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An Assessment of American Plaice (*Hippoglossoides platessoides*) in NAFO Division 3M

by

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Abstract

The present assessment evaluates the status of the 3M American plaice stock. The catch at age matrix, EU survey abundance at age and the respective mean weights were updated. The surveys and models indicate that the stock suffered a continuous decline till the second half of the 2000's, even with catches kept at a low level since 1996. All of the 1991 to 2005 year-classes are estimated to be weak. Since 2006 the recruitment improved, particularly the 2006, 2012, 2013 and 2015 year classes. The stock has increased in recent years due to improved recruitment (at age 3) since 2009, and recovered to the levels of the mid 1990s, when the fishery was closed. Both catches and *F* remain low, although slightly higher catches are observed since 2013.

Introduction

General considerations

On Flemish Cap American plaice mainly occurs at depths shallower than 600 m. The last full assessment was done in 2017 (Alpoim *et al*., 2017).

Catch trends and TAC regulation

Nominal catches from 1960-2019 were obtained from NAFO Secretariat and recalculated from NAFO statistical data base, using the NAFO STATLANT 21A Extraction Tool on May 6th 2020. STACFIS catches, since 1988, were estimated based in several sources, but in recent years are estimated by the NAFO Catch Estimation Strategy Advisory Group (CESAG). In the early-1960's catches were relatively low with the exception of 1961. Catches were high between 1964 and 1966, with a peak in 1965 of 5 341 tonnes. Till the end of the 1960's catches remained at a low level within 80 tonnes and 150 tonnes, jumping to a higher 600 - 1 100 tonnes level on the early-1970's. Since 1974 this stock became regulated and catches ranged from 600 tonnes (1981) to 5 600 tonnes (1987). After 1987 catches declined to 300 tonnes (1996), following the fast decline of the stock biomass and the reduction of the Spanish directed effort (1992). From 1986 to 1989 and in 1995 catches exceed the TAC. Since 1997 catches have remained low and declined to a historical minimum in 2012 (63 tonnes). Catches increased in recent years, oscillating between 120 and 300 tonnes and are taken as bycatch partially in the Div. 3M cod fishery (Table 1 and Fig.1).

Since 1974 till 1993 a TAC of 2 000 tonnes has been in effect for this stock with the exception of 1978 (TAC of 4 000 tonnes). A reduction to 1 000 tonnes was agreed for 1994 and 1995, and finally a moratorium was agreed thereafter (Table 1 and Fig.1).

In the recent year catches of 3M American plaice by Contracting Parties are mainly a by-catch of trawl fisheries directed to other species.

Survey data

The plan of stratification of the Flemish Cap (Bishop, 1994) used by the surveys is presented in Fig. 2.

In the 2002 assessment (Alpoim *et al.,* 2002 - SCR 02/62) and in the 2003 update (Alpoim, 2003 - SCR 03/44) of the status of the stock several historical survey data were analysed, this analysis is summarized in Fig 3. Since 2003 only EU-Spain/Portugal survey was conducted. This was the only survey updated and used in this assessment.

EU-Spain/Portugal Survey (1988-2019) (González Troncoso *et al*, 2020 - SCR 20/011).

EU- Spain/Portugal has conducted a random bottom trawl survey up to a depth of 730 metres (400 fathoms) on Flemish Cap since 1988. All surveys had a stratified design following NAFO specifications. The surveys were conducted in June-July of each year. Towing speed was around 3.5 knots. Trawling effective time is 30 min. The fishing gear used was a Lofoten gear with effective 30 mm mesh size in the codend. The full description of the survey could be found in the survey protocol (Vázquez *et al*, 2014).

In June 2003 a new Spanish research vessel, the RV "*Vizconde de Eza*" (VE), replaced the RV "*Cornide de Saavedra*" (CS) that had carried out the whole EU survey series, with the exception of the years of 1989 and 1990. In order to preserve the full use of the 1988-2002 survey indices available for several target species, the original time series needed to be converted to the new RV units.

During 2003 and 2004 Flemish Cap surveys, 130 pairs of parallel hauls (selected at random from the annual coverage of the bank) were performed simultaneously by the two vessels, at depths less than 730 m. Those pairs of parallel hauls were distributed over the swept area trying in one hand to maximize the sampled area and on the other to guarantee a large enough number of hauls with acceptable catches of all target species, namely the ones from severely depleted stocks (cod and American plaice). Both vessels were fishing with the same gear, a Lofoten trawl gear with 35 mm mesh size at the codend, which remained unchanged throughout the series. With the comparative fishing trials concluded and the conversion factors estimated, the indices from R/V CS were transformed to the R/V VE scale to make them comparable. The results of the calibration shown that the new RV VE is 33% more efficient than the former RV CS as regards American plaice (González-Troncoso and Casas, 2005 – SCR 05/29). 1988-2002 data are transformed R/V CS data, 2003-2019 data are original from R/V VE (González-Troncoso et al, 2020 - SCR 20/011).

The methodological aspects and results of the calibration are presented in SCR 05/29 (González-Troncoso and Casas, 2005).

Biomass and abundance estimates

Estimates for biomass and abundance are presented in Table 2 and Fig. 3.

Stock length composition

The stock length composition matrix was updated since the last assessment (Alpoim *et al*., 2017; González-Troncoso *et al*, 2018, 2019 and 2020). Length compositions (Table 3 and Fig. 4) from 1988 to 2019 were given by the EU survey.

Length weight relationships

Length weight relationships for the 3M American plaice (1988-2019) were calculated with EU survey length/weight data from both males and females (González-Troncoso, *pers. comm*. 2020) and used in this assessment on an annual basis (Table 4).

Stock abundance-at-age

The EU survey series presents different age reading criteria due to changes in the age reader along the series. The series can be split in two periods: the first from 1988 to 1992 that follows the criteria of one age reader and a second period from 1993 to 2001 in which several age readers have a very good agreement between them. Some effort has been spent in order to revisit the otoliths from the former years under the present accepted criteria, but, due to the size of the otoliths collections from several years and to the deterioration of some sets due to the enhancing methods used before, this work is difficult to achieve. In order to have the same criteria for all the series a combined age length key from 1993 to 2001 was used backwards over 1988-1992. Since 2001 both age reader and criteria used are the same (Alpoim *et al.,* 2002 - SCR 02/62).

The age-length keys used in 2003 and 2004 became from the sampling of the two RV ("*Vizconde de Eza*" and "*Cornide Saavedra*") in order to have a more complete age length key (ALK).

Abundance-at-age of the stock is presented in Table 5. The standardized log observed abundance-at-age of the stock is plotted in the Fig. 5, where is evident that the survey can track the good and weak year-classes.

Stock mean weights at age

The annual EU survey length weight relationships (Table 4) were used to calculate mean weights at age in the 3M American plaice stock for the period 1988-2019 (Table 6). For assessment purposes, on the years/ages where weight at age data are missing, the average mean weights at age for all the period were used.

Maturity ogive

The criterion applied in this work was the same applied in previous years. The spawning stock biomass was calculated as 50% of age 5 and age 6 plus.

Commercial Data

Length composition of the commercial catch and by-catch

The length compositions presented in the 2017 Portuguese and Russian Research Reports (Vargas *et al*., 2018; Fomin and Pochtar, 2018) were used to estimate the length composition of the 2017 total catch. The length composition presented in the 2018 Portuguese Research Report (Vargas *et al*., 2019) was used to estimate the length composition of the 2018 total catch. The length compositions presented in the 2019 Spanish and Russian Research Reports (González-Costas *et al*, 2020; Fomin and Pochtar, 2020) were used to estimate the length composition of the 2019 total catch.

The length composition presented in the 2019 Portuguese Research Report (Vargas *et al*., 2020) was not used to estimate the length composition of the 2019 total catch due to the low level of sample and the Portuguese amount of catches, instead the Spanish and Russian length frequencies were used.

From these length distributions a mean weight in the catch was derived in order to transform the correspondent catch in weight into a catch number. Each mean weight was calculated as:

$$\overline{W} = \frac{\sum (N_{LC} * \overline{W}_{LC})}{\sum N_{LC}}$$

where N_{LC} is the number observed in length-class *LC* and $\overline{W}_{LC}$ is the mean weight of the length-class *LC*. Mean weights at length were given by the length/weight relationships from the EU bottom trawl survey series (Table 4).

The breakdown of the total catch is presented in Table 7. The commercial catch at length matrix (Alpoim *et al*, 2017) was updated with the 2017, 2018 and 2019 data (Table 8 and Fig. 6).

Catch at age

The catch-at-age was given by the same age length keys already used to get survey abundance-at-age (Table 9).

Catch mean weights-at-age

The annual EU survey length weight relationships (Table 4) were used to calculate mean weights-at-age in the catch of 3M American plaice for the period 1988-2019 (Table 10). For assessment purposes, on the years/ages where weight at age data are missing, the average mean weights at age for all the period were used.

Partial recruitment vector

A *F* index was first derived by determining the ratio between the sum of the 1988-2019 age composition of the catch and American plaice EU survey abundance, both data sets were standardized to numbers-per-thousand prior to analysis. Those indicators of *F* at age were then divided by its highest value, recorded at age 4. Assuming a flat top recruitment curve this observed partial recruitment vector was adjusted to a general logistic curve (Table 11, Fig. 7). The expected values were used in the yield per recruit analysis.

Vectors used in yield-per-recruit analysis

A yield-per-recruit analysis was conducted incorporating the following sets of vectors (Table 12A), all of them considered to be representative, in terms of growth and maturity, of 3M American plaice:

1) Mean weights at age in the commercial catch.
2) Mean weights at age in the stock.
3) Female maturity ogive at age.
4) Expected (logit) partial recruitment vector.
5) Natural mortality (*M*) set at 0.2 or 0.15.

Assessment

Comments on trends on stock indicators

The two former USSR-Russian survey series showed a decreasing trend in biomass and abundance between 1976 and 1993. The Russian surveys in 2001-2002 show very low estimates of biomass and abundance. From 1978 till 1985 Canadian series was stable, with survey biomass and abundance around 6 700 tonnes and 10 million fish. A continuous decline in abundance and biomass is observed since the beginning of EU survey 1988 till 2007 when the abundance and biomass reached the lowest values of this series (1 053 tonnes and 1.4 million fishes). From 2008 to 2011, due to improved recruitment (in particular the 2006 year-class), biomass and abundance indices increased rapidly. From 2012 to 2014, abundance declined mainly due to the entry of the week 2010-2011 year-classes. After 2014, recruitment (2012 year-classes onward) has improved slightly and the EU's survey abundance shows an upward trend. The EU's survey biomass since 2008 shows the same trend, but with a faster upward trend due to the growth of existing year classes. In recent years the stock recovered to the levels of mid 90´s (Tables 2 and 5, Fig. 3 and 5). Results of the 1996 Canadian survey are comparable with the 1996 EU survey (Fig. 3) (Alpoim *et al.*, 2002; Alpoim, 2003; González-Troncoso *et al*, 2020).

A proxy to fishing mortality has been giving by the ratio between catch and EU survey biomass for ages fully recruited to the fishery (ages 8-11). Despite the variability, this index decreased, from high values in the beginning of the series (1988), to 0.011 in 2005. In 2011 reached the minimum of the series (0.002), since then fluctuated at or below 0.05. F has increased slightly in recent years (Table 13, Fig. 9).

The 1990 year-class, that was the best represented in the EU survey till 2005 (Table 5) is now in the 16+ group and lost its strength. In the period between 1992 and 2005, all the recruiting year-classes were poorly represented in the EU survey. The 2006-2008 year classes (13-11 years old in 2019) were good after a long period of week year-classes, but unfortunately 2010-2011 year-classes were not so good. Since then, the strength of the year-classes seems to improve. EU's survey spawning stock biomass (SSB), both sexes included, declined since 1988 reaching a minimum in 2007. As new recruitment entered in the SSB, the SSB indices increased, from 2011 to 2016 indices were stable around 3 500 tonnes, and since then increased, been in 2019 at 7 100 tonnes (Table 14).

Age 3 is the first age to appear in all the years of the EU survey series, so it was used to evaluate the stock/recruitment relationship (29 points). With the addition of the good recruitment (since 2006) at low SSB levels, no apparent relation can be seen, without these year-classes (since 2016) very poor recruitment for an SSB less than 9 000 t is observed (Table 14, Fig. 10).

In Fig. 11 it is plotted an EU survey index of stock reproductive potential, the log of the R/SSB ratio for each year-class and with both sexes included in spawning biomass. Before 1991 an average of 0.121 recruits at age 3 were produced per kg of SSB, from 1991 till 2000 this average was reduced to only 0.011 recruits per kg of SSB. The 2001 and 2002 mean (0.086 recruits per kg of SSB) although was higher than the previous period didn't generated good recruitments due to the poor level of SSB. The 2003 - 2005 mean is at the level of the period 1991-2000. 2006-2009 values were the highest of the time series (0.489 recruits per kg of SSB) but in 2010 the index decreased to 10% of the previous value. After 2011 this index increased and stabilized at high levels (Table 14, Fig.11). The recruitment failure seems not to be caused by the shrimp fishery developed in Flemish Cap since the beginning of 1990´s, because estimation of by-catch gives very low figures for American plaice (Kulka, 1999).

Yield-per-recruit analyses

A yield-per-recruit analysis was conducted, incorporating the sets of vectors already described. This analysis gives (Tab. 12, Fig. 8):

For M = 0.2, $F_{0.1}$ = 0.161 and F_{max} = 0.337.
For M = 0.15, $F_{0.1}$ = 0.124 and F_{max} = 0.248.

XSA

The XSA, using the Lowestoft VPA Suite (Darby and Flatman, 1994), was updated by adding the 2017, 2018 and 2019 data. The month with a peak of spawning for 3M American plaice is May (Serebryakov *et al.*, 1987) and was used to estimate the proportion of *F* and *M* before spawning. The ratios between annual catches and EU survey bottom biomass were considered to be a proxy of mean fishing mortalities from 1988 to 2019. The survey biomass can be considered representative of the mean annual biomass (EU survey is conducted around the middle of the year). The 2019 *F* index was multiplied by the observed PR to have a starting guess of *F* at age in the terminal year. In order to get the *F's* for the last age through 1988-2019 the selection at age 15 was multiplied by the *F* index of each year. The rest of the data were already described above. Table 15 presents the full set of input data files, for XSA analysis, with all years and ages available and natural mortality (*M*) assumed constant at 0.15.

In the last assessment (Alpoim *et al*, 2017; NAFO, 2017) several trials were investigated the impact of changing: 1) the first age in the assessment (age 1 or 4); 2) the first age that *q* is independent of age (12 or 14); 3) the first year of the tuning fleet (1998 or 1994); 4) splitting the tuning series in two (1988-1993 and 1994-2016); 5) or changing *M* from 0.2 to 0.15. All the runs have the following settings: a) no year weights were applied, due to the short time series; b) final estimates not shrunk towards mean *F*; c) Minimum *Log (S.E.)* for the terminal population estimates derived from each fleet (Threshold se) was 0.5. The XSA with age 4 onwards, *M*=0.15 and splitting the tuning fleet was considered the one with the better diagnostics, this XSA run was updated with the 2017, 2018 and 2019 data.

A summary of the XSA run diagnostics and plots of the log catchability residuals are presented in Table 16 and in Fig. 12. The XSA with the update values (2017-2019) showed better diagnostics comparing with last assessment (but the number of interactions increased to 124). The strong retrospective pattern decreased, although some bias (to overestimated) is observed in total biomass, SSB and recruitment (Fig. 13).

XSA 4+ Biomass and Spawning stock biomass (SSB) show a steady decline, but since 2009 (2010 for SSB) show an extremely rapid increase. All of the 1991 to 2005, 2009 and 2010 year-classes are estimated to be weak. Since 2006 (with the exception of the 2009-2010 year classes) the recruitment improved, and is pushing both 4+ biomass and SSB up. Fishing mortality declined from the mid-1980s to the mid-2000s. After a small increased it decreased and reached the minimum of the period analysed in 2011, since then fluctuated at or below 0.1. *F* has increased slightly in recent years (Table 17, Fig. 14).

Bayesian Model

The VPA-type Bayesian model with all data (ages 1-16+, tuning from 1988-2016 and with variability on *M*=0.2 with a c.v. of 0.05) run in the last assessment was updated with the 2017-2019 and run with variability on *M*=0.1.5 with the same c.v. (0.05).
The model run performed with the following input sets:

Catch data: catch numbers and mean weight at age for 1988-2019.
Catchability analysis: dependent on stock size for the age 4.
Priors: for survivors at age at the end of the final assessment year, for survivors from the last true age at the end of every year, for numbers at age of the survey and for the natural mortality.

The VPA-type Bayesian model full diagnostic and results output is presented in Table 18 and Fig. 15-23.

Conclusions

All of the 1991 to 2005 year-classes are estimated to be weak. Since 2006 the recruitment improved, particularly the 2006, 2012, 2013 and 2015 year classes.

Stock biomass and SSB recorded a minimum in 2007, due to consistent year-to-year recruitment failure from the 1991 to 2005 year-classes. Stock biomass and SSB increased from 2007 to 2012 and have remained stable at a relatively low level. From 2016 to 2019 both biomasses recovered, to the levels of mid 90´s, when the fishery was closed.

Fishing mortality index (C/B) declined from the mid-1980s to the mid-2000s and since 2000 fluctuated at or below 0.1. In recent years F has increased.

Stock status

The stock has increased in recent years due to improved recruitment (at age 3) since 2009, and recovered to the levels of the mid 1990s, when the fishery was closed. Both catches and *F* remain low, although slightly higher catches are observed since 2013.

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TABLE 1. Nominal catches (tonnes) from 1960-2019, STACFIS catches (tonnes) from 1988-2019 and TAC (tonnes) from 1974-2020 of American plaice from NAFO Division 3M.

Year	Nominal catches (1)														
	Country										Flatfishes (NS)	Yellowtail f.	GRAND	STACFIS	TAC
	Canada	Japan	USSR/SUN	Poland	E/ESP	E/GBR	E/PRT	E/DEU	Other	Total	Total	Total	TOTAL	catches	
1960	-	-	-	-	-	-	-	-	-	0	316	-	316	-	-
1961	-	-	-	-	-	-	-	-	-	0	2282	-	2282	-	-
1962	14	-	-	-	-	-	-	-	-	14	707	-	721	-	-
1963	-	-	51	108	-	20	-	-	-	179	-	-	179	-	-
1964	-	-	1831	8	-	37	-	-	-	1876	-	-	1876	-	-
1965	19	-	4964	216	-	83	-	-	2	5284	57	-	5341	-	-
1966	-	-	4003	17	-	53	-	-	-	4073	-	-	4073	-	-
1967	57	-	-	63	-	33	-	-	1	154	-	-	154	-	-
1968	100	-	121	-	-	4	-	-	-	225	6	-	231	-	-
1969	12	-	113	-	-	-	-	-	-	125	-	-	125	-	-
1970	-	-	62	-	-	-	-	-	-	62	17	-	79	-	-
1971	-	-	1079	-	-	-	-	-	-	1079	-	-	1079	-	-
1972	-	-	665	8	17	65	-	-	106	861	-	-	861	-	-
1973	68	-	312	39	-	85	-	-	-	504	3	127	634	-	-
1974	211	-	1110	-	-	607	-	-	-	1928	3	12	1943	-	2000
1975	140	-	958	-	8	80	522	-	-	1708	5	31	1744	-	2000
1976	191	-	809	15	28	-	149	-	-	1192	-	137	1329	-	2000
1977	30	-	987	7	18	-	457	1	118	1618		10	1628	-	2000
1978	7	49	581	21	36	2	486	100	51	1333	3		1336	-	4000
1979	10	63	457	2	16	-	248	-	-	796	4	-	800	-	2000
1980	1	1	909	5	3	-	232	34		1185	64		1249	-	2000
1981	-	47	309	-	276	-	-	-	-	632	-	-	632	-	2000
1982	-	53	1002	-	17	-	-	-	-	1072	3	-	1075	-	2000
1983	-	9	1238	-	434	-	208	-	-	1889	3	-	1892	-	2000
1984	-	1	711	-	204	-	196	190		1302	1		1303	-	2000
1985	-	2	971	-	163	-	266	318		1720			1720	-	2000
1986	-	3	962	-	1048	-	1741	-	-	3754	-	3	3757	-	2000
1987	-	-	501	-	4137	-	969	-	-	5607	20	-	5627	-	2000
1988	-	78	228	-	1608	-	941	-	6	2861	127	1	2989	2800	2000
1989	-	402	88	-	2166	-	1238	-	-	3894	72	-	3966	3500	2000
1990	-	308	-	-	102	-	359	-	21	790	38	94	922	790	2000
1991	-	450	5	-	605	2	996	-	24	2082	3	1	2086	1600	2000
1992	-	50	-	-	390	-	314	-	11	765	-	1	766	765	2000
1993	-	49	-	-	244	-	231	-	181	705	46	20	771	275	2000
1994	-	-	-	-	3	-	251	-	-	254	-	84	338	669	1000
1995	-	-	-	-	125	-	118	-	-	243	14	-	257	1300	1000
1996	-	-	-	-	105	-	29	-	8	142	2	28	172	300	0
1997	-	-	-	-	56	-	52	-	-	108	-	-	108	208	0
1998	-	-	-	-	140	-	47	-	1	188	3	2	193	294	0
1999	-	-	4	-	220	-	18	-	1	243	5	-	248	255	0
2000	-	-	55	-	169	-	27	-	1	252	1	6	259	133	0
2001	-	-	14	-	89	-	162	-	3	268	24	135	427	149	0
2002	-	5	4	-	74	-	73	-	1	157	66	32	255	128	0
2003	-	3	7	-	75	-	28	-	17	130	-	15	145	131	0

Year	Nominal catches (1)														
	Country										Flatfishes (NS)	Yellowtail f.	GRAND	STACFIS	TAC
	Canada	Japan	USSR/SUN	Poland	E/ESP	E/GBR	E/PRT	E/DEU	Other	Total	Total	Total	TOTAL	catches	
2004	-	4	4	-	39	-	58	-	3	108	-	-	108	81	0
2005	-	-	-	-	59	-	11	-	14	84	1	3	88	45	0
2006	-	-	5	-	32	-	34	-	12	83	-	-	83	46	0
2007	-	-	-	-	41	-	32	-	5	78	-	34	112	76	0
2008	-	-	1	-	15	-	16	-	33	65	-	1	66	68	0
2009	-	-	24	-	17	-	35	-	11	87	-	6	93	70	0
2010	-	-	22	-	10	-	26	-	4	62	3	-	65	65	0
2011	1	-	-	-	13	-	32	-	17	63	-	-	63	63	0
2012	-	-	24	-	21	-	102	-	10	157	-	1	158	123	0
2013	-	-	22	-	66	-	146	-	12	246	-	-	246	246	0
2014	-	-	23	2	69	-	113	-	39	246	-	-	246	247	0
2015	-	-	23	-	68	-	111	-	18	220	-	-	220	268	0
2016	-	-	16	-	25	2	123	-	7	173	-	-	173	161	0
2017	-	-	13	-	12	-	104	-	30	159	-	-	159	157	0
2018		2	4	-	12	-	104	-	75	197	-	-	197	215	0
2019		3	5	-	27	-	208	-	57	300	-	-	300	302	0
2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0

(1) - Recalculated from NAFO statistical data base using the NAFO STATLANT 21A Extraction Tool, on 6-May-2020 and information from NAFO Secretariat.

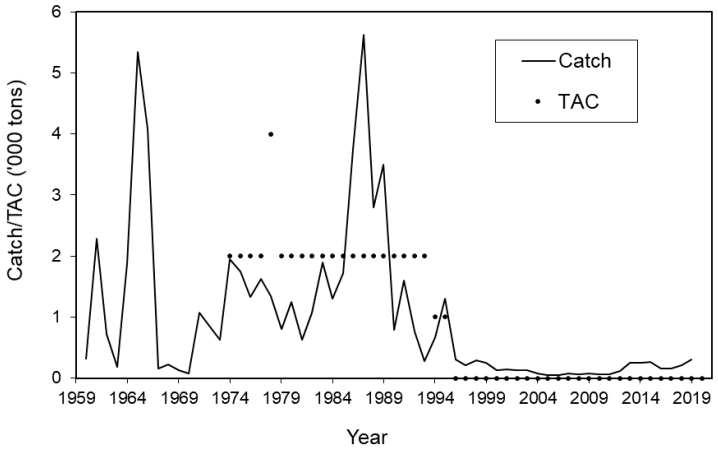

Figure 1. American plaice in Div. 3M: STACFIS catches and agreed TAC's

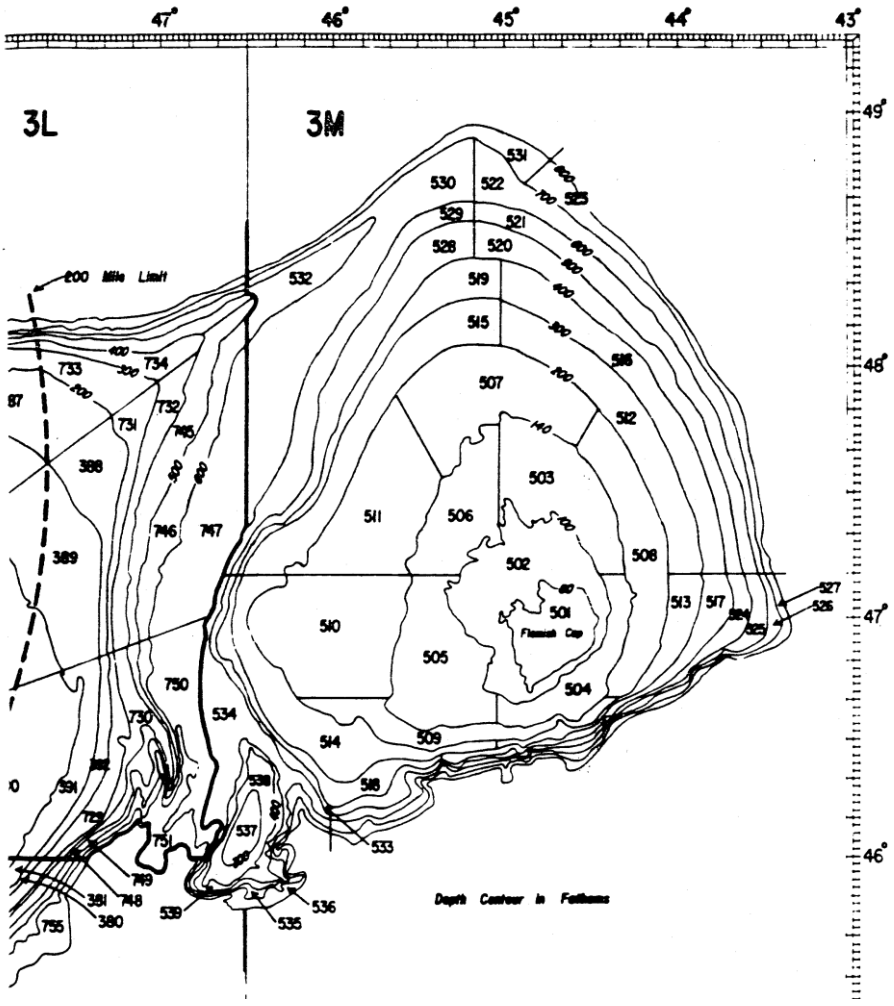

Figure. 2. Stratification scheme for stratified- randowm groundfish surveys in Div 3M (Bishop 1994).

Table 2. EU surveys in Div.3M from 1988-2019: estimates of biomass (tonnes) and abundance (000's) of A. plaice.

	Depth range	Area	Year															
Stratum	(m)	(sq. n. mi.)	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
501	128-146	342	1306	1000	505	1078	709	1079	661	2230	1462	381	156	372	345	1043	141	1292
502	148-183	838	2845	3602	1375	2663	1714	1267	1199	1335	943	740	1587	1810	976	835	1262	713
503	185-256	628	1367	1118	1668	1247	631	444	325	252	168	495	284	97	21	93	75	17
504	185-256	348	2199	461	817	320	557	572	853	489	268	203	343	53	100	85	128	
505	185-256	703	2599	3093	1830	1407	837	1291	1230	549	500	619	744	73	56	112	189	82
506	185-256	496	479	1130	954	501	601	305	808	123	32	13	35	40	25	37	63	29
507	258-366	822	1174	531	837	389	639	319	316	249	72	83	47	19	15	28	52	30
508	258-366	646	417	164	263	251	727	487	171	132	56	123	165	3		45	43	14
509	258-366	314	103	163	343		373	205	20	500	55	36					1	9
510	258-366	951	2323	1491	2000	1308	1406	1459	2236	708	415	287	36	72	45	95	36	54
511	258-366	806	1186	1168	1316	401	372	292	303	109	68	32	29	37	23	27	59	29
512	367-549	670	9	19	45	17	11	15	33	12	32	7				4		11
513	367-549	249	3		20					3								
514	367-549	602	8	8	7	389	29		24	15	4		4	9				
515	367-549	666	23	99	3	97	37	109	40	68	23	7	7					6
516	550-731	634	5			4	9	12	5									
517	550-731	216																
518	550-731	210																
519	550-731	414				15	4	5	3	11								
total biomass			16046	14047	11983	10087	8656	7861	8227	6785	4098	3026	3437	2585	1606	2404	2049	2286
s.e.			1845	2048	1276	1180	954	1040	1373	1083	912	708	751	869	332	429	729	748
mean catch per tow (kg)			19.95	17.47	14.90	12.55	10.76	9.79	10.23	8.44	5.09	3.76	4.27	3.21	2.00	2.99	2.55	2.86
s.e.			2.29	2.55	1.59	1.47	1.19	1.29	1.71	1.35	1.13	0.88	0.93	1.08	0.41	0.53	0.91	0.93
total abundance (000's)			27410	27391	20946	17643	13728	11648	11247	9376	5658	3770	3800	2672	2132	3168	1971	2769
mean number per tow			34.09	34.01	26.05	21.79	17.05	14.47	13.96	11.66	7.02	4.69	4.73	3.32	2.65	3.94	2.45	3.44

Table 2. cont.

Stratum	Depth range (m)	Area (sq. n. mi.)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
501	128-146	342	1507	1038	714	284	144	548	716	693	462	329	181	410	219	1014	764	945
502	148-183	838	768	796	354	209	513	370	1084	1141	1272	1202	1872	1248	1307	4379	1807	831
503	185-256	628	427	101	74	101	147	74	103	364	468	266	223	462	488	410	534	1042
504	185-256	348	395	359	109	153	440	36	91	1201	749	671	258	376	178	342	285	801
505	185-256	703	72	45	63	81	88	72	200	190	716	267	328	443	592	277	421	1602
506	185-256	496	26	71	61	99	37	57	34	160	185	341	187	309	282	314	751	805
507	258-366	822	84	31	37	20	47	32	28	160	156	166	208	117	253	215	389	289
508	258-366	646	55	175	163	58	128	47	49	65	187	156	249	220	346	114	241	206
509	258-366	314	77	18				77			30	25		2	12	2		121
510	258-366	951	45	87	97	24	163	54	115	35	123	153	105	86	325	190	403	336
511	258-366	806	69	35	19	22	50	64	26	33	121	121	185	124	308	188	397	559
512	367-549	670						11			11					10	16	18
513	367-549	249													2			20
514	367-549	602								32				3	3	16	39	28
515	367-549	666		4		3	7	1		10	13		5	22	10	4	51	52
516	550-731	634																
517	550-731	216																
518	550-731	210															12	
519	550-731	414																
total biomass			3525	2760	1691	1053	1766	1442	2446	4084	4491	3698	3800	3821	4325	7475	6109	7654
s.e.			740	684	342	159	300	327	526	780	534	439	671	556	481	1547	558	852
mean catch per tow (kg)			4.38	3.43	2.10	1.31	2.20	1.79	3.04	5.08	5.59	4.61	4.73	4.76	5.37	9.29	7.60	9.52
s.e.			0.92	0.85	0.43	0.20	0.37	0.41	0.65	0.96	0.67	0.54	0.84	0.70	0.60	1.93	0.70	1.07
total abundance (000's)			4015	3326	2188	1401	3263	2839	4962	6917	6614	4670	4477	4951	6525	10127	7187	7796
mean number per tow			4.99	4.14	2.72	1.74	4.06	3.53	6.17	8.60	8.23	5.81	5.57	6.16	8.12	12.60	8.94	9.70

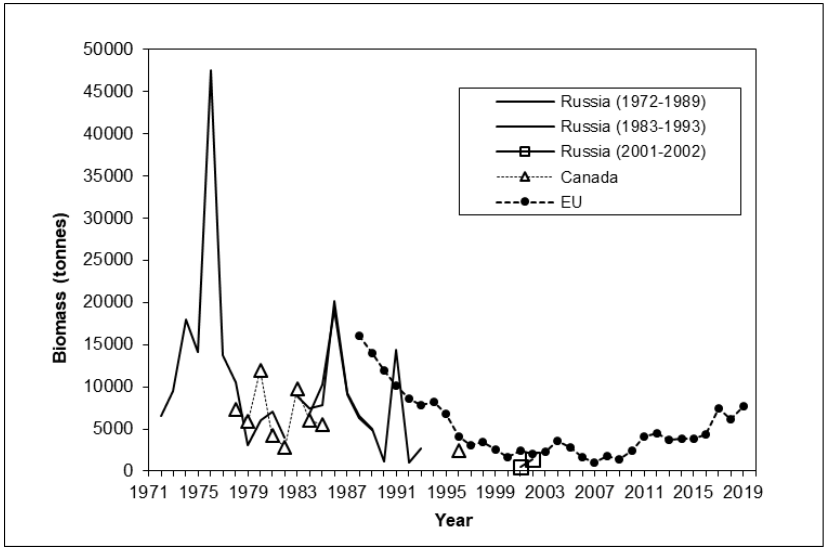

Figure 3A. American plaice in Div. 3M: trends in biomass in the surveys.

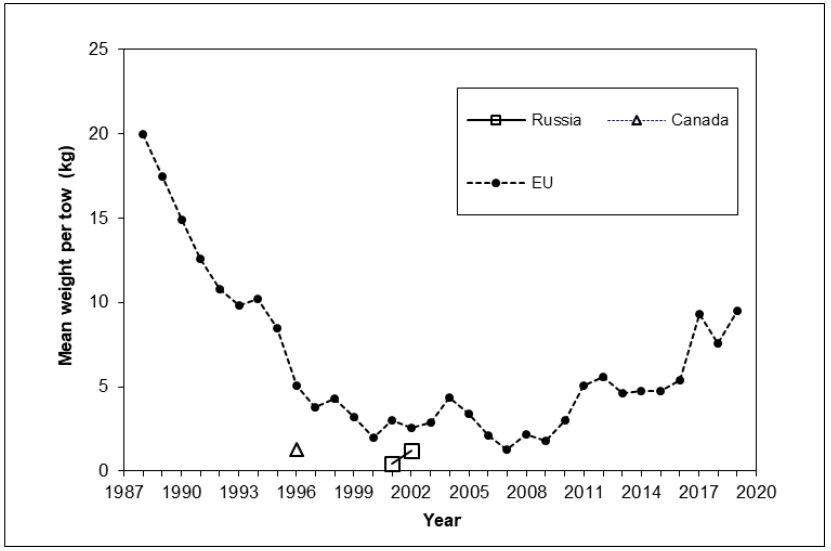

Fig.3C. American plaice in Div. 3M: mean weight per tow in the surveys.

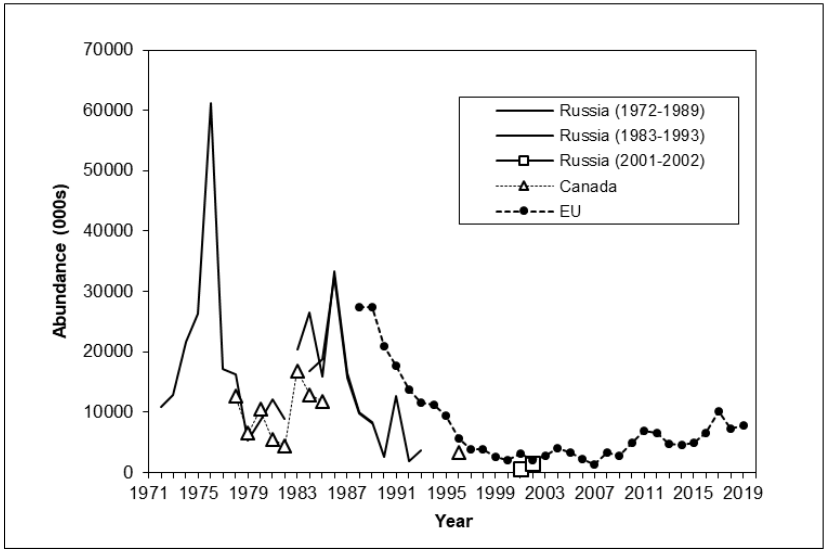

Fig.3B. American plaice in Div. 3M: trends in abundance in the surveys.

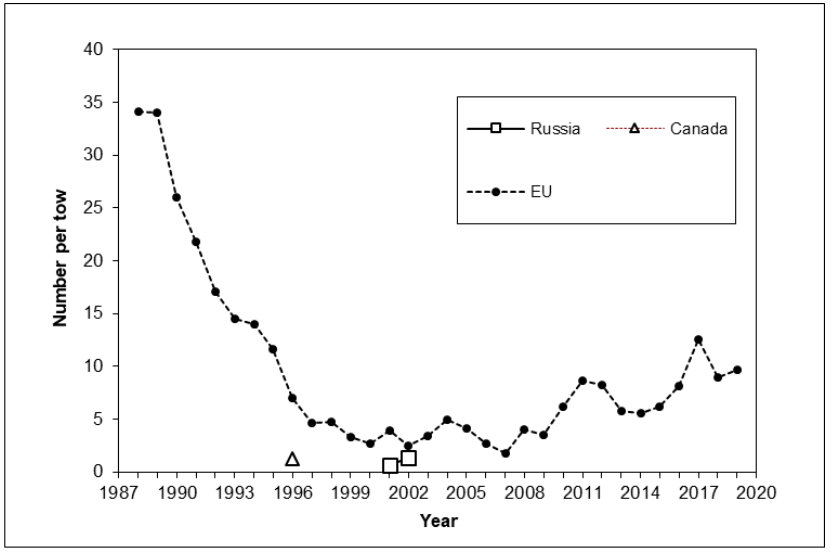

Fig.3D. American plaice in Div. 3M: mean number per tow in the surveys.

Table 3. Length composition (absolute frequencies in '000) of the 3M American plaice stock, EU survey 1988-2019.

Length group	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Length group
4							7																										4
6				20																													6
8				20																20													8
10		41	8	27								7	8							174	16	6				13	8	7	34			8	10
12	68	14		46					8	8			7			7			7	13	19	13	10		7	13		7	21			7	12
14	555	14		48	48																16	6	10				7	7	8			15	14
16	1274	104	149	136	230		8	14	7	8						6	13				45	13		29		14	7	55	14		15		16
18	295	327	411	101	443	19	31	15	32	16			7	8			7	8			383	46	54	155		27	132	186	48	65	34	23	18
20	55	1205	146	77	253	37	33				16		8	31		7	22	8	14	13	838	146	169	161	30	105	129	268	102	349	47	22	20
22	166	2836	188	461	131	191	31		14		16		16			14	66	39	7		243	101	117	86	38	52	47	68	62	480	80	58	22
24	295	3199	391	828	272	565	44	45	38	30	8	8	8	8	9	13	109	24	14		52	171	177	100	67	7	35	62	260	78	14		24
26	575	1602	690	469	360	619	129	45	24	60	8	15	8	31	8	7	127	40	7	7		589	340	240	80		88	286	594	111	60	63	26
28	932	499	1301	456	392	360	297	113	68	44	45	31	44	54	32	27	73	48	31		16	361	605	574	195	14	108	361	834	282	259	108	28
30	1434	637	2964	782	452	657	729	212	111	30	15	8	31	23	24	72	69	149	49		8	121	580	805	376	40	95	387	376	329	796	222	30
32	2459	998	2836	1625	568	563	965	639	286	189	77	54	69	68	32	64	57	178	62	41	8	20	660	741	606	140	63	144	247	408	512	218	32
34	3019	2020	1600	2522	1105	595	864	663	352	181	219	121	133	200	73	129	122	138	90	59	62	27	465	583	849	350	87	61	409	606	338	297	34
36	3582	3495	1726	2749	2251	1302	1161	1292	757	426	413	256	250	365	109	336	403	250	230	106	83	55	304	561	843	663	192	123	566	571	343	741	36
38	2651	2627	1790	2269	2042	1397	1710	1688	1040	678	401	258	258	682	145	482	404	419	387	121	225	151	219	607	682	604	581	299	467	802	469	887	38
40	2740	1959	1427	1384	1576	1439	1511	1420	979	456	500	316	289	443	195	413	459	420	364	202	242	185	277	672	657	564	648	380	339	1254	718	680	40
42	2873	1680	1282	787	1266	1178	594	930	594	321	379	209	250	265	106	376	455	370	221	148	192	160	296	535	768	554	552	475	405	1612	800	717	42
44	2663	2017	1492	1020	630	936	708	472	356	295	375	205	130	172	96	136	263	227	123	87	95	126	78	179	519	462	488	267	308	955	611	854	44
46	788	1165	1318	883	604	705	803	451	232	216	339	218	221	138	189	123	134	139	98	67	64	138	80	88	251	533	411	285	181	539	384	750	46
48	467	527	763	582	602	349	729	405	312	285	285	327	156	177	289	136	197	177	169	81	67	93	76	119	130	133	313	397	299	388	344	337	48
50	203	191	291	184	331	397	419	468	233	317	330	260	133	211	310	206	344	203	97	101	157	83	151	139	108	86	192	413	314	387	340	416	50
52	162	164	101	117	120	236	273	279	104	153	235	271	76	187	233	142	412	261	91	61	156	97	138	253	153	121	88	189	347	399	418	399	52
54	72	47	46	28	40	62	117	183	66	29	90	60	21	98	77	45	208	109	35	60	174	82	58	151	117	93	95	95	180	260	330	467	54
56	55	15	21	14	7	24	76	31	34	21	44	35	7		44	21	54	104	85	33	91	34	97	142	81	48	48	48	67	130	110	254	56
58	28	6	6	7		16		6	6	7	6	6		6		8	20	16				14			44	20	56	48	15	32	99	124	58
60								6	6			6							7	7	9				15	14	7	35	14	65	33	93	60
62							6																							19	20	23	62
64																													14		6	7	64
66					6																										7	7	66
68																														6			68
Total	27410	27391	20946	17643	13728	11648	11247	9376	5658	3770	3800	2672	2132	3168	1971	2769	4015	3326	2188	1401	3263	2839	4962	6917	6614	4670	4477	4951	6525	10127	7187	7796	Total
Mean length (cm)	36.6	34.3	36.4	36.6	37.5	38.6	40.0	40.8	40.7	41.7	43.3	44.3	41.6	41.8	45.8	41.8	42.5	42.3	42.1	38.9	33.3	34.7	34.9	36.7	39.3	40.9	41.1	38.7	37.5	40.3	41.4	43.7	Mean length (cm)

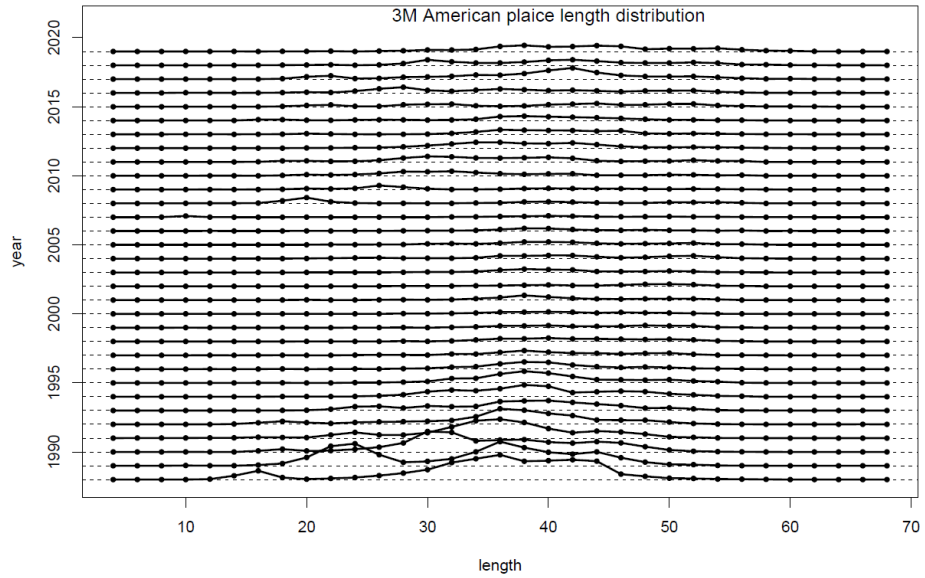

Figure 4. Length composition of the 3M American plaice stock, EU survey 1988-2019

Table 4. EU survey length weight relationships of 3M American plaice.

Year	a	b	n
1988	0.0048	3.2121	1211
1989	0.0055	3.1810	1192
1990	0.0043	3.2420	1314
1991	0.0043	3.2404	1032
1992	0.0048	3.2130	1296
1993	0.0030	3.3362	1036
1994	0.0029	3.3373	1066
1995	0.0027	3.3474	772
1996	0.0048	3.1978	571
1997	0.0046	3.2116	437
1998	0.0044	3.2260	442
1999	0.0043	3.2294	452
2000	0.0082	3.0444	411
2001	0.0044	3.2074	570
2002	0.0029	3.3242	225
2003	0.0044	3.2292	400
2004	0.0064	3.1222	602
2005	0.0043	3.2177	345
2006	0.0058	3.1403	312
2007	0.0042	3.2301	209
2008	0.0062	3.1235	410
2009	0.0051	3.1802	420
2010	0.0037	3.2660	398
2011	0.0033	3.3053	528
2012	0.0037	3.2771	752
2013	0.0042	3.2452	672
2014	0.0038	3.2786	617
2015	0.0038	3.2772	718
2016	0.0042	3.2521	946
2017	0.0035	3.2946	1095
2018	0.0051	3.2008	974
2019	0.0037	3.2871	968

Table 5. Population abundance (000s) at age (yrs) of A. plaice from Div. 3M EU survey 1988-2019.

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1988	483	1339	1619	3955	3725	3423	5016	3004	1802	1157	669	418	230	358	138	74	27410
1989	55	1827	6621	2682	2787	2544	3794	2548	1616	1089	672	429	221	332	117	57	27391
1990	8	665	1581	5311	2456	1802	2785	2066	1427	995	648	432	242	337	128	62	20946
1991	154	353	1628	2530	2796	1945	2645	1855	1283	879	575	378	186	262	91	83	17643
1992	24	795	886	1210	1544	1682	2433	1642	1142	813	541	363	187	287	108	71	13728
1993		27	1536	1082	775	447	4116	467	782	367	257	299	354	1065	32	42	11648
1994	7	47	45	2134	1034	878	983	3425	322	654	224	221	252	519	490	9	11247
1995		29	115	741	2127	1368	1377	913	1536	161	181	145	145	292	219	28	9376
1996	8	39	116	260	585	1666	894	545	403	630	144	78	82	109	69	28	5658
1997	8	16	110	25	122	419	1204	270	413	293	487	129	25	93	47	110	3770
1998		25	31	47	72	266	622	903	526	356	301	288	88	113	57	105	3800
1999	7		23	65	79	80	241	472	510	255	338	207	121	117	59	98	2672
2000	16	25	7	84	106	153	119	153	392	427	231	185	74	56	46	59	2132
2001		40	52	58	104	56	111	268	438	581	478	420	190	162	111	99	3168
2002			32	65	17	89	66	126	159	190	297	221	249	142	131	187	1971
2003	7	6	32	93	80	58	79	147	300	258	431	426	272	272	148	160	2769
2004		117	280	73	79	107	105	127	246	316	285	598	426	404	327	525	4015
2005		31	111	288	106	106	126	102	224	206	225	252	353	403	252	540	3326
2006	7	28	37	107	133	139	72	57	123	163	200	193	192	211	200	326	2188
2007	207	7	13	35	106	119	49	49	35	47	76	122	143	82	75	236	1401
2008	43	1501	69		32	127	120	108	104	111	63	47	118	110	150	561	3263
2009	26	292	1108	147	29	21	78	56	92	90	132	120	63	106	120	357	2839
2010	20	341	605	2004	301	187	72	139	122	70	56	176	125	114	134	497	4962
2011		396	599	1384	2467	454	94	49	90	176	144	55	107	148	82	672	6917
2012	7	60	447	629	980	2833	447	84	111	143	125	115	45	133	130	324	6614
2013	27	198	76	311	718	866	1596	138	64	94	109	108	55	61	54	195	4670
2014	8	344	219	144	135	510	816	1569	190	65	55	62	46	64	50	200	4477
2015	20	578	695	599	101	109	328	609	1320	140	49	33	41	47	55	228	4951
2016	70	179	1179	1273	936	263	240	406	518	1079	77	49	21	27	34	175	6525
2017		847	441	923	1397	891	282	549	883	1528	1623	209	68	71	85	329	10127
2018		211	980	717	902	1133	651	300	288	467	617	519	66	60	46	228	7187
2019	30	137	458	918	719	1032	911	794	318	240	488	652	504	307	75	213	7796

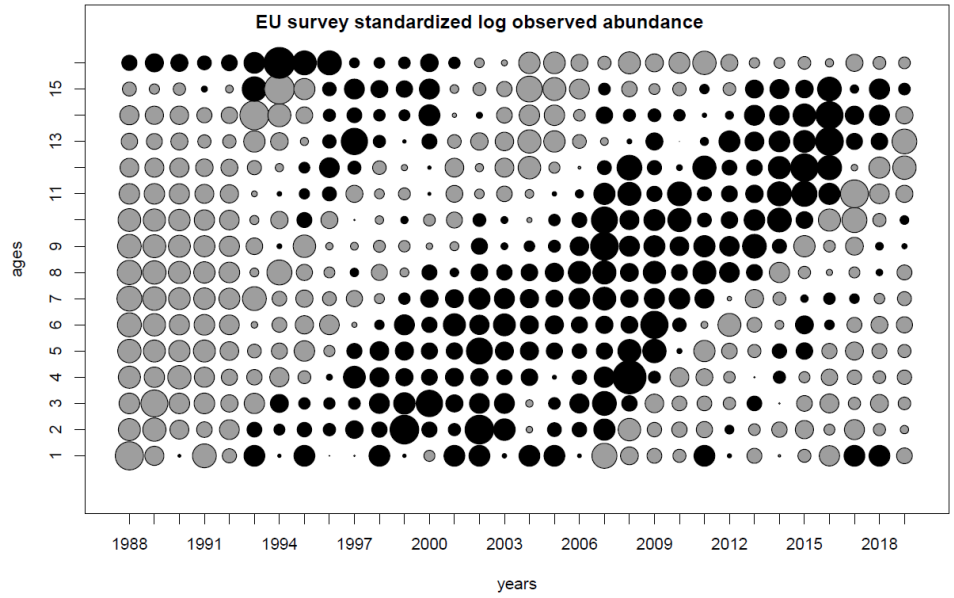

Figure 5. EU survey standardized log observed abundance at age of the 3M American plaice stock, 1988-2019 (grey-positive, black-negative).

Table 6. Population weights (kg) at age (yrs) of the A. plaice from Div. 3M EU survey, 1988-2019.

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
1988	0.027	0.048	0.152	0.338	0.495	0.620	0.721	0.786	0.801	0.820	0.876	0.959	1.201	1.208	1.537	1.742
1989	0.013	0.090	0.151	0.295	0.523	0.630	0.725	0.815	0.839	0.856	0.912	0.991	1.181	1.186	1.462	1.646
1990	0.010	0.062	0.189	0.312	0.425	0.564	0.709	0.829	0.857	0.893	0.956	1.029	1.179	1.200	1.412	1.578
1991	0.015	0.070	0.157	0.341	0.478	0.563	0.660	0.770	0.799	0.829	0.886	0.953	1.141	1.157	1.417	1.634
1992	0.029	0.063	0.158	0.315	0.516	0.616	0.684	0.758	0.807	0.832	0.910	1.000	1.182	1.190	1.408	1.712
1993		0.061	0.160	0.295	0.407	0.579	0.727	0.755	0.798	0.874	0.906	0.932	1.075	1.218	1.839	1.628
1994	0.001	0.062	0.162	0.316	0.490	0.568	0.650	0.808	0.954	0.917	1.025	1.025	1.271	1.228	1.540	1.895
1995		0.044	0.191	0.330	0.488	0.624	0.668	0.789	0.888	1.222	1.279	1.468	1.518	1.515	1.563	2.082
1996	0.017	0.055	0.190	0.332	0.469	0.589	0.708	0.823	0.929	0.864	1.081	1.390	1.307	1.519	1.649	1.777
1997	0.017	0.049	0.171	0.236	0.427	0.559	0.673	0.643	0.859	0.998	1.007	1.215	1.275	1.437	1.607	1.515
1998		0.090	0.174	0.260	0.384	0.514	0.652	0.778	0.826	1.027	1.239	1.322	1.501	1.513	1.606	1.650
1999	0.010		0.166	0.315	0.440	0.546	0.568	0.773	0.849	0.998	1.178	1.275	1.462	1.705	1.563	1.587
2000	0.016	0.091	0.115	0.245	0.409	0.522	0.614	0.673	0.756	0.748	0.848	0.939	1.222	1.177	1.295	1.386
2001		0.072	0.210	0.245	0.374	0.434	0.528	0.603	0.622	0.702	0.703	0.853	1.076	1.321	1.427	1.487
2002			0.191	0.287	0.398	0.444	0.668	0.757	0.711	0.871	1.098	1.151	1.298	1.415	1.486	1.524
2003	0.017	0.041	0.134	0.327	0.361	0.457	0.543	0.669	0.674	0.735	0.794	0.858	0.886	1.028	1.314	1.499
2004		0.110	0.182	0.307	0.457	0.565	0.594	0.691	0.710	0.754	0.785	0.837	0.999	1.092	1.240	1.490
2005		0.094	0.180	0.295	0.396	0.527	0.643	0.620	0.747	0.792	0.795	0.827	0.885	0.920	1.048	1.413
2006	0.018	0.119	0.212	0.350	0.475	0.600	0.711	0.673	0.715	0.679	0.792	0.845	0.769	0.876	0.925	1.294
2007	0.010	0.079	0.128	0.354	0.588	0.621	0.695	0.987	0.912	0.949	0.783	0.767	0.913	0.874	0.873	1.537
2008	0.018	0.081	0.123		0.304	0.613	0.729	0.749	0.930	0.846	0.880	0.824	0.907	0.971	0.944	1.410
2009	0.018	0.085	0.191	0.240	0.383	0.735	0.735	0.776	0.887	0.853	0.817	0.940	0.804	0.878	0.923	1.385
2010	0.021	0.086	0.199	0.301	0.427	0.478	0.590	0.661	0.940	0.878	0.892	0.834	0.798	1.012	0.982	1.388
2011		0.073	0.195	0.301	0.521	0.635	0.713	0.854	0.986	1.119	1.041	0.956	1.046	1.249	1.161	1.541
2012	0.017	0.111	0.244	0.369	0.485	0.679	0.774	0.818	0.958	1.253	1.267	1.073	1.132	1.036	1.493	1.548
2013	0.014	0.084	0.313	0.474	0.570	0.736	0.877	1.089	0.979	1.255	1.338	1.143	1.188	1.528	1.204	1.539
2014	0.010	0.081	0.227	0.317	0.654	0.824	0.891	0.964	1.041	1.072	1.692	1.432	1.336	1.140	1.457	1.667
2015	0.023	0.078	0.225	0.301	0.521	0.755	0.955	1.050	1.152	1.380	1.364	1.295	1.316	1.483	1.526	1.511
2016	0.017	0.080	0.201	0.308	0.513	0.594	0.929	1.148	1.105	1.263	1.605	1.717	1.383	1.281	1.179	1.605
2017		0.094	0.192	0.358	0.512	0.728	0.791	0.937	1.032	1.025	1.132	1.345	1.480	1.513	1.635	1.414
2018		0.119	0.301	0.366	0.583	0.787	0.978	1.135	1.185	1.313	1.411	1.520	1.513	1.728	1.584	2.031
2019	0.020	0.134	0.315	0.479	0.612	0.757	0.994	1.145	1.136	1.343	1.527	1.601	1.599	1.494	1.656	2.204
mean	0.016	0.080	0.191	0.320	0.471	0.608	0.722	0.823	0.887	0.967	1.057	1.104	1.183	1.253	1.374	1.604

Table 7. Criteria applied to convert total catches in weight to total catches in number, 2017-2019.

YEAR	TOTAL CATCH (tonnes)	BREAKDOWN TOTAL CATCH (tonnes)	LENGTHS COMPOSITION				MEAN WEIGHT (kg)	TOTAL CATCH IN NUMBER (000's)
			Country	Source	Gear	Paper		
2017	157.1	143.2	Portugal	Commercial	OTB	scs 18/08	1.281	111.8
		13.9	Russia	Commercial	OTB	scs 18/13	0.967	14.4
2018	215.3	215.3	Portugal	Commercial	OTB	scs 19/09	1.246	172.9
2019	302.0	27.9	Spain	Commercial	OTB	scs 20/07	1.018	27.4
		0.0	Portugal	Commercial	OTB	scs 20/09	1.439	0.0
		274.1	Russia	Commercial	OTB	scs 20/13	1.011	271.3

Table 8. Length composition (absolute frequencies in '000) of the 3M American plaice catches, 1988-2019.

Length group	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Length group
14																							0.5				0.1	0.1					14
16		19.3	0.8				0.7	3.0															0.2				1.1						16
18		60.5	3.9				2.9	3.2																1.6		0.3	3.6	2.2	1.3				18
20	6.9	126.5	2.0		5.3	1.8	3.3																0.9	4.7	0.4	1.3	8.9	4.8	4.3				20
22	10.4	88.0	8.2	5.8	1.3	6.9	3.2						0.3	0.1			0.1						1.0	6.3	0.9	9.3	30.2	11.3	10.8				22
24	65.6	35.8	10.4	6.6	1.4	14.3	4.8	9.7	5.1		0.2			0.2			0.1						3.1	7.9	1.4	10.1	34.1	25.3	19.5				24
26	186.5	41.3	20.2	0.0	7.4	16.1	18.3	9.7	0.4		0.2		0.7	0.5	0.3	0.02				1.9			2.9	20.4	1.5	25.9	32.1	35.9	24.6				26
28	345.3	131.2	43.2	23.2	23.7	17.1	30.6	24.3	10.0		0.5		9.4	3.0	1.1	0.1	1.3		0.2	3.3	1.0		2.3	47.1	4.0	36.9	53.8	53.6	46.2			1.0	28
30	276.2	226.7	91.7	28.2	37.5	23.2	71.1	45.4	31.6		0.7		16.3	10.0	2.2	0.5	2.3		2.4	7.9	1.6		7.9	51.0	5.0	43.3	49.3	73.5	85.8	0.5		1.5	30
32	303.9	365.4	131.9	109.7	36.7	23.0	94.4	136.9	63.4		1.8	5.2	21.5	18.1	5.1	2.5	4.2		2.9	16.4	1.0	3.7	10.0	39.9	17.3	75.1	31.2	60.6	84.9			5.7	32
34	611.2	569.3	96.5	203.1	61.0	19.9	81.3	142.1	98.4	14.6	4.0	10.4	23.4	22.5	17.9	3.0	4.5	0.2	11.2	17.3	3.1	2.4	19.0	16.8	17.3	37.2	31.9	47.2	58.3	1.7	1.1	9.7	34
36	621.5	603.5	86.9	283.0	90.5	28.5	88.0	225.2	86.5	13.0	6.2	25.9	23.6	29.7	27.9	10.8	7.9	0.5	7.8	21.3	5.7	15.9	11.7	7.2	18.1	43.2	16.3	33.3	27.8	2.8	5.0	17.2	36
38	372.9	477.8	71.1	147.1	122.7	37.5	128.1	294.5	74.7	24.4	15.6	51.9	24.5	31.1	24.7	15.2	12.8	1.5	10.9	19.4	5.7	14.7	13.7	3.0	27.1	39.2	31.2	26.9	15.3	4.0	13.8	23.9	38
40	372.9	356.7	70.6	146.2	108.2	29.4	112.6	249.8	47.4	37.8	22.6	15.6	23.0	28.9	24.1	25.1	12.8	3.9	11.2	11.6	5.2	23.2	5.9	5.5	23.3	23.6	34.6	29.0	11.9	10.0	15.1	46.0	40
42	473.1	696.1	82.1	147.7	57.1	34.6	44.9	166.2	47.2	22.8	17.8	20.8	17.1	22.2	22.9	22.1	9.8	3.6	8.4	15.3	5.2	12.2	3.5	0.7	20.3	21.7	25.4	19.4	4.6	10.2	14.8	51.1	42
44	397.1	630.2	125.0	320.8	67.8	32.6	55.2	86.1	23.3	8.1	44.0	36.3	12.9	18.1	12.8	5.5	12.3	1.5	3.9	6.4	2.1	3.7	2.5		21.7	18.7	22.1	14.7	3.4	15.1	20.6	44.2	44
46	158.8	405.0	132.8	295.7	79.8	25.6	63.3	84.6	14.1	17.2	36.5	31.1	11.6	14.3	10.7	16.0	7.1	2.7	4.3	4.5	4.1	4.9	2.9		10.9	11.7	14.6	9.3	1.6	21.3	20.2	27.8	46
48	76.0	97.4	73.9	120.1	86.9	23.0	59.4	78.4	12.7	33.5	30.9	46.7	9.8	12.6	9.8	10.9	6.0	5.4	1.3	2.2	4.1	4.9	1.4	0.4	3.5	12.9	19.6	14.6	1.9	13.1	20.3	18.9	48
50	62.2	68.0	30.3	106.6	63.2	22.0	35.4	94.0	8.4	24.4	37.8	25.9	6.5	6.5	6.4	14.8	6.5	8.0	1.8	2.2	5.2	8.6	2.0	0.4	2.4	10.4	7.5	14.4	3.0	15.4	21.7	21.6	50
52	72.5	35.8	9.6	9.1	33.1	12.7	24.3	58.5	2.8	16.3	36.1	10.4	6.9	3.6	5.4	6.9	5.6	6.6	0.4	0.4	6.2		1.7		1.3	3.9	3.6	10.0	2.3	14.8	18.6	11.2	52
54	34.5	27.5	6.7	3.0	10.3	3.8	10.8	40.2	0.6	4.1	5.3		0.8	1.5	1.9	3.0	2.4	3.4	1.1	0.6	6.2		0.7		0.8	4.2	2.9	5.3	1.4	11.5	10.3	11.0	54
56	17.3	13.8	3.4	0.004	5.4	1.6	7.4	7.2	0.3	1.7	4.4		0.4	0.5	0.2	0.2	0.2	0.5	0.2	0.2	2.1		1.9		0.5	3.4	1.1	3.6	0.7	3.2	6.0	3.1	56
58	3.5		0.8	0.002	4.8	0.7		1.5			0.03			0.1			0.04				2.6		2.6		0.0	2.1	4.8	1.2	0.6	1.7	2.3	2.3	58
60					0.01	0.1		1.5						0.04					0.1		2.1		1.3			0.2	0.03	1.3	0.1	0.9	2.0	2.0	60
62			0.1			0.001	0.6							0.1		1.0										0.1		0.5	0.1		1.1	0.6	62
64														0.01									0.5						0.03				64
66																							0.2										66
68																			0.1														68
Total	4468.2	5075.7	1102.2	1955.9	904.0	374.5	940.5	1762.1	527.0	218.0	264.8	280.2	208.7	223.8	173.5	137.5	95.8	37.7	68.3	131.1	63.1	94.1	100.3	212.8	177.7	434.7	459.9	497.9	410.3	126.2	172.9	298.6	Total
Mean length (cm)	37.9	38.7	39.5	41.6	41.8	39.6	39.5	40.8	37.9	44.6	46.7	43.9	39.3	40.3	41.3	44.1	42.8	48.4	40.2	38.2	46.1	41.6	38.0	30.8	39.6	36.2	34.7	35.2	32.7	47.9	47.5	44.3	Mean length (cm)

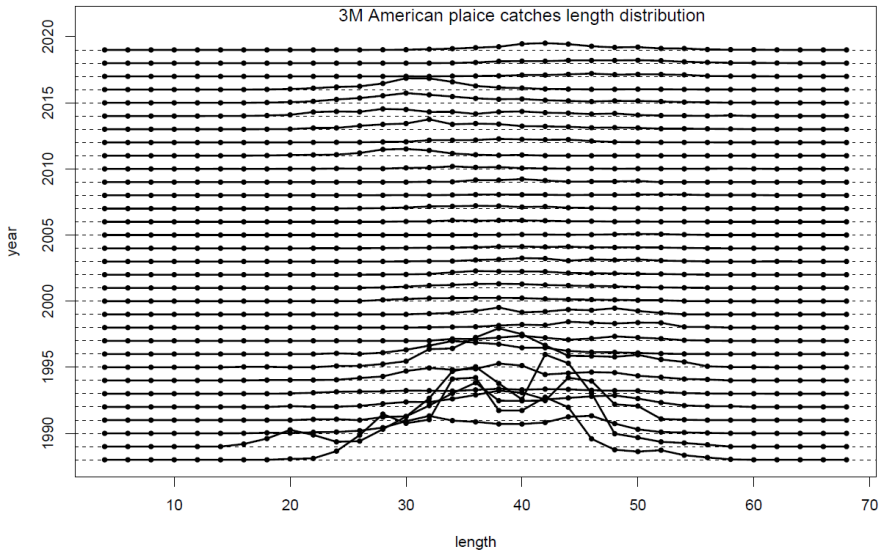

Figure 6. Length composition of the 3M American plaice catches, 1988-2019

Table 9. Catch in number (000s) at age (yrs) of the 3M American plaice, 1988-2019.

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+	Total
1988		7	311	731	549	440	720	532	386	265	173	118	65	102	43	25	4468
1989		175	209	573	527	482	886	715	520	356	230	148	80	118	39	19	5076
1990		7	49	183	112	87	158	147	110	78	55	39	24	33	13	7	1102
1991		1	19	133	185	168	342	331	243	174	124	84	50	68	23	12	1956
1992		4	17	76	75	76	136	124	100	77	60	46	31	45	23	14	904
1993			47	42	26	11	112	13	24	12	9	11	15	49	2	2	375
1994		4	6	219	98	77	75	254	24	48	16	17	20	40	43	1	941
1995		6	24	167	458	235	231	155	250	31	35	30	30	58	45	7	1762
1996			13	60	101	173	63	41	23	34	6	3	3	3	2	0.4	527
1997					4	17	61	12	28	23	35	13	3	9	4	10	218
1998			0.3	1	2	7	28	57	36	31	32	33	8	14	7	10	265
1999				4	6	8	27	59	60	35	40	21	9	5	3	5	280
2000		0.2	0.1	19	25	25	12	13	33	35	17	13	6	3	3	4	209
2001			5	6	16	8	10	21	30	41	35	29	10	6	3	3	224
2002			1	8	4	17	13	21	22	23	24	17	12	4	3	5	174
2003			0.02	2	2	2	3	6	13	12	23	25	16	15	9	10	138
2004		0.1	1	2	3	3	4	4	8	10	8	16	10	9	7	9	96
2005				0.1	0.2	0.4	1	1	2	2	2	3	5	5	4	12	38
2006			1	5	7	4	2	3	4	7	7	5	6	6	5	6	68
2007			2	22	22	17	6	4	3	3	8	14	11	8	6	5	131
2008					2	6	4	4	4	4	2	1	4	3	4	23	63
2009				1	4	2	7	5	6	8	11	7	6	14	9	14	94
2010	0.5	2	6	35	10	7	2	5	3	2	1	5	4	2	3	13	100
2011		12	45	86	63	4	0.4	0.2	0.3	1	0.2	0.0	0.1	0.3	0.2	1	213
2012		1	9	16	26	79	14	3	4	4	4	3	1	4	3	7	178
2013		11	109	70	67	56	79	6	3	4	5	6	2	3	2	11	435
2014		62	107	69	15	37	43	91	9	6	2	3	3	3	2	9	460
2015		26	122	145	37	11	28	32	66	8	2	2	2	3	2	12	498
2016		10	88	167	84	17	10	6	9	13	1	1	0.2	0.3	1	2	410
2017			0.1	2	7	11	3	10	16	26	35	5	2	2	2	6	126
2018			0.2	2	16	28	23	12	11	18	26	22	3	3	2	9	173
2019		0.2	6	26	26	53	57	41	15	9	15	20	15	9	2	5	299

Table 10. Mean weight (kg) at age (yrs) of the 3M American plaice catches, 1988-2019.

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16+
1988		0.097	0.200	0.312	0.449	0.572	0.684	0.762	0.790	0.823	0.886	0.981	1.215	1.271	1.590	1.736
1989		0.079	0.165	0.342	0.479	0.617	0.750	0.842	0.860	0.882	0.928	0.985	1.136	1.185	1.484	1.717
1990		0.072	0.191	0.320	0.424	0.558	0.738	0.889	0.924	0.963	1.031	1.095	1.223	1.262	1.481	1.618
1991		0.115	0.189	0.367	0.480	0.598	0.763	0.891	0.929	0.962	1.035	1.087	1.188	1.206	1.361	1.477
1992		0.086	0.210	0.327	0.487	0.606	0.723	0.855	0.919	0.966	1.074	1.169	1.373	1.381	1.574	1.666
1993			0.162	0.296	0.394	0.580	0.756	0.813	0.865	0.979	1.039	1.059	1.179	1.339	1.819	1.627
1994		0.061	0.155	0.314	0.487	0.562	0.653	0.824	0.969	0.954	1.068	1.065	1.318	1.289	1.561	1.895
1995		0.044	0.190	0.335	0.494	0.626	0.684	0.816	0.925	1.244	1.320	1.474	1.532	1.547	1.571	2.108
1996			0.225	0.331	0.425	0.535	0.671	0.733	0.852	0.825	1.002	1.302	1.202	1.385	1.539	1.333
1997					0.445	0.639	0.726	0.682	0.949	1.059	1.097	1.270	1.261	1.509	1.508	1.513
1998			0.185	0.269	0.396	0.554	0.776	0.889	0.950	1.140	1.337	1.380	1.461	1.509	1.589	1.613
1999				0.365	0.495	0.536	0.581	0.786	0.872	0.943	1.109	1.194	1.337	1.445	1.439	1.389
2000		0.115	0.115	0.268	0.359	0.444	0.566	0.637	0.706	0.692	0.782	0.891	1.225	1.140	1.290	1.389
2001			0.263	0.283	0.340	0.401	0.471	0.595	0.615	0.691	0.703	0.805	0.975	1.150	1.298	1.534
2002			0.231	0.341	0.398	0.436	0.622	0.692	0.658	0.734	0.813	0.850	0.992	1.349	1.378	1.470
2003			0.232	0.419	0.419	0.554	0.613	0.754	0.746	0.786	0.868	0.949	0.968	1.084	1.311	1.567
2004		0.125	0.242	0.331	0.432	0.539	0.554	0.704	0.716	0.788	0.795	0.815	0.926	0.998	1.100	1.333
2005				0.436	0.573	0.721	0.902	0.806	0.928	0.977	0.941	1.045	1.116	1.181	1.292	1.442
2006			0.275	0.377	0.438	0.596	0.674	0.534	0.678	0.627	0.719	0.747	0.692	0.732	0.790	1.144
2007			0.177	0.306	0.472	0.567	0.614	0.778	0.604	0.816	0.612	0.691	0.723	0.653	0.716	1.203
2008					0.307	0.554	0.760	0.717	0.946	0.853	0.967	0.898	0.939	0.986	1.026	1.567
2009				0.341	0.429	0.653	0.622	0.668	0.752	0.619	0.705	0.816	0.737	0.745	0.787	1.018
2010	0.026	0.095	0.193	0.355	0.466	0.502	0.615	0.601	0.865	0.726	0.807	0.747	0.758	0.996	0.906	1.732
2011		0.093	0.196	0.281	0.384	0.552	0.669	0.773	0.874	0.923	0.712	0.834	0.744	1.021	0.987	0.980
2012		0.117	0.251	0.389	0.514	0.721	0.781	0.802	0.866	0.976	1.009	0.876	0.927	0.908	1.267	1.106
2013		0.107	0.250	0.372	0.486	0.619	0.854	1.069	0.959	1.371	1.418	1.155	1.282	1.595	1.247	1.613
2014		0.118	0.225	0.308	0.551	0.680	0.836	0.874	0.977	0.867	1.613	1.469	1.536	1.093	1.363	1.682
2015		0.119	0.239	0.330	0.467	0.614	0.733	0.938	1.063	1.214	1.439	1.303	1.170	1.489	1.478	1.485
2016		0.094	0.224	0.328	0.437	0.488	0.543	0.926	0.879	1.079	1.581	1.965	1.356	1.276	0.853	1.494
2017			0.283	0.481	0.641	0.863	0.900	1.146	1.292	1.299	1.394	1.583	1.525	1.467	1.336	1.581
2018			0.496	0.541	0.664	0.851	1.098	1.251	1.306	1.410	1.448	1.541	1.483	1.701	1.614	1.956
2019		0.235	0.378	0.495	0.653	0.822	0.978	1.112	1.123	1.210	1.371	1.478	1.449	1.402	1.544	2.072
mean	0.026	0.104	0.227	0.352	0.465	0.599	0.716	0.817	0.886	0.950	1.051	1.110	1.155	1.228	1.316	1.533

Table 11. 3M American plaice exploitation pattern given by the generalized logit of the 1988-2019 observed partial recruitment.

Age	F at age index	Observed PR	Logit PR	Squared difference
1	0.019	0.016	0.004	0.000
2	0.265	0.219	0.219	0.000
3	0.767	0.634	0.659	0.001
4	1.209	1.000	0.892	0.012
5	1.089	0.901	0.969	0.005
6	1.006	0.832	0.992	0.025
7	0.941	0.778	0.998	0.048
8	1.024	0.847	0.999	0.023
9	1.032	0.853	1.000	0.022
10	1.096	0.906	1.000	0.009
11	1.202	0.994	1.000	0.000
12	1.145	0.947	1.000	0.003
13	1.058	0.875	1.000	0.016
14	1.108	0.916	1.000	0.007
15	1.031	0.853	1.000	0.022
16	0.965	0.798	1.000	0.041
		Minimum sum of squares		0.232

Curve parameters	a	b	m
	3.313	1.296	558.569

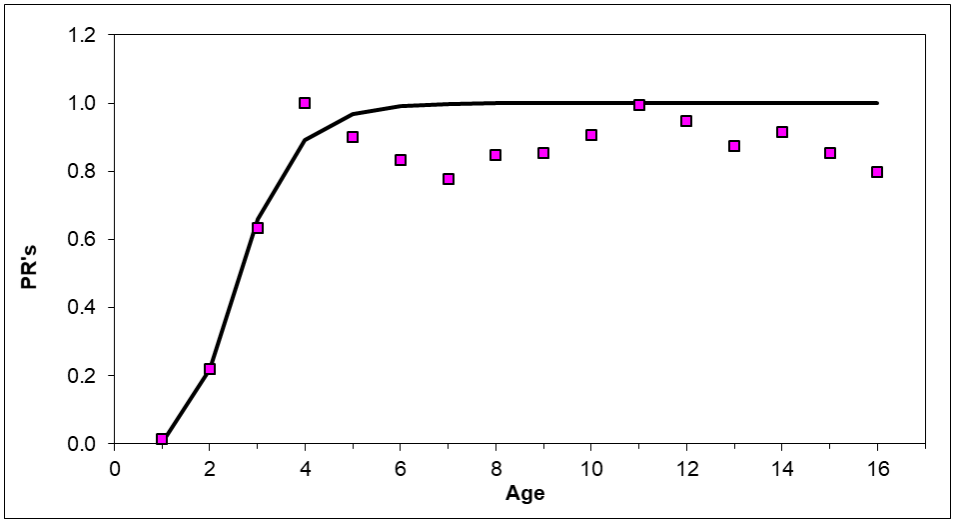

Figure 7. 3M American plaice partial recruitment (logit – line, observed - squares), 1988-2019.

Table 12 A. Yield per recruit parameters for 3M American plaice.

Age	mean weights 88-19 (kg)		mat og. (%)	PR 88-19	Ref. M
	stock	catch			
1	0.016	0.026	0.000	0.004	0.20
2	0.080	0.104	0.000	0.219	0.20
3	0.191	0.227	0.000	0.659	0.20
4	0.320	0.352	0.000	0.892	0.20
5	0.471	0.465	0.500	0.969	0.20
6	0.608	0.599	1.000	0.992	0.20
7	0.722	0.716	1.000	0.998	0.20
8	0.823	0.817	1.000	0.999	0.20
9	0.887	0.886	1.000	1.000	0.20
10	0.967	0.950	1.000	1.000	0.20
11	1.057	1.051	1.000	1.000	0.20
12	1.104	1.110	1.000	1.000	0.20
13	1.183	1.155	1.000	1.000	0.20
14	1.253	1.228	1.000	1.000	0.20
15	1.374	1.316	1.000	1.000	0.20
16+	1.604	1.533	1.000	1.000	0.20

Ref. M
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15
0.15

Table 12 B. Yield per recruit results for 3M American plaice.

	M=0.2				
	Ref F	B	Y	SSB	Slope
	0.000	2570	0	2079	2,200
	0.000	2570	0	2079	1,743
	0.030	2080	52	1601	1,098
	0.060	1732	85	1265	711
	0.090	1476	107	1020	469
	0.120	1282	121	836	313
	0.150	1130	130	695	209
F0.1	**0.161**	**1085**	**133**	**653**	**220**
	0.180	1010	136	585	138
	0.210	912	140	496	88
	0.240	831	143	425	53
	0.270	764	145	366	28
	0.330	658	146	277	-3
Fmax	**0.337**	**648**	**146**	**269**	**0**
	0.360	616	146	243	-13
	0.390	579	145	213	-20
	0.420	546	145	188	-25
	0.450	518	144	167	-29
	0.480	492	143	148	-31

	M=0.15				
	Ref F	B	Y	SSB	Slope
	0.000	4279	0	3719	3,791
	0.000	4279	0	3719	2,840
	0.030	3267	85	2721	1,592
	0.060	2601	133	2069	921
	0.090	2138	161	1619	540
	0.120	1803	177	1296	313
F0.1	**0.124**	**1765**	**178**	**1260**	**379**
	0.150	1552	186	1057	174
	0.180	1359	191	876	86
	0.210	1207	194	734	30
	0.240	1084	195	622	-7
Fmax	**0.248**	**1056**	**195**	**597**	**0**
	0.270	983	195	532	-31
	0.330	829	192	397	-57
	0.360	769	191	346	-64
	0.390	718	189	303	-68
	0.420	673	187	267	-70
	0.450	633	185	236	-70
	0.480	599	183	209	-70

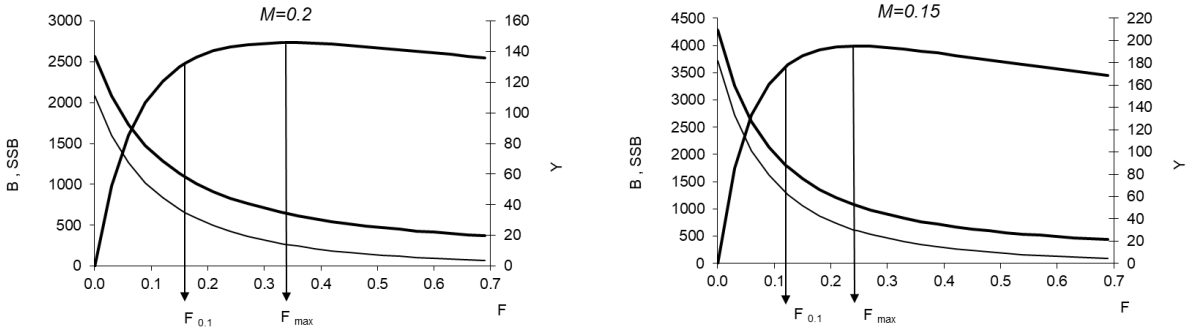

Figure 8. Yield, B and SSB per recruit curves for 3M American plaice.

Table 13. Trend of the 3M American plaice F index based in EU survey series (ages 8-11).

Year	Catch (tonnes)	Survey (tonnes)	C/B
1988	1082	5338	0.203
1989	1576	4979	0.317
1990	364	4443	0.082
1991	817	3692	0.221
1992	336	3335	0.101
1993	53	1531	0.034
1994	295	3903	0.076
1995	443	2512	0.176
1996	84	1525	0.055
1997	97	1311	0.074
1998	163	1874	0.087
1999	176	1450	0.121
2000	69	915	0.076
2001	84	1178	0.072
2002	65	700	0.093
2003	44	833	0.053
2004	23	724	0.032
2005	6	573	0.011
2006	13	395	0.033
2007	13	184	0.071
2008	12	327	0.036
2009	21	310	0.068
2010	8	318	0.025
2011	1	477	0.002
2012	13	513	0.025
2013	22	478	0.046
2014	96	1873	0.051
2015	114	2420	0.047
2016	29	2523	0.011
2017	114	4829	0.024
2018	92	2166	0.043
2019	95	2338	0.041

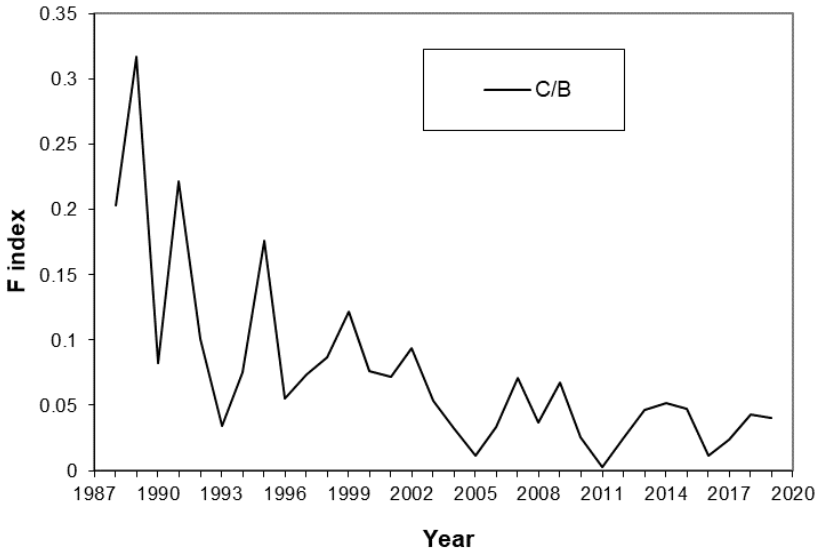

Figure 9. Trend of the 3M American plaice F index based in EU survey.

Table 14. Evolution of Recruitment ('000) and SSB ('000 tonnes) EU survey indices during the period 1988-2019.

Year	SSB	Age 3 recruits	R age 3/SSB *	Ln(R age 3/SSB) *
1988	13.5	1619	0.121	-2.1
1989	11.4	6621	0.078	-2.6
1990	9.4	1581	0.164	-1.8
1991	8.3	1628	0.005	-5.2
1992	7.6	886	0.015	-4.2
1993	7.0	1536	0.016	-4.1
1994	7.3	45	0.015	-4.2
1995	6.1	115	0.005	-5.3
1996	3.8	116	0.006	-5.1
1997	2.9	110	0.002	-6.1
1998	3.4	31	0.015	-4.2
1999	2.5	23	0.013	-4.4
2000	1.6	7	0.020	-3.9
2001	2.4	52	0.118	-2.1
2002	2.0	32	0.054	-2.9
2003	2.2	32	0.016	-4.1
2004	3.4	280	0.004	-5.5
2005	2.6	111	0.026	-3.7
2006	1.7	37	0.665	-0.4
2007	1.0	13	0.577	-0.5
2008	1.7	69	0.356	-1.0
2009	1.3	1108	0.357	-1.0
2010	1.7	605	0.045	-3.1
2011	3.0	599	0.074	-2.6
2012	4.0	447	0.172	-1.8
2013	3.4	76	0.350	-1.0
2014	3.7	219	0.119	-2.1
2015	3.4	695	0.285	-1.3
2016	3.6	1179	0.127	-2.1
2017	7.2	441		
2018	5.5	980		
2019	7.1	458		

(*) recruits per kg of SSB index

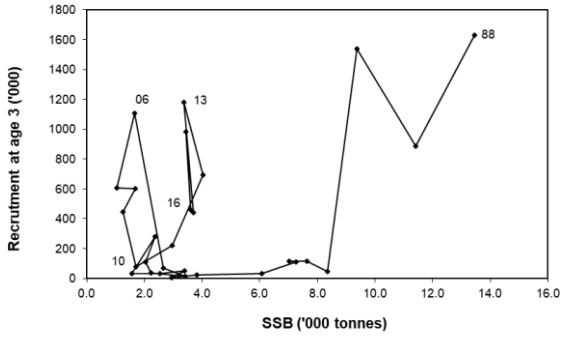

Figure 10. SSB-Recruitment scatter plot based in EU survey series.

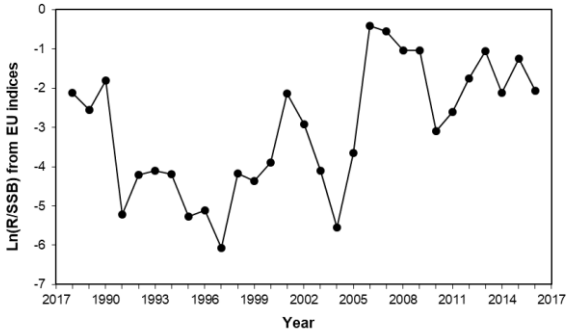

Figure 11. Recruit at age 3 produced per kg of SSB index from EU indices.

Table 15. Lowestoft XSA input files for 3M American plaice (2020 assessment)

AMERICAN PLAICE NAFO DIVISION 3M INDEX OF INPUT FILES
JUNE 2020
1
pla3mla.txt
pla3mcn.txt
pla3mcw.txt
pla3msw.txt
pla3mnm.txt
pla3mmo.txt
pla3mpf.txt
pla3mpm.txt
pla3mfo.txt
pla3mfn.txt
pla3mtun.txt

AMERICAN PLAICE NAFO 3M LANDINGS tons

1	1
1988	2019
1	16
5	**Catches Age 4+**
2800.0	2737.2
3500.0	3451.5
800.0	780.2
1600.0	1596.3
800.0	761.2
300.0	267.4
700.0	667.9
1300.0	1295.2
300.0	297.0
200.0	208.0
300.0	293.9
255.0	255.0
133.0	133.0
149.0	147.6
128.0	127.7
131.0	131.0
81.1	80.7
45.0	45.0
46.0	45.6
76.4	76.1
68.0	68.0
70.1	70.1
65.0	63.7
63.0	53.0
122.0	119.6
246.0	217.5
247.0	215.5
268.0	235.8
160.9	140.3
157.1	157.1
215.3	215.2
302.0	299.6

AMERICAN PLAICE NAFO 3M CATCH NUMBERS thousands

1	2														
1988	2019														
1	16														
1															
0.000	7.173	311.143	730.939	549.470	439.632	720.274	532.354	386.160	264.927	173.455	117.634	64.944	102.356	42.774	24.999
0.000	175.482	209.362	573.039	526.509	481.596	886.452	715.483	519.799	355.616	229.522	147.672	80.390	117.524	38.517	18.755
0.000	6.843	48.514	183.081	112.480	86.964	158.021	146.640	109.896	78.140	55.217	39.041	24.185	33.081	13.221	6.859
0.000	0.826	18.908	132.757	185.009	168.106	341.718	331.450	242.806	173.529	124.320	84.203	49.967	67.842	22.925	11.569
0.000	4.055	16.669	75.811	75.174	76.423	135.610	123.772	99.740	76.833	60.036	46.126	31.165	45.422	22.935	14.216
0.000	0.000	46.566	42.316	26.310	10.898	111.805	13.051	23.865	12.333	8.865	10.874	14.948	48.678	1.740	2.265
0.000	3.947	5.540	218.845	97.846	77.178	75.464	253.952	23.683	47.534	16.248	16.864	20.150	39.615	42.826	0.830
0.000	6.202	24.070	167.228	457.569	234.940	230.745	154.915	250.209	31.301	34.815	29.966	29.784	58.238	45.446	6.630
0.000	0.000	13.477	60.135	101.313	172.912	63.443	41.371	23.070	34.003	6.211	2.755	3.395	2.958	1.545	0.411
0.000	0.000	0.000	0.000	4.127	16.665	61.358	12.153	27.868	22.766	34.742	13.361	2.599	8.714	3.699	9.932
0.000	0.000	0.311	0.795	1.779	6.961	27.531	56.541	36.400	30.980	31.954	32.958	7.613	13.894	6.838	10.197
0.000	0.000	0.000	3.687	5.715	7.562	26.536	58.790	60.383	34.501	40.136	20.555	9.220	4.569	3.244	5.283
0.000	0.163	0.109	19.370	24.736	25.180	11.505	13.399	33.195	34.508	17.427	13.385	5.704	3.081	2.956	3.939
0.000	0.000	5.460	6.313	15.595	7.634	10.087	20.963	30.316	41.413	35.175	28.772	10.327	5.885	3.041	2.790
0.000	0.000	1.310	7.507	3.971	17.199	13.147	20.828	22.316	22.896	23.896	16.694	12.272	3.689	3.027	4.771
0.000	0.000	0.018	1.635	1.813	1.740	3.117	6.465	13.057	12.298	22.889	24.817	15.526	15.103	8.891	10.150
0.000	0.061	1.466	1.742	2.988	3.077	4.142	4.227	8.421	9.758	8.405	15.530	10.408	9.371	7.340	8.877
0.000	0.000	0.000	0.058	0.235	0.407	0.927	0.626	1.871	2.474	1.950	2.846	5.218	5.262	4.246	11.595
0.000	0.000	0.859	5.373	7.441	4.493	2.172	2.958	3.848	6.616	6.628	5.314	6.224	5.512	4.797	6.065
0.000	0.000	1.907	21.572	21.764	16.798	5.993	3.843	3.390	3.482	8.444	13.666	11.297	8.045	6.109	4.742
0.000	0.000	0.000	0.000	2.455	6.414	4.467	4.481	3.637	3.953	1.955	1.467	3.783	3.076	4.468	22.900
0.000	0.000	0.000	1.223	4.025	1.578	7.177	5.241	5.725	8.491	11.223	7.417	5.582	13.544	9.302	13.620
0.477	2.373	5.560	34.550	10.171	7.328	1.994	5.473	2.976	1.529	1.388	4.977	3.664	1.939	2.831	13.098
0.000	11.518	45.437	86.191	62.826	3.961	0.433	0.180	0.349	0.508	0.231	0.019	0.147	0.258	0.190	0.585
0.000	1.010	9.217	15.712	25.937	79.389	13.729	2.954	3.793	3.739	3.574	3.414	1.407	4.375	2.773	6.725
0.000	10.933	109.460	70.014	67.198	55.911	78.871	5.779	2.844	4.399	5.078	5.629	2.399	2.657	2.464	11.038
0.000	62.482	107.082	69.427	14.845	37.196	42.768	90.752	8.573	5.515	2.363	2.667	2.801	2.693	1.938	8.814
0.000	25.697	121.859	145.115	37.145	10.964	27.830	31.630	66.257	8.395	2.335	1.648	2.039	2.759	2.390	11.880
0.000	10.087	88.022	167.365	84.256	17.468	10.421	6.268	8.873	13.075	0.631	0.616	0.154	0.275	0.570	2.256
0.000	0.000	0.094	1.724	7.283	10.831	3.354	9.587	16.179	25.996	34.652	4.524	2.158	2.029	1.594	6.165
0.000	0.000	0.178	1.585	15.647	27.646	22.527	11.636	10.569	18.456	26.205	21.523	3.110	2.955	1.775	9.062
0.000	0.154	6.162	25.513	25.909	53.103	56.820	41.111	15.092	9.058	15.477	19.814	15.146	8.657	2.130	4.504

Table 15. cont.

AMERICAN PLAICE NAFO 3M CATCH WEIGHT AT AGE kg

1	3														
1988	2019														
1	16														
1															
0.026	0.097	0.200	0.312	0.449	0.572	0.684	0.762	0.790	0.823	0.886	0.981	1.215	1.271	1.590	1.736
0.026	0.079	0.165	0.342	0.479	0.617	0.750	0.842	0.860	0.882	0.928	0.985	1.136	1.185	1.484	1.717
0.026	0.072	0.191	0.320	0.424	0.558	0.738	0.889	0.924	0.963	1.031	1.095	1.223	1.262	1.481	1.618
0.026	0.115	0.189	0.367	0.480	0.598	0.763	0.891	0.929	0.962	1.035	1.087	1.188	1.206	1.361	1.477
0.026	0.086	0.210	0.327	0.487	0.606	0.723	0.855	0.919	0.966	1.074	1.169	1.373	1.381	1.574	1.666
0.026	*0.104*	0.162	0.296	0.394	0.580	0.756	0.813	0.865	0.979	1.039	1.059	1.179	1.339	1.819	1.627
0.026	0.061	0.155	0.314	0.487	0.562	0.653	0.824	0.969	0.954	1.068	1.065	1.318	1.289	1.561	1.895
0.026	0.044	0.190	0.335	0.494	0.626	0.684	0.816	0.925	1.244	1.320	1.474	1.532	1.547	1.571	2.108
0.026	*0.104*	0.225	0.331	0.425	0.535	0.671	0.733	0.852	0.825	1.002	1.302	1.202	1.385	1.539	1.333
0.026	*0.104*	*0.227*	*0.352*	0.445	0.639	0.726	0.682	0.949	1.059	1.097	1.270	1.261	1.509	1.508	1.513
0.026	*0.104*	0.185	0.269	0.396	0.554	0.776	0.889	0.950	1.140	1.337	1.380	1.461	1.509	1.589	1.613
0.026	*0.104*	*0.227*	0.365	0.495	0.536	0.581	0.786	0.872	0.943	1.109	1.194	1.337	1.445	1.439	1.389
0.026	0.115	0.115	0.268	0.359	0.444	0.566	0.637	0.706	0.692	0.782	0.891	1.225	1.140	1.290	1.389
0.026	*0.104*	0.263	0.283	0.340	0.401	0.471	0.595	0.615	0.691	0.703	0.805	0.975	1.150	1.298	1.534
0.026	*0.104*	0.231	0.341	0.398	0.436	0.622	0.692	0.658	0.734	0.813	0.850	0.992	1.349	1.378	1.470
0.026	*0.104*	0.232	0.419	0.419	0.554	0.613	0.754	0.746	0.786	0.868	0.949	0.968	1.084	1.311	1.567
0.026	0.125	0.242	0.331	0.432	0.539	0.554	0.704	0.716	0.788	0.795	0.815	0.926	0.998	1.100	1.333
0.026	*0.104*	*0.227*	0.436	0.573	0.721	0.902	0.806	0.928	0.977	0.941	1.045	1.116	1.181	1.292	1.442
0.026	*0.104*	0.275	0.377	0.438	0.596	0.674	0.534	0.678	0.627	0.719	0.747	0.692	0.732	0.790	1.144
0.026	*0.104*	0.177	0.306	0.472	0.567	0.614	0.778	0.604	0.816	0.612	0.691	0.723	0.653	0.716	1.203
0.026	*0.104*	*0.227*	*0.352*	0.307	0.554	0.760	0.717	0.946	0.853	0.967	0.898	0.939	0.986	1.026	1.567
0.026	*0.104*	*0.227*	0.341	0.429	0.653	0.622	0.668	0.752	0.619	0.705	0.816	0.737	0.745	0.787	1.018
0.026	0.095	0.193	0.355	0.466	0.502	0.615	0.601	0.865	0.726	0.807	0.747	0.758	0.996	0.906	1.732
0.026	0.093	0.196	0.281	0.384	0.552	0.669	0.773	0.874	0.923	0.712	0.834	0.744	1.021	0.987	0.980
0.026	0.117	0.251	0.389	0.514	0.721	0.781	0.802	0.866	0.976	1.009	0.876	0.927	0.908	1.267	1.106
0.026	0.107	0.250	0.372	0.486	0.619	0.854	1.069	0.959	1.371	1.418	1.155	1.282	1.595	1.247	1.613
0.026	0.118	0.225	0.308	0.551	0.680	0.836	0.874	0.977	0.867	1.613	1.469	1.536	1.093	1.363	1.682
0.026	0.119	0.239	0.330	0.467	0.614	0.733	0.938	1.063	1.214	1.439	1.303	1.170	1.489	1.478	1.485
0.026	0.094	0.224	0.328	0.437	0.488	0.543	0.926	0.879	1.079	1.581	1.965	1.356	1.276	0.853	1.494
0.026	*0.104*	0.283	0.481	0.641	0.863	0.900	1.146	1.292	1.299	1.394	1.583	1.525	1.467	1.336	1.581
0.026	*0.104*	0.496	0.541	0.664	0.851	1.098	1.251	1.306	1.410	1.448	1.541	1.483	1.701	1.614	1.956
0.026	0.235	0.378	0.495	0.653	0.822	0.978	1.112	1.123	1.210	1.371	1.478	1.449	1.402	1.544	2.072

AMERICAN PLAICE NAFO 3M STOCK WEIGHT AT AGE kg

1	4														
1988	2019														
1	16														
1															
0.027	0.048	0.152	0.338	0.495	0.620	0.721	0.786	0.801	0.820	0.876	0.959	1.201	1.208	1.537	1.742
0.013	0.090	0.151	0.295	0.523	0.630	0.725	0.815	0.839	0.856	0.912	0.991	1.181	1.186	1.462	1.646
0.010	0.062	0.189	0.312	0.425	0.564	0.709	0.829	0.857	0.893	0.956	1.029	1.179	1.200	1.412	1.578
0.015	0.070	0.157	0.341	0.478	0.563	0.660	0.770	0.799	0.829	0.886	0.953	1.141	1.157	1.417	1.634
0.029	0.063	0.158	0.315	0.516	0.616	0.684	0.758	0.807	0.832	0.910	1.000	1.182	1.190	1.408	1.712
0.016	0.061	0.160	0.295	0.407	0.579	0.727	0.755	0.798	0.874	0.906	0.932	1.075	1.218	1.839	1.628
0.001	0.062	0.162	0.316	0.490	0.568	0.650	0.808	0.954	0.917	1.025	1.025	1.271	1.228	1.540	1.895
0.016	0.044	0.191	0.330	0.488	0.624	0.668	0.789	0.888	1.222	1.279	1.468	1.518	1.515	1.563	2.082
0.017	0.055	0.190	0.332	0.469	0.589	0.708	0.823	0.929	0.864	1.081	1.390	1.307	1.519	1.649	1.777
0.017	0.049	0.171	0.236	0.427	0.559	0.673	0.643	0.859	0.998	1.007	1.215	1.275	1.437	1.607	1.515
0.016	0.090	0.174	0.260	0.384	0.514	0.652	0.778	0.826	1.027	1.239	1.322	1.501	1.513	1.606	1.650
0.010	*0.080*	0.166	0.315	0.440	0.546	0.568	0.773	0.849	0.998	1.178	1.275	1.462	1.705	1.563	1.587
0.016	0.091	0.115	0.245	0.409	0.522	0.614	0.673	0.756	0.748	0.848	0.939	1.222	1.177	1.295	1.386
0.016	0.072	0.210	0.245	0.374	0.434	0.528	0.603	0.622	0.702	0.703	0.853	1.076	1.321	1.427	1.487
0.016	*0.080*	0.191	0.287	0.398	0.444	0.668	0.757	0.711	0.871	1.098	1.151	1.298	1.415	1.486	1.524
0.017	0.041	0.134	0.327	0.361	0.457	0.543	0.669	0.674	0.735	0.794	0.858	0.886	1.028	1.314	1.499
0.016	0.110	0.182	0.307	0.457	0.565	0.594	0.691	0.710	0.754	0.785	0.837	0.999	1.092	1.240	1.490
0.016	0.094	0.180	0.295	0.396	0.527	0.643	0.620	0.747	0.792	0.795	0.827	0.885	0.920	1.048	1.413
0.018	0.119	0.212	0.350	0.475	0.600	0.711	0.673	0.715	0.679	0.792	0.845	0.769	0.876	0.925	1.294
0.010	0.079	0.128	0.354	0.588	0.621	0.695	0.987	0.912	0.949	0.783	0.767	0.913	0.874	0.873	1.537
0.018	0.081	0.123	*0.320*	0.304	0.613	0.729	0.749	0.930	0.846	0.880	0.824	0.907	0.971	0.944	1.410
0.018	0.085	0.191	0.240	0.383	0.735	0.735	0.776	0.887	0.853	0.817	0.940	0.804	0.878	0.923	1.385
0.021	0.086	0.199	0.301	0.427	0.478	0.590	0.661	0.940	0.878	0.892	0.834	0.798	1.012	0.982	1.388
0.016	0.073	0.195	0.301	0.521	0.635	0.713	0.854	0.986	1.119	1.041	0.956	1.046	1.249	1.161	1.541
0.017	0.111	0.244	0.369	0.485	0.679	0.774	0.818	0.958	1.253	1.267	1.073	1.132	1.036	1.493	1.548
0.014	0.084	0.313	0.474	0.570	0.736	0.877	1.089	0.979	1.255	1.338	1.143	1.188	1.528	1.204	1.539
0.010	0.081	0.227	0.317	0.654	0.824	0.891	0.964	1.041	1.072	1.692	1.432	1.336	1.140	1.457	1.667
0.023	0.078	0.225	0.301	0.521	0.755	0.955	1.050	1.152	1.380	1.364	1.295	1.316	1.483	1.526	1.511
0.017	0.080	0.201	0.308	0.513	0.594	0.929	1.148	1.105	1.263	1.605	1.717	1.383	1.281	1.179	1.605
0.016	0.094	0.192	0.358	0.512	0.728	0.791	0.937	1.032	1.025	1.132	1.345	1.480	1.513	1.635	1.414
0.016	0.119	0.301	0.366	0.583	0.787	0.978	1.135	1.185	1.313	1.411	1.520	1.513	1.728	1.584	2.031
0.020	0.134	0.315	0.479	0.612	0.757	0.994	1.145	1.136	1.343	1.527	1.601	1.599	1.494	1.656	2.204

Table 15. cont.

```
AMERICAN PLAICE NAFO 3M NATURAL MORTALITY
     1     5
  1988  2019
     1    16
     3
  0.15

AMERICAN PLAICE NAFO 3M PROPORTION MATURE AT AGE
     1     6
  1988  2019
     1    16
     2
  0.00  0.00  0.00  0.00  0.50  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00

AMERICAN PLAICE NAFO 3M PROPORTION OF F BEFORE SPAWNING
     1     7
  1988  2019
     1    16
     3
  0.42

AMERICAN PLAICE NAFO 3M PROPORTION OF M BEFORE SPAWNING
     1     8
  1988  2019
     1    16
     3
  0.42

AMERICAN PLAICE NAFO 3M F ON OLDEST AGE GROUP BY YEAR
     1     9
  1988  2019
     1    16
     5
 0.173
 0.270
 0.070
 0.189
 0.086
 0.029
 0.064
 0.150
 0.047
 0.063
 0.074
 0.103
 0.065
 0.061
 0.080
 0.045
 0.028
 0.010
 0.028
 0.061
 0.031
 0.058
 0.022
 0.002
 0.021
 0.040
 0.044
 0.040
 0.010
 0.020
 0.036
 0.035
```

Table 15. cont.

AMERICAN PLAICE NAFO 3M F AT AGE IN LAST YEAR

1	10														
1988	2019														
1	16														
2															
0.001	0.009	0.026	0.041	0.037	0.034	0.032	0.034	0.035	0.037	0.040	0.038	0.035	0.037	0.035	0.032

AMERICAN PLAICE NAFO 3M SURVEY TUNNING DATA

101															
EU BOTTOM TRAWL SURVEY															
1988	2019														
1	1	0.5	0.6												
1	15														
10555	483.2	1338.8	1618.6	3955.0	3725.0	3423.3	5016.5	3003.7	1802.1	1156.9	669.2	417.7	230.1	357.9	138.1
10555	55.0	1826.7	6621.2	2681.7	2786.6	2544.4	3794.3	2547.7	1615.7	1088.6	672.3	428.6	221.5	332.5	117.5
10555	7.6	665.1	1581.3	5311.4	2455.6	1802.2	2784.7	2066.0	1427.1	994.9	647.8	432.2	242.3	337.2	128.1
10555	153.6	353.2	1627.9	2530.3	2795.7	1944.8	2645.4	1855.1	1282.8	878.9	575.3	378.4	185.9	261.8	90.7
10555	23.5	795.4	885.5	1210.3	1544.0	1681.7	2432.7	1642.2	1141.8	813.1	541.5	362.9	187.2	286.8	108.4
10555	0.0	27.2	1535.5	1082.4	775.0	446.8	4115.8	467.5	781.9	366.6	257.5	299.0	354.4	1064.7	32.2
10555	7.5	47.2	45.4	2133.9	1033.6	878.2	983.2	3425.5	321.8	654.2	224.2	221.4	252.0	519.2	490.4
10555	0.0	28.6	114.6	741.1	2127.1	1367.6	1376.8	913.0	1535.9	161.3	180.8	145.1	145.0	292.1	219.0
10555	8.0	39.1	115.9	259.7	585.5	1666.2	894.1	545.4	403.4	630.4	144.3	77.9	82.2	109.4	69.0
10555	8.1	16.1	110.0	24.9	122.4	418.8	1203.8	269.8	413.4	292.5	487.5	128.9	24.9	92.9	46.6
10555	0.0	24.7	31.5	46.5	71.9	266.5	622.2	902.6	525.8	355.8	301.0	288.5	88.0	113.4	56.7
10555	7.4	0.0	23.2	65.4	78.7	79.5	241.0	471.6	509.9	254.8	337.8	207.1	121.3	117.1	59.1
10555	15.6	25.1	6.8	84.2	105.7	153.0	118.7	153.5	391.6	427.0	231.1	185.0	74.0	55.6	46.3
10555	0.0	39.8	52.2	58.2	104.1	56.1	111.0	267.6	437.9	580.7	478.5	419.8	189.9	161.6	111.4
10555	0.0	0.0	32.2	65.5	16.5	88.8	65.9	126.3	158.6	189.6	297.4	221.4	248.7	141.8	131.4
10555	7.1	6.2	31.6	93.3	79.8	58.2	79.3	147.4	299.7	258.0	431.4	425.5	271.9	272.2	148.0
10555	0.0	117.2	279.7	73.5	79.1	106.9	104.5	127.0	246.3	315.8	285.2	598.0	426.1	404.0	326.6
10555	0.0	31.5	111.4	287.8	106.3	105.9	125.9	101.5	224.4	206.4	225.1	251.5	353.0	403.2	252.3
10555	7.3	28.2	36.7	106.5	132.7	139.0	72.2	56.6	123.0	163.2	199.8	193.4	192.4	211.3	200.2
10555	207.2	6.7	13.4	35.2	105.8	119.4	49.3	48.6	34.5	47.3	75.8	122.0	143.2	82.1	74.9
10555	43.0	1501.3	68.6	0.0	32.0	126.8	119.8	108.0	104.0	111.1	62.6	46.9	117.9	109.9	150.0
10555	25.9	292.3	1107.7	147.1	29.4	20.8	78.2	55.8	92.2	90.4	132.3	119.8	63.3	105.9	120.5
10555	20.2	341.3	604.5	2003.6	301.1	186.8	71.8	139.4	121.6	70.1	56.2	175.6	124.6	113.8	134.4
10555	0.0	395.7	599.4	1384.4	2467.0	454.3	93.5	49.3	89.6	175.9	144.1	55.1	106.9	148.1	82.3
10555	7.2	59.7	446.9	629.0	979.9	2833.3	447.2	84.1	110.8	142.7	125.5	115.3	44.7	133.0	130.1
10555	26.6	197.7	76.4	310.7	717.8	865.9	1596.4	138.2	64.1	94.0	109.3	108.3	54.7	60.9	53.8
10555	8.2	343.5	218.6	144.4	135.5	510.3	815.5	1569.1	190.1	64.6	55.4	61.7	46.1	63.6	49.9
10555	20.0	577.7	694.8	598.7	101.4	108.6	328.0	609.2	1319.7	139.6	49.0	33.2	41.1	47.0	54.8
10555	70.0	178.5	1179.2	1272.6	936.5	263.3	239.9	405.9	517.5	1078.6	76.8	49.3	20.6	27.4	34.1
10555	0.0	847.3	441.3	922.9	1397.4	890.9	282.1	548.8	882.9	1527.9	1622.9	209.0	68.3	71.2	85.2
10555	0.0	211.5	980.2	717.0	902.2	1133.1	651.1	299.6	288.5	467.2	617.4	519.0	65.9	60.3	45.7
10555	30.0	136.8	457.9	918.3	718.5	1032.2	911.4	794.2	318.2	240.0	487.6	651.9	503.5	306.6	75.4

Table 16. Extended Survivor Analysis diagnostics (Lowestoft VPA Version 3.1) (run A4_t-split_q14_m015)

AMERICAN PLAICE NAFO DIVISION 3M INDEX OF INPUT FILES JUNE 2020
CPUE data from file pla3mtun.txt

Catch data for 32 years. 1988 to 2019. Ages 4 to 16.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
EU SURVEY 1988-1993	1988	2019	4	15	0.5	0.6
EU SURVEY 1994-2019	1994	2019	4	15	0.5	0.6

Time series weights :
Tapered time weighting not applied

Catchability analysis :
Catchability independent of stock size for all ages
Catchability independent of age for ages >= 14

Terminal population estimation :
Final estimates not shrunk towards mean F
Minimum standard error for population estimates derived from each fleet = .500
Prior weighting not applied

Tuning converged after 124 iterations

Regression weights

1	1	1	1	1	1	1	1	1	1

Fishing mortalities

Age	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
4	0.016	0.065	0.018	0.159	0.15	0.104	0.084	0.001	0.001	0.013
5	0.04	0.035	0.024	0.093	0.043	0.106	0.077	0.004	0.01	0.021
6	0.083	0.019	0.054	0.062	0.065	0.039	0.063	0.012	0.02	0.042
7	0.037	0.006	0.078	0.067	0.059	0.06	0.045	0.015	0.03	0.049
8	0.085	0.004	0.049	0.041	0.097	0.054	0.016	0.05	0.061	0.066
9	0.052	0.007	0.101	0.057	0.074	0.09	0.018	0.051	0.068	0.1
10	0.035	0.011	0.086	0.154	0.142	0.092	0.022	0.064	0.071	0.072
11	0.052	0.006	0.092	0.152	0.11	0.078	0.008	0.071	0.081	0.075
12	0.156	0.001	0.114	0.193	0.106	0.099	0.025	0.073	0.054	0.077
13	0.147	0.006	0.076	0.104	0.131	0.104	0.011	0.11	0.062	0.047
14	0.107	0.013	0.225	0.19	0.154	0.175	0.017	0.192	0.204	0.234
15	0.193	0.013	0.18	0.181	0.196	0.188	0.047	0.126	0.243	0.211

XSA population numbers (Thousands)

AGE YEAR \AGE	4	5	6	7	8	9	10	11	12	13	14	15
2010	2.29E+03	2.81E+02	9.92E+01	5.99E+01	7.26E+01	6.33E+01	4.80E+01	2.95E+01	3.71E+01	2.88E+01	2.05E+01	1.74E+01
2011	1.47E+03	1.94E+03	2.32E+02	7.86E+01	4.97E+01	5.74E+01	5.17E+01	3.99E+01	2.41E+01	2.73E+01	2.14E+01	1.59E+01
2012	9.62E+02	1.19E+03	1.61E+03	1.96E+02	6.72E+01	4.26E+01	4.91E+01	4.40E+01	3.41E+01	2.07E+01	2.34E+01	1.82E+01
2013	5.15E+02	8.13E+02	9.96E+02	1.32E+03	1.56E+02	5.51E+01	3.31E+01	3.88E+01	3.46E+01	2.62E+01	1.65E+01	1.61E+01
2014	5.38E+02	3.78E+02	6.38E+02	8.05E+02	1.06E+03	1.29E+02	4.48E+01	2.44E+01	2.87E+01	2.45E+01	2.03E+01	1.18E+01
2015	1.58E+03	3.99E+02	3.12E+02	5.14E+02	6.54E+02	8.27E+02	1.03E+02	3.34E+01	1.88E+01	2.22E+01	1.85E+01	1.50E+01
2016	2.24E+03	1.22E+03	3.09E+02	2.58E+02	4.17E+02	5.33E+02	6.50E+02	8.11E+01	2.66E+01	1.47E+01	1.72E+01	1.34E+01
2017	1.92E+03	1.77E+03	9.75E+02	2.50E+02	2.12E+02	3.53E+02	4.51E+02	5.48E+02	6.92E+01	2.23E+01	1.25E+01	1.46E+01
2018	1.59E+03	1.65E+03	1.52E+03	8.29E+02	2.12E+02	1.74E+02	2.89E+02	3.64E+02	4.39E+02	5.53E+01	1.72E+01	8.88E+00
2019	2.07E+03	1.37E+03	1.40E+03	1.28E+03	6.93E+02	1.71E+02	1.40E+02	2.32E+02	2.89E+02	3.58E+02	4.47E+01	1.21E+01

Estimated population abundance at 1st Jan 2020

0.00E+00	1.76E+03	1.15E+03	1.16E+03	1.05E+03	5.58E+02	1.34E+02	1.12E+02	1.85E+02	2.30E+02	2.94E+02	3.05E+01

Taper weighted geometric mean of the VPA populations:

6.58E+02	5.28E+02	4.29E+02	3.46E+02	2.65E+02	2.01E+02	1.55E+02	1.18E+02	8.59E+01	6.08E+01	4.27E+01	2.49E+01

Standard error of the weighted Log(VPA populations) :

1.0489	1.0378	1.0393	1.0494	1.0059	0.9603	0.9217	0.9137	0.8787	0.8306	0.7535	0.6643

Table 16. cont.

Log catchability residuals.
Fleet : EU SURVEY 1988-1993

Age	1988	1989	1990	1991	1992	1993	1994-2016
4	0.05	0.32	0.42	0.37	-0.48	-0.68	99.99
5	0.03	0.14	0.61	-0.04	0.07	-0.8	99.99
6	-0.08	0.2	0.15	0.86	-0.24	-0.9	99.99
7	-0.5	-0.23	-0.18	0.16	0.74	-0.01	99.99
8	-0.52	-0.22	0.03	0.34	0.61	-0.24	99.99
9	-0.68	-0.45	-0.17	0.26	0.68	0.35	99.99
10	-0.28	-0.41	-0.25	0.04	0.73	0.17	99.99
11	-0.29	0.16	-0.24	-0.15	0.32	0.21	99.99
12	-0.07	-0.01	0.42	-0.35	-0.12	0.12	99.99
13	-0.37	0.19	0.1	0.31	-0.53	0.3	99.99
14	-0.48	-0.23	0.04	-0.4	0.83	0.24	99.99
15	0	0.14	0.09	-0.05	0.13	-0.16	99.99

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	4	5	6	7	8	9	10	11	12	13	14	15
Mean Log q	-8.7198	-8.6479	-8.7215	-7.8192	-8.0781	-8.1363	-8.3178	-8.5336	-8.593	-8.7339	-7.333	-7.333
S.E(Log q)	0.4706	0.4552	0.5774	0.4263	0.4165	0.5192	0.4151	0.2613	0.2572	0.3624	0.4895	0.1209

Regression statistics :
Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
4	0.69	0.729	8.31	0.57	6	0.34	-8.72
5	1.05	-0.098	8.72	0.46	6	0.54	-8.65
6	1.09	-0.162	8.88	0.42	6	0.7	-8.72
7	2.57	-6.081	9.13	0.79	6	0.38	-7.82
8	1.29	-1.041	8.52	0.76	6	0.53	-8.08
9	2.57	-5.179	10.94	0.73	6	0.54	-8.14
10	1.78	-2.643	10.07	0.74	6	0.5	-8.32
11	1.44	-1.982	9.72	0.84	6	0.3	-8.53
12	2.19	-2.199	12.21	0.46	6	0.42	-8.59
13	-7.62	-2.953	-21.87	0.03	6	1.73	-8.73
14	3.54	-1.809	13.98	0.11	6	1.44	-7.33
15	0.9	1.908	6.92	0.99	6	0.09	-7.31

Fleet : EU SURVEY 1994-2019

Age	1988-1994	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
4	99.99	0.86	0.36	-0.07	-1.94	-1.31	-0.86	-0.22	-0.33	-0.28	0.46	0.04
5	99.99	0.57	1.07	0.22	-0.81	-0.92	-0.8	-0.36	0.04	-1.59	-0.09	0.29
6	99.99	0.28	0.82	0.84	-0.31	-0.29	-1.06	-0.34	-1.19	-0.27	-0.57	-0.05
7	99.99	0.6	0.99	0.57	0.61	0.08	-0.38	-0.67	-0.64	-1.02	-0.36	-0.01
8	99.99	1.38	0.8	0.29	-0.61	0.38	-0.15	-0.83	0.18	-0.46	-0.21	0.1
9	99.99	0.23	0.97	0.07	-0.05	-0.05	-0.23	-0.41	0.14	-0.38	0.33	0.17
10	99.99	0.93	-0.23	0.5	-0.14	-0.08	-0.66	-0.28	0.1	-0.58	0.24	0.47
11	99.99	0	0.14	-0.11	0.52	0.14	0.16	-0.6	0.02	-0.39	0.45	0.49
12	99.99	0.04	-0.05	-0.41	-0.02	0.4	0.08	-0.18	0.17	-0.59	0.15	0.99
13	99.99	-0.07	0.34	-0.1	-1.26	0.09	0.08	-0.53	0.24	0.05	-0.03	0.52
14	99.99	0.1	0.5	0.08	-0.11	0.3	0.22	-0.93	0.02	-0.3	-0.05	0.11
15	99.99	0.57	0.05	-0.17	-0.44	0	0.29	-0.35	0.03	0.1	0.09	0.48

Age	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
4	1.25	0.26	-0.32	99.99	0.01	0.68	0.78	0.39	0.39	-0.43	-0.11	0.29
5	0.38	0.46	0.32	-0.34	-0.76	0.71	0.88	0.44	0.55	-0.38	-0.69	0.4
6	0.33	0.41	0.2	0.35	-1.01	0.88	0.88	0.8	0.1	0.02	-0.83	0.08
7	0.09	-0.09	-0.62	0.25	-0.11	0.21	0.18	0.87	0.24	0.05	-0.41	-0.04
8	-0.07	-0.75	-0.49	0.18	-0.51	0.5	-0.2	0.05	-0.3	0.25	-0.24	-0.22
9	0.52	-0.03	-1.39	0.15	-0.08	0.14	-0.09	0.47	-0.35	-0.11	-0.02	-0.56
10	0.02	0.25	-0.95	-0.19	0.15	-0.31	0.52	0.4	0.42	-0.27	-0.36	-0.19
11	0.23	0.08	-0.33	-0.59	0.18	-0.16	0.46	0.27	0.29	0.05	-0.41	-0.88
12	0.45	0.14	-0.23	-0.69	0.21	0.67	-0.14	0.31	0.27	-0.15	-0.35	-0.34
13	0.82	0.51	0.25	0.13	-0.03	0.65	0.47	-0.09	-0.11	-0.2	-0.23	-0.56
14	0.16	0.03	-0.52	-0.22	-0.02	0.34	0.51	0.43	-0.02	-0.21	-0.41	-0.96
15	-0.12	-0.31	-0.7	0.47	0.32	0.72	0.22	0.63	-0.12	0.12	-0.03	-0.47

Table 16. cont.

Age	2017	2018	2019
4	0.08	0.01	0
5	0.39	0.02	-0.01
6	0.12	-0.08	-0.08
7	0.14	-0.22	-0.31
8	0.78	0.18	-0.03
9	0.41	0.01	0.14
10	0.55	-0.19	-0.13
11	0.29	-0.26	-0.05
12	0.17	-0.78	-0.12
13	0.28	-0.69	-0.53
14	0.41	-0.07	0.62
15	0.4	0.34	0.51

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	4	5	6	7	8	9	10	11	12	13	14	15
Mean Log q	-9.9887	-9.8027	-9.3859	-9.1885	-8.9832	-8.6451	-8.4718	-8.3504	-8.2094	-8.2816	-7.7493	-7.7493
S.E(Log q)	0.6749	0.6414	0.6029	0.4858	0.5073	0.4313	0.4315	0.3657	0.4048	0.4579	0.3987	0.3845

Regression statistics :
Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
4	0.85	1.281	9.46	0.77	25	0.57	-9.99
5	0.78	2.378	8.99	0.83	26	0.46	-9.8
6	0.88	1.083	8.97	0.78	26	0.53	-9.39
7	0.91	1.002	8.85	0.83	26	0.44	-9.19
8	0.85	1.576	8.45	0.83	26	0.42	-8.98
9	0.98	0.2	8.57	0.8	26	0.43	-8.65
10	1.05	-0.396	8.64	0.76	26	0.46	-8.47
11	0.99	0.087	8.32	0.83	26	0.37	-8.35
12	1.05	-0.476	8.43	0.76	26	0.43	-8.21
13	0.98	0.149	8.2	0.71	26	0.46	-8.28
14	0.93	0.611	7.44	0.74	26	0.37	-7.75
15	1.06	-0.456	7.9	0.74	26	0.4	-7.65

Terminal year survivor and F summaries :

Age 4 Catchability constant w.r.t. time and dependent on age
Year class = 2015

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	1760	0.688	0	0	1	1	0.013

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1760	0.69	0	1	0	0.013

Age 5 Catchability constant w.r.t. time and dependent on age
Year class = 2014

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	1152	0.474	0.011	0.02	2	1	0.021

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1152	0.47	0.01	2	0.023	0.021

Age 6 Catchability constant w.r.t. time and dependent on age
Year class = 2013

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	1159	0.375	0.047	0.12	3	1	0.042

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1159	0.38	0.05	3	0.125	0.042

Table 16. cont.

Age 7 Catchability constant w.r.t. time and dependent on age
Year class = 2012

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	1050	0.3	0.166	0.55	4	1	0.049

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1050	0.3	0.17	4	0.552	0.049

Age 8 Catchability constant w.r.t. time and dependent on age
Year class = 2011

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	558	0.26	0.101	0.39	5	1	0.066

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
558	0.26	0.1	5	0.388	0.066

Age 9 Catchability constant w.r.t. time and dependent on age
Year class = 2010

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	134	0.232	0.13	0.56	6	1	0.1

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
134	0.23	0.13	6	0.559	0.1

Age 10 Catchability constant w.r.t. time and dependent on age
Year class = 2009

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	112	0.21	0.184	0.88	7	1	0.072

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
112	0.21	0.18	7	0.876	0.072

Age 11 Catchability constant w.r.t. time and dependent on age
Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	185	0.194	0.116	0.6	8	1	0.075

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
185	0.19	0.12	8	0.596	0.075

Age 12 Catchability constant w.r.t. time and dependent on age
Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	230	0.181	0.136	0.75	9	1	0.077

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
230	0.18	0.14	9	0.747	0.077

Table 16. cont.

Age 13 Catchability constant w.r.t. time and dependent on age
Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	294	0.172	0.167	0.97	10	1	0.047

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
294	0.17	0.17	10	0.971	0.047

Age 14 Catchability constant w.r.t. time and dependent on age
Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	30	0.163	0.189	1.16	11	1	0.234

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
30	0.16	0.19	11	1.16	0.234

Age 15 Catchability constant w.r.t. time and age (fixed at the value for age) 14
Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
EU SURVEY 1988-1993	1	0	0	0	0	0	0
EU SURVEY 1994-2016	8	0.161	0.126	0.78	11	1	0.211

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
8	0.16	0.13	11	0.778	0.211

A4_t-split_q14_M0.15

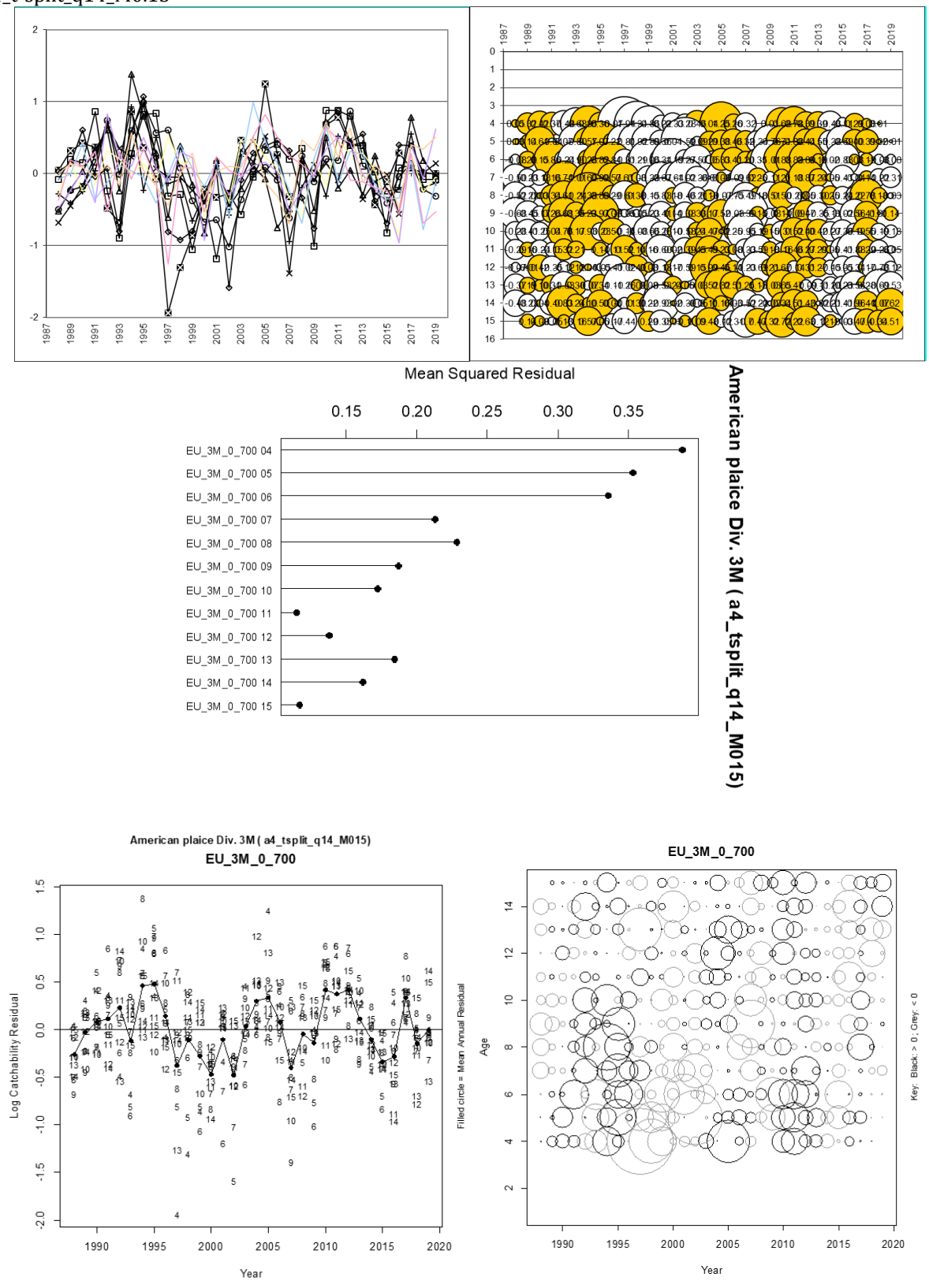

Figure 12. Log catchability residuals

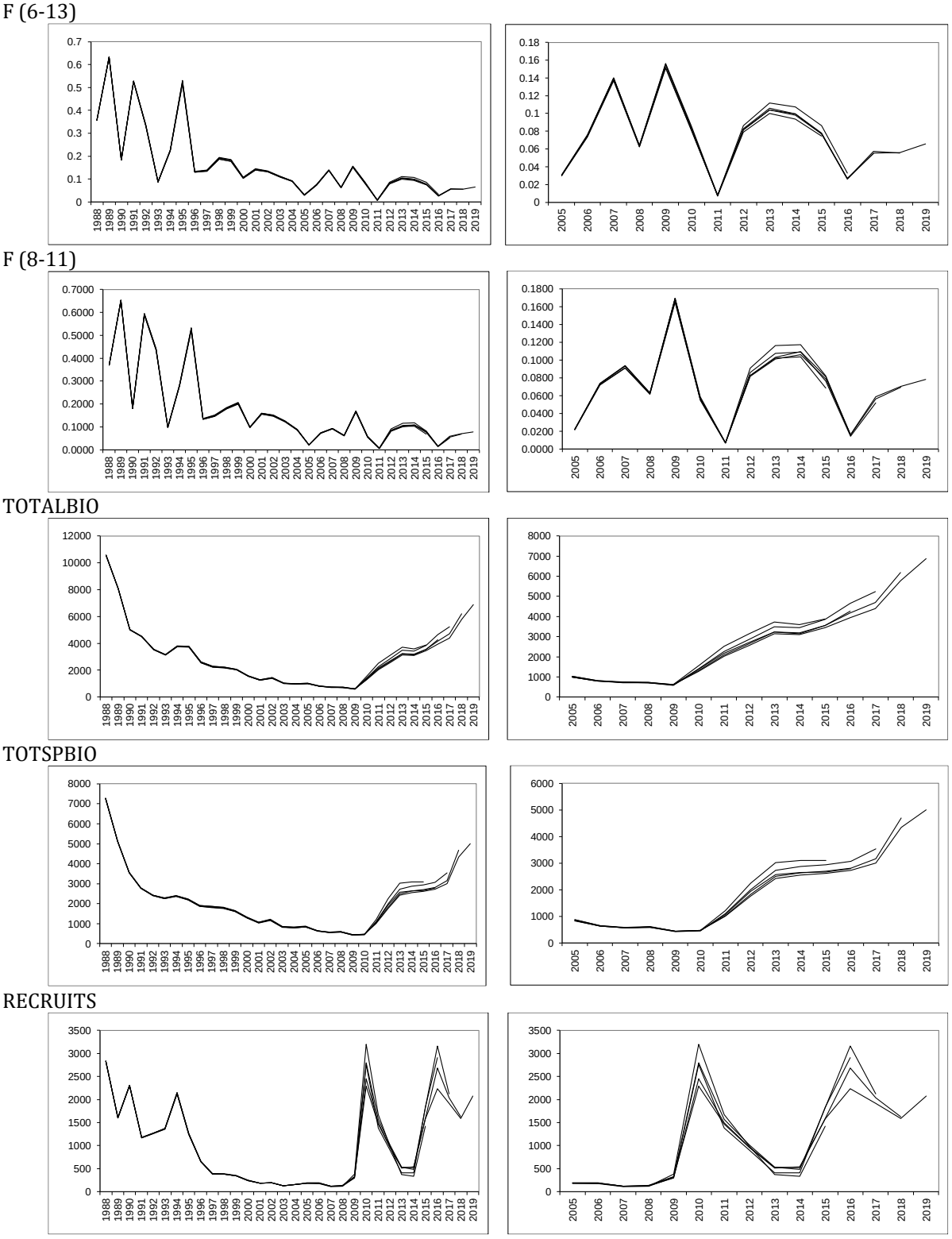

Figure 13. XSA retrospective analysis (run A4_t-split_q14_m015), last year 2019-2015: average fishing mortality (ages 6-13), average fishing mortality (ages 8-11), biomass, spawning stock biomass and recruitment (age 4).

Table 17. Extended Survivor Analysis results (run A4_t-split_q14_m015).

YEAR	RECRUITS Age 4 (Thousands)	TOTAL BIOMASS (Tonnes)	SPAWNING BIOMASS (Tonnes)	FBAR 6-13	FBAR 8-11
1988	2836	10566	7273	0.357	0.370
1989	1607	8086	5132	0.633	0.651
1990	2312	5015	3561	0.183	0.181
1991	1180	4524	2791	0.526	0.590
1992	1274	3553	2422	0.333	0.436
1993	1372	3153	2280	0.087	0.098
1994	2150	3792	2397	0.224	0.280
1995	1265	3780	2228	0.519	0.522
1996	663	2604	1909	0.130	0.133
1997	389	2277	1862	0.135	0.147
1998	385	2228	1813	0.187	0.178
1999	348	2069	1654	0.178	0.201
2000	247	1588	1319	0.104	0.097
2001	184	1292	1071	0.140	0.156
2002	198	1443	1208	0.132	0.148
2003	132	1038	852	0.109	0.123
2004	159	990	823	0.090	0.087
2005	186	1025	869	0.030	0.022
2006	187	817	650	0.074	0.072
2007	123	738	574	0.138	0.092
2008	139	730	603	0.063	0.062
2009	328	616	444	0.152	0.166
2010	2294	1272	470	0.081	0.056
2011	1470	2028	1005	0.007	0.007
2012	962	2570	1762	0.081	0.082
2013	515	3137	2419	0.104	0.101
2014	538	3108	2552	0.098	0.106
2015	1579	3453	2611	0.077	0.079
2016	2238	3949	2730	0.026	0.016
2017	1917	4394	3000	0.056	0.059
2018	1589	5774	4338	0.056	0.070
2019	2073	6873	5004	0.066	0.078

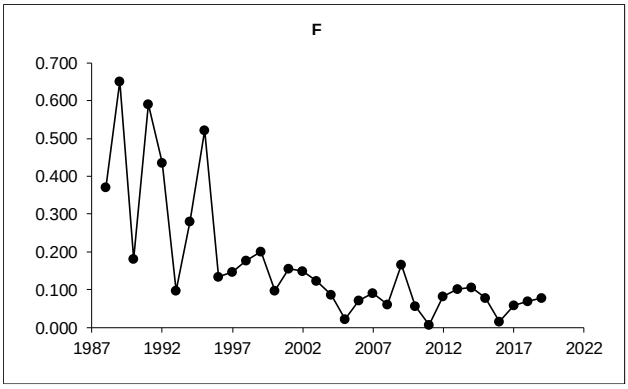

Figure 14 A. Extended Survivor Analysis results for F (age 8-11).

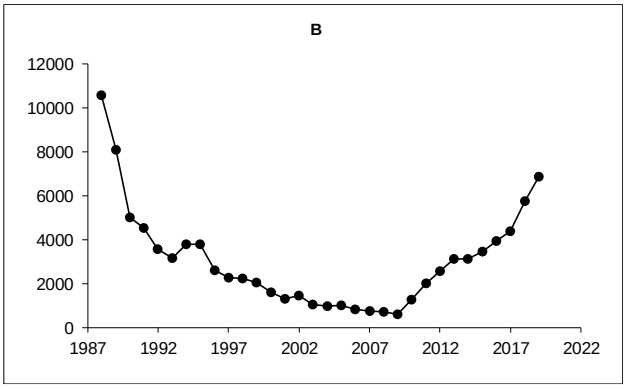

Figure 14 B. Extended Survivor Analysis results for 4+. biomass (tonnes).

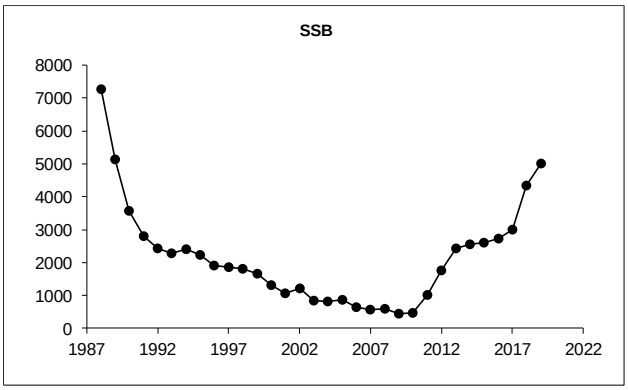

Figure 14 C. Extended Survivor Analysis results for spawning biomass (tonnes).

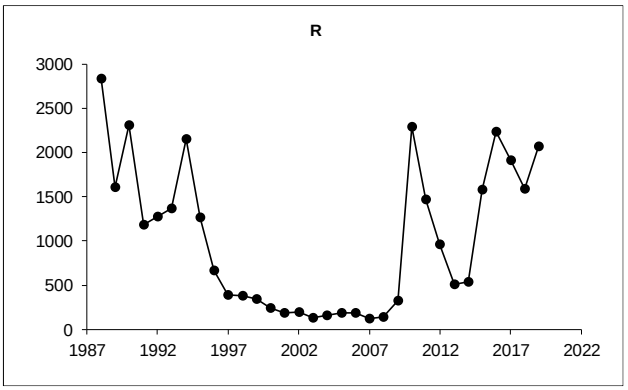

Figure 14 D. Extended Survivor Analysis results for recruits at age 4 ('000).

Table 18. VPA-type Bayesian model results.

	B quantiles			SSB quantiles			R quantiles			F_{bar} quantiles		
Year	**50%**	**5%**	**95%**	**50%**	**5%**	**95%**	**50%**	**5%**	**95%**	**50%**	**5%**	**95%**
1988	12018	11498	12711	9861	9431	10481	2224	1989	2491	0.331	0.306	0.349
1989	9656	9204	10317	8050	7651	8624	2144	1900	2457	0.557	0.506	0.600
1990	6390	5954	7002	5015	4641	5528	2364	2104	2771	0.150	0.135	0.163
1991	5895	5484	6492	4539	4204	5013	3494	3130	3988	0.477	0.419	0.523
1992	5062	4623	5679	3814	3467	4314	2149	1827	2543	0.323	0.275	0.363
1993	4708	4285	5319	3449	3104	3959	1356	1125	1704	0.069	0.058	0.079
1994	5177	4737	5782	3770	3435	4250	824	670	996	0.205	0.178	0.230
1995	5122	4670	5814	3959	3601	4517	804	665	984	0.356	0.304	0.405
1996	3828	3413	4459	3110	2754	3634	668	561	798	0.087	0.073	0.101
1997	3531	3100	4169	3110	2726	3704	479	402	587	0.089	0.072	0.105
1998	3493	3092	4073	3134	2754	3670	363	292	456	0.115	0.098	0.132
1999	3294	2900	3851	2957	2590	3492	413	327	527	0.132	0.112	0.151
2000	2586	2264	3028	2356	2057	2771	271	218	342	0.066	0.055	0.076
2001	2266	1964	2689	2072	1788	2469	328	256	414	0.102	0.086	0.120
2002	2540	2204	3004	2355	2035	2784	375	309	479	0.090	0.076	0.105
2003	1868	1612	2220	1717	1471	2049	386	317	477	0.069	0.057	0.081
2004	1882	1612	2223	1689	1433	1998	244	207	306	0.050	0.043	0.058
2005	1918	1606	2333	1726	1434	2130	278	223	344	0.013	0.011	0.015
2006	1490	1265	1742	1264	1062	1494	563	449	724	0.045	0.039	0.052
2007	1379	1202	1622	1148	994	1353	4020	3154	5128	0.055	0.047	0.064
2008	1833	1542	2132	1357	1128	1620	2540	1995	3353	0.039	0.033	0.045
2009	1868	1617	2182	930	805	1087	1785	1382	2356	0.097	0.082	0.115
2010	2455	2114	2867	1010	859	1213	978	731	1363	0.033	0.027	0.038
2011	3066	2652	3593	1598	1387	1870	986	772	1290	0.004	0.003	0.005
2012	3696	3180	4320	2590	2212	3065	2230	1523	3226	0.048	0.040	0.055
2013	4660	4023	5481	3602	3083	4256	3156	2104	5077	0.059	0.049	0.068
2014	4849	4175	5671	3843	3282	4535	2946	1752	5072	0.069	0.058	0.081
2015	5394	4616	6316	4023	3426	4776	2021	1109	3746	0.055	0.046	0.066
2016	5669	4804	6700	4063	3435	4818	3476	1742	7307	0.012	0.010	0.014
2017	5901	4901	7115	4120	3496	4889	1502	697	3142	0.042	0.035	0.051
2018	7783	6390	9552	5708	4776	6852	1111	399	3072	0.052	0.042	0.064
2019	8578	6966	10666	6378	5197	7882	2346	656	7808	0.064	0.051	0.086
2020				6677	5115	8427						

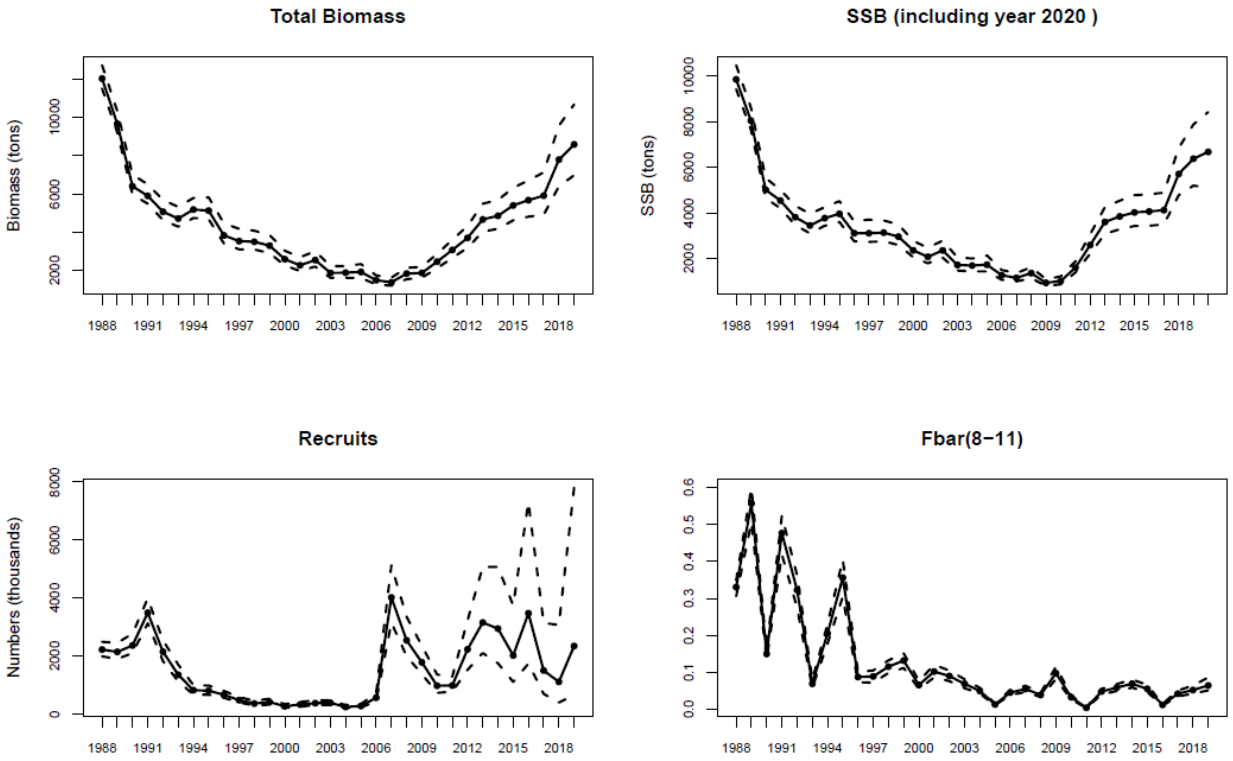

Figure 15. VPA type Bayesian model results with the 90 confidence intervals (recruits at age 1)

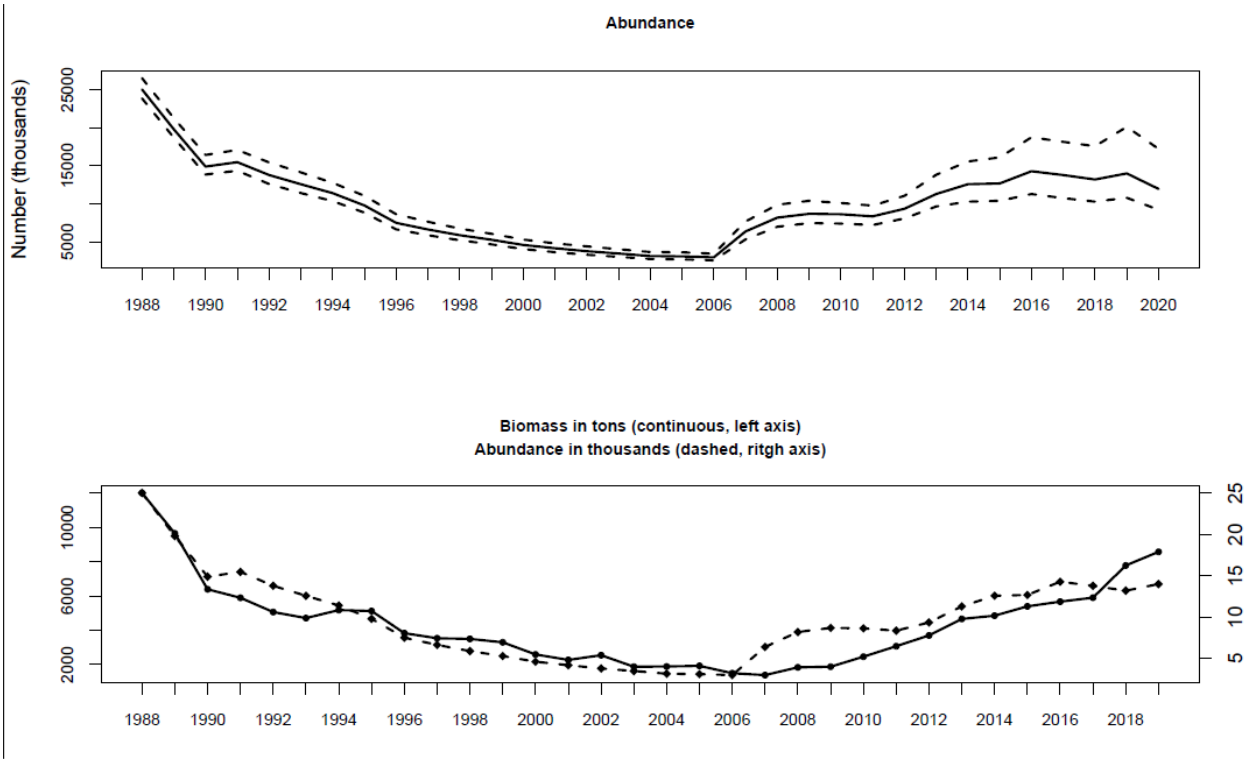

Figure16. VPA type Bayesian model: trends in the Abundance and biomass.

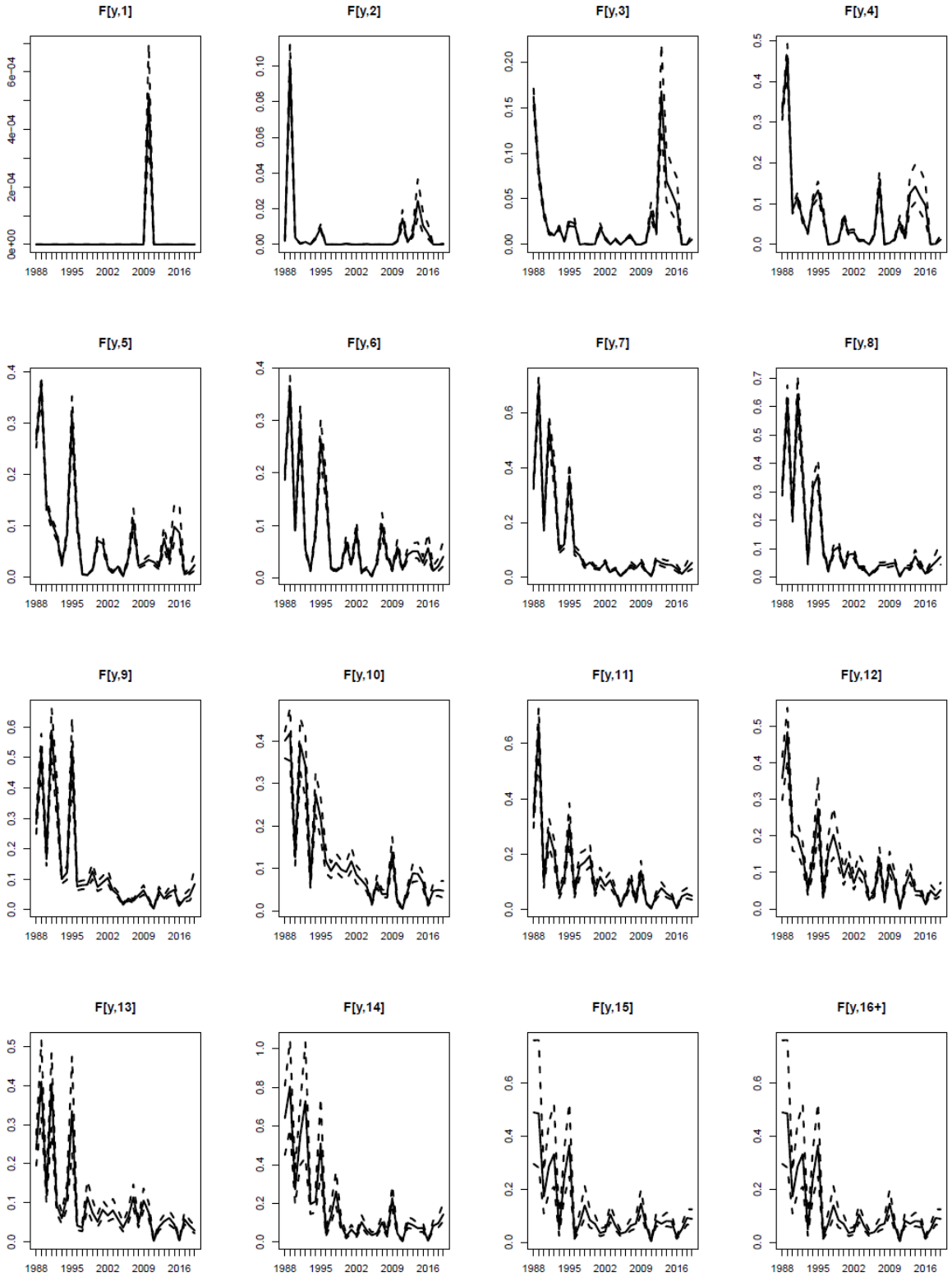

Figure 17. VPA type Bayesian model results: Estimated fishing mortality at age.

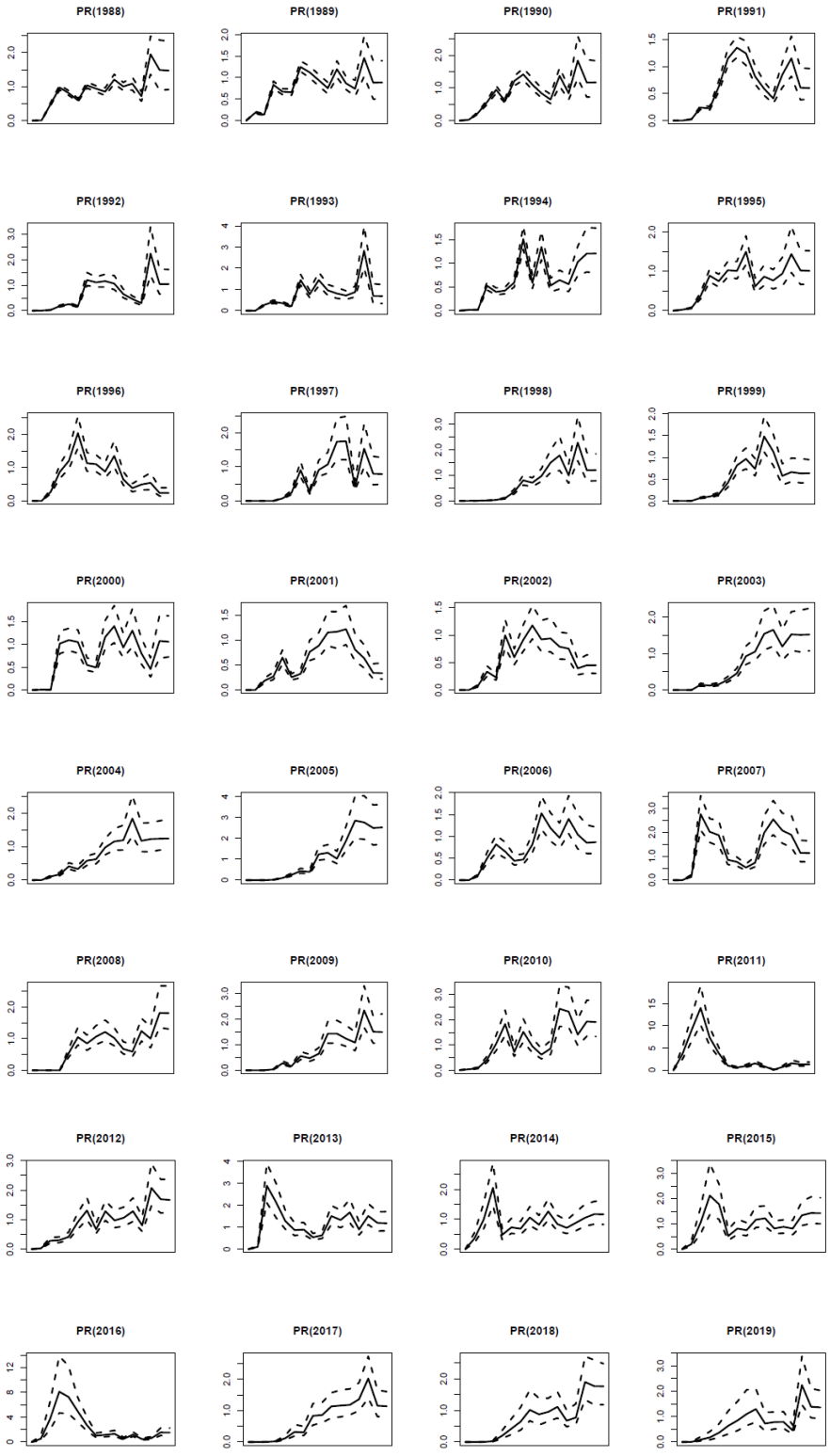

Figure 18. VPA type Bayesian model results: Estimated PR(F/Fbar) per age and year.

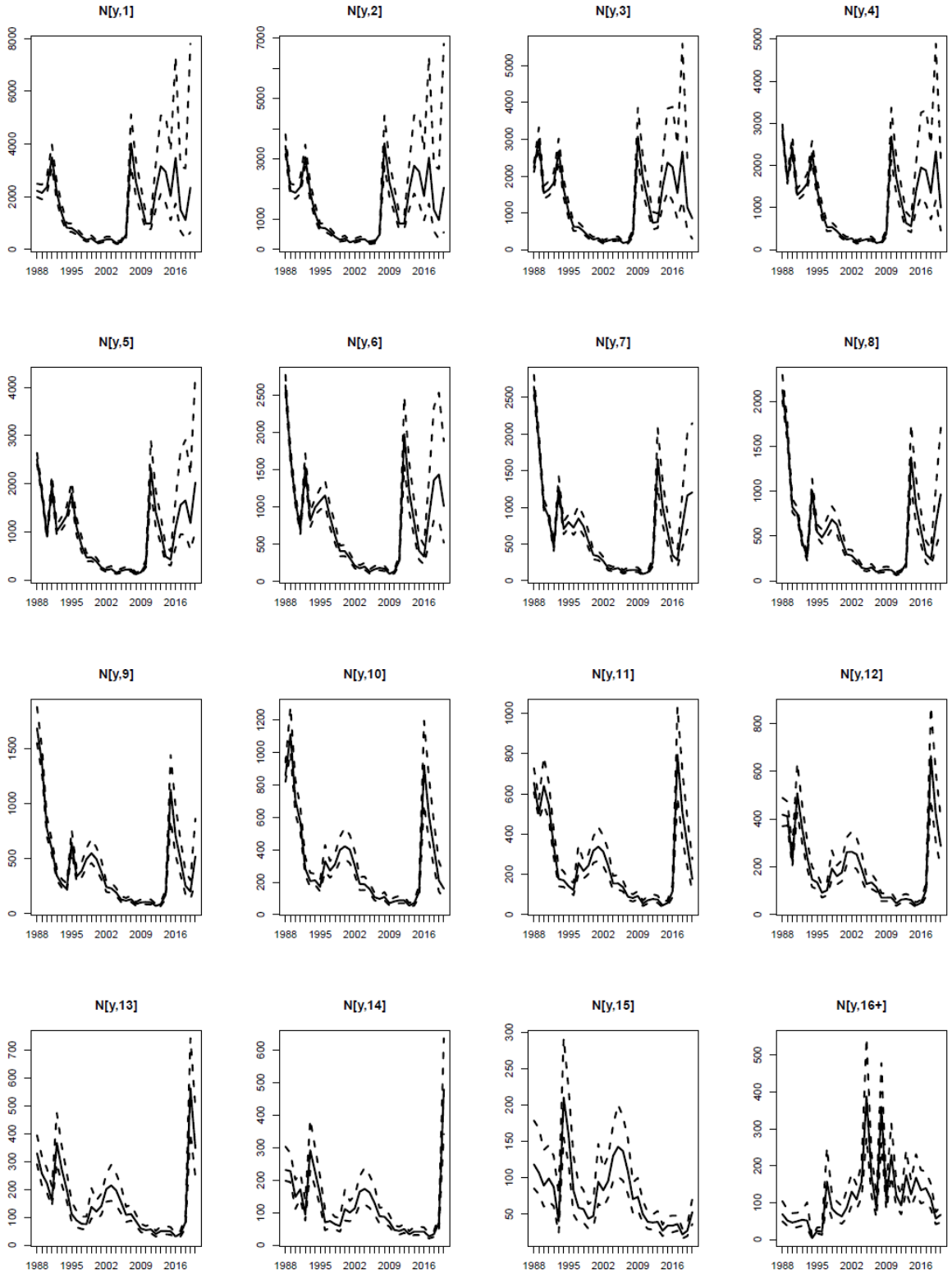

Figure 19. VPA type Bayesian model results: Estimated numbers at age.

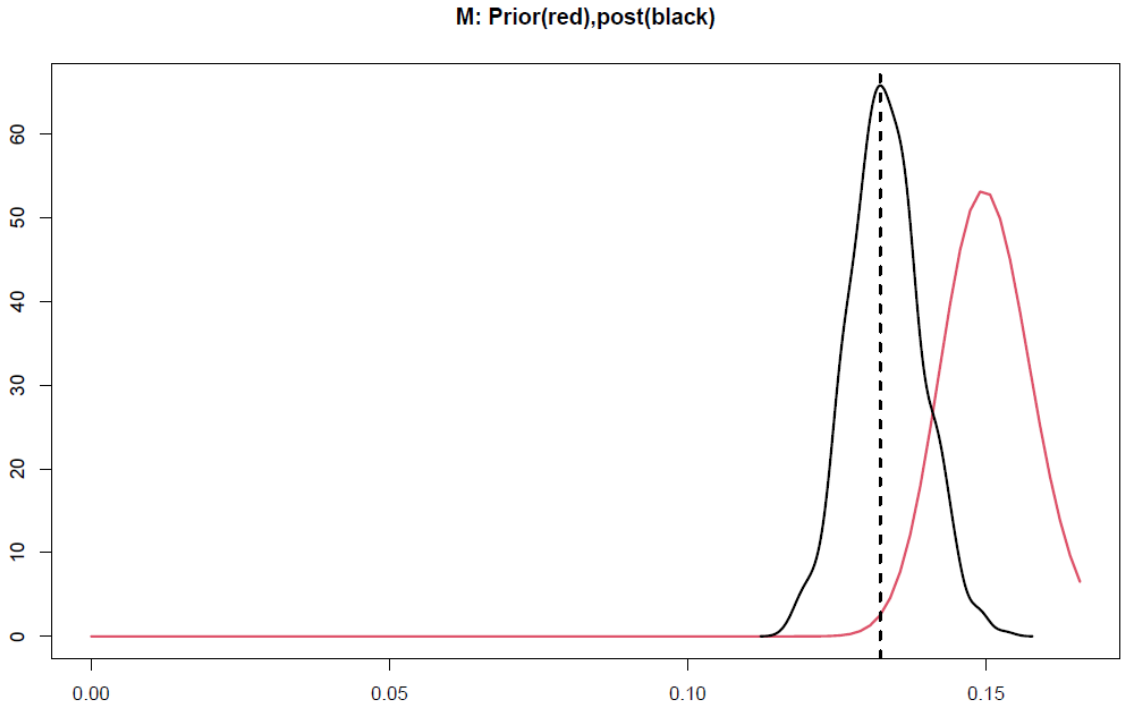

Figure 20. VPA type Bayesian model results: Estimated natural mortality.

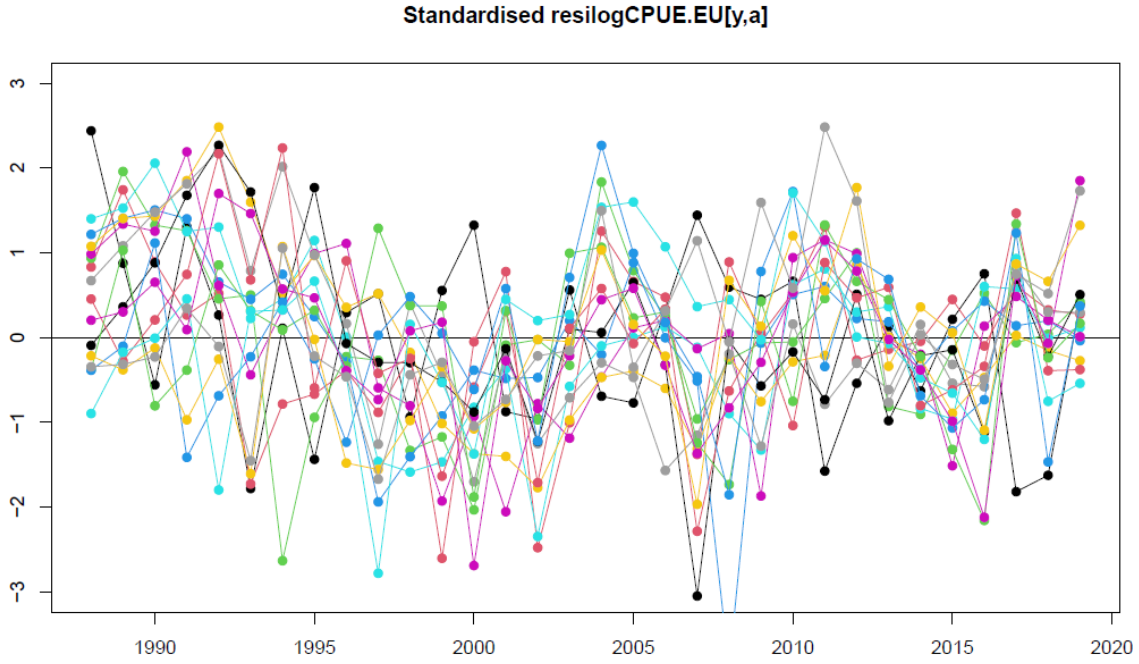

Figure 21. VPA type Bayesian model results: Standardised residuals (observed minus fitted value) in logarithmic scale of EU survey abundance indices by age.

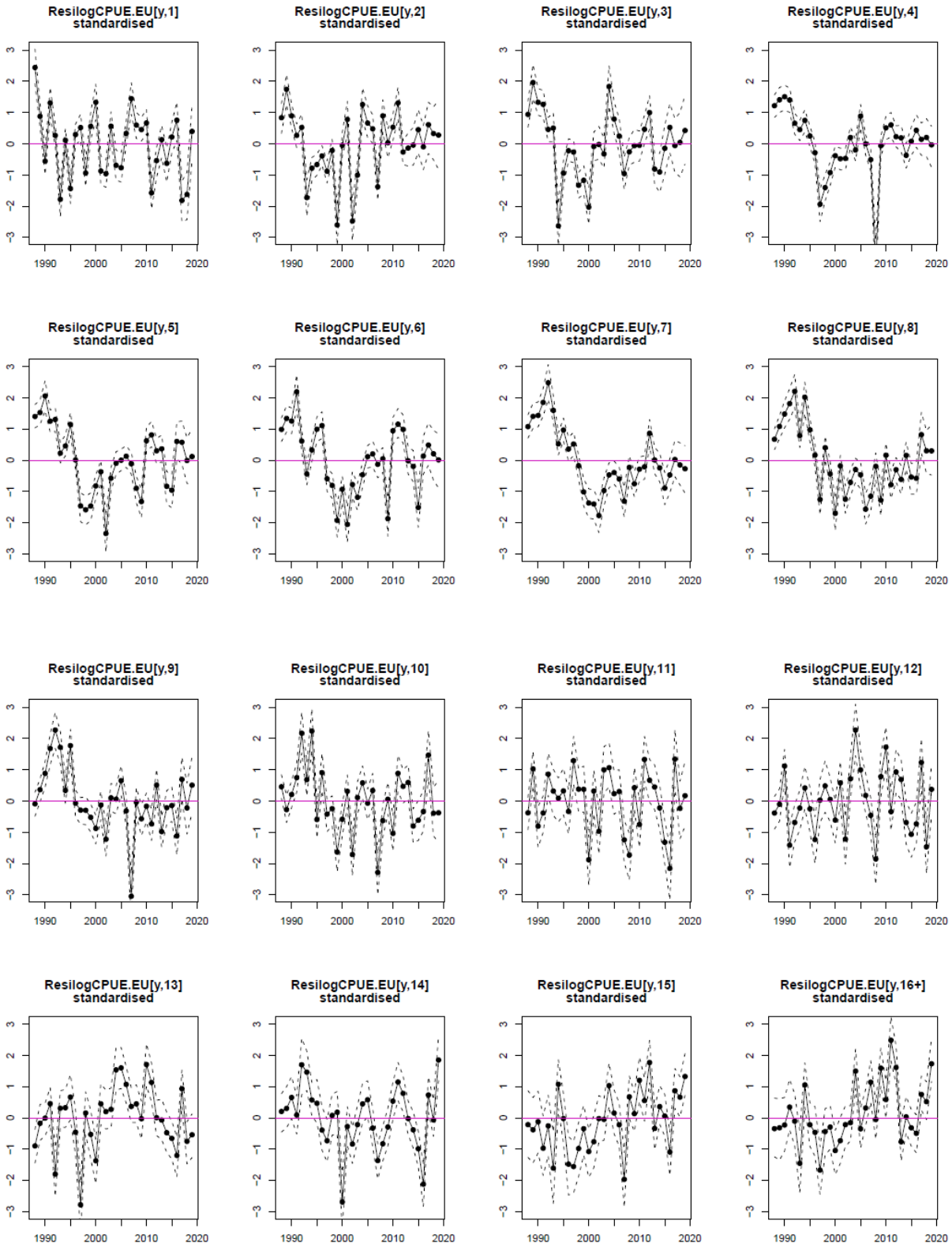

Figure 22. VPA type Bayesian model results: Standardised residuals (observed minus fitted value) in logarithmic scale of EU survey abundance indices by age.

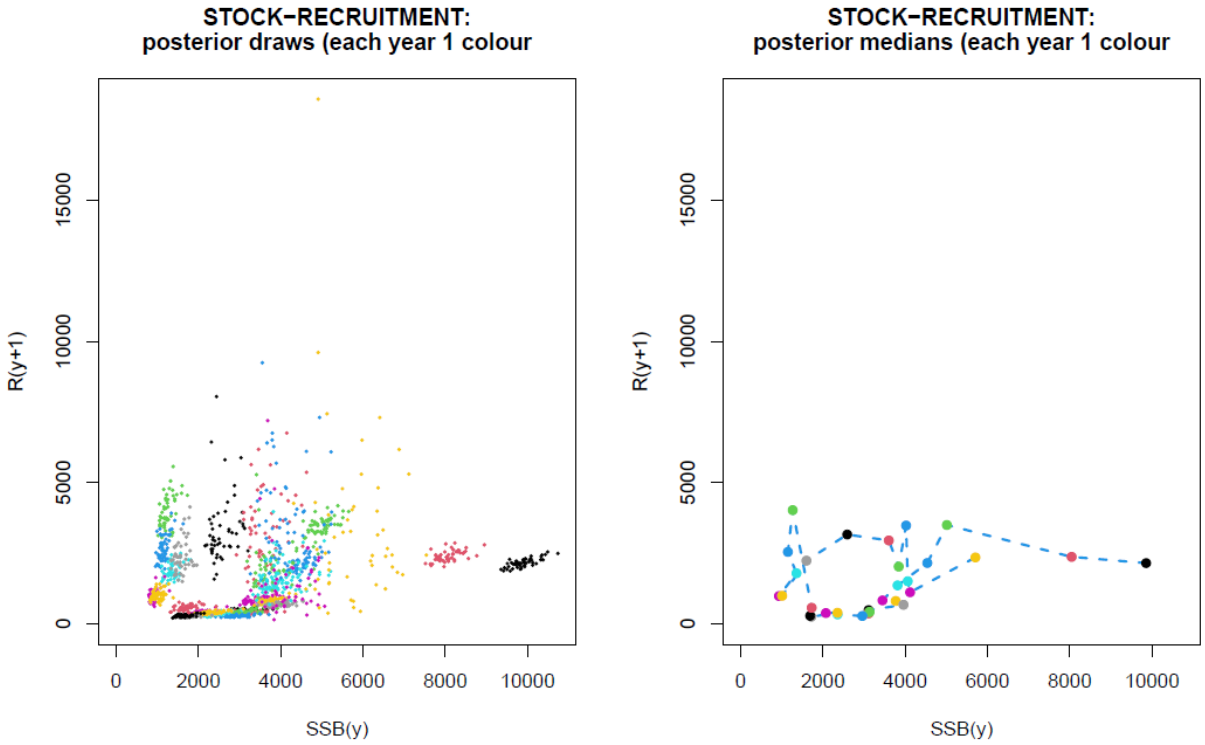

Figure 23. VPA type Bayesian model results: Stock- Recruitment plots.

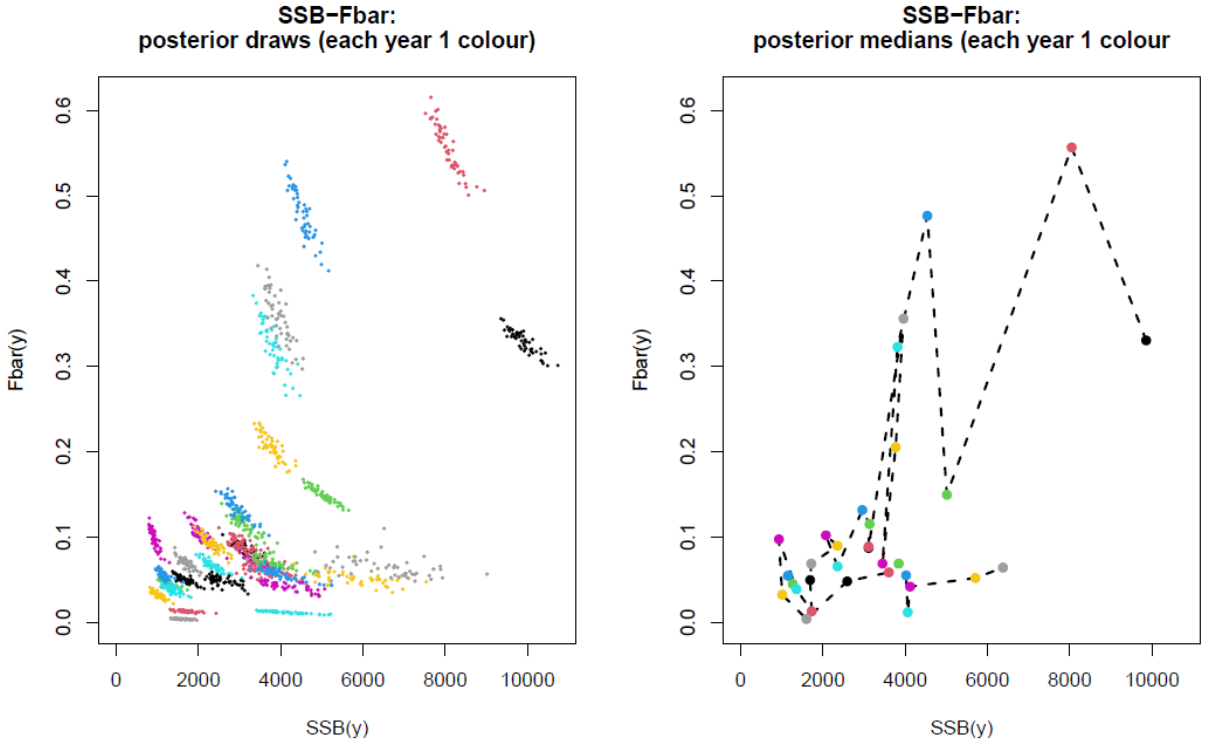

Figure 24. VPA type Bayesian model results: Fbar versus SSB plots.