

10.2 Biological composition of the catch

Only data on bycatch from the Danish fishery were available to the Working Group (Table 10.2.1). The Danish sprat fishery was conducted with a 2.2% and 9.1% bycatch of herring in 2019 in the North Sea and Division 3.a, respectively. The total amount of herring caught as bycatch in the sprat fishery has mostly been less than 10%.

The estimated quarterly landings at age in numbers for the period 1974–2019 are presented in Table 10.2.2. In the model year 2019 (1 July 2019–30 June 2020), one-year old sprat contributed 52% of the total landings, which is lower compared to the 1990–2018 average (63%) and the lowest since 2011 (45%). 2-year olds contributed 26% in 2019 (model year), which is above the 1990–2018 average (22%). 0-year olds contributed 18% of the total landings, which is higher than the 1990–2018 average (9%).

Denmark, Sweden, and Norway provided age data of commercial landings in 2019 (Table 10.2.4). All quarters were covered. The sample data were used to raise the landings data from the North Sea, Skagerrak, and Kattegat. The landings by UK-England (168 t), UK-Scotland (1324 t), Germany (3441 t) and Belgium (<1 t) were unsampled. The sampling level has been greatly improved since 2014 because of the implementation of a sampling programme for collecting haul-based samples from the Danish sprat fishery. The sampling level in 2019 (model year) was 1.8 samples per 2000 t. The required sampling level in the EU directive for the collection of fisheries data (Commission Regulation 1639/2001) is 1 sample per 2000 tonnes (see also the Stock Annex). This level was met by Denmark and Sweden. The total sampling level was above the EU directive required minimum level.

The number of samples used for the assessment, both length and age-length samples, is shown in Table 10.2.4–5 and Figure 10.2.1.

10.3 Fishery Independent Information

10.3.1 IBTS Q1 and Q3

Table 11.3.1 and Figure 11.3.1 and 11.3.2 give the time-series of IBTS indices by age (calculated using a delta-GAM model formulation; see WKSPRAT report (2018) for further details). The data source is the IBTS Q1 data from 1983–2020. The index for IBTS Q1 1-year old in 2020 (age-0 in the model and the table, serving as a recruitment index) was the fifth highest in the time-series, 20% higher than last year's index. There has been a tendency for an increase in the IBTS age 0 in the time-series since 1990. IBTS Q3 survey indices were also used in the assessment, and the 2019 values were 15% higher for age-1 and 71% and 60% higher for age-2 and age-3, respectively, compared to 2018. To track changes in Subarea 4 and Division 3.a, separately, IBTS indices for the North Sea and 3.a, respectively, are shown in Figure 11.3.2c and 11.3.3.

10.3.2 Acoustic Survey (HERAS)

Abundance indices were provided by WGIPS (ICES, 2019) (see Section 1.4.2). The abundance indices for Subarea 4 and Division 3.a were summed (Table 11.3.2 and Figure 11.3.2b). The 2019 values were 14% lower, 177% higher, and 577% higher (age-1, age-2, and age-3, respectively) compared to the 2018-values. To track changes in Subarea 4 and Division 3.a separately, WGIPS abundance indices for the North Sea and 3.a, respectively, are shown in Figure 11.3.4.

10.4 Mean weights-at-age and maturity-at-age

Mean weights-at-age in catches are given in Table 11.2.3 and Figure 11.4.1. Mean weights in model season 1 and 2 (S1 and S2; quarter 3 and 4), where most of the catches are taken, show a declining trend over the past decade. In 2019, the mean weights of age-1 and age-3 fish in S1 were the lowest observed for nearly two decades. Mean weight of age-2 in 2019 was about the same as in 2018, which was the lowest observed for two decades. Mean weight-at-age was also very low in S2 (Figure 11.4.1).

Proportion of mature fish was derived from IBTSQ1, following the benchmark procedure. Long-term average maturity ogives were used in the assessment model (0.0, 0.41, 0.87, and 0.95 for age-0 to age-3+). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2013).

10.5 Recruitment

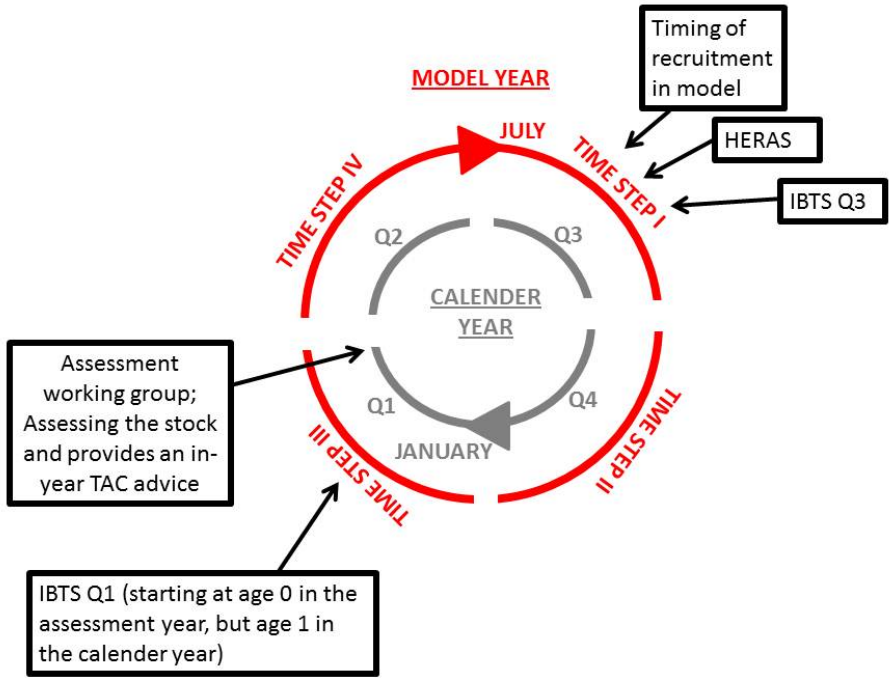
The IBTS Q1 age-1 index (age-0 in the model) (Table 10.3.1) is used as a recruitment index for this stock. The 2020 value, indicative of the 2019 recruitment, was the fifth highest in the time-series, and 20% higher than year. The recruitment estimated by the model for 2019 is 15% higher than the recruitment in 2018 and twice as high as the 1990-2018 arithmetic mean. At the most recent benchmark, it was decided to implement a power model (directly within the assessment model) to the age-0 IBTS Q1 index to dampen the effect of very high index values. This was done to reduce the retrospective bias on recruitment (see WKSPRAT 2018 for further details).

10.6 Stock Assessment

The stock assessment was benchmarked in November 2018 (WKSPRAT: ICES, 2018). During the WKSPRAT benchmark meeting in 2018, sprat in Subarea 4 and Division 3.a were merged into one stock assessment model. Also, a number of other modifications were made to the configuration of the assessment model (see WKSPRAT report (ICES, 2018) for further details).

In-year advice is the only possible type of advice for this short-lived species with a fishery dominated by 1- and 2-year-old fish. This, however, requires information about incoming 1-year-old fish. In order to meet this requirement and to come up with a model that logically matches the natural life cycle of sprat, the annual time-step in the model was shifted, relative to the calendar year, to a time-step going from July to June (see text table below). SSB and recruitment was estimated at 1 July. In figures and tables with assessment output and input, the years refer to the shifted model year (July to June) and in each figure and table it is noted whether model year or calendar year apply (when the model year is given the year refers to the year at the beginning of the model year; for example: 2000 refers to the model year 1 July 2000 to 30 June 2001). The following schematic illustrates the shifted model year relative to the calendar year and provides an overview of the timing of surveys etc.

Model year		Calendar year	
2000	Season 1	2000	Quarter 3
2000	Season 2	2000	Quarter 4
2000	Season 3	2001	Quarter 1
2000	Season 4	2001	Quarter 2



10.6.1 Input data

10.6.1.1 Catch data

Information on catch data are provided in Tables 10.1.1–2 and in Figures 10.1.13 and 10.6.1. Sampling effort is presented in Table 10.2.5 and Figure 10.2.1.

Since catches in quarter 2 (season 4 in the model) are often less than 5000 tonnes, these are poorly estimated by the model and the number of samples from these catches are low (sometimes no samples). Furthermore, at the time of the assessment working group, S4 catches are unknown. Therefore, during the latest benchmark it was decided to move S4 catches into S1 in the following model year. In 2020, only 638 t were taken in quarter 1 and as a result, only one age sample was taken. To avoid the resulting high uncertainty in the age distribution of these catches, they were transferred to 2019 quarter 4, leading to a total catch of 34 456 t in this quarter.

10.6.1.2 Weight-at-age

The mean weights at age observed in the catch are given in Table 10.2.3 and Figure 10.4.1 by season. It is assumed that the mean weights in the stock are the same as in the catch. The mean weight at age of S1 that is used to calculated SSB.

10.6.1.3 Surveys

Three surveys were included (Tables 10.3.1–3), IBTS Q1 (1975–present), IBTS Q3 (1991–present) and HERAS (Q3) (2003–present). 0-group (young-of-the-year) sprat is unlikely to be fully recruited by the time of IBTS Q3 and HERAS, and for this reason these age indices were excluded from the model. Internal consistency in survey data and external consistency between surveys are presented in Figures 10.3.1–5.

10.6.1.4 Natural mortality

New natural mortalities were available from the 2017 North Sea key run from WGSAM (ICES, 2017). The major changes were changes to the mackerel consumption leading to a much lower M of 0-group in the second half of the year. HAWG reviewed stock recruitment plots based on the old and new M's and considered that updating the entire time-series of Ms did not affect the stock recruitment plot substantially and did not lead to a change in the perception of B_{lim}/B_{pa}. Therefore, the new M's were used. Variable mortality is applied as three year averages up till 2015, and after this the average mortality for 2013–2015 is used. Natural mortalities used in the model are given in Table 10.6.1.

10.6.1.5 Proportion mature

Proportion of mature fish was derived from IBTSQ1, following the benchmark procedure. Long-term average maturity ogives were used in the assessment model (0.0, 0.41, 0.87, and 0.95 for age-0 to age-3+). More details about the maturity staging are given in Section 4.5.3.2 in the WKSPRAT 2013 report (ICES, 2013).

10.6.2 Stock assessment model

The assessment was made using SMS (Lewy and Vinther, 2004) with quarterly time-steps (referred to as season S1–S4). Three surveys were included, IBTS Q1 ages 1–4+, IBTS Q3 ages 1–3 and HERAS (Q3) ages 1–3. 0-group sprat is unlikely to be fully recruited to the IBTSQ3 or HERAS in Q3 and these age indices were excluded from runs. External consistency between IBTS Q1, IBTS Q3 and HERAS can be found in the benchmark report (WKSPRAT: ICES, 2018).

The model converged and fitted the catches of the main ages caught in the main seasons reasonably (ages 1–2, seasons 1 and 2, Table 10.6.2). All surveys had low CVs (Table 10.6.2). There were no patterns in the residuals raising concern. Although, there appears to be a periodic cycling (on a decadal time-scale) between positive and negative residuals in the IBTS Q3 survey and the catches (Figures 10.6.2–3). Common CVs were estimated for the groups: 1 to 3-year olds in IBTS Q1 and 2 and 3-year olds in IBTS Q3 and HERAS.

The retrospective analyses showed a tendency to overestimate recruitment (5 years mohn´s rho = 0.31) (Figure 10.6.5). As 41% of the recruiting year class contributes to the SSB at the end of the year, there is a similar large retrospective pattern in SSB (5 year mohn´s rho = 0.35).The assessment model was improved with this respect during the last benchmark and Mohn´s rho was reduced by roughly a factor of 3 due to the improvement.

The final outputs detailing trends in mean F, SSB and recruitment are given in Figures 10.6.4–7 and Tables 10.6.3–4.

10.7 Reference points

A B_{lim} of 94 000 t (Figure 10.7.1) and B_{pa} of 125 000 t were agreed at the most recent benchmark. B_{pa} is defined as the upper 90% confidence interval of B_{lim} and calculated based on a terminal SSB CV of 0.173.

10.8 State of the stock

The sprat stock is abundant judging by all the surveys and by the assessment output. The stock has been well above B_{pa} since 2013 and above B_{lim} since 1991. The current SSB is more than twice the B_{lim}, and among the six highest since 1980. Fishing mortality has been decreasing and is now for the first time in five years below the long-term average. The advised TAC was based on the predicted catch at F equal to F_{cap} (0.69). A large overshoot of F_{cap} is seen in simulations applying the escapement strategy on very large incoming year classes, and this is the rationale for implementing an F_{cap} as otherwise, the escapement strategy is not precautionary at large stock sizes.

A stock summary from the assessment output can be found in Table 10.6.4 and Figure 10.6.7.

10.9 Short-term projections

Management strategy evaluations for this stock were made in December 2018 (WKSPRATMSE: ICES, 2018). These evaluations clearly show that the current management strategy ($B_{escapement}$) is not precautionary unless an additional constraint is imposed on the fishing mortality (referred to as F_{cap}). During the WKSPRATMSE (ICES, 2018) 0.69 was found to be the optimal F_{cap} value (from both a full MSE and a shortcut MSE, see the WKSPRATMSE report (WKSPRATMSE: ICES, 2018) for further details), which is a revision of the previous value of 0.7. This means, that the fishing mortality ($F_{bar}(1–2)$) derived from the $B_{escapement}$ strategy, should not exceed 0.69.

SSB in 2020 is expected to be higher than 2019, above the long-term average, and well above B_{pa}. Using the input and assumptions detailed above, the projection for an F = 0 is an SSB in July 2021 of 393 000 t (Table 11.9.2). The F_{MSY} approach prescribes the use of an F value of 0.69 (F_{cap}, see explanation above) and results in a TAC advice of 207 807 t (July 2020–June 2021), which is expected to result in an SSB of 263 000 t in July 2021, well above B_{pa}.

10.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2018 benchmark (ICES, 2018). A complete overview of the choices made during the benchmark can be found in the WKSPRAT report (ICES, 2018) and these are also described in the Stock Annex for sprat in Division 3.a and Subarea 4.

The assessment shows medium to high CVs for the catches but low CVs for surveys. The CVs of F, SSB and recruitment are generally low (see Table 10.6.2 and Figure 10.6.4). The model converged and fitted the catches of the main ages caught in the main seasons (the periods with most samples) reasonably well (ages 1–2, season 2, Table 10.6.2). The retrospective pattern in SSB and recruitment (5 years mohn´s rho of 0.35 and 0.31, respectively) is slightly above the advised limit of 0.3 discussed in WKFORBIAS (2019). However, the Mohn's rho has not been consistently above 0.3 (i.e. last year it was 0.29) and 0.35 is within the 90% confidence intervals of Mohn´s rho distribution from the MSE, this was not considered to cause concern about the quality of the assessment.

There appears to be a systematic pattern in the catch residuals of model season 1 (quarter 3), which remains unexplained.

10.11 Management Considerations

A management plan needs to be developed for this stock. Sprat is an important forage fish, thus also multispecies considerations should be made.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year class. Thus, the fishery in a given year will be dependent on that year's incoming year class.

Industrial fisheries are allocated a bycatch of 8954 t and 6659 t of juvenile herring in 2020 in the North Sea and Division 3.a, respectively. It is important to continue monitoring bycatch of juvenile herring to ensure compliance with this allocation.

Despite the fact that sprat in the North Sea and 3.a is assessed as a single stock, schedule of the TAC setting are different between these two management areas. In the North Sea the TAC is set from 1 July to 30 June in line with the in year-advice provided for the stock, while the TAC for Division 3.a is still based on a calendar year from 1 January to 31 December creating an inherent mismatch.

10.11.1 Stock units

After the latest benchmark, sprat in the Subarea 4 and Division 3.a is considered to be one cohesive stock. This is documented in the WKSPRAT report (ICES, 2018). In addition, there are several peripheral areas of the North Sea and Division 3.a where there may be populations of sprat that behave as separate stocks from the main stock. Local depletion of sprat in such areas can be an issue of ecological concern.

10.12 Ecosystem Considerations

Sprat is an important prey species in the North Sea ecosystem. The influence of the sprat fishery on other fish species and seabirds are at present not documented to be substantial.

In the North Sea, the key predators consuming sprats are included in the stock assessment, using SMS estimates of sprat consumption for each predatory fish stock, and estimates for seabirds. Impacts of changes in zooplankton communities and consequent changes in food densities for sprats are not included in the assessment, but it may be useful to explore the possibility of including this, or a similar proxy bottom-up driver, in future assessments. However, the effect of changes in productivity is included in the observed quarterly weight at age and in the estimated recruitment, as a decline in e.g. available food can lead to lower observed weights and lower estimated recruitment even in the absence of a causal link in the model.

10.13 Changes in the environment

Temperatures in this area have been increasing over the last few decades. This may have implications for sprat, although the correlation between temperature and recruitment from the model has been found to be low (see WKSPRAT: ICES, 2018).

Table 10.1.1. North Sea & 3.a sprat. Landings (' 000 t) 1996–2019. See ICES CM 2006/ACFM:20 for earlier data. Catch in coastal areas of western Norway excluded. Data provided by Working Group members. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Division 27.4.a																								
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*					*	*	0.1	0.1		*
Norway														*		*								0.1
Sweden						0.1																		
UK (Scot-land)																0.5						*	*	
Germany																				*	*			
Nether-lands																				*				
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*		0.5			*	*	0.1	0.1	*	0.1
Division 27.4.b																								
Denmark	76.5	93.1	119.3	160.3	162.9	143.9	126.1	152.9	175.9	204.0	79.5	55.5	51.4	115.6	80.8	90.9	65.7	44.7	121.3	234.4	177.6	100.6	156.5	110.3
Norway	52.8	3.1	15.3	13.1	0.9	5.9	*		0.1		0.8	3.7	1.3	4.0	8.0	0.1	6.2	*	8.9	0.3	19.6	9.7	9.3	10.0
Sweden	0.5		1.7	2.1		1.4				*				0.3	0.6	1.1	1.8	0.1	3.9	5.5	11.7	8.1	7.6	7.5
UK(Scot-land)				1.4								0.1		2.5	1.1	1.9	0.7						*	1.3
UK(Engl.& Wales)														*								*	*	
Germany																3.3	0.5	0.6	1.5	3.1	5.4	6.0	3.7	3.4

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Nether-lands																1.1	2.7	0.4	2.4	1.2	1.0	1.6	1.6	
Faroe Is-lands																					4.7	1.0	1.0	
Total	129.8	96.2	136.3	176.9	163.8	151.2	126.1	152.9	176.0	204.1	80.3	59.3	52.7	122.4	90.4	98.4	77.5	45.8	138.0	244.6	220.0	127.0	179.7	132.6
Division 27.4.c																								
Denmark	3.9	5.7	11.8	3.3	28.2	13.1	14.8	22.3	16.8	2.0	23.8	20.6	8.1	8.2	48.5	20.0	3.2	15.4	2.2	34.0	18.7	1.5	6.2	8.9
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9		1.8	3.2	9.9	3.0	1.7	0.1	8.8	0.6		0.5	0.6
Sweden														0.6	0.6	0.2	0.4	1.3		1.2	0.4			
UK(Scot-land)													0.2			0.4					*			
UK(Engl.& Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	0.1	0.2
Germany																*	*	1.0		0.6	0.2			
Nether-lands				0.2												4.2	1.0	0.7	*	1.2	0.8	*	0.7	
Belgium																*		*	*	*	*	*		*
France																				*		*		
Total	6.5	7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8	8.4	10.6	53.0	35.2	8.0	20.1	2.3	45.8	20.6	1.6	7.5	9.6
Division 27.3.a																								
Denmark	10.4	11.6	11.2	17.2	12.8	20.2	13.4	10.2	14.4	31.9	7.8	9.9	5.8	6.9	8.4	8.0	8.4	1.9	16.7	11.7	6.7	1.0	2.9	3.9

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sweden	6.6	3.8	6.2	9.3	6.4	7.6	4.3	5.5	6.5	7.7	4.4	4.2	2.4	1.6	1.4	2.0	1.5	1.1	1.5	1.3	1.1	0.2	1.1	1.7
Germany																			*				*	
Faroe Islands																					*			
Total	17.0	15.4	17.4	26.5	19.2	27.7	17.7	15.7	20.9	39.6	12.2	14.1	8.2	8.5	9.8	10.0	9.9	3.0	18.3	13.0	7.9	1.2	4.0	5.6
Total North Sea and Skagerrak-Kattegat																								
Denmark	91.1	110.4	142.3	181.5	203.9	177.3	155.4	185.4	207.1	237.9	111.2	86.7	65.4	130.7	137.7	119.0	77.4	62.1	140.2	280.1	203.1	103.3	165.6	123.1
Norway	52.8	3.2	31.3	18.8	2.7	9.5	*		0.1		9.8	6.7	1.3	5.8	11.1	10.0	9.1	1.7	9.0	9.1	20.2	9.7	9.8	10.6
Sweden	7.1	3.8	7.9	11.4	6.4	9.1	4.3	5.5	6.5	7.8	4.4	4.2	2.4	2.5	2.6	3.3	3.7	2.5	5.4	8.1	13.2	8.3	8.7	9.2
UK(Scotland)				1.4								0.1	0.2	2.5	1.1	2.8	0.7				*	*	*	1.3
UK(Engl.& Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6	0.5	*	*	*	*	*	*	0.2
Germany																3.3	0.5	1.6	1.6	3.7	5.6	6.0	3.7	3.4
Netherlands				0.2												5.3	3.7	1.1	2.4	2.4	1.8	1.6	2.3	
Faroe Islands																					4.7	1.0	1.0	
Belgium																*		*	*	*	*	*		*
France																				*		*		
Total	153.6	118.8	181.7	214.9	215.1	197.9	161.3	192.2	215.2	247.3	125.9	97.9	69.3	141.6	153.3	144.1	95.5	68.9	158.7	303.3	248.5	129.9	191.2	147.8

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
* < 50 t																								

Table 10.1.2. North Sea & 3.a sprat. Catches (tonnes) by quarter. Catches in coastal areas of Norway excluded. Data for 1996–1999 in ICES CM 2007/ACFM:11.

Year	Quarter	Division				Total	Year	Quarter	Division				Total
		27.4.a	27.4.b	27.4.c	27.3.a				27.4.a	27.4.b	27.4.c	27.3.a	
2000	1		18 126	28 063		46 189	**2010**	1		10 976	17 072	1462	29 510
	2		1722	45		1767		2		3235	3	648	3886
	3		131 306	1216		132 522		3		14 220		3405	17 625
	4		12 680	2718		15 398		4		62 006	35 973	4278	102 257
	Total		163 834	32 042		195 876		Total		90 437	53 048	9793	153 278
2001	1	115	40 903	9716		50 734	**2011**	1		3747	21 039	3216	28 002
	2		1071			1071		2		2067	3	617	2687
	3		44 174	481		44 655		3		22 309	451	2311	25 072
	4	79	65 102	8538		73 719		4	8	70 256	13 759	3887	87 910
	Total	194	151 249	18 735		170 177		Total	8	98 380	35 252	10 031	143 671
2002	1	1 136	2182	2790		6108	**2012**	1		81	1649	4668	6399
	2		435	93		528		2		2924	0	909	3832
	3		70 504	647		71 151		3		26 779	307	1631	28 717

Year	Quarter	Division				Total	Year	Quarter	Division				Total
		27.4.a	27.4.b	27.4.c	27.3.a				27.4.a	27.4.b	27.4.c	27.3.a	
	4		52 942	12 911		65 853		4		47 765	6060	2728	56 553
	Total	1 136	126 063	16 441		143 640		Total		77 549	8016	9936	95 501
2003	1		11 458	7727	5217	24 402	**2013**	1		1281	3158	1296	5734
	2		625	26	1397	2049		2		32	0	443	474
	3		56 207	165	1720	58 092		3		25 577	720	211	26 509
	4		84 629	15 651	7349	107 629		4		18 892	16 276	943	36 110
	Total		152 919	23 570	15 683	192 172		Total		45 781	20 154	2893	68 827
2004	1		827	1831	4456	7113	**2014**	1		59	125	384	568
	2	7	260	16	1510	1793		2		11 631	3	1415	13 050
	3		54 161	496	4138	58 794		3	1	88 457	1428	9622	99 507
	4		120 685	15 937	10 775	147 397		4	7	37 851	822	6905	45 586
	Total	7	175 932	18 280	20 879	215 097		Total	8	137 999	2378	18 327	158 711
2005	1		11 538	2457	8148	22 143	**2015**	1	*	14 816	16 972	1442	33 230
	2		2515	123	4722	7360		2		16 843	107	619	17 568
	3		107 530		19 418	126 948		3		124 512	335	6528	131 375
	4		82 474	1033	7296	90 803		4	25	88 395	28 375	4389	121 184
	Total		204 057	3613	39 584	247 254		Total	25	244 566	45 789	12 978	303 358

Year	Quarter	Division				Total	Year	Quarter	Division				Total
		27.4.a	27.4.b	27.4.c	27.3.a				27.4.a	27.4.b	27.4.c	27.3.a	
2006	1	47	13 713	33 534	8105	55 399	**2016**	1	68	18 487	5969	746	25 250
	2		190	8	324	522		2		8927	51	669	9 647
	3		40 051	8	1440	41 499		3	*	158 522	111	4664	163 297
	4	2	26 579	77	2335	28 993		4	2	34 070	14 466	1764	50 301
	Total	49	80 533	33 627	12 204	126 413		Total	70	220 007	20 596	7843	248 516
2007	1		582	247	2646	3475	**2017**	1	1	3432	1220	92	4 745
	2		241	3	1291	1535		2		1327	0	33	1 360
	3		16 603		5357	21 960		3	*	92 885	217	227	93 329
	4	769	41 850	23 531	4761	70 911		4	94	29 310	174	849	30 426
	Total	769	59 276	23 781	14 055	97 881		Total	95	126 954	1611	1200	129 860
2008	1		2872	43	2890	5805	**2018**	1	*	8994	1628	168	10 790
	2		52	*	1017	1069		2		11 898	0	224	12 122
	3		21 787		636	22 423		3		112 361	1	1328	113 690
	4		27 994	8334	3672	40 001		4		46 411	5922	2249	54 582
	Total		52 706	8377	8215	69 298		Total	*	179 664	7551	3969	191 184
2009	1		36	1268	2600	3904	**2019**	1		389	9592	627	10 609
	2		2526	1	300	2827		2	2	3606	11	379	3999

Year	Quarter	Division				Total	Year	Quarter	Division				Total
		27.4.a	27.4.b	27.4.c	27.3.a				27.4.a	27.4.b	27.4.c	27.3.a	
	3	22	41 513		3300	44 835		3	2	95 829	7	2 249	98 087
	4		78 373	9336	2400	90 109		4	49	32 750	3	2 296	35 098
	Total	22	122 448	10 604	8600	141 675		Total	53	132 574	9614	5551	147 793

* < 0.5 t

Table 10.2.1. North Sea & 3.a sprat. Species composition in Danish sprat fishery in tonnes and percentage of the total catch. Left: North Sea, right: Division 3.a.

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	129 315	11 817	573	673	6	220	11	2 174	1 187	145 978
Tonnes	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
Tonnes	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
Tonnes	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 141	170 862
Tonnes	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	801	167 471
Tonnes	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 504	194 210
Tonnes	2004	179 944	10 144	474	334	0	4 351	3	3 836	1 821	200 906
Tonnes	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 251
Tonnes	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033
Tonnes	2007	74 734	6 596	168	900	6	126	18	6	253	82 807
Tonnes	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563
Tonnes	2009	112 721	7 222	44	307	3	116	1	1 526	407	122 345
Tonnes	2010	112 395	4 410	11	119	2	18	0	1 236	577	118 769
Tonnes	2011	109 376	8 073	35	191	0	127	0	1 881	345	120 026
Tonnes	2012	67 263	8 573	2	354	0	246	0	93	411	76 943
Tonnes	2013	55 792	5 176	47	445	0	277	2	1	369	62 109
Tonnes	2014	123 180	11 402	0	897	0	70	16	16	1 700	137 280
Tonnes	2015	265 356	4 568	5	1 809	0	527	0	147	3 311	275 723
Tonnes	2016	192 718	11 107	18	4 223	0	439	0	46	2 093	210 643
Tonnes	2017	100 833	5 130	1	1 344	0	197	0	503	12 386	120 394
Tonnes	2018	161 536	7 528	174	716	0	366	0	24	344	170 687
Tonnes	2019	118 302	2 757	1	897	1	176	0	3	503	122 639
Percent	1998	88.6	8.1	0.4	0.5	0.0	0.2	0.0	1.5	0.8	100.0
Percent	1999	91.4	4.2	0.2	0.6	0.0	0.2	0.0	2.9	0.4	100.0
Percent	2000	90.3	5.6	1.6	1.0	0.0	0.4	0.0	0.2	0.9	100.0
Percent	2001	79.9	8.2	0.0	1.0	0.1	0.2	0.0	10.0	0.7	100.0
Percent	2002	83.9	9.9	1.2	1.5	0.0	0.4	0.0	2.4	0.5	100.0
Percent	2003	88.8	5.3	0.4	0.6	0.0	0.4	0.0	2.8	1.8	100.0
Percent	2004	89.6	5.0	0.2	0.2	0.0	2.2	0.0	1.9	0.9	100.0
Percent	2005	85.9	9.0	1.1	0.2	0.0	0.4	0.0	2.9	0.4	100.0
Percent	2006	86.0	7.5	0.5	0.3	0.0	0.8	0.0	4.5	0.5	100.0
Percent	2007	90.3	8.0	0.2	1.1	0.0	0.2	0.0	0.0	0.3	100.0
Percent	2008	85.4	11.1	0.0	0.5	0.0	0.5	0.0	0.0	2.4	100.0
Percent	2009	92.1	5.9	0.0	0.3	0.0	0.1	0.0	1.2	0.3	100.0
Percent	2010	94.6	3.7	0.0	0.1	0.0	0.0	0.0	1.0	0.5	100.0
Percent	2011	91.1	6.7	0.0	0.2	0.0	0.1	0.0	1.6	0.3	100.0
Percent	2012	87.4	11.1	0.0	0.5	0.0	0.3	0.0	0.1	0.5	100.0
Percent	2013	89.8	8.3	0.1	0.7	0.0	0.4	0.0	0.0	0.6	100.0
Percent	2014	89.7	8.3	0.0	0.7	0.0	0.1	0.0	0.0	1.2	100.0
Percent	2015	96.2	1.7	0.0	0.7	0.0	0.2	0.0	0.1	1.2	100.0
Percent	2016	91.5	5.3	0.0	2.0	0.0	0.2	0.0	0.0	1.0	100.0
Percent	2017	83.8	4.3	0.0	1.1	0.0	0.2	0.0	0.4	10.3	100.0
Percent	2018	94.6	4.4	0.1	0.4	0.0	0.2	0.0	0.0	0.2	100.0
Percent	2019	96.5	2.2	0.0	0.7	0.0	0.1	0.0	0.0	0.4	100.0

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	9 143	3 385	230	467	54	0	49	7	2 866	16 202
Tonnes	1999	16 603	8 470	138	1 026	210	5	75	3 337	2 896	32 760
Tonnes	2000	12 578	8 034	5	1 062	308	8	52	13	3 556	25 617
Tonnes	2001	18 236	8 196	75	1 266	50	13	35	4 281	1 271	33 423
Tonnes	2002	11 451	12 982	21	1 164	3	6	30	606	2 280	28 541
Tonnes	2003	8 182	4 928	340	252	4	4	4	1	567	14 282
Tonnes	2004	13 374	4 620	97	976	18	24	27	116	2 155	21 408
Tonnes	2005	30 157	6 171	244	871	63	18	20	746	1 758	40 047
Tonnes	2006	6 814	2 852	215	276	13	3	45	1	232	10 451
Tonnes	2007	7 116	2 043	34	190	31	8	4	1	469	9 896
Tonnes	2008	4 805	1 948	14	285	0	0	11	462	39	7 563
Tonnes	2009	4 839	3 016	37	169	15	0	1	53	47	8 177
Tonnes	2010	2 851	2 134	25	142	6	1	2	135	171	5 466
Tonnes	2011	4 754	2 461	0	43	0	7	1	141	40	7 447
Tonnes	2012	5 707	5 495	9	149	7	10	5	0	228	11 610
Tonnes	2013	1 143	1 751	2	46	0	0	1	1	27	2 971
Tonnes	2014	16 751	3 777	5	343	1	20	5	12	888	21 801
Tonnes	2015	11 448	5 831	0	565	0	29	8	1	154	18 036
Tonnes	2016	7 001	2 140	0	335	1	19	3	0	78	9 579
Tonnes	2017	963	328	0	172	0	19	1	0	32	1 515
Tonnes	2018	2 872	257	2	150	1	11	0	0	12	3 304
Tonnes	2019	3 429	351	0	59	0	2	0	0	8	3 850
Percent	1998	56.4	20.9	1.4	2.9	0.3	0.0	0.3	0.0	17.7	100.0
Percent	1999	50.7	25.9	0.4	3.1	0.6	0.0	0.2	10.2	8.8	100.0
Percent	2000	49.1	31.4	0.0	4.1	1.2	0.0	0.2	0.1	13.9	100.0
Percent	2001	54.6	24.5	0.2	3.8	0.2	0.0	0.1	12.8	3.8	100.0
Percent	2002	40.1	45.5	0.1	4.1	0.0	0.0	0.1	2.1	8.0	100.0
Percent	2003	57.3	34.5	2.4	1.8	0.0	0.0	0.0	0.0	4.0	100.0
Percent	2004	62.5	21.6	0.5	4.6	0.1	0.1	0.1	0.5	10.1	100.0
Percent	2005	75.3	15.4	0.6	2.2	0.2	0.0	0.0	1.9	4.4	100.0
Percent	2006	65.2	27.3	2.1	2.6	0.1	0.0	0.4	0.0	2.2	100.0
Percent	2007	71.9	20.6	0.3	1.9	0.3	0.1	0.0	0.0	4.7	100.0
Percent	2008	63.5	25.8	0.2	3.8	0.0	0.0	0.1	6.1	0.5	100.0
Percent	2009	59.2	36.9	0.5	2.1	0.2	0.0	0.0	0.6	0.6	100.0
Percent	2010	52.2	39.0	0.5	2.6	0.1	0.0	0.0	2.5	3.1	100.0
Percent	2011	63.8	33.0	0.0	0.6	0.0	0.1	0.0	1.9	0.5	100.0
Percent	2012	49.2	47.3	0.1	1.3	0.1	0.1	0.0	0.0	2.0	100.0
Percent	2013	38.5	58.9	0.1	1.6	0.0	0.0	0.0	0.0	0.9	100.0
Percent	2014	76.8	17.3	0.0	1.6	0.0	0.1	0.0	0.1	4.1	100.0
Percent	2015	63.5	32.3	0.0	3.1	0.0	0.2	0.0	0.0	0.9	100.0
Percent	2016	73.1	22.3	0.0	3.5	0.0	0.2	0.0	0.0	0.8	100.0
Percent	2017	63.6	21.6	0.0	11.4	0.0	1.2	0.1	0.0	2.1	100.0
Percent	2018	86.9	7.8	0.1	4.5	0.0	0.3	0.0	0.0	0.4	100.0
Percent	2019	89.1	9.1	0.0	1.5	0.0	0.1	0.0	0.0	0.2	100.0

Table 10.2.2. North Sea & 3.a sprat. Catch in numbers by age (1000's) by season and year. (Model year)

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 has been moved to S1 in the following year

Year	Season	age 0	age 1	age 2	age 3
1974	1	0	16101061	2155723	475613
1974	2	1884146	11544114	866399	48228
1974	3	2842702	11091303	1336036	34534
1974	4	1302331	2511315	359117	14822
1975	1	250931	27723510	10052550	260182
1975	2	1179567	14541887	4378415	166807
1975	3	5240024	4755878	2206781	66186
1975	4	0	0	0	0
1976	1	2143211	42209830	2888653	180913
1976	2	7439656	18762732	1613139	88604
1976	3	7703416	6925346	267638	8289
1976	4	0	0	0	0
1977	1	2690194	12786056	5181867	109712
1977	2	2520082	4904593	3679153	67688
1977	3	15857197	1843468	2200876	37836
1977	4	0	0	0	0
1978	1	454090	32184524	427473	96435
1978	2	5517665	10344970	1209584	116695
1978	3	6154606	4973568	1119045	29941
1978	4	0	0	0	0
1979	1	3579389	36866800	644042	117139
1979	2	1052920	11355949	2152261	63386
1979	3	3882781	6399259	332781	25964
1979	4	0	0	0	0
1980	1	0	14237558	17421360	1481066
1980	2	0	9415158	11520576	979415

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 has been moved to S1 in the following year

Year	Season	age 0	age 1	age 2	age 3
1980	3	2536060	3866612	389674	8724
1980	4	0	0	0	0
1981	1	428776	12322431	1483241	130805
1981	2	40632	3540737	3025289	202048
1981	3	374254	3854059	319763	9835
1981	4	0	0	0	0
1982	1	545769	6350511	601581	64879
1982	2	818525	5021082	1070960	55333
1982	3	2530673	401839	46913	3525
1982	4	0	0	0	0
1983	1	5613728	2819244	969599	155653
1983	2	2375763	1334333	588678	91112
1983	3	1697718	596857	7271	0
1983	4	0	0	0	0
1984	1	954757	6475021	417235	2532
1984	2	521866	2535354	247654	4803
1984	3	405095	612407	10648	1053
1984	4	0	0	0	0
1985	1	0	1304457	1972027	37680
1985	2	0	576004	870780	16638
1985	3	84760	215856	150819	14916
1985	4	0	0	0	0
1986	1	0	177780	452745	347620
1986	2	0	156913	399604	306818
1986	3	580936	58710	740	0
1986	4	0	0	0	0
1987	1	2236	2250587	128512	2525

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 has been moved to S1 in the following year

Year	Season	age 0	age 1	age 2	age 3
1987	2	49451	1790264	267597	978
1987	3	209788	826994	34626	32980
1987	4	0	0	0	0
1988	1	4082942	2096911	2830054	42364
1988	2	1163964	314106	527986	11526
1988	3	1817700	637489	129384	5491
1988	4	0	0	0	0
1989	1	12451	1706824	3613841	5716
1989	2	783	76415	88925	342
1989	3	469458	416920	34789	12751
1989	4	0	0	0	0
1990	1	1568	2633068	2234213	342514
1990	2	1225	2058041	1746290	267714
1990	3	291837	62050	1941	429
1990	4	0	0	0	0
1991	1	40504	1684266	2416750	8159
1991	2	1552315	2936717	614233	9587
1991	3	208352	64565	1036	99
1991	4	0	0	0	0
1992	1	18948	9695465	1315325	177584
1992	2	222991	1185132	132166	16491
1992	3	1279875	1583952	259251	5821
1992	4	0	0	0	0
1993	1	264173	3026867	5339043	247839
1993	2	1441317	4911453	1324444	31435
1993	3	1867838	1819506	338969	43965
1993	4	0	0	0	0

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 has been moved to S1 in the following year

Year	Season	age 0	age 1	age 2	age 3
1994	1	445326	40720484	516854	100737
1994	2	1856101	7146622	1455656	142774
1994	3	818875	2936362	559871	22813
1994	4	0	0	0	0
1995	1	170693	24466578	3192395	371759
1995	2	612010	8620522	2863267	505875
1995	3	1797666	4488224	533786	128194
1995	4	0	0	0	0
1996	1	299367	233497	816511	286503
1996	2	1083655	776795	2208631	911256
1996	3	1670742	289815	113580	49534
1996	4	0	0	0	0
1997	1	6447	2286585	130593	202822
1997	2	148657	4395265	1078225	277615
1997	3	596223	728240	181187	46667
1997	4	0	0	0	0
1998	1	86124	3567341	1498339	258993
1998	2	5465889	2665032	1451844	326463
1998	3	1615982	1096547	489541	241493
1998	4	0	0	0	0
1999	1	830	15939248	477815	69219
1999	2	90557	2456063	254931	44836
1999	3	1967130	3351942	641059	183015
1999	4	0	0	0	0
2000	1	6101	9822669	1767256	70160
2000	2	81906	801375	384854	49827
2000	3	1093613	2807143	1310052	176418

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 has been moved to S1 in the following year

Year	Season	age 0	age 1	age 2	age 3
2000	4	0	0	0	0
2001	1	13056	5767627	315550	7694
2001	2	550512	3967343	1528712	498496
2001	3	143017	531588	59709	13418
2001	4	0	0	0	0
2002	1	63416	6586442	594557	108679
2002	2	927294	4326530	661656	59022
2002	3	1182692	1199165	296900	65718
2002	4	0	0	0	0
2003	1	197639	4003316	594498	68144
2003	2	2785630	6826281	1115905	218400
2003	3	713229	39824	29774	26427
2003	4	0	0	0	0
2004	1	229309	4217281	731500	78913
2004	2	24806798	4735686	264373	53425
2004	3	5233945	309955	44145	15707
2004	4	0	0	0	0
2005	1	97602	13409729	479222	88858
2005	2	839944	7903545	228337	22051
2005	3	1089274	5408581	230703	38557
2005	4	0	0	0	0
2006	1	0	1987696	1401797	295158
2006	2	319709	493221	1003837	235542
2006	3	176742	129541	176585	10933
2006	4	0	0	0	0
2007	1	0	1693273	189551	67672
2007	2	609939	4186796	1681648	254768

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 has been moved to S1 in the following year

Year	Season	age 0	age 1	age 2	age 3
2007	3	404452	329724	19675	20964
2007	4	0	0	0	0
2008	1	11590	422430	1447939	329770
2008	2	2087187	1901763	1006626	260966
2008	3	893785	131774	41692	21858
2008	4	0	0	0	0
2009	1	0	4776947	219922	39037
2009	2	231412	8163927	554425	137328
2009	3	168362	3385107	519516	88967
2009	4	0	0	0	0
2010	1	12414	1732171	689166	90040
2010	2	349703	3105417	3011291	2157387
2010	3	298472	2412405	683264	90603
2010	4	0	0	0	0
2011	1	2469	1847215	1105017	281708
2011	2	420004	4234059	2917969	999295
2011	3	57320	250247	95834	42266
2011	4	0	0	0	0
2012	1	147896	2527701	729427	121665
2012	2	187098	3756225	1690250	281071
2012	3	78240	463743	86910	30157
2012	4	0	0	0	0
2013	1	10002	1973364	411558	72705
2013	2	462029	2176971	745578	144434
2013	3	193678	1554	2447	4794
2013	4	0	0	0	0
2014	1	2640874	9499013	627237	105519

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that all catches in S4 has been moved to S1 in the following year

Year	Season	age 0	age 1	age 2	age 3
2014	2	1215080	4046244	323320	92685
2014	3	1755944	2496884	177328	21685
2014	4	0	0	0	0
2015	1	1682642	12947813	2926867	161595
2015	2	615375	10862082	1632428	226924
2015	3	374504	1926029	733105	90223
2015	4	0	0	0	0
2016	1	4450616	12775033	4537366	439570
2016	2	3593237	1451842	1251213	301252
2016	3	533954	47715	7358	2718
2016	4	0	0	0	0
2017	1	1767809	9076648	738627	88295
2017	2	1302514	2796713	182538	82806
2017	3	658881	807010	184005	68052
2017	4	0	0	0	0
2018	1	4548741	11562002	2878462	310552
2018	2	2090509	2888456	1516387	534059
2018	3	157673	1090798	254223	15776
2018	4	0	0	0	0
2019	1	4107847	8278419	3109083	196243
2019	2	945227	2315850	992645	154144
2019	3	0	0	0	0
2019	1	0	0	0	0

Table 10.2.3. North Sea & 3.a sprat. Mean weight at age (kg) in catches by season and year. (Model year)

Catch-at-age used as input for the assessment model (years refer to the model years)					
Note that weights in S4 are not used since there is no catches in S4					
Year	**Season**	**age 0**	**age 1**	**age 2**	**age 3**
1974	1	0.0063	0.0083	0.0135	0.0184
1974	2	0.0058	0.0089	0.0150	0.0197
1974	3	0.0050	0.0077	0.0150	0.0197
1974	4	0.0066	0.0107	0.0183	0.0163
1975	1	0.0048	0.0086	0.0129	0.0172
1975	2	0.0075	0.0111	0.0168	0.0216
1975	3	0.0048	0.0106	0.0154	0.0192
1975	4	0.0062	0.0116	0.0170	0.0171
1976	1	0.0049	0.0070	0.0113	0.0134
1976	2	0.0043	0.0090	0.0153	0.0190
1976	3	0.0022	0.0059	0.0104	0.0126
1976	4	0.0034	0.0057	0.0085	0.0106
1977	1	0.0054	0.0082	0.0126	0.0180
1977	2	0.0059	0.0110	0.0146	0.0196
1977	3	0.0023	0.0080	0.0106	0.0138
1977	4	0.0025	0.0063	0.0083	0.0122
1978	1	0.0038	0.0069	0.0122	0.0146
1978	2	0.0044	0.0103	0.0155	0.0196
1978	3	0.0031	0.0089	0.0123	0.0166
1978	4	0.0020	0.0052	0.0087	0.0094
1979	1	0.0050	0.0058	0.0087	0.0113
1979	2	0.0057	0.0105	0.0150	0.0173
1979	3	0.0032	0.0077	0.0129	0.0165
1979	4	0.0029	0.0106	0.0121	0.0153
1980	1	0.0063	0.0052	0.0068	0.0083
1980	2	0.0051	0.0052	0.0069	0.0083
1980	3	0.0032	0.0086	0.0131	0.0168

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that weights in S4 are not used since there is no catches in S4

Year	Season	age 0	age 1	age 2	age 3
1980	4	0.0046	0.0073	0.0105	0.0101
1981	1	0.0038	0.0099	0.0129	0.0156
1981	2	0.0082	0.0126	0.0153	0.0194
1981	3	0.0049	0.0089	0.0157	0.0194
1981	4	0.0060	0.0139	0.0191	0.0192
1982	1	0.0085	0.0089	0.0171	0.0155
1982	2	0.0071	0.0110	0.0160	0.0219
1982	3	0.0029	0.0075	0.0115	0.0174
1982	4	0.0044	0.0078	0.0114	0.0160
1983	1	0.0044	0.0092	0.0128	0.0152
1983	2	0.0042	0.0124	0.0169	0.0211
1983	3	0.0034	0.0094	0.0174	0.0163
1983	4	0.0038	0.0093	0.0127	0.0156
1984	1	0.0060	0.0081	0.0121	0.0166
1984	2	0.0053	0.0122	0.0168	0.0164
1984	3	0.0093	0.0135	0.0197	0.0197
1984	4	0.0093	0.0135	0.0197	0.0197
1985	1	0.0063	0.0093	0.0135	0.0197
1985	2	0.0051	0.0093	0.0135	0.0197
1985	3	0.0073	0.0099	0.0166	0.0166
1985	4	0.0073	0.0099	0.0166	0.0166
1986	1	0.0063	0.0073	0.0099	0.0166
1986	2	0.0051	0.0073	0.0099	0.0166
1986	3	0.0083	0.0164	0.0228	0.0163
1986	4	0.0084	0.0156	0.0208	0.0156
1987	1	0.0066	0.0086	0.0117	0.0153
1987	2	0.0060	0.0093	0.0112	0.0165

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that weights in S4 are not used since there is no catches in S4

Year	Season	age 0	age 1	age 2	age 3
1987	3	0.0064	0.0125	0.0175	0.0206
1987	4	0.0068	0.0125	0.0167	0.0189
1988	1	0.0042	0.0088	0.0115	0.0138
1988	2	0.0046	0.0085	0.0113	0.0137
1988	3	0.0052	0.0132	0.0208	0.0158
1988	4	0.0063	0.0117	0.0155	0.0175
1989	1	0.0054	0.0086	0.0099	0.0170
1989	2	0.0044	0.0082	0.0109	0.0130
1989	3	0.0048	0.0077	0.0125	0.0155
1989	4	0.0046	0.0086	0.0115	0.0129
1990	1	0.0046	0.0070	0.0092	0.0115
1990	2	0.0038	0.0069	0.0092	0.0113
1990	3	0.0044	0.0099	0.0133	0.0156
1990	4	0.0048	0.0089	0.0119	0.0135
1991	1	0.0128	0.0143	0.0154	0.0168
1991	2	0.0048	0.0146	0.0189	0.0168
1991	3	0.0052	0.0101	0.0147	0.0172
1991	4	0.0062	0.0118	0.0152	0.0186
1992	1	0.0081	0.0099	0.0124	0.0148
1992	2	0.0058	0.0121	0.0153	0.0178
1992	3	0.0035	0.0096	0.0141	0.0179
1992	4	0.0042	0.0078	0.0104	0.0118
1993	1	0.0065	0.0109	0.0123	0.0138
1993	2	0.0075	0.0107	0.0135	0.0164
1993	3	0.0022	0.0080	0.0116	0.0152
1993	4	0.0023	0.0128	0.0154	0.0134
1994	1	0.0068	0.0067	0.0095	0.0129

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that weights in S4 are not used since there is no catches in S4

Year	Season	age 0	age 1	age 2	age 3
1994	2	0.0087	0.0104	0.0125	0.0151
1994	3	0.0030	0.0082	0.0097	0.0140
1994	4	0.0038	0.0068	0.0090	0.0131
1995	1	0.0032	0.0082	0.0117	0.0121
1995	2	0.0051	0.0101	0.0133	0.0155
1995	3	0.0084	0.0096	0.0129	0.0158
1995	4	0.0058	0.0107	0.0142	0.0161
1996	1	0.0071	0.0108	0.0142	0.0175
1996	2	0.0079	0.0115	0.0150	0.0169
1996	3	0.0029	0.0062	0.0087	0.0103
1996	4	0.0031	0.0057	0.0077	0.0086
1997	1	0.0071	0.0128	0.0148	0.0163
1997	2	0.0058	0.0120	0.0161	0.0199
1997	3	0.0071	0.0097	0.0122	0.0147
1997	4	0.0052	0.0095	0.0127	0.0144
1998	1	0.0056	0.0139	0.0166	0.0186
1998	2	0.0050	0.0124	0.0153	0.0177
1998	3	0.0043	0.0061	0.0095	0.0094
1998	4	0.0039	0.0073	0.0097	0.0110
1999	1	0.0053	0.0097	0.0115	0.0121
1999	2	0.0046	0.0116	0.0135	0.0164
1999	3	0.0036	0.0094	0.0118	0.0138
1999	4	0.0052	0.0097	0.0129	0.0146
2000	1	0.0067	0.0122	0.0148	0.0185
2000	2	0.0062	0.0149	0.0174	0.0183
2000	3	0.0051	0.0105	0.0131	0.0150
2000	4	0.0036	0.0046	0.0080	0.0135

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that weights in S4 are not used since there is no catches in S4

Year	Season	age 0	age 1	age 2	age 3
2001	1	0.0078	0.0109	0.0118	0.0159
2001	2	0.0048	0.0116	0.0136	0.0166
2001	3	0.0062	0.0127	0.0150	0.0162
2001	4	0.0065	0.0120	0.0161	0.0181
2002	1	0.0073	0.0109	0.0141	0.0154
2002	2	0.0077	0.0122	0.0142	0.0158
2002	3	0.0047	0.0101	0.0133	0.0145
2002	4	0.0060	0.0116	0.0129	0.0155
2003	1	0.0042	0.0125	0.0146	0.0228
2003	2	0.0058	0.0108	0.0145	0.0167
2003	3	0.0049	0.0115	0.0135	0.0141
2003	4	0.0050	0.0092	0.0123	0.0139
2004	1	0.0088	0.0116	0.0139	0.0154
2004	2	0.0041	0.0094	0.0126	0.0153
2004	3	0.0030	0.0097	0.0112	0.0130
2004	4	0.0044	0.0093	0.0115	0.0129
2005	1	0.0076	0.0097	0.0130	0.0154
2005	2	0.0066	0.0103	0.0115	0.0141
2005	3	0.0055	0.0080	0.0114	0.0138
2005	4	0.0047	0.0087	0.0115	0.0130
2006	1	0.0063	0.0108	0.0133	0.0152
2006	2	0.0055	0.0143	0.0158	0.0180
2006	3	0.0041	0.0095	0.0129	0.0134
2006	4	0.0050	0.0093	0.0124	0.0139
2007	1	0.0063	0.0119	0.0131	0.0149
2007	2	0.0065	0.0101	0.0127	0.0151
2007	3	0.0045	0.0075	0.0106	0.0126

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that weights in S4 are not used since there is no catches in S4

Year	Season	age 0	age 1	age 2	age 3
2007	4	0.0048	0.0089	0.0118	0.0133
2008	1	0.0088	0.0103	0.0114	0.0131
2008	2	0.0044	0.0076	0.0126	0.0142
2008	3	0.0034	0.0076	0.0082	0.0085
2008	4	0.0044	0.0068	0.0090	0.0081
2009	1	0.0063	0.0096	0.0123	0.0142
2009	2	0.0046	0.0095	0.0130	0.0160
2009	3	0.0043	0.0077	0.0103	0.0135
2009	4	0.0087	0.0096	0.0105	0.0141
2010	1	0.0066	0.0080	0.0097	0.0137
2010	2	0.0047	0.0094	0.0114	0.0148
2010	3	0.0050	0.0072	0.0094	0.0130
2010	4	0.0038	0.0071	0.0095	0.0107
2011	1	0.0052	0.0085	0.0101	0.0134
2011	2	0.0044	0.0089	0.0114	0.0145
2011	3	0.0042	0.0102	0.0128	0.0171
2011	4	0.0050	0.0092	0.0123	0.0139
2012	1	0.0085	0.0087	0.0106	0.0150
2012	2	0.0072	0.0087	0.0119	0.0152
2012	3	0.0040	0.0069	0.0113	0.0146
2012	4	0.0047	0.0087	0.0117	0.0132
2013	1	0.0061	0.0096	0.0120	0.0150
2013	2	0.0043	0.0097	0.0124	0.0156
2013	3	0.0026	0.0051	0.0071	0.0084
2013	4	0.0022	0.0094	0.0128	0.0153
2014	1	0.0086	0.0086	0.0104	0.0168
2014	2	0.0070	0.0079	0.0116	0.0139

Catch-at-age used as input for the assessment model (years refer to the model years)

Note that weights in S4 are not used since there is no catches in S4

Year	Season	age 0	age 1	age 2	age 3
2014	3	0.0053	0.0083	0.0116	0.0119
2014	4	0.0065	0.0099	0.0101	0.0115
2015	1	0.0076	0.0082	0.0104	0.0150
2015	2	0.0072	0.0088	0.0109	0.0155
2015	3	0.0038	0.0078	0.0107	0.0153
2015	4	0.0044	0.0082	0.0109	0.0123
2016	1	0.0041	0.0077	0.0112	0.0145
2016	2	0.0051	0.0074	0.0118	0.0145
2016	3	0.0073	0.0143	0.0199	0.0235
2016	4	0.0076	0.0141	0.0188	0.0212
2017	1	0.0064	0.0083	0.0103	0.0139
2017	2	0.0038	0.0078	0.0099	0.0162
2017	3	0.0042	0.0064	0.0098	0.0130
2017	4	0.0076	0.0141	0.0188	0.0212
2018	1	0.0046	0.00664	0.0086	0.0126
2018	2	0.0053	0.0074	0.0097	0.0134
2018	3	0.0041	0.0067	0.0095	0.0136
2018	4	0.0057	0.0065	0.00762	0.0129
2019	1	0.0051	0.0063	0.0087	0.0120
2019	2	0.0053	0.0076	0.0096	0.0141
2019	3	0.0057	0.0100	0.0144	0.0165
2019	4	0.0065	0.0103	0.0134	0.0161

Table 10.2.4. North Sea and Division 3.a sprat. Sampling for biological parameters in 2019. This table only shows age-length samples, and therefore the number of samples may differ from Table 10.2.5.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	9.76	15	1 557	695
	2	3.94	4	403	190
	3	81.50	65	6 790	2 796
	4	27.87	32	3 336	1 315
	Total	123.08	116	12086	4996
Norway	1	0.57			
	2	0.00			
	3	6.78			
	4	3.23	4	298	182
	Total	9.78	4	298	182
Sweden	1	0.11	5	471	470
	2	0.05			
	3	7.07			
	4	1.95	9	576	569
	Total	9.18	14	1047	1039
All countries	1	10.61	20	2028	1165
	2	4.00	4	403	190
	3	98.09	65	6790	2796
	4	35.10	45	4210	2066
Total		147.79	134	13 431	6 217

Table 10.2.5. North Sea and Division 3.a sprat. Number of biological samples taken from 1991 and onward. The number of samples may differ from Table 8.2.4, since this table shows both length and age-length samples. These are the samples used to generate the catch-at-age matrix for the assessment model (Model year).

Year	S1	S2	S3	S4
1974	15	31	102	25
1975	67	46	40	11
1976	54	70	53	16
1977	37	51	32	18
1978	52	78	47	22
1979	86	55	90	9
1980	0	0	49	28
1981	61	32	29	14
1982	27	48	13	16
1983	11	44	27	8
1984	9	23	29	7

Year	S1	S2	S3	S4
1985	4	4	0	4
1986	4	1	0	1
1987	16	15	4	3
1988	8	4	9	1
1989	13	0	7	2
1990	4	0	13	1
1991	6	56	15	8
1992	42	35	24	4
1993	21	30	24	7
1994	42	50	32	5
1995	40	47	41	4
1996	2	12	8	3
1997	9	34	12	1
1998	25	38	16	3
1999	41	25	25	1
2000	29	23	22	14
2001	23	9	17	4
2002	26	37	28	7
2003	12	60	17	2
2004	26	43	24	15
2005	77	56	56	2
2006	23	7	13	0
2007	34	40	13	4
2008	10	9	14	5
2009	33	36	18	5
2010	35	28	15	3
2011	28	57	20	3
2012	37	88	15	3
2013	31	23	2	10

Year	S1	S2	S3	S4
2014	116	19	19	13
2015	165	47	21	2
2016	90	30	3	0
2017	69	21	11	6
2018	65	60	20	5
2019	65	45	0	0

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q1

IBTS Q1 survey index (sa 4 and 3a combined; years and ages apply to the model year)				
Index is calculated using a delta GAM model formulation (see Stock Annex)				
Year	**Age 0**	**Age 1**	**Age 2**	**Age 3**
1982	252619	551262	574173	47111
1983	619180	553686	100186	25687
1984	374594	292408	75083	19254
1985	116338	137304	39250	9993
1986	503284	86061	25143	9769
1987	248663	789924	77117	15148
1988	744970	154929	114877	11326
1989	360108	185946	47580	21180
1990	1412224	176334	33438	7582
1991	1882139	281520	36961	9645
1992	1863182	1224852	103248	10709
1993	1195289	887347	132008	8288
1994	2258852	2257140	263386	10391
1995	604673	967027	199658	28253
1996	599335	270098	168138	27513
1997	1072937	1104108	180777	16056
1998	5183400	583736	73757	5308
1999	2017439	1164352	150449	25036

IBTS Q1 survey index (sa 4 and 3a combined; years and ages apply to the model year)				
Index is calculated using a delta GAM model formulation (see Stock Annex)				
Year	**Age 0**	**Age 1**	**Age 2**	**Age 3**
2000	1997862	1309083	239142	13995
2001	1191954	968965	87712	10393
2002	2493114	589410	66441	5540
2003	4084377	685280	106637	9076
2004	8918279	675529	29062	2718
2005	1230441	1416990	58676	7654
2006	1917763	1035569	162880	12506
2007	1526985	803061	47400	8526
2008	4133598	312030	34043	3833
2009	3288300	2489705	118665	17586
2010	1078333	926246	206207	47562
2011	3356603	3143308	245116	36666
2012	1137772	1116849	203191	29306
2013	3886605	443621	50655	9871
2014	7727188	3460669	317090	26651
2015	2112309	3409890	675849	37763
2016	10317128	1707447	128002	15146
2017	10440866	1547476	94598	11384
2018	6097175	2511994	226057	9585
2019	7316245	2219294	421523	40023

Table 10.3.1. North Sea sprat. Abundance indices by age from IBTS Q3

IBTS Q3 survey index (sa 4 and 3a combined; years and ages apply to the model year and calendar year)			
Index is calculated using a delta GAM model formulation (see Stock Annex)			
Year	**Age 1**	**Age 2**	**Age 3**
1992	14555861	2633020	104865
1993	5767651	3015219	217792
1994	16468664	1326478	95089
1995	30622687	7433288	454582
1996	2317117	2219591	215543
1997	13080865	1171944	200385
1998	2676263	1107920	117795
1999	13792780	1719505	82599
2000	8212868	3228536	133847
2001	8998081	2277278	187452
2002	10011480	1319291	102476
2003	11610320	1272970	66231
2004	14371331	1945227	122791
2005	52835449	2266372	102272
2006	9340785	5459057	155440
2007	10549586	1552282	184767
2008	7894186	2085499	130785
2009	35252950	3032568	337850
2010	35355908	9422666	428224
2011	16742275	8341042	1191533
2012	11469646	5231406	575643
2013	9052264	3060010	414534
2014	63182232	3573736	215965
2015	59775893	18619852	653613
2016	27891385	4266699	482295
2017	27754797	2886164	173266
2018	18709889	3123833	200733

IBTS Q3 survey index (sa 4 and 3a combined; years and ages apply to the model year and calendar year)			
Index is calculated using a delta GAM model formulation (see Stock Annex)			
Year	**Age 1**	**Age 2**	**Age 3**
2019	40210818	8468920	521293

Table 10.3.2. North Sea and Division 3.a sprat. HERAS survey index.

HERAS abundance index (sa 4 and 3.a summed), data are from WGIPS (2019)			
Years and ages apply to the model year and calendar year			
Year	**Age 1**	**Age 2**	**Age 3**
2006	21923	21368	1413
2007	42862	5837	2252
2008	17188	7868	840
2009	47690	16920	2815
2010	20328	14087	1174
2011	26581	14207	3412
2012	22036	12831	4693
2013	9347	6342	2049
2014	59020	20274	3982
2015	27082	22676	10142
2016	58604	33989	8160
2017	38135	3664	1465
2018	109180	10113	779
2019	93775	28020	5275

Table 10.6.1. North Sea and Division 3.a sprat. Natural mortality input (Model year). From multispecies SMS (WKSAM: ICES, 2017) 2017 key run.

Year	Season	age 0	age 1	age 2	age 3
1974	1	0.483	0.456	0.402	0.280
1974	2	0.327	0.235	0.217	0.188
1974	3	0.297	0.275	0.175	0.175

Year	Season	age 0	age 1	age 2	age 3
1974	4	0.445	0.409	0.318	0.318
1975	1	0.518	0.492	0.422	0.237
1975	2	0.289	0.220	0.200	0.169
1975	3	0.329	0.299	0.218	0.218
1975	4	0.474	0.442	0.423	0.423
1976	1	0.490	0.466	0.415	0.290
1976	2	0.318	0.242	0.225	0.195
1976	3	0.364	0.332	0.240	0.240
1976	4	0.485	0.443	0.421	0.421
1977	1	0.441	0.411	0.368	0.312
1977	2	0.373	0.245	0.227	0.199
1977	3	0.380	0.351	0.248	0.248
1977	4	0.490	0.440	0.432	0.432
1978	1	0.411	0.398	0.385	0.330
1978	2	0.347	0.230	0.218	0.192
1978	3	0.382	0.356	0.208	0.208
1978	4	0.445	0.396	0.374	0.374
1979	1	0.436	0.424	0.419	0.405
1979	2	0.416	0.252	0.245	0.227
1979	3	0.393	0.366	0.232	0.232
1979	4	0.444	0.389	0.377	0.377
1980	1	0.470	0.464	0.444	0.415
1980	2	0.447	0.261	0.257	0.230
1980	3	0.388	0.355	0.232	0.232
1980	4	0.419	0.372	0.336	0.336
1981	1	0.501	0.486	0.448	0.360
1981	2	0.409	0.271	0.267	0.232
1981	3	0.361	0.314	0.222	0.222
1981	4	0.376	0.330	0.267	0.267

Year	Season	age 0	age 1	age 2	age 3
1982	1	0.511	0.431	0.377	0.245
1982	2	0.331	0.231	0.217	0.177
1982	3	0.305	0.231	0.182	0.182
1982	4	0.318	0.277	0.205	0.205
1983	1	0.532	0.429	0.349	0.224
1983	2	0.336	0.235	0.217	0.194
1983	3	0.296	0.207	0.173	0.173
1983	4	0.312	0.259	0.168	0.168
1984	1	0.539	0.425	0.287	0.182
1984	2	0.397	0.236	0.209	0.189
1984	3	0.309	0.239	0.177	0.177
1984	4	0.321	0.274	0.197	0.197
1985	1	0.549	0.502	0.373	0.198
1985	2	0.482	0.277	0.251	0.210
1985	3	0.323	0.249	0.178	0.178
1985	4	0.318	0.269	0.165	0.165
1986	1	0.590	0.534	0.422	0.254
1986	2	0.452	0.313	0.288	0.227
1986	3	0.346	0.258	0.188	0.188
1986	4	0.335	0.284	0.169	0.169
1987	1	0.596	0.484	0.443	0.256
1987	2	0.470	0.315	0.299	0.232
1987	3	0.356	0.217	0.190	0.190
1987	4	0.338	0.281	0.185	0.185
1988	1	0.622	0.502	0.455	0.258
1988	2	0.493	0.342	0.316	0.270
1988	3	0.371	0.238	0.220	0.220
1988	4	0.361	0.301	0.233	0.233
1989	1	0.603	0.509	0.433	0.214

Year	Season	age 0	age 1	age 2	age 3
1989	2	0.525	0.332	0.294	0.261
1989	3	0.356	0.228	0.221	0.221
1989	4	0.374	0.312	0.281	0.281
1990	1	0.518	0.489	0.402	0.244
1990	2	0.496	0.331	0.283	0.261
1990	3	0.337	0.260	0.249	0.249
1990	4	0.387	0.319	0.287	0.287
1991	1	0.462	0.423	0.320	0.263
1991	2	0.396	0.269	0.232	0.211
1991	3	0.310	0.264	0.223	0.223
1991	4	0.389	0.320	0.287	0.287
1992	1	0.410	0.360	0.281	0.255
1992	2	0.312	0.227	0.204	0.180
1992	3	0.294	0.275	0.212	0.212
1992	4	0.371	0.299	0.270	0.270
1993	1	0.456	0.414	0.340	0.303
1993	2	0.238	0.209	0.190	0.173
1993	3	0.272	0.253	0.192	0.192
1993	4	0.347	0.274	0.244	0.244
1994	1	0.502	0.446	0.348	0.337
1994	2	0.292	0.223	0.197	0.182
1994	3	0.258	0.219	0.190	0.190
1994	4	0.318	0.248	0.223	0.223
1995	1	0.512	0.460	0.338	0.308
1995	2	0.290	0.223	0.195	0.182
1995	3	0.222	0.191	0.178	0.178
1995	4	0.265	0.211	0.190	0.190
1996	1	0.504	0.395	0.263	0.214
1996	2	0.363	0.227	0.202	0.177

Year	Season	age 0	age 1	age 2	age 3
1996	3	0.215	0.171	0.151	0.151
1996	4	0.238	0.195	0.156	0.156
1997	1	0.451	0.293	0.210	0.155
1997	2	0.298	0.204	0.187	0.154
1997	3	0.227	0.193	0.171	0.171
1997	4	0.269	0.214	0.171	0.171
1998	1	0.430	0.283	0.226	0.190
1998	2	0.362	0.197	0.176	0.145
1998	3	0.252	0.209	0.173	0.173
1998	4	0.318	0.245	0.197	0.197
1999	1	0.421	0.287	0.232	0.214
1999	2	0.291	0.191	0.169	0.152
1999	3	0.275	0.241	0.191	0.191
1999	4	0.335	0.267	0.242	0.242
2000	1	0.406	0.342	0.253	0.219
2000	2	0.355	0.199	0.180	0.170
2000	3	0.254	0.213	0.157	0.157
2000	4	0.279	0.236	0.192	0.192
2001	1	0.409	0.328	0.233	0.190
2001	2	0.299	0.213	0.202	0.195
2001	3	0.266	0.225	0.191	0.191
2001	4	0.306	0.258	0.213	0.213
2002	1	0.434	0.321	0.240	0.171
2002	2	0.315	0.223	0.214	0.206
2002	3	0.252	0.206	0.194	0.194
2002	4	0.323	0.262	0.218	0.218
2003	1	0.419	0.269	0.215	0.168
2003	2	0.295	0.229	0.208	0.204
2003	3	0.259	0.229	0.226	0.226

Year	Season	age 0	age 1	age 2	age 3
2003	4	0.383	0.308	0.286	0.286
2004	1	0.436	0.276	0.231	0.192
2004	2	0.278	0.216	0.193	0.185
2004	3	0.231	0.212	0.208	0.208
2004	4	0.376	0.302	0.278	0.278
2005	1	0.442	0.321	0.227	0.216
2005	2	0.309	0.219	0.181	0.174
2005	3	0.220	0.201	0.179	0.179
2005	4	0.367	0.291	0.225	0.225
2006	1	0.504	0.315	0.226	0.215
2006	2	0.265	0.212	0.172	0.166
2006	3	0.217	0.197	0.172	0.172
2006	4	0.364	0.277	0.202	0.202
2007	1	0.480	0.312	0.204	0.184
2007	2	0.287	0.222	0.170	0.166
2007	3	0.210	0.175	0.152	0.152
2007	4	0.312	0.237	0.175	0.175
2008	1	0.478	0.307	0.187	0.166
2008	2	0.269	0.203	0.157	0.151
2008	3	0.200	0.173	0.167	0.167
2008	4	0.304	0.225	0.197	0.197
2009	1	0.444	0.362	0.233	0.162
2009	2	0.327	0.200	0.158	0.150
2009	3	0.190	0.170	0.163	0.163
2009	4	0.293	0.215	0.190	0.190
2010	1	0.527	0.412	0.312	0.170
2010	2	0.395	0.217	0.179	0.164
2010	3	0.207	0.182	0.159	0.159
2010	4	0.309	0.226	0.197	0.197

Year	Season	age 0	age 1	age 2	age 3
2011	1	0.511	0.437	0.386	0.182
2011	2	0.381	0.239	0.193	0.179
2011	3	0.229	0.202	0.179	0.179
2011	4	0.338	0.254	0.224	0.224
2012	1	0.509	0.432	0.344	0.176
2012	2	0.368	0.238	0.191	0.178
2012	3	0.219	0.176	0.145	0.145
2012	4	0.292	0.225	0.180	0.180
2013	1	0.399	0.367	0.285	0.150
2013	2	0.271	0.209	0.164	0.158
2013	3	0.206	0.175	0.148	0.148
2013	4	0.270	0.221	0.178	0.178
2014	1	0.367	0.335	0.245	0.140
2014	2	0.257	0.198	0.167	0.154
2014	3	0.211	0.181	0.153	0.153
2014	4	0.272	0.227	0.184	0.184
2015	1	0.365	0.339	0.249	0.139
2015	2	0.237	0.194	0.164	0.149
2015	3	0.212	0.177	0.149	0.149
2015	4	0.278	0.224	0.181	0.181
2016	1	0.377	0.347	0.260	0.143
2016	2	0.255	0.200	0.165	0.153
2016	3	0.212	0.177	0.149	0.149
2016	4	0.278	0.224	0.181	0.181
2017	1	0.377	0.347	0.260	0.143
2017	2	0.255	0.200	0.165	0.153
2017	3	0.212	0.177	0.149	0.149
2017	4	0.278	0.224	0.181	0.181
2018	1	0.377	0.347	0.260	0.143

Year	Season	age 0	age 1	age 2	age 3
2018	2	0.255	0.200	0.165	0.153
2018	3	0.212	0.177	0.149	0.149
2018	4	0.278	0.224	0.181	0.181
2019	1	0.377	0.347	0.260	0.143
2019	2	0.255	0.200	0.165	0.153
2019	3	0.212	0.177	0.149	0.149
2019	4	0.278	0.224	0.181	0.181

Table 10.6.2. North Sea sprat. Assessment diagnostics.

Date: 03/17/20 Start time:10:24:13 run time:0 seconds

objective function (negative log likelihood): 262.46

Number of parameters: 139

Maximum gradient: 0.0235217

Akaike information criterion (AIC): 802.921

Number of observations used in the likelihood:

Catch	CPUE	S/R	Stomach	Sum
736	278	46	0	1060

objective function weight:

Catch	CPUE	S/R
1.00	1.00	0.10

unweighted objective function contributions (total):

Catch	CPUE	S/R	Stom.	Stom N.	Penalty	Sum
369.2	-107.9	11.8	0.0	0.0	0.00	273

unweighted objective function contributions (per observation):

Catch	CPUE	S/R	Stomachs
0.50	-0.39	0.26	0.00

contribution by fleet:

IBTS Q1 total: -53.794 mean: -0.354

IBTS Q3 total: -43.182 mean: -0.514

Acoustic total: -10.951 mean: -0.261

F, season effect:

---

age: 0

1974-2019: 0.036 0.213 0.401 0.250

age: 1

1974-2019: 0.523 0.533 0.221 0.250

age: 2

1974-2019: 0.248 0.487 0.136 0.250

age: 3

1974-2019: 0.217 0.492 0.320 0.250

F, age effect:

	0	1	2	3
1974-2019:	0.038	0.418	1.479	1.479

Exploitation pattern (scaled to mean F=1)

		0	1	2	3
1974-2019	season 1:	0.001	0.190	0.320	0.280
	season 2:	0.007	0.194	0.627	0.634
	season 3:	0.013	0.080	0.176	0.413
	season 4:	0.008	0.091	0.322	0.322

sqrt(catch variance) ~ CV:

---

	season			
age	1	2	3	4
0	1.414	1.414	1.140	0.100
1	0.851	0.704	1.414	0.100
2	1.027	1.062	1.414	0.100
3	1.027	1.062	1.414	0.100

Survey catchability:

---

	age 0	age 1	age 2	age 3
IBTS Q1	0.000	1.477	2.808	4.390
IBTS Q3	0.788	1.011	0.941	
Acoustic	1.097	2.374	6.268	

Stock size dependent catchability (power model)

----------	age 0	age 1	age 2	age 3
IBTS Q1	1.57	1.00	1.00	1.00
IBTS Q3	1.00	1.00	1.00	
Acoustic	1.00	1.00	1.00	

sqrt(Survey variance) ~ CV:

---

	age 0	age 1	age 2	age 3
IBTS Q1	0.46	0.41	0.41	0.41
IBTS Q3	0.46	0.32	0.32	
Acoustic	0.45	0.47	0.47	

Recruit-SSB		alfa	beta	recruit s2	recruit s
Sprat	Hockey stick -break.:	1398.274	9.000e+004	0.615	0.784

Table 10.6.3. North Sea and Division 3.a Sprat. Assessment output: Stock numbers (thousands) (years, seasons, and age refer to the model year)
Table 1 Sprat : Stock numbers (thousands)

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
1974	531294000	327375000	234228000	171491000	137815000	70157300	44368400	30735600	10751800	4981450	1949210	1337180	485763	266256	106519	55662
1975	708503000	420914000	310678000	217664000	108873000	45286100	24551900	15479900	18389800	6315140	1454130	819530	700274	313832	73535	25672
1976	329513000	201433000	144462000	97671400	135557000	57280300	30084700	18259000	9953490	3384450	735216	401498	553735	231750	51185	17097
1977	629835000	404571000	275123000	183776000	60113100	28230300	15554200	9460970	11723700	4542310	1159990	658025	274826	121080	31438	11607
1978	1030770000	682344000	478123000	321279000	112636000	60230300	37920800	24110200	6095220	2827400	1071470	705327	434786	223541	86289	42765
1979	533480000	344586000	226051000	150975000	205930000	116064000	77472800	50437000	16220000	8301940	3970410	2743890	514618	275645	133608	76667
1980	328643000	204749000	128429000	84091800	96809100	36348900	16549600	9330450	34170900	9215640	1301230	640591	1934750	598072	85260	22087
1981	93374300	56509100	37182200	25481900	55308500	26511100	15676300	10308800	6430720	2702210	908526	577744	473380	228709	78994	36819
1982	48913000	29314800	20873500	15141600	17489200	9039330	5686460	4096850	7409220	3459550	1310670	884621	470590	263068	102839	52216
1983	65947200	38631000	27211700	19705600	11017300	4886550	2611870	1806060	3106050	1149420	260735	153825	762913	346574	79438	29057
1984	33146600	19317200	12888300	9320330	14420500	7563950	4777650	3429950	1393340	722731	284155	194252	154549	93221	37105	19296
1985	23122800	13325800	8136680	5770670	6758380	3023060	1683300	1154810	2607350	1079060	309245	195763	175316	92110	27226	11822
1986	78564100	43491900	27416400	19066700	4197470	1918250	1087920	756170	882128	380578	125433	82578	176004	94573	32832	15847
1987	40500500	22305300	13892500	9671750	13636800	7728740	5176620	4023160	568976	317318	178434	136557	83096	56843	34098	23509
1988	60276600	32317100	19527600	13194900	6898670	3101930	1627770	1130920	3037550	1168840	319693	194939	133079	66352	18801	7917
1989	53727800	29371100	17322600	12072600	9193330	5138900	3424420	2643000	836627	480241	281924	211339	160760	116661	70605	48365

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
1990	73002800	43403000	26100200	18185700	8304260	3581420	1797770	1194480	1934970	716285	169126	95266	196010	91488	21832	7936
1991	111661000	70263300	47023200	34086300	12350300	6863310	4434730	3178110	868593	478478	220740	151681	77471	46766	21904	12267
1992	103357000	68505900	49789400	36620300	23104000	13306100	8724870	6110600	2307520	1261940	547221	370808	123024	71924	31722	16933
1993	148792000	94136000	73159200	54304100	25277100	11504100	6383790	4233160	4531220	1721880	416051	243227	295922	126171	30594	11238
1994	127237000	76908900	57071700	43615500	38364600	20863300	14139900	10599400	3217460	1728510	830683	591070	199383	112116	54401	31616
1995	35891200	21462400	15853100	12398100	31742500	14197800	7992550	5708420	8273280	3303270	871324	530341	498270	220562	58306	23101
1996	60221400	36302300	24952700	19690000	9515340	4658520	2682320	1974960	4622780	2078870	593662	380250	457836	231220	66982	28846
1997	48601800	30909300	22758200	17840200	15520600	9162550	5886920	4396670	1625350	888886	340820	231492	349961	212458	83571	42424
1998	109096000	70824400	48613200	36783500	13631600	6927010	3806310	2614930	3548620	1458660	333258	194831	230859	106852	24849	8893
1999	77300400	50654100	37593600	28163500	26768400	16334400	10937100	7878280	2046170	1145930	489438	334085	167342	99665	42998	22694
2000	72790600	48398000	33506800	25393700	20154200	10183900	5898150	4126490	6031410	2640230	716483	447029	279994	136279	36949	15081
2001	60700900	40243800	29448500	22007900	19218800	9676880	5428860	3724340	3260110	1414580	354901	210587	381355	186182	46479	17660
2002	81359700	52565900	37814400	28636800	16201400	8048250	4383170	3039950	2876160	1198310	278230	161590	184422	89162	20607	7476
2003	105903000	69503200	51207400	38740800	20739300	11863200	7028010	4945220	2340160	1160020	362679	221549	135977	75062	23343	9946
2004	186658000	120328000	89653700	69014300	26424500	12880700	6612400	4437650	3633790	1371880	263188	142136	173924	74881	14261	4441
2005	65683000	42154200	30596700	24030300	47396500	25356100	14935400	10741100	3279790	1565930	478239	301663	110961	57095	17383	7503
2006	83504400	50329000	38076200	29835300	16652000	8248740	4496940	3135050	8026590	3338360	782339	460229	246876	112597	26204	9513
2007	60069200	37081200	27435400	21665600	20726300	10436000	5712590	4095750	2376020	1033610	254231	154622	383698	184175	44903	17150

Year/Age Quarter	A00S1	A00S2	A00S3	A00S4	A01S1	A01S2	A01S3	A01S4	A02S1	A02S2	A02S3	A02S4	A03S1	A03S2	A03S3	A03S4
2008	137938000	85372300	64500200	51653000	15853300	8520120	5048010	3717710	3230000	1579400	479137	303458	144192	76914	23221	9947
2009	113163000	72487700	51878300	42284500	38113400	21665700	14425400	11174200	2967330	1671720	731897	515439	257391	162397	71142	38928
2010	118962000	70117500	46816900	37462800	31559800	16531200	10481900	7913440	9009610	4449590	1718750	1180760	458580	274042	106631	54738
2011	90353100	54147300	36709200	28780100	27505500	14374800	9125390	6816860	6310230	3005170	1231510	846470	1014800	619512	255609	134956
2012	72394900	43421100	29686400	23322100	20524800	9651160	5472730	4005030	5289840	2179640	621048	398610	784220	408922	116718	50121
2013	168991000	113180000	85403800	68114500	17420000	9072300	5507820	4098630	3197720	1488710	493591	327047	374955	212256	70121	32579
2014	187417000	129736000	99793600	80017600	51999100	32481400	23202800	18286200	3286430	2048400	1108940	839358	300901	214345	117060	74852
2015	99598400	68996000	53786500	42534600	60965700	31410600	18610700	13594900	14571400	6592320	1924580	1229680	760797	411009	120418	51420
2016	135526000	92650300	70397800	54887800	32214800	13419500	6412440	4296180	10862800	3447360	512085	270860	1069500	426120	62880	17230
2017	185758000	127143000	97297800	76884400	41570800	21015400	12230500	8892390	3432790	1508040	423970	268125	240506	127379	35810	14927
2018	170291000	116583000	89341100	70781400	58230500	30568500	18486500	13656700	7105320	3325480	1058620	693191	236299	132285	42163	19072
2019	199213000	136390000	104546000	84549400	53608300	28337600	17258800	14456000	10912200	5166970	1682820	1449880	594615	336287	109685	94503
2020	0				64035800				11550800				1289290			

Table 10.6.4. North Sea & 3.a Sprat. Assessment output: Estimated recruitment, spawning-stock biomass (SSB), average fishing mortality (F), and landings weight (Yield). All estimates refers to the model year.

Year	Recruits (in 1000s)	SSB (tonnes)	F (ages 1–2)	Yield (tonnes)
1974	531386	605010	1.149	463344
1975	708740	602595	1.605	732312
1976	329471	494350	1.647	628598
1977	629855	336381	1.439	385257
1978	1031211	387317	0.951	458804
1979	533516	618468	0.623	463638
1980	328484	424641	2.152	387434
1981	93362	302247	1.041	280582
1982	48935	180773	0.954	162357
1983	65923	87029	1.602	115440
1984	33132	64861	0.917	113444
1985	23115	59755	1.263	62514
1986	78531	22834	1.04	27520
1987	40508	55105	0.35	53942
1988	60249	57125	1.241	103652
1989	53704	42235	0.302	58420
1990	73002	41274	1.468	78180
1991	111663	85221	0.685	125815
1992	103388	120331	0.8	156471
1993	148783	165215	1.557	208848
1994	127293	134054	0.678	424206
1995	35891	196418	1.439	446555
1996	60249	107152	1.33	95496
1997	48593	107581	0.976	125174
1998	109125	133252	1.645	188907
1999	77284	129056	0.862	243158
2000	72784	183506	1.422	222027
2001	60672	124742	1.494	153321

Year	Recruits (in 1000s)	SSB (tonnes)	F (ages 1–2)	Yield (tonnes)
2002	81328	110084	1.577	174713
2003	105899	138413	1.207	174988
2004	186697	171785	1.845	231352
2005	65660	226613	1.272	280275
2006	83470	170587	1.618	78028
2007	60069	133252	1.559	99902
2008	137895	100912	1.311	69892
2009	113125	184795	0.846	170934
2010	118925	185165	0.976	145415
2011	90332	164226	0.884	122472
2012	72421	132853	1.347	96030
2013	168931	107152	1.19	60207
2014	187446	216858	0.565	190268
2015	99633	346972	1.351	298227
2016	135570	222571	2.204	227169
2017	185766	175080	1.397	135824
2018	170288	213630	1.24	190779
2019	199236	226613	1.015	136523
2020		265933		

Table 10.9.1. North Sea and Division 3.a Sprat. Input to forecast (years and age refer to the model year).

Age	Age 0	Age 1	Age 2	Age 3
Stock numbers(2020) (millions)	128111	64036	11551	1289
Exploitation pattern Q1	0.002	0.292	0.49	0.429
Exploitation pattern Q2	0.011	0.297	0.962	0.972
Exploitation pattern Q3	0.02	0.121	0.264	0.619
Exploitation pattern Q4	0	0.002	0.008	0.008
Weight in the stock Q1 (gram)	5.351	7.055	9.186	12.825
Weight in the catch Q1 (gram)	5.35	7.05	9.19	12.82
Weight in the catch Q2 (gram)	4.82	7.6	9.73	14.55
Weight in the catch Q3 (gram)	4.7	7.69	11.21	14.39
Weight in the catch Q4 (gram)	6.6	10.3	13.26	16.71
Proportion mature(2019)	0	0.41	0.87	0.95
Proportion mature(2020)	0	0.41	0.87	0.95
Natural mortality Q1	0.38	0.35	0.26	0.14
Natural mortality Q2	0.26	0.2	0.16	0.15
Natural mortality Q3	0.21	0.18	0.15	0.15
Natural mortality Q4	0.28	0.22	0.18	0.18

Table 10.9.2. Sprat North Sea Division 3.a. Short-term predictions options table. Years refer to the model year.

Catch options. Landings and SSB are in thousands of tonnes.					
3-year average weight-at-age was used to calculate SSB. Recruitment(2020) = geom average 2009–2018.					
Basis	F(2020)	Landings(2020)	SSB(2021)	%SSB change	%TAC change
F_{cap}	0.69	207.8065	262.7235	-1.21	50.58
$F_{(status\ quo)}$	1.015	269.7096	226.8775	-14.69	95.44
F=0	0	0.001	393.3348	47.91	-100
F=0.1	0.1	39.33497	367.6805	38.26	-71.5
F=0.2	0.2	74.87602	344.8219	29.66	-45.74
F=0.3	0.3	107.0927	324.3962	21.98	-22.4
F=0.4	0.4	136.387	306.0933	15.1	-1.17
F=0.5	0.5	163.1051	289.6472	8.92	18.19
F=0.6	0.6	187.5449	274.8297	3.35	35.9
F=0.7	0.7	209.9641	261.4445	-1.69	52.14
F=0.8	0.8	230.5859	249.3222	-6.25	67.09
F=0.9	0.9	249.6039	238.3167	-10.38	80.87
F=1.0	1	267.1866	228.3014	-14.15	93.61
$B_{escapement}$ without F_{cap}	3.492	480.0401	124.9997	-53	247.85

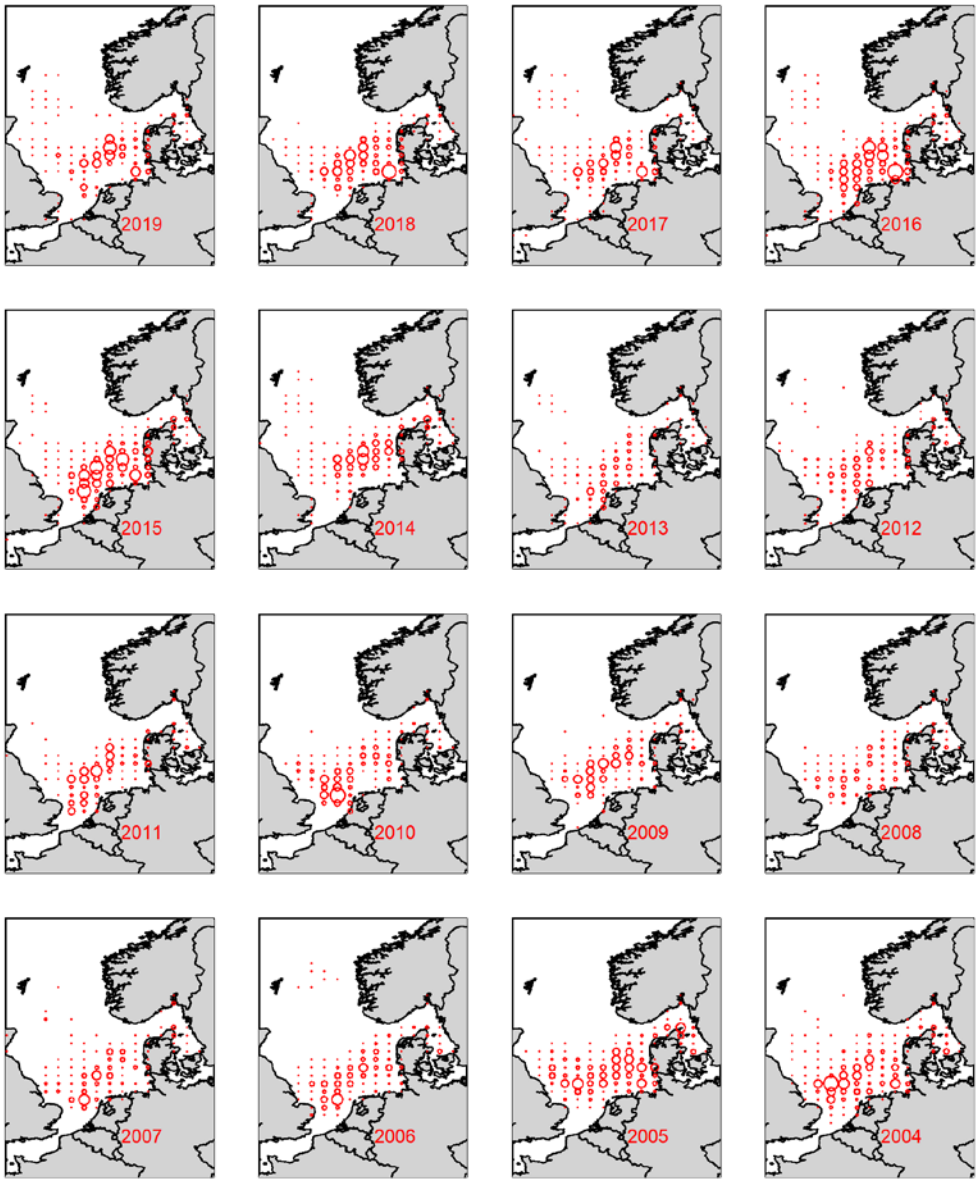


Figure 10.1.1. North Sea and Division 3.a sprat. Sprat catches in the North Sea and Division 3.a (in tonnes) for each calendar year by statistical rectangle.

Figure 10.2.1. North Sea and Division 3.a sprat. Number of samples taken in the North Sea and Division 3.a for each calendar year by statistical rectangle.

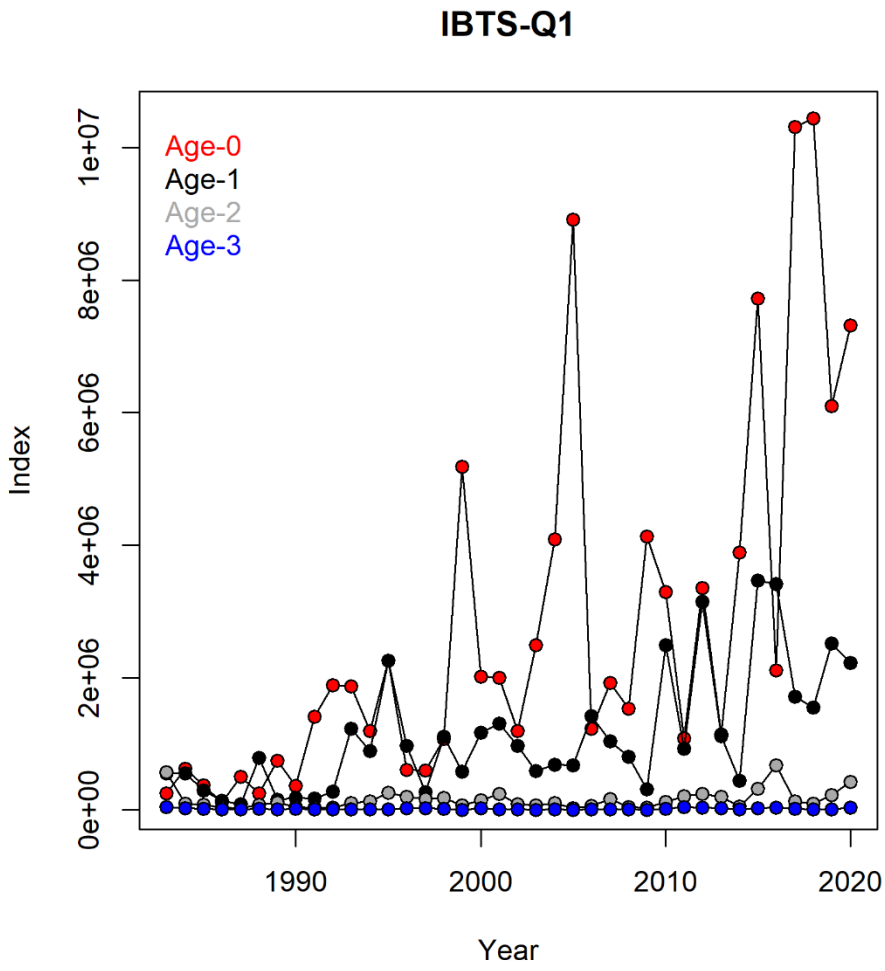


Figure 10.3.1. North Sea and Division 3.a sprat. IBTS Q1 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

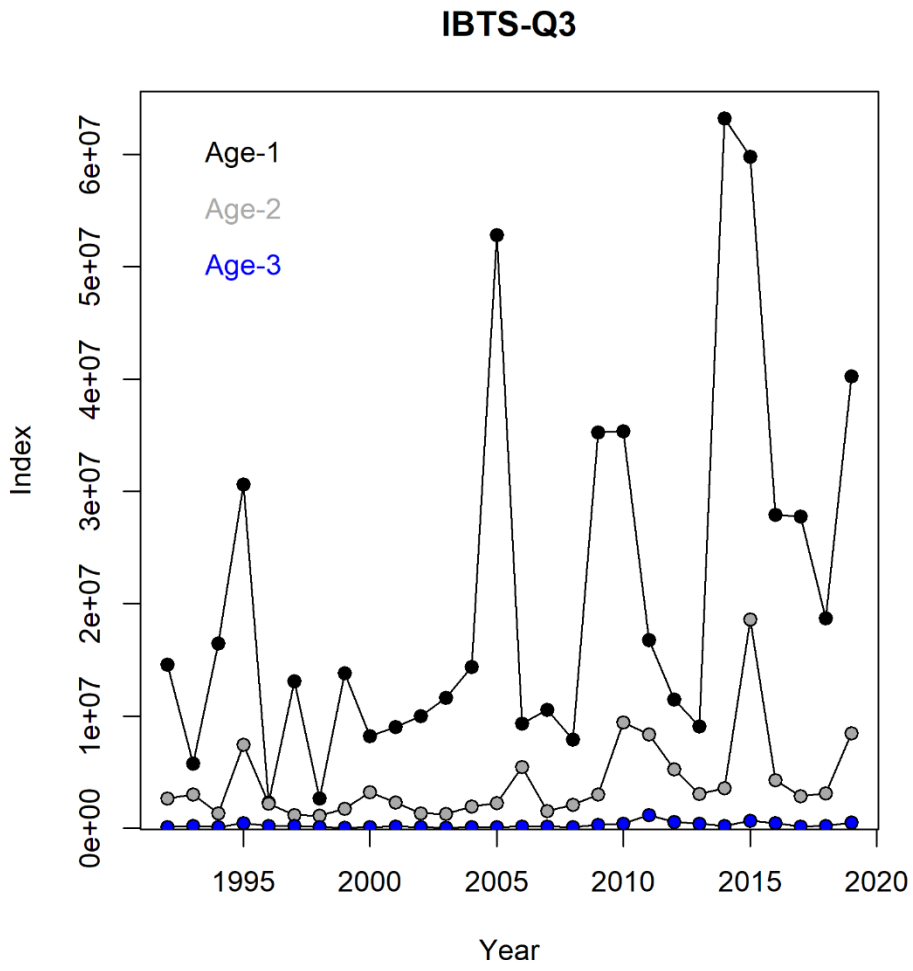


Figure 10.3.2a. North Sea and Division 3.a sprat. IBTS Q3 survey index for Subarea 4 and Division 3.a combined. The index is calculated using a delta-GAM model formulation (see WKSPRAT report (ICES, 2018) for details). Years refer to the calendar year.

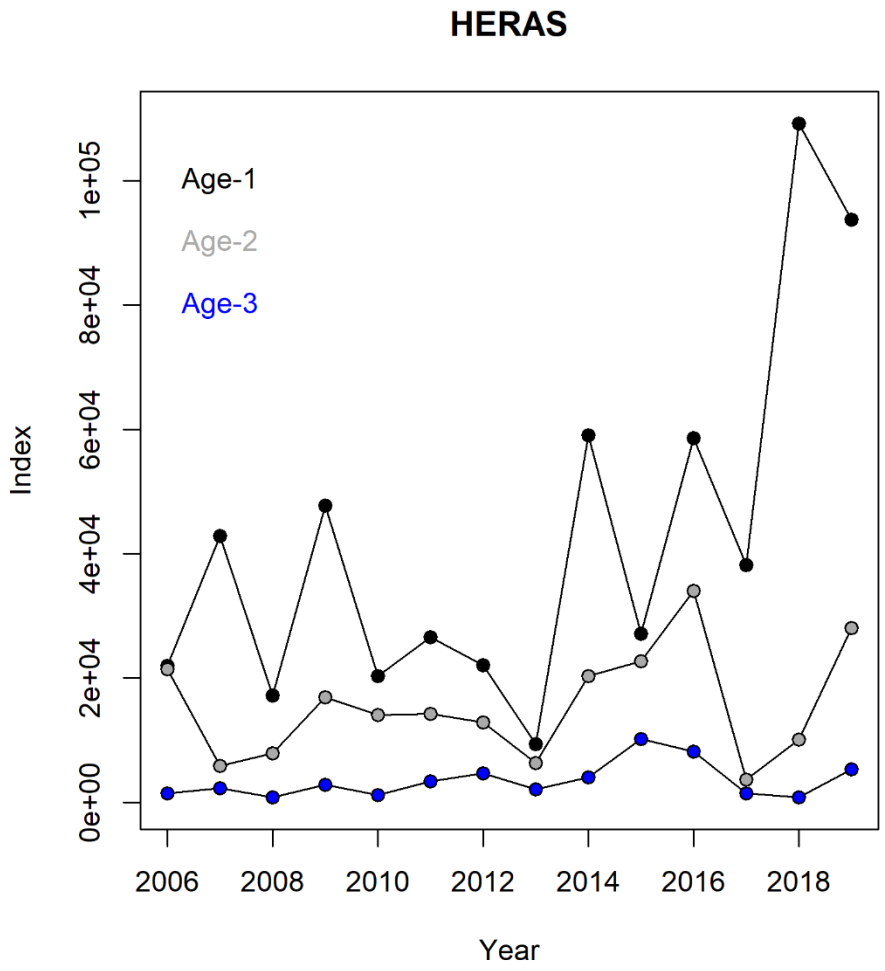
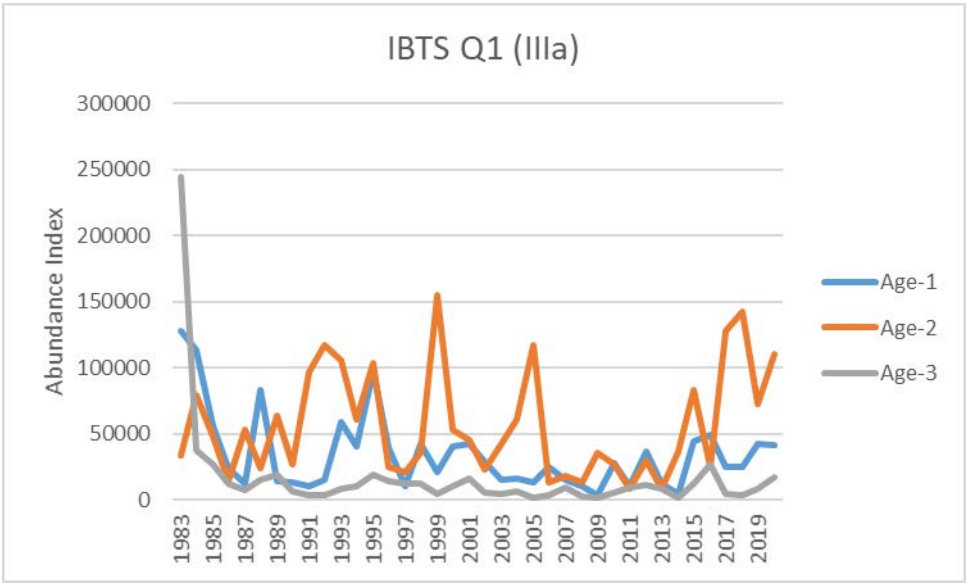


Figure 10.3.2b. North Sea and Division 3.a sprat. HERAS survey index for Subarea 4 and Division 3.a combined (sum of abundance indices published by WGIPS). Years refer to the calendar year.



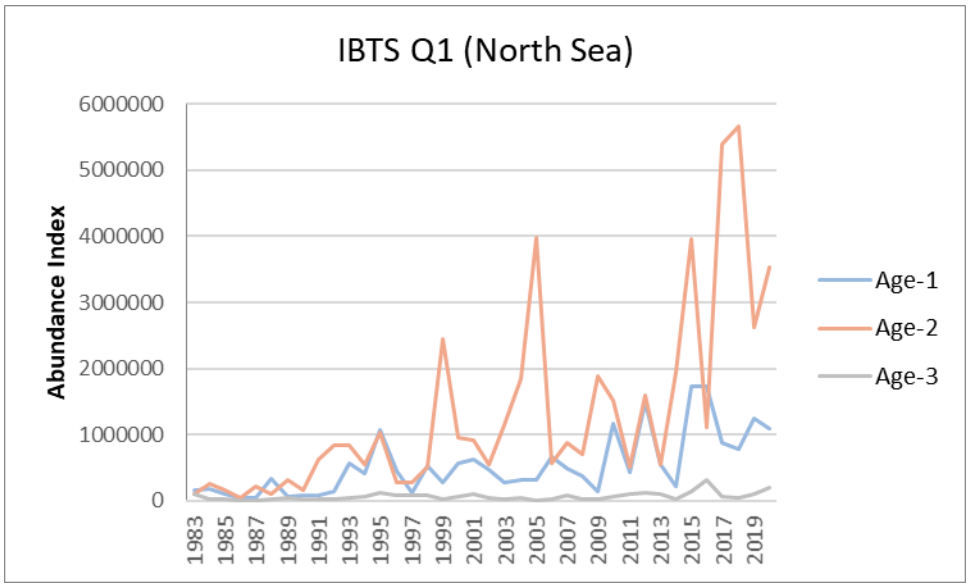


Figure 10.3.2c. North Sea (bottom figure) and Division 3.a sprat (top figure). Modelled IBTS Q1 indices for age 1, age 2, and age 3. Indices are additive, hence, adding the indices presented here results in the index time-series used as input for the model.

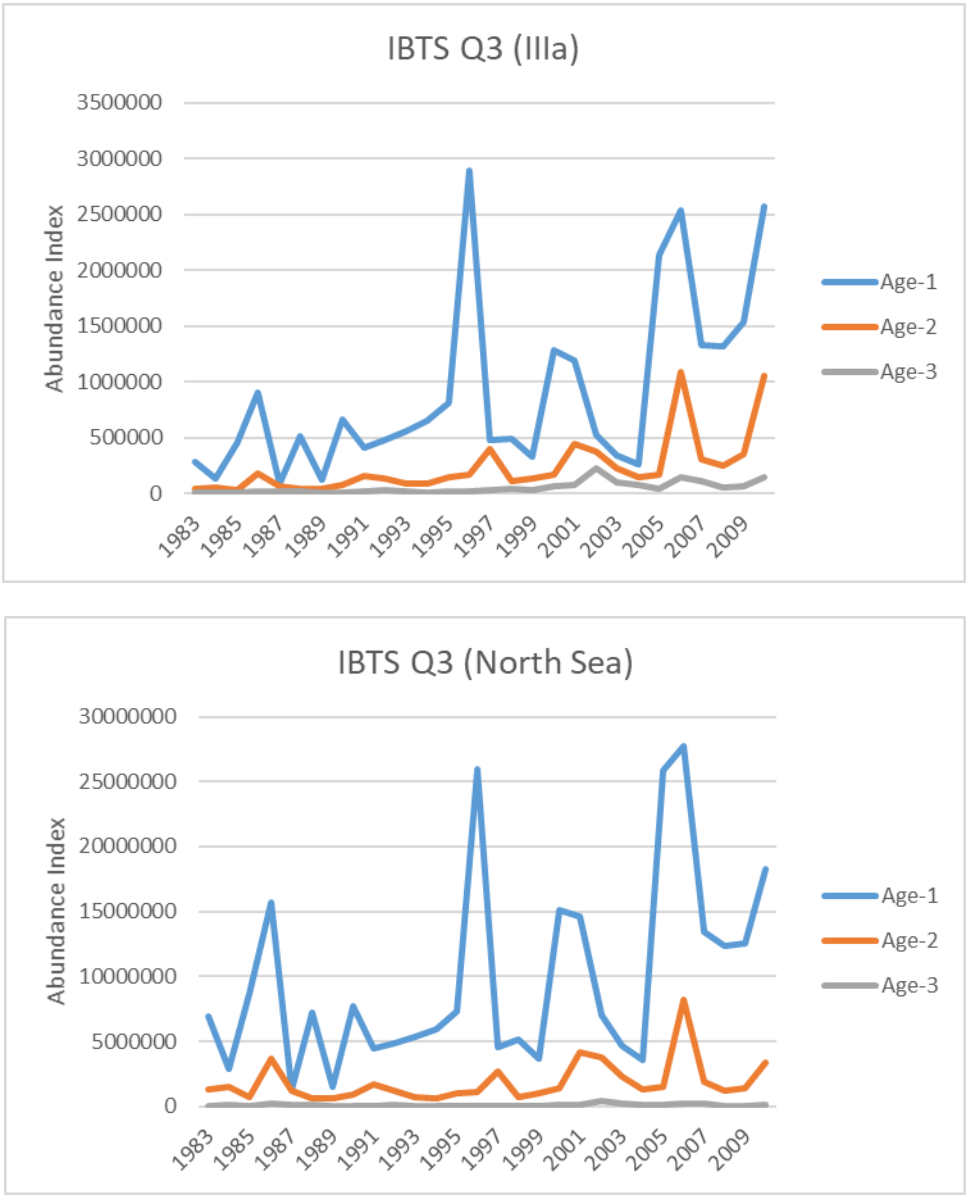
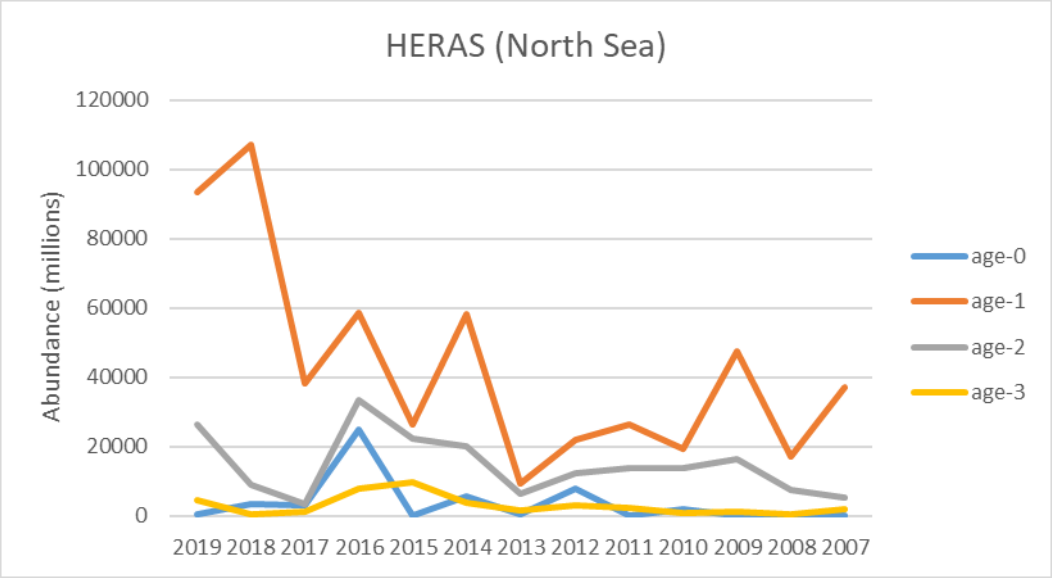


Figure 10.3.3. North Sea (bottom figure) and Division 3.a sprat (top figure). Modelled IBTS Q3 indices for age 1, age 2, and age 3. Indices are additive, hence, adding the indices presented here results in the index time-series used as input for the model.


HERAS (North Sea)
Abundance (millions)
120000
100000
80000
60000
40000
20000
0
2019 2018 2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007
age-0
age-1
age-2
age-3

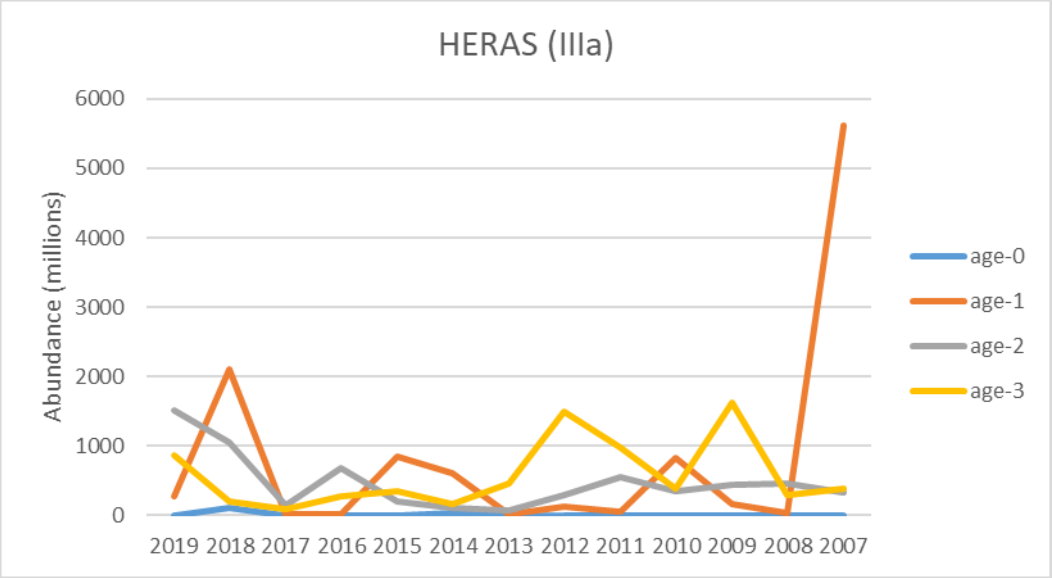
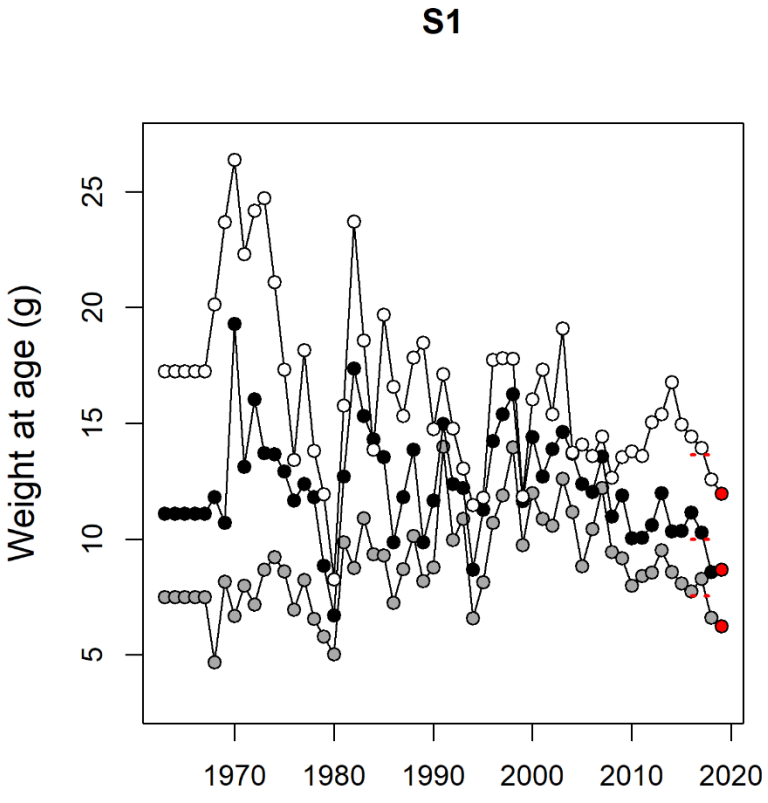


Figure 10.3.4. North Sea and Division 3.a sprat. HERAS survey index (abundance) for Subarea 4 and Division 3.a, respectively. Data were taken from the most recent WGIPS report.



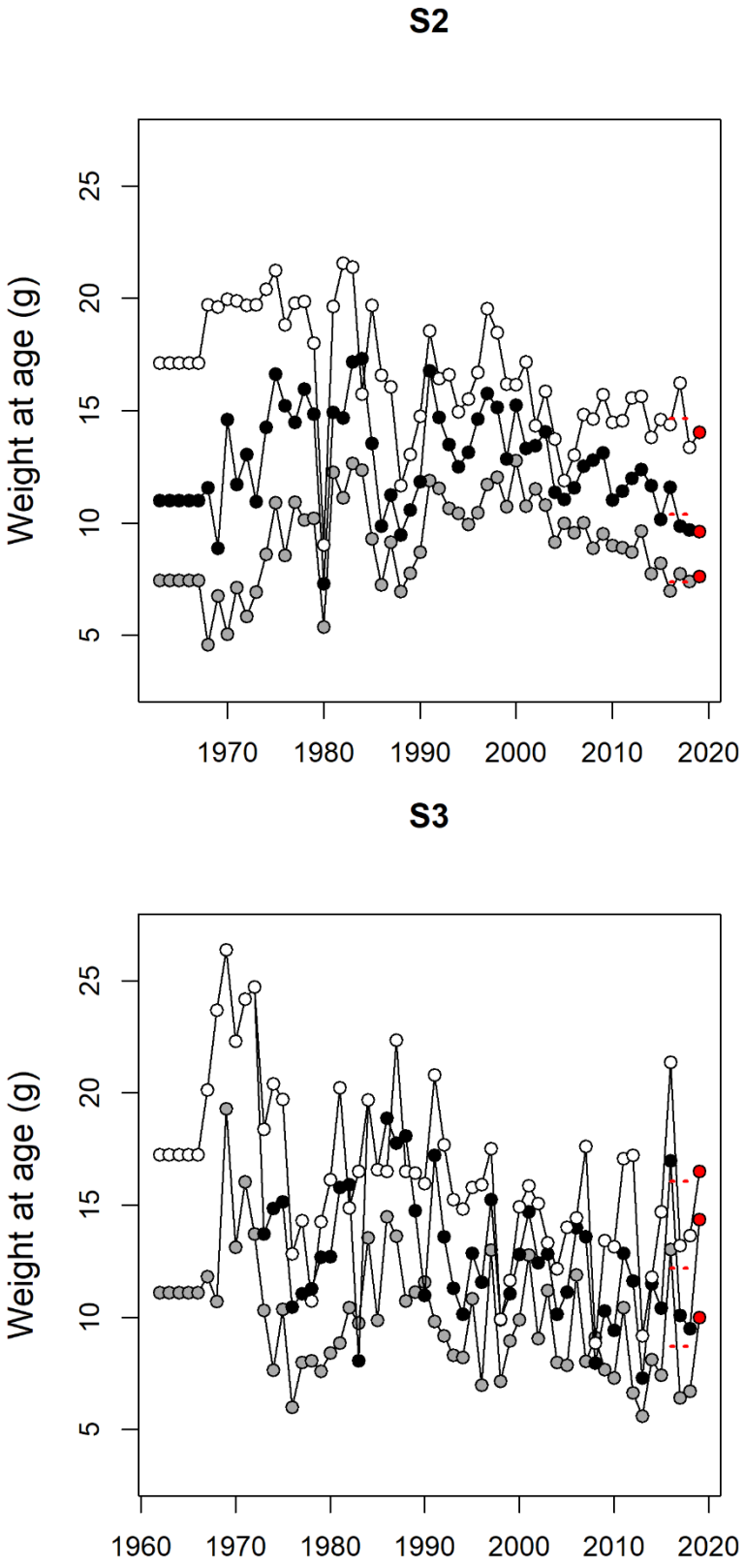


Figure 10.4.1. North Sea & 3.a sprat. Top: Mean weight at age in season 1 (years refer to the model year). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the 3-year average used in the forecast last year. Middle: Mean weight at age in season 2 (years refer to the model year). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the average of the three previous years.

Bottom: Mean weight at age in season 3 (years refer to the model year). Age 1 (grey), age 2 (black), age 3 (white). Red dot is the status quo weight and the red dashed line refer to the average of the three previous years.

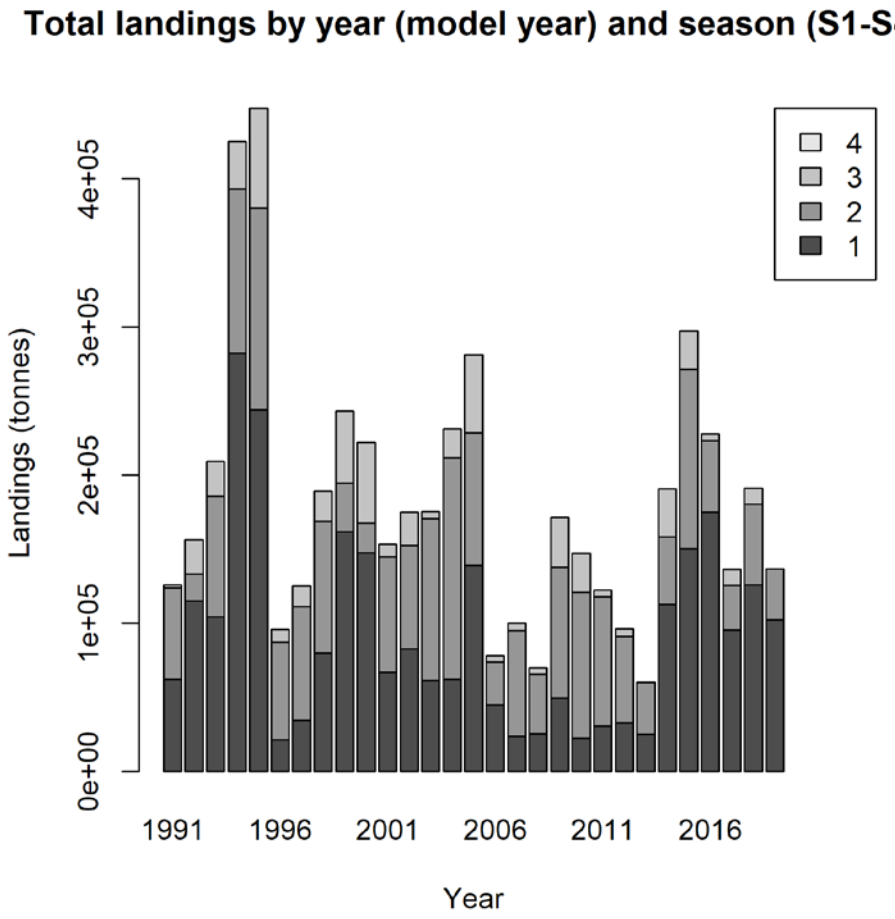


Figure 10.6.1. North Sea & 3.a sprat. Seasonal distribution of catches (Calendar year). Year and season 1-4 refer to the time-steps of the model. Note that since the model year of 2018 is not yet finished, the 2018 column will be updated

next year. Also note that there are no catches shown for S4, since these are moved to S1 in the following year (see WKSPRAT report (ICES, 2018) for details).

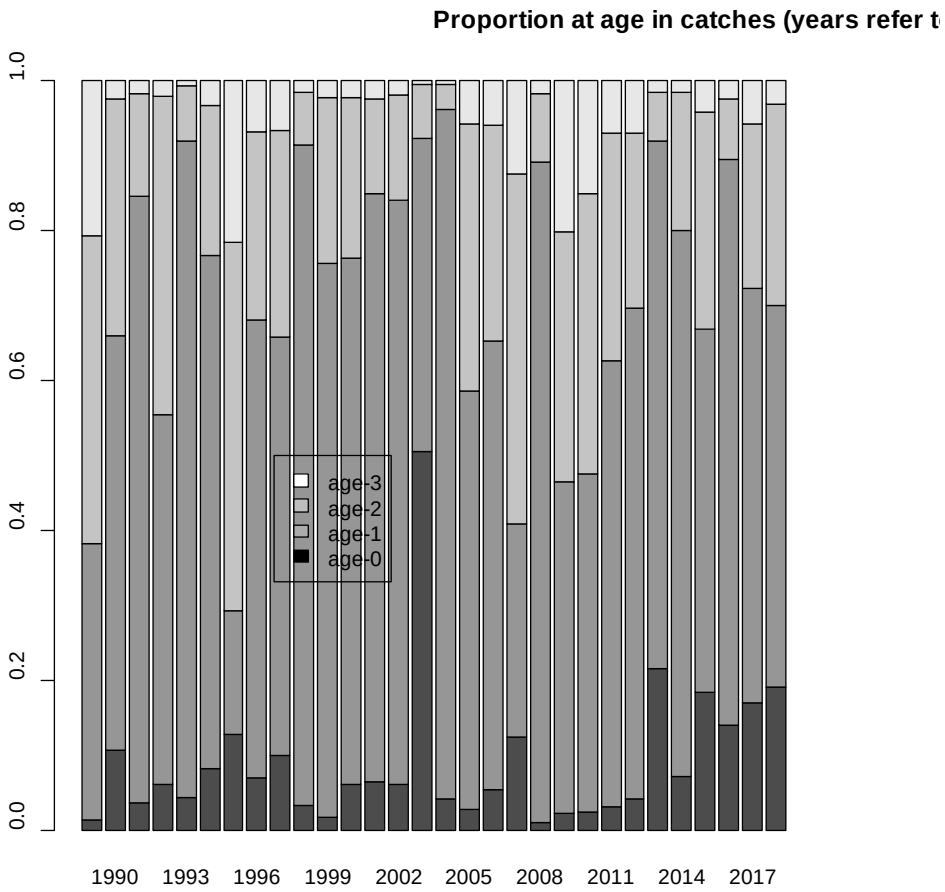


Figure 10.6.1. North Sea & 3.a sprat. Proportion of each age group in the catches. Year and age refer to the model year.

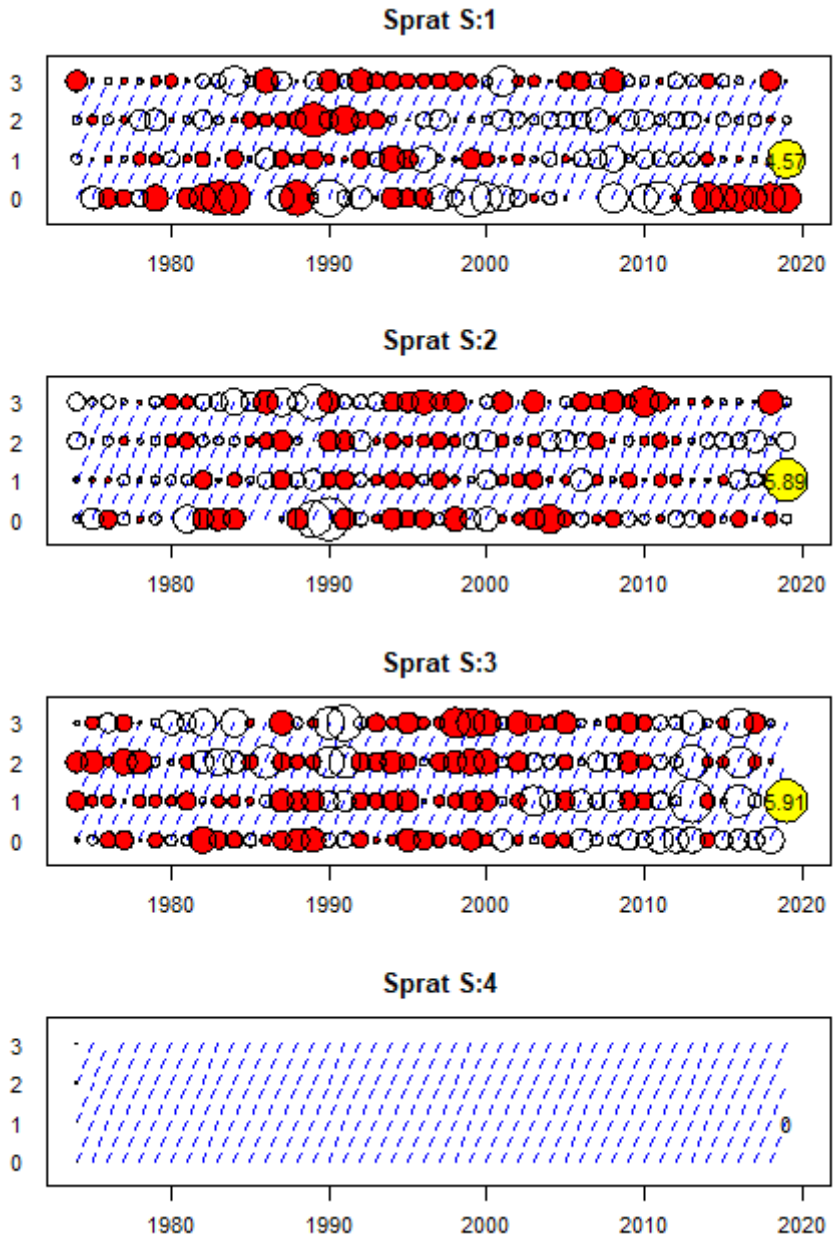


Figure 10.6.2. North Sea & 3.a sprat. Catch residuals by age. (Model year)

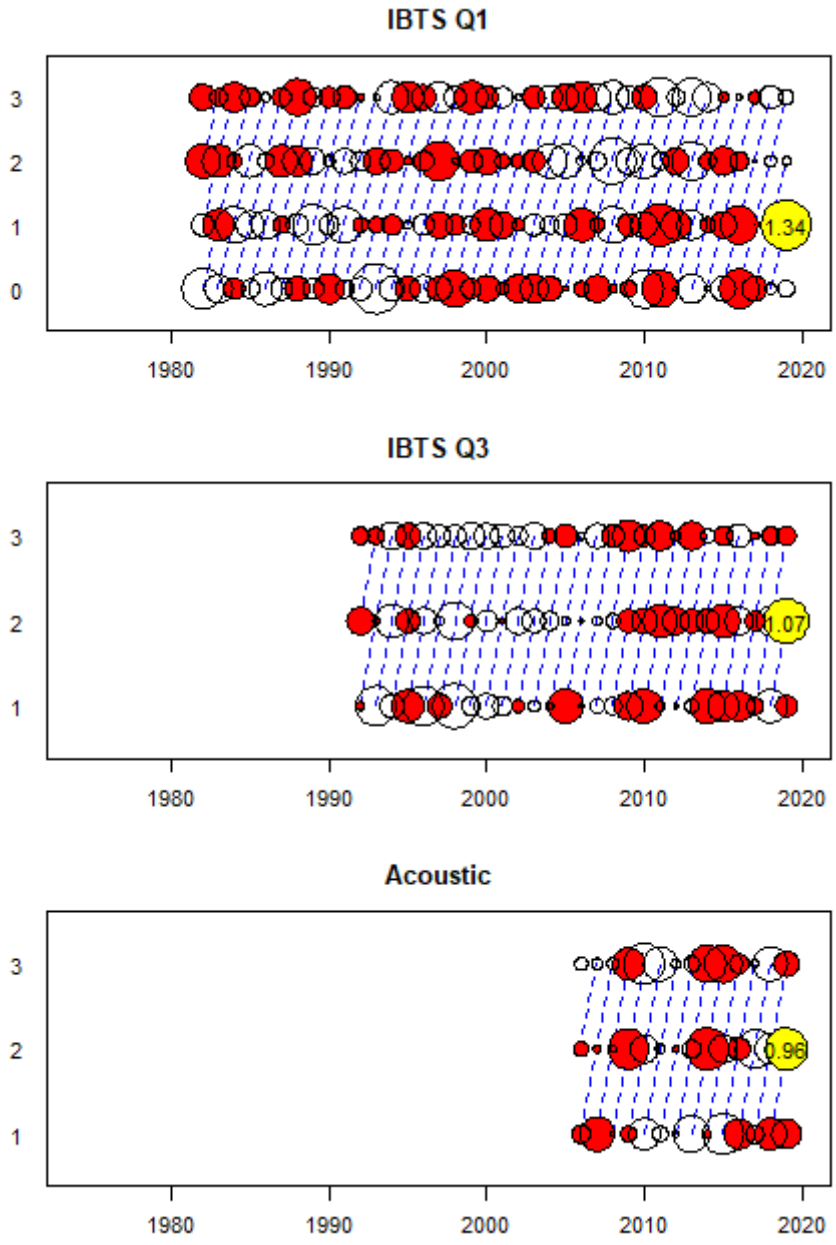


Figure 10.6.3. North Sea & 3.a sprat. Survey residuals by age. (Model year)

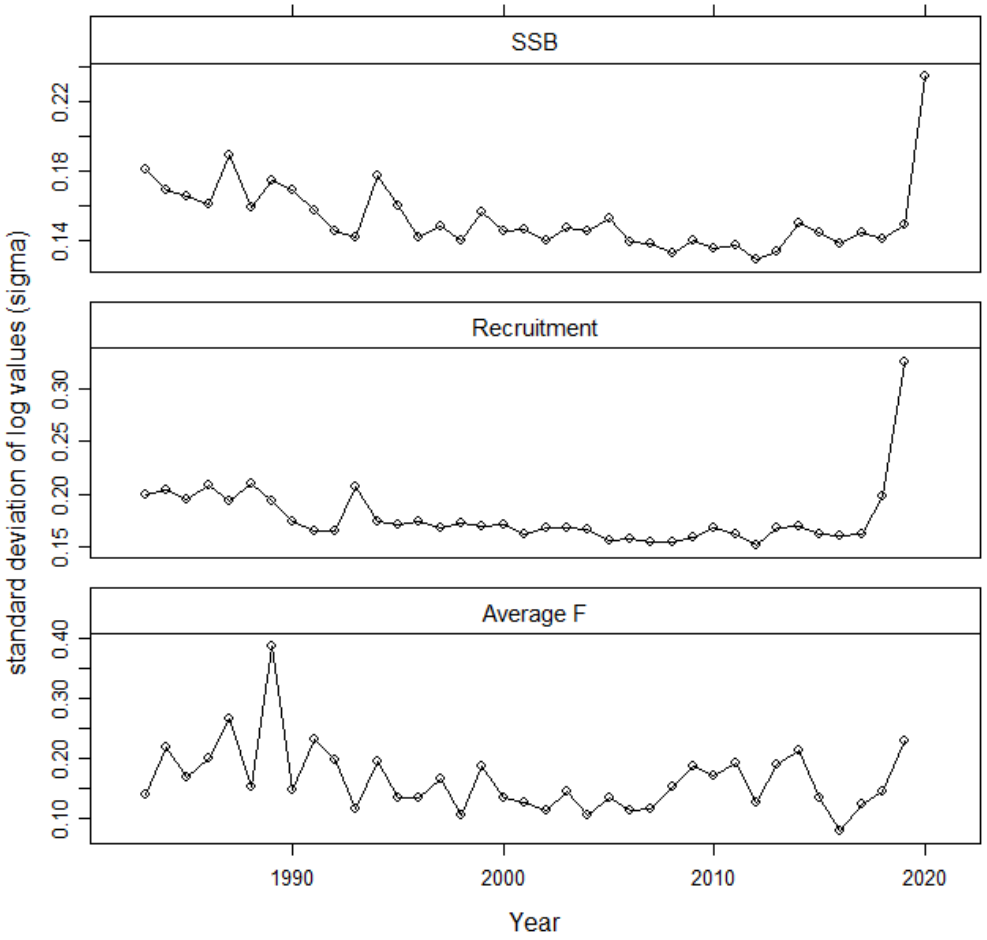


Figure 10.6.4. North Sea & 3.a sprat. Coefficients of variance (Model year).

Figure 10.6.5. North Sea & 3.a sprat. Retrospective analysis (Model year)

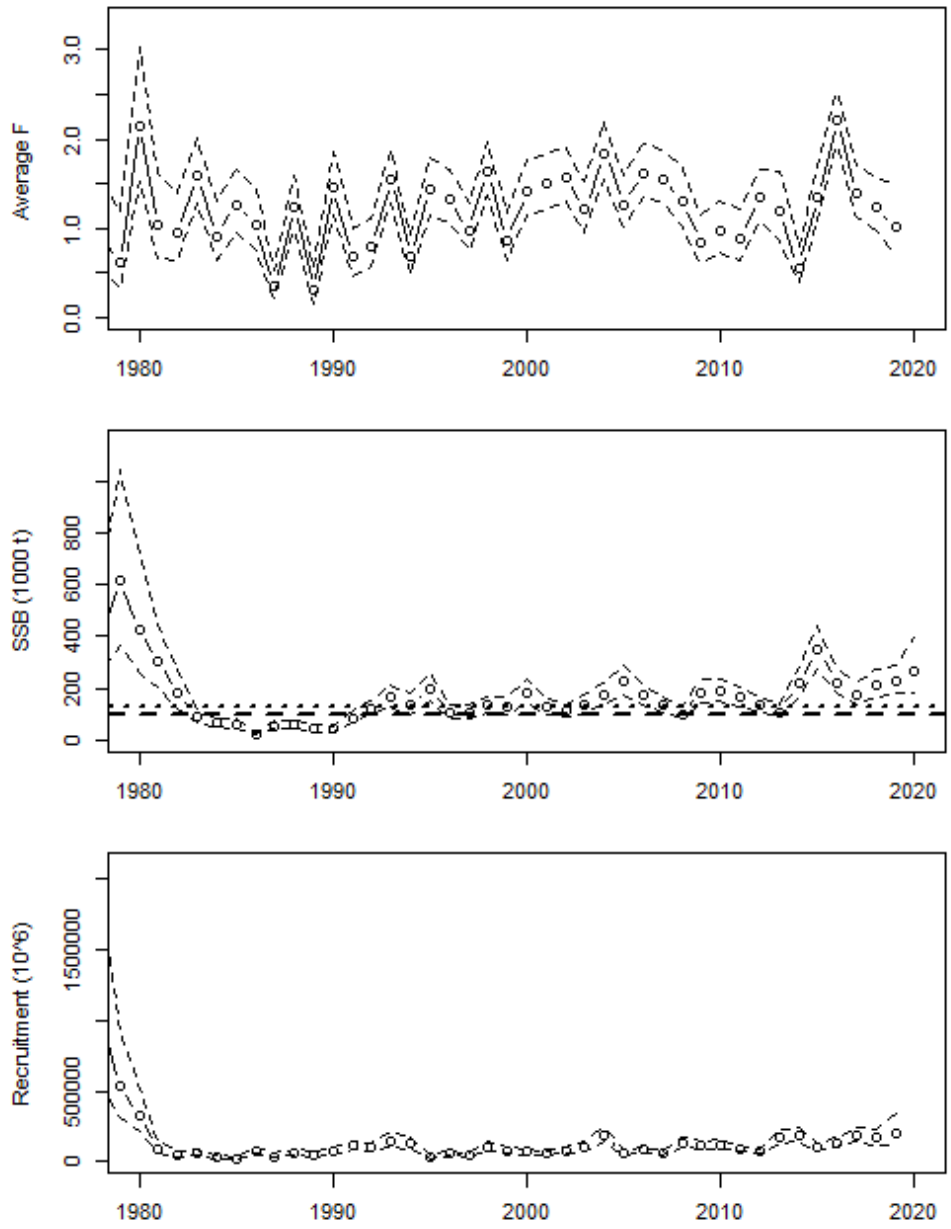


Figure 10.6.6. North Sea & 3.a sprat. Temporal development in Mean F, SSB and recruitment. Hatched lines are 95% confidence intervals (Model year).

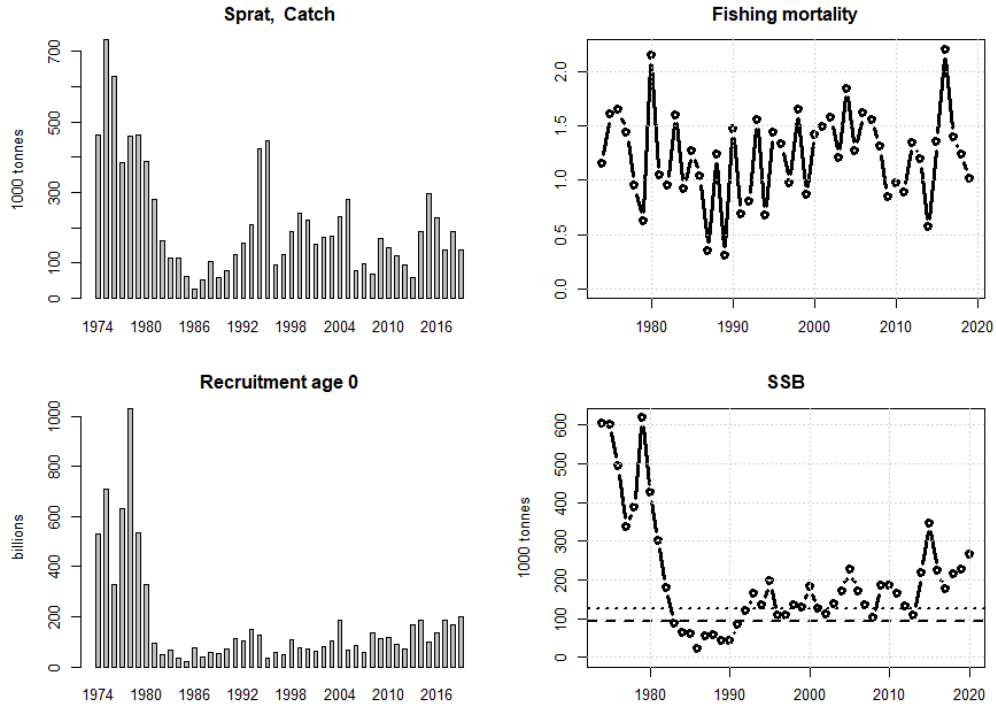


Figure 10.6.7. North Sea & 3.a sprat. Assessment summary (Model year)

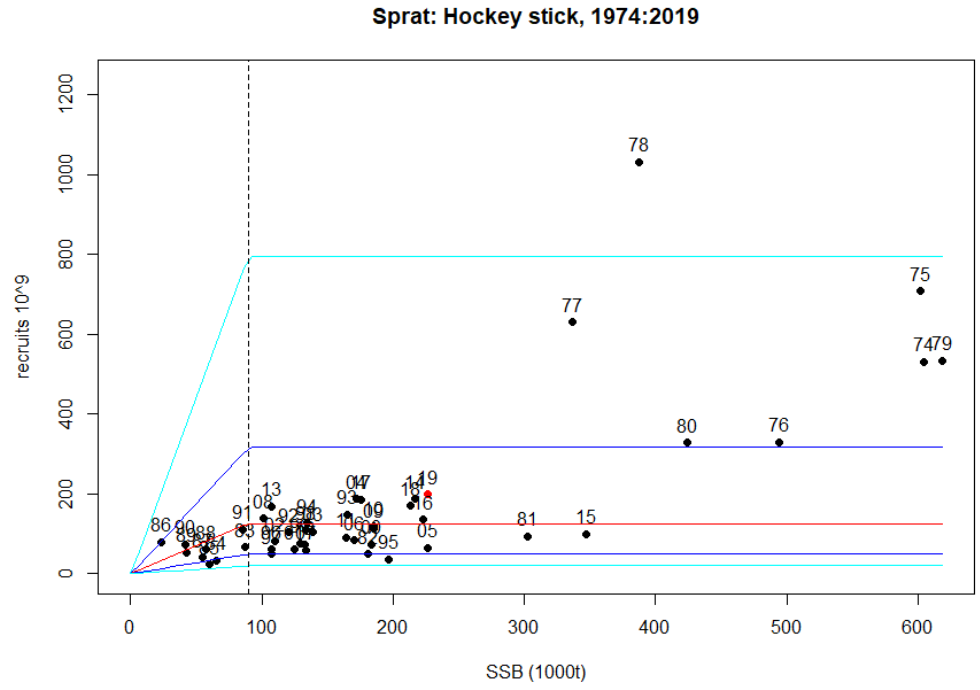


Figure 10.7.1. North Sea & 3.a sprat. Stock-recruitment relationship (Model year).

10.14 Audit of spr.27.3a4 (Sprat in the North Sea)

Working Group: HAWG **Stock Name: spr.4-3.a**

Date: 23/03/2020
Auditor: Henrik Mosegaard, Christophe Loots

General

During the the previous benchmark in 2018 the stock unit was re-defined, combining division 3.a and subarea 4.

For single-stock summary sheet advice:
Short description of the assessment: extremely useful for reference of ACOM.

1) **Assessment type:** Update abbreviated advice
2) **Assessment**: Analytical assessment
3) **Forecast**: presented
4) **Assessment model**: SMS in quarterly steps. Tuning data IBTS Q1 (age 0-3), IBTS Q3 (age 1-3), HERAS (age 1-3)
5) **Data issues:** all identified issues resolved
6) **Consistency**: Second assessment for the re-defined stock Mohn's Rho slightly higher than 0.3 but well within MSE 95% cf interval
7) **Stock status**: B>Bescapement, F is higher than Fcap (0.69).
8) **Management Plan**: No management plan has been developed.

General comments
This was a well documented, well ordered and considered section. It was easy to follow and interpret…. etc

Technical comments

There is no technical issue with this stock

Conclusions
The assessment has been performed correctly

10.15 References

WKSPRAT 2013. Report of the Benchmark Workshop on Sprat Stocks. ICES CM 2013/ACOM:48

WGSAM 2017. Interim Report of the Working Group on Multispecies Assessment Methods (WGSAM). ICES CM 2017/SSGEPI:20

WKSPRAT 2018. Report of the Benchmark Workshop on Sprat. ICES CM 2018/ACOM:35. 60 pp

ICES. 2020. ICES Working Group of International Pelagic Surveys (WGIPS). ICES Scientific Reports. 2:xx. xxx pp. http://doi.org/10.17895/ices.pub.xxx (to be published)

ICES. 2020. Workshop on Catch Forecast from Biased Assessments (WKFORBIAS; outputs from 2019 meeting). ICES Scientific Reports. 2:28. 38 pp. http://doi.org/10.17895/ices.pub.5997