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Assessment of the Cod Stock in NAFO Division 3M

by

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Abstract

An assessment of the cod stock in NAFO Division 3M is performed. A Bayesian model, as used in the last assessments, was used to perform the analysis. Results indicate a fairly substantial increase in SSB, reaching a value well above B_{lim}. The six-years retrospective plot shows that the recruitment is overestimated every year. Three year projections indicate that fishing at the $F_{statusquo}$ level should allow SSB to increase slowly, although abundance will remain at levels below those observed at the beginning of the series. If the fishing mortality were return to the levels seen before 1995, stock recovery would become improbable.

Introduction

This stock had been on fishing moratorium since 1999 to 2009 following its collapse, which has been attributed to three simultaneous circumstances: a stock decline due to overfishing, an increase in catchability at low abundance levels and a series of very poor recruitments starting in 1993. The assessments performed since the collapse of the stock confirmed the poor situation, with SSB at very low levels, well below B_{lim} (Vázquez and Cerviño, 2005). Nevertheless, Spawning Stock Biomass (SSB) was estimated to increase a bit in 2004, 2005 and 2006 (Fernández, *et al.*, 2007) and above average recruitment levels were estimated for 2005 and 2006. Another large increase in SSB in 2007-2009, largely due to the recruitments in 2005-2006, has happened, reaching in 2009 the second highest values of the studied series (González-Troncoso and Vázquez, 2010).

Since 1974, when a TAC was established for the first time, estimated catches ranged from 48000 tons in 1989 to a minimum value of 5 tons in 2004. Annual catches were about 30000 tons in the late 1980's (notwithstanding the fact that the fishery was under moratorium in 1988-1990) and diminished since then as a consequence of the stock decline. Since 1998 yearly catches have been less than 1000 tons and from 2000 to 2005 they were under 100 tons, mainly attributed to by-catches from other fisheries. Estimated commercial catches in 2006, 2007, 2008 and 2009 are 339, 345, 889 and 1161 tons (Table 1 and Figure 1), respectively, which represent more than a ten-fold increase over the average yearly catch during the period 2000-2005. The results of the 2009 assessment led to a reopening of the fishery with 5500 tons of catch in 2010. The estimated catch for 2010 is 9291 tons, which almost double the TAC.

A VPA based assessment of the cod stock in Flemish Cap was approved by NAFO Scientific Council (SC) in 1999 for the first time and was annually updated until 2002. However, most recent catches were very small undermining the VPA based assessment, as its results are quite sensitive to assumed natural mortality when catches are at low levels. Cerviño and Vázquez (2003) developed a method which combines survey abundance indices at age with catchability at age, the latter estimated from the last reliable accepted XSA. The method estimates abundances at age with their associated uncertainty and allows calculating the SSB distribution and, hence, the probability that SSB is above or below any reference value. The method has been used to assess the stock since 2003. In 2007 results from an alternative Bayesian model were also presented (Fernández *et al.*, 2007) and in 2008 this Bayesian model was further developed and approved by the NAFO SC (Fernández *et al.*, 2008).

An assessment of this stock using the Bayesian model used last years is presented. A B_{lim} of 14000 tons was proposed by the NAFO Scientific Council in 2000. The appropriateness of this value given the results from the new method used to assess the stock was examined in 2008, concluding that it is still an appropriate reference.

Material and Methods

Used data

Commercial data

Length distributions

In 2010 length sampling of catch was conducted by Lithuania (Statkus, 2011), Norway (pers. com.), Portugal (Vargas *et al.*, 2010), Spain (González-Costas *et al.*, 2010) and UK (pers. com.). Length frequency distributions from the commercial catch and from the EU survey (Casas and González-Troncoso, 2011) are shown in Figure 2.

Lithuania has measured 200 individuals in one single sample. This length distribution has a clear mode at 60 cm. with a range of 34-86 cm, but it was not considered representative of the whole catch due to the small size sample. Norway has 12 samples with a total of 3902 individuals measured. Of these, 2 samples were from a trawl vessel (507 individuals) and 8 from a twin trawl vessel (3395 individuals). As the split catches for the two gears are no available, both length distributions were added, as a plot shows that there are no differences between them. The range of the distribution is from 23 to 119 cm, with a mode in 57 cm. The length distribution of Portugal is made from 182 samples with 17658 individuals measured. The range of lengths is 18-111 cm. The mode is in 54 cm. Spain provided the data from 34 samples and 8445 individuals measured. The range of the distribution is 35-115 cm and it has a mode in 54 cm. 24 samples are available from UK, with a total of 2678 individuals measured. The range is 42-132 cm, with a not well-defined mode between 90 and 105 cm. The EU survey has a well-defined mode around 18 cm, following with another mode in 33 cm and two more, weaker, around 48 and 57 cm. The range is from 12 to 117 cm.

The Portuguese length distribution starts in 18 cm, the Spanish one in 35 cm and the UK one in 42 cm, with the highest percentage of highest lengths with a mode around 100 cm. The EU survey has a great presence of individuals of around 18 cm.

Catch-at-age

Catch-at-age is presented in Table 2. As no age-length keys (ALK) were available for commercial catch from 1988 to 2008, each year the corresponding ALKs from the EU survey were applied in order to calculate annual catch-at-age. A commercial ALK was available for 2009 for the Portuguese commercial data and was applied to the total commercial length distribution. For 2010, two ALKs were available, one for the Portuguese data from the same reader as last years for commercial data and for survey data, and another one for the commercial Spanish data from a new reader. It was observed some differences between both ALKs, as we can see in Figure 3, in which mean length per age is presented for both ALKs. In order to maintain the consistency of the series, it was decided to use the Portuguese ALK for all the commercial catch because comes from the same reader as the previous years for commercial and EU survey data.

The range of ages in the catch goes from 1 to 8+. No catch-at-age was available for 2002-2005 due to the lack of length distribution information because of low catches.

Figure 4 shows a bubble plot of catch proportions at age over time (with larger bubbles corresponding to larger values), indicating that the bulk of the catch (including 2010 catch) is comprised of 3-5 years age cod. In years 2006 and 2009, catches containing mostly age 4 individuals. In 2007 there has been much more spread over the ages, and in 2008 the greatest presence was ages 2 to 4.

Figure 5 shows standardised catch proportions at age (each age standardised independently to have zero mean and standard deviation 1 over the range of years considered). Assuming that the selection pattern at age is not too variable over time, it should be possible to follow cohorts from such figure. Some strong and weak cohorts can be followed, although the pattern is not too evident. It is remarkable the recruitment (age 1) in the year 2010, that is the highest positive value in the series.

Mean weight-at-age

Mean weight-at-age has been computed separately for the catch and for the stock, using length-weight relationships from the Portuguese commercial sampling and from the EU survey, respectively. Both are presenting in Figure 6. The commercial weights are smaller than those from the EU survey. The Portuguese length-weight relationship was applied to the commercial data to calculate weight-at-age in the catch. Results are showed in Table 4.

The SOP (sum over ages of the product of catch weight-at-age and numbers at age) for the commercial catch only differs in 1.7% from the estimated total catch.

Survey data

The EU bottom trawl survey of Flemish Cap has been carried out since 1988, targeting the main commercial species down to 730 m of depth. The surveyed zone includes the complete distribution area for cod, which rarely occurs deeper than 500 m. The survey procedures have been kept constant throughout the entire period, although in 1989 and 1990 a different research vessel was used. Since 2003, the survey has been carried out with a new research vessel (R/V *Vizconde de Eza*, replacing R/V *Cornide de Saavedra*) and conversion factors to transform the values from the years before 2003 have been implemented (González- Troncoso and Casas, 2005).

The results of the survey for the years 1988-2010 are present in Casas and González-Troncoso, 2011.

Survey indices of abundance at age are presented in Table 3. Figure 7 displays the estimated biomass and abundance indices over time. Biomass and abundance show a high increase since 2005, higher in biomass than in abundance, following an extremely low period starting in the mid 1990’s. It must be noted that 2009 biomass is at the level of the first years of the assessment but abundance is roughly the same as in 1994. In 2010 the biomass has suffered a bit decrease, probably due to the opening of the fishery, but it is still at the level of the first year assessment biomass. The abundance has had a marked increase due to the incoming recruitment. Figure 8 shows a bubble plot of the abundances at age, in logarithmic scale, with each age standardised separately (each age to have mean 0 and standard deviation 1 over the range of survey years). Grey and black bubbles indicate values above and below average, respectively, with larger sized bubbles corresponding to larger magnitudes. The plot indicates that the survey is able to detect strength of recruitment and to track cohorts through time very well. It clearly shows a series of consecutive recruitment failures from 1996 to 2004, leading to very weak cohorts. Cohorts recruited from 2005 onwards appear to be above average.

Mean weight-at-age in the stock shows a strong increasing trend since the late 1990’s, although in 2008 all the ages decreased their mean weight-at-age, but still remain higher than at the beginning of the series. In 2009 youngest and oldest ages increased theirs mean weight-at-age with respect to 2008, while the ages 3-4 decreased them (see Table 5 and Figure 9). In 2010 all ages except 3 and 7 decreased their mean weight-at-age with respect to 2009, reaching more or less the level of the 2008 values.

Maturity at age

Maturity ogives from the EU survey are available for years 1990-1998, 2001-2006 and 2008-2010. For those years logistic regression models for proportion mature at age have been fitted independently for each year. For 1988 and 1989 the 1990 maturity ogive was applied. For 1999 and 2000 maturity ogive was computed as a mixture of 1998 and 2001 data, and for 2007 as a mixed of 2006 and 2008 maturity ogive. Maturity data for 1991 were of poor quality and did not allow a good fit, so a mixture of the ogives for 1990 and 1992 was used. The median of the maturity ogives for the whole period are presented in the Table 6.

Figure 10 displays the evolution of the a50 (age at which 50% of fish are mature) through the years (estimate and 90% uncertainty limits). The figure shows a continuous decline of the a50 through time, from above 5 years old in the late 1980's to just above 3 years old since about 2000. Since 2005 the a50 has increased slowly, reaching 3.5 years in 2010.

Assessment methodology

The Bayesian model used last years was updated with 2010 data. For years with catch-at-age data, it works starting from cohort survivors and reconstructing cohorts backwards in time using catch-at-age and the assumed mortality rate. When catch-at-age is not available for a year but an estimate of total catch in weight is available, this information can be incorporated in the model by means of an observation equation relating (stochastically) the estimated catch weight to the underlying population abundances (hence aiding in the estimation of fishing mortalities). An advantage of the model is that it allows combining years with catch-at-age and years where only total catch is available. Years with no information on commercial catch are also allowed. A detailed description of the model is in Fernandez *et al.*, 2008. The priors were chosen this year as last assessment. The inputs of the assessment of this year are as follow:

Catch data for 23 years, from 1988 to 2010

Years with catch-at-age: 1988-2001, 2006-2010

Tuning with EU survey for 1988 to 2010

Ages from 1 to 8+ in both cases

Catchability analysis

Catchability dependent on stock size for ages 1 and 2

Priors over parameters:

Priors over the survivors:

For (2010, a), a=1,…,7 and (y, 7), y=1988,…,2009

$$surv(y,a) \sim LN\left(median = medrec \times e^{-medM - \sum_{age=1}^{a} medFsurv(age)}, cv = cvsurv \right),$$

where medrec=15000

medFsurv(1,…,7)={0.0001, 0.1, 0.5, 0.7, 0.7, 0.7, 0.7}

cvsurv=1

Prior over F for years with no catch-at-age:

For a=1,…,7 and y=2002,…,2005

$$F(y,a) \sim LN\left(median = medF(a),\ cv = cvF\right)$$

where medF=c(0.0001, 0.005, 0.01, 0.01, 0.01, 0.005, 0.005)

cvsurv=0.7

Prior over the total catch in the years with no catch-at-age data:

For y=2002,…,2005

$$CW(y) \sim LN\left(median = CW_{\mathrm{mod}}(y),\ cv = cvCW\right)$$

where CW_{mod} is arised from the Baranov equation

cvCW=0.05

Prior over the EU survey abundance at age indices:

For a=1,…,8 and y=1988,…,2010

$$I(y) \sim LN\left(median = \mu(y,a),\ cv = \sqrt{e^{\frac{1}{\psi(a)}} - 1} \right)$$

$$\mu(y,a) = q(a)\left(N(y,a)\frac{e^{-\alpha Z(y,a)} - e^{-\beta Z(y,a)}}{(\beta-\alpha)Z(y,a)} \right)^{\gamma(a)}$$

$$\gamma(a)\begin{cases} \sim N(\text{mean}=1, \text{variance}=0.25), \ if\ a=1,2 \\ =1,\ if\ a \geq 3 \end{cases}$$

$$\log(q(a)) \sim N(\text{mean}=0, \text{variance}=5)$$

$$\psi(a) \sim gamma(shape=2, rate=0.07)$$

where I is the EU survey abundance index

q is the survey catchability at age

N is the commercial abundance index

α = 0.5, β = 0.58 (survey made in July)

Z is the total mortality

Prior over natural mortality, M:

$$M \sim LN(\text{median}=0.218, cv=0.3)$$

In 2008 STACFIS recommended *that retrospective analysis be performed as a standard diagnostic of the assessment with the Bayesian model*. So, six year retrospective plot was made.

Three years projections were made with six different scenarios, as later described, in order to see the possible evolution of the stock. The settings and the results are explained above.

Results

Assessment results regarding to total biomass, SSB, recruitment and F_{bar} (ages 3-5) are presented in Table 7 and Figure 11. The SSB graph also includes the expected value at the beginning of the year 2011. To calculate it, weight-at-age and maturity-at-age random draws from the three last years with data were used (assuming always that maturity at age 1 is equal to 0, as there is no estimate of recruitment in 2011). The results indicate that there has been a substantial increase in SSB in the last few years, with the largest increase occurring from 2007 onwards. SSB in 2009 (and even its confidence intervals) are well above B_{lim}, and in 2010 is the highest value of the time series, very close to 1989 SSB. The SSB at the beginning of 2011 is even expected above this value, although the uncertainty associated with this value is very high.

It must be noted that, although SSB is in 2010 at the level of the beginning of the time series, total biomass and abundance are at the level of the year 1994 due to age of first maturity has been reduced.

Recruitment in 2005-2010 have been above the mean of the period, although the actual recruitment levels for these years can not yet be precisely estimated (wide uncertainty limits in Figure 11 and Table 7). 2010 recruitment is at the level of the first years assessment, only below the two strong year classes of 1990 and 1991.

F_{bar} (mean for ages 3-5) has been at very low levels in the period 2001-2009 (Figure 11), although an unusual high value has been estimated for 2006. In 2010, when the fishery was reopen, the F_{bar} has increased up to 0.27, although the 5500 tons TAC corresponded to a target F_{bar} around 0.14 was established. Table 8 and Figure 13 provide more detailed information on the estimated F-at-age values, indicating that the increase in F_{bar} in 2006 is mostly due to fishing mortality at age 3. In 2008 the highest fishing mortalities are in ages 5 and 6, in 2009 in ages 7 and 8+ and in 2010 in ages 4 and 6.

Figure 12 shows total biomass and abundance by year. Except in the first years of the assessment, there is a good concordance between numbers and weight, although in last years biomass has increased more than abundance. The projection for the year 2011 indicates a new increase in total biomass but a decrease in abundance.

Estimates of stock abundance at age for 1988-2011 are presented in Table 9 and Figure 14. Abundance at age in 2011 are the survivors of the same cohort in 2010, the last assessment year, so only abundances of ages older than age 1 can be estimated.

Figure 15 depicts the prior and posterior distributions of survivors at age at the end of the final assessment year, where by survivors(2010, a) it is meant individuals of age a + 1 at the beginning of 2011 (in other words, survivors(2010, a) = N(2011, a + 1)). The plotting range for the horizontal axis is the 95% prior credible interval in all cases, to facilitate comparison between prior and posterior distributions; the same procedure will be followed in all subsequent prior-posterior plots. There has been very substantial updating of the prior distribution for survivors of ages 4 and older. This is no the case for younger ages, with prior and posterior distributions being much closer; this behaviour was expected as few ages of these cohorts have been observed to date.

Figure 16 displays prior and posterior distributions for survivors of the last true age at the end of every year. By survivors(y, 7) it is meant individuals of age 8 (not 8+) at the beginning of year y + 1. Whereas the prior distribution is the same every year, posterior distributions vary substantially depending on the year, displaying particularly low values between 2002 and 2005 and in years 2008 and 2010.

Bubble plot of raw residuals (observed minus fitted values) for the EU survey abundance indices at age (in logarithmic scale) is presented in Figure 17. No obvious trends over time or any other particular patterns emerge from the residuals plot.

Bubble plot of standardised residuals (observed minus fitted values divided by estimated standard deviations and in logarithmic scale) for the EU survey abundance at age indices is displayed in Figure 18. As the residuals have been standardised, they should be mostly in the range (—2, 2) if model assumptions about variance are not contradicted by the data. This graph should highlight year effects, identified as years in which most of the residuals are above or below zero. In 1988 all residuals are negative except for the one for age 7, whereas the opposite happens in 1996 and 1997, suggesting year effects (i.e. survey catchabilities that are below average in 1988 and above average in 1996 and 1997). All residuals were positive in 2008-2010 except for ages 1 in 2008, 1 and 2 in 2009 and 5 and 7 (this last value is almost 0) in 2010.

Figure 19 shows the parameter $\log(\varphi(a))$, which corresponds to log(catchability) of the EU survey's for ages $a \geq 3$. For ages a = 1, 2 catchability depends also on stock abundance and this dependence is regulated via the parameter $\gamma(a)$, for which results are in Figure 20. The posterior probability that $\gamma(a) > 1$ for a = 1, 2 is very high, pointing towards an increase in survey catchabilities for the younger ages that occurs when abundance of those ages increases.

Biological Referent Points

Figure 21a shows a SSB-Recruitment plot and Figure 21b a SSB-F_{bar} plot, both with the 14 000 value of B_{lim} indicated with a vertical red line. The value of B_{lim} appears as a reasonable choice for B_{lim}: only low recruitments have been observed with SSB below this level whereas both high and low recruitments have been seen at higher SSB values. SSB is well above B_{lim} in 2011. In Figure 21a, we can see a very high uncertainty in the recruitment of year 2010. Figure 22 shows the Bayesian Yield per Recruit with respect to F_{bar}, in which the estimated values for $F_{0.1}$ (0.13), F_{max} (0.21) and F_{2010} (0.28) are indicated.

Retrospective pattern

A retrospective analysis of six years was made (Figure 23). Recruitment is over estimated year by year. No patterns are observed for total biomass, SSB and F_{bar}.

Projections

Stochastic projections over a three years period (2012-2014) have been performed. The 2011 data were included in the tables in order to compare the results. Variability of input data was taken from the results of the Bayesian assessment. Input data were as follows:

Numbers aged 2 to 8+ in 2011: estimates from the assessment

Recruitments for 2011-2014: Recruits per spawner were estimated for each year (Figure 24). As the variability over the years of the assessment is very high, using just the last 3 years was not considered realistic. Hence, in the projections, recruits per spawner were drawn randomly from all years (1988-2010).

Maturity ogive: Drawn randomly from the maturity ogives (with their associated uncertainty) of the last three years of the assessment (2008-2010).

Weight-at-age in stock and weight-at-age in catch: Drawn randomly from the last 3 years (2008-2010) (Tables 4 and 5).

PR at age for 2010-2013: There is only one year of open fishery, so the PR was calculated as the PR of that year (2010). Last year an average of the PRs for 1988-1998 was used, the period in which the fishery had been open before 2010. The two PR are compared in Figure 25, showing differences between the two PRs.

F_{bar}(ages 3-5): Six options were considered. All Scenarios assumed that the 2011 catch is the TAC (10 000 tons):

1. Average of F_{bar} in 2008-2010 (median value at 0.128).
2. $F_{0.1}$ (median value at 0.130).
3. Average of F_{bar} in 1988-1995 (median value at 0.967), as these years correspond to the period when SSB was above B_{lim}.
4. F_{max} (median value at 0.210).
5. F=0.
6. $F_{statusquo}$ (median value at 0.280).

Results for the six options are presented in Tables 10-21 and Figures 26 and 27. They indicate that total biomass and SSB has a very high probability of reaching levels higher than the 1988-2010 estimated level for all options except option 3 (F_{bar} equal to the average of 1988-1995 F_{bar}). The increase in SSB is higher then in total biomass. However, the huge increase predicted for SSB does not have a counterpart for the mature abundances, which are projected to remain at levels below these of the late 1980´s or just above. This is largely due to the fact that weight-at-age and maturity-at-age used for the projection period, namely random draws from the last 3 assessment years, are much higher than those assumed to have applied at the end of the 1980's.

Results indicate that fishing at the F_{bar} level currently estimated for 2010 should allow SSB to increase slowly, although abundance will remain at levels below those observed at the beginning of the series. If the fishing mortality were return to the levels seen before 1995, stock recovery would become improbable.

The projected values for the period 2012-2014 are heavily reliant on the relatively abundant six most recent cohorts, namely those recruited in 2005-2010.

References

Cerviño, S. and A. Vázquez, 2003. Re-opening criteria for Flemish Cap cod: a survey-based method. NAFO SCR Doc. 03/38. Serial Number N4856.

Fernández, C., S. Cerviño and A. Vázquez, 2007. A Survey-based assessment of cod in division 3M. NAFO SCR Doc. 07/39. Serial Number N5526.

Fernández, C., S. Cerviño and A. Vázquez, 2008. Assessment of the Cod Stock in NAFO Division 3M. NAFO SCR Doc. 08/26. Serial Number N5391.

González-Costas, F., D. González-Troncoso, G. Ramilo, E. Román , J. Lorenzo, M. Casas, C. Gonzalez, A. Vázquez , and M. Sacau. Spanish Research Report for 2010. NAFO SCS Doc. 11/07. Serial Number N5884

González-Troncoso, D. and J. M. Casas, 2005. Calculation of the calibration factors from the comparative experience between the R/V *Cornide de Saavedra* and the R/V *Vizconde de Eza* in Flemish Cap in 2003 and 2004. SCR Doc. 05/29, Serial Number N5115.

González-Troncoso, D. and A. Vázquez. Assessment of the 3M Cod Stock in NAFO Division 3M. NAFO SCR Doc. 10/41. Serial Number N5800.

Vázquez, A. and S. Cerviño, 2005. A review of the status of the cod stock in NAFO division 3M. NAFO SCR Doc. 05/38. Serial Number N5124.

Casas, M. and González-Troncoso D., 2011. Results from the bottom trawl survey on Flemish Cap of June-July 2010. NAFO SCR Doc 11/21. Serial Number N5904.

Vargas, J., R. Alpoim, E. Santos and A. M. Ávila de Melo, 2011. Portuguese research report for 2010. NAFO SCS Doc. 11/05. Serial Number N5881.

Statkus, R., 2011.Lithuania Research Report for 2010. NAFO SCS Doc. 11/04. Serial Number N5880

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Table 1.- Total commercial cod catch in Division 3M. Reported nominal catches since 1960 and estimated total catch since 1988 in tons

Year	Estimated[1]	Portugal	Russia	Spain	France	Faroes	UK	Poland	Norway	Germany	Cuba	Others	Total
1960		9	11595	607					46	86		10	12353
1961		2155	12379	851	2626		600	336		1394		0	20341
1962		2032	11282	1234			93	888	25	4		349	15907
1963		7028	8528	4005	9501		2476	1875		0		0	33413
1964		3668	26643	862	3966		2185	718	660	83		12	38797
1965		1480	37047	1530	2039		6104	5073	11	313		458	54055
1966		7336	5138	4268	4603		7259	93		259		0	28956
1967		10728	5886	3012	6757		5732	4152		756		46	37069
1968		10917	3872	4045	13321		1466	71		0		458	34150
1969		7276	283	2681	11831					20		52	22143
1970		9847	494	1324	6239		3	53		0		35	17995
1971		7272	5536	1063	9006			19		1628		25	24549
1972		32052	5030	5020	2693	6902	4126	35	261	506		187	56812
1973		11129	1145	620	132	7754	1183	481	417	21		18	22900
1974		10015	5998	2619		1872	3093	700	383	195		63	24938
1975		10430	5446	2022		3288	265	677	111	28		108	22375
1976		10120	4831	2502	229	2139		898	1188	225		134	22266
1977		6652	2982	1315	5827	5664	1269	843	867	45	1002	553	27019
1978		10157	3779	2510	5096	7922	207	615	1584	410	562	289	33131
1979		9636	4743	4907	1525	7484		5	1310	0	24	76	29710
1980		3615	1056	706	301	3248		33	1080	355	1	62	10457
1981		3727	927	4100	79	3874			1154	0		12	13873
1982		3316	1262	4513	119	3121	33		375	0		14	12753
1983		2930	1264	4407		1489			111	3		1	10205
1984		3474	910	4745		3058			47	454	5	9	12702
1985		4376	1271	4914		2266			405	429	9	5	13675
1986		6350	1231	4384		2192				345	3	13	14518
1987		2802	706	3639	2300	916				0		269	10632
1988	28899	421	39	141		1100				0	3	14	1718
1989	48373	170	10	378						0		359	917
1990	40827	551	22	87		1262				0		840	2762
1991	16229	2838	1	1416		2472	26		897	0	5	1334	8989
1992	25089	2201	1	4215		747	5			0	6	51	7226
1993	15958	3132	0	2249		2931				0		4	8316
1994	29916	2590	0	1952		2249			1	0		93	6885
1995	10372	1641	0	564		1016				0		0	3221
1996	2601	1284	0	176		700	129			16		0	2305
1997	2933	1433	0	1			23			0		0	1457
1998	705	456	0							0		0	456
1999	353	2	0							0		0	2
2000	55	30	6							0		0	36
2001	37	56	0							0		0	56
2002	33	32	1							0		0	33
2003	16	7	0							0		9	16
2004	5	18	2							0		3	23
2005	19	16	0			7				0		3	26
2006	339	51	1	16						0		55	123
2007	345	58	6	33						0		28	125
2008	889	219	74	42		0				0		66	401
2009	1161	856	87	85		22				0		122	1172
2010	9192	1482	374			1183	761		519	0		85	4404

[1] Recalculated from NAFO Statistical data base using the NAFO 21A Extraction Tool

Table 2.- Catch-at-age (thousands)

	1	2	3	4	5	6	7	8+
1988	1	3500	25593	11161	1399	414	315	162
1989	0	52	15399	23233	9373	943	220	205
1990	7	254	2180	15740	10824	2286	378	117
1991	1	561	5196	1960	3151	1688	368	76
1992	0	15517	10180	4865	3399	2483	1106	472
1993	0	2657	14530	3547	931	284	426	213
1994	0	1219	25400	8273	386	185	14	182
1995	0	0	264	6553	2750	651	135	232
1996	0	81	714	311	1072	88	0	0
1997	0	0	810	762	143	286	48	0
1998	0	0	8	170	286	30	19	2
1999	0	0	15	15	96	60	3	1
2000	0	10	54	1	1	4	1	0
2001	0	9	0	4	2	0	2	2
2002								
2003								
2004								
2005								
2006	0	22	19	81	2	10	2	0
2007	0	2	30	1	27	1	14	5
2008	1	89	136	133	3	40	1	3
2009	0	23	51	210	108	0	32	7
2010	34	452	1145	1498	808	388	4	103

Table 3.- EU bottom trawl survey abundance at age (thousands)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1988	4850	78920	49050	13370	1450	210	220	60	0	0	0	0	0	0
1989	22100	12100	106400	63400	23800	1600	200	100	0	0	0	0	0	0
1990	2660	14020	5920	19970	18420	5090	390	170	90	30	0	0	0	0
1991	146100	29400	20600	2500	7800	2100	300	100	0	0	0	0	0	0
1992	75480	44280	6290	2540	410	1500	270	10	0	0	10	0	0	0
1993	4600	156100	35400	1300	1500	200	600	100	0	0	0	0	0	0
1994	3340	4550	31580	5760	150	70	10	120	0	10	0	0	0	0
1995	1640	13670	1540	4490	1070	40	30	0	20	10	0	0	0	0
1996	41	3580	7649	1020	2766	221	9	6	0	0	0	0	0	0
1997	42	171	3931	5430	442	1078	24	0	0	0	0	6	0	0
1998	27	94	106	1408	1763	87	165	0	6	0	0	0	0	0
1999	7	96	128	129	792	491	21	7	0	0	0	0	0	0
2000	186	16	343	207	100	467	180	11	17	0	0	5	0	5
2001	487	2048	15	125	81	15	146	101	6	6	6	0	0	0
2002	0	1340	609	24	68	36	28	96	33	0	6	0	0	0
2003	665	53	610	131	22	47	7	8	37	25	0	0	0	0
2004	0	3379	25	602	168	5	10	3	5	16	0	0	0	0
2005	8069	16	1118	78	708	136		17	8	8	0	0	0	0
2006	19710	3883	62	1481	86	592	115	7	0	7	14	0	7	0
2007	3910	11620	5020	21	1138	58	425	74	13	20	0	0	0	0
2008	6090	16670	12440	4530	70	940	60	230	80	0	10	0	0	0
2009	5139	7479	16150	14310	4154	26	1091	0	335	0	0	14	0	0
2010	66370	27689	8654	7633	4911	1780	8	442	46	251	26	0	0	0

Table 4.- Weight-at-age (kg) in catch

	1	2	3	4	5	6	7	8+
1988	0.058	0.198	0.442	0.821	2.190	3.386	5.274	7.969
1989		0.209	0.576	0.918	1.434	2.293	4.721	7.648
1990	0.080	0.153	0.500	0.890	1.606	2.518	3.554	7.166
1991	0.118	0.229	0.496	0.785	1.738	2.622	3.474	6.818
1992		0.298	0.414	0.592	1.093	1.704	2.619	3.865
1993		0.210	0.509	0.894	1.829	2.233	3.367	4.841
1994		0.289	0.497	0.792	1.916	2.719	2.158	4.239
1995			0.415	0.790	1.447	2.266	3.960	5.500
1996		0.286	0.789	1.051	1.543	2.429		
1997			0.402	0.640	0.869	1.197	1.339	
1998			0.719	1.024	1.468	1.800	2.252	3.862
1999			0.92	1.298	1.848	2.436	3.513	4.893
2000		0.583	0.672	1.749	2.054	2.836	3.618	
2001		0.481		1.696	2.560		3.905	5.217
2002		0.588	1.323	1.388	2.572	3.770	5.158	5.603
2003		0.462	1.063	1.455	2.978	3.696	5.859	6.120
2004		0.839	1.677	2.009	3.353	5.576	6.241	8.273
2005		0.895	1.618	2.368	3.259	4.767	6.177	6.553
2006		1.081	1.462	2.283	3.966	5.035	6.332	
2007		0.974	1.858	3.388	4.062	6.128	6.809	9.440
2008	0.088	0.448	1.364	3.037	3.498	5.248	6.643	8.251
2009	0.172	0.507	1.026	2.087	3.727		5.900	9.534
2010	0.162	0.700	1.279	1.829	2.764	4.372	4.199	8.575

Table 5.- Weight-at-age (kg) in stock

	1	2	3	4	5	6	7	8+
1988	0.03	0.10	0.31	0.68	1.97	3.59	5.77	6.93
1989	0.04	0.24	0.54	1.04	1.60	2.51	4.27	6.93
1990	0.04	0.17	0.34	0.85	1.50	2.43	4.08	5.64
1991	0.05	0.17	0.50	0.86	1.61	2.61	4.26	7.69
1992	0.05	0.25	0.49	1.38	1.70	2.63	3.13	6.69
1993	0.04	0.22	0.66	1.21	2.27	2.37	3.45	5.89
1994	0.06	0.21	0.59	1.32	2.26	4.03	4.03	6.72
1995	0.05	0.24	0.47	0.96	1.85	3.16	5.56	8.48
1996	0.04	0.25	0.53	0.80	1.32	2.27	4.00	5.03
1997	0.08	0.32	0.64	1.00	1.31	2.10	2.00	9.57
1998	0.07	0.36	0.75	1.19	1.66	1.99	3.10	7.40
1999	0.10	0.37	0.92	1.30	1.85	2.44	3.51	4.89
2000	0.10	0.58	0.96	1.61	1.91	2.83	3.47	5.28
2001	0.08	0.48	1.25	1.70	2.56	3.42	3.91	5.22
2002	0.00	0.42	1.12	1.43	2.47	3.59	4.86	5.31
2003	0.05	0.33	0.90	1.50	2.86	3.52	5.52	5.80
2004	0.07	0.6	1.42	2.07	3.22	5.31	5.88	7.84
2005	0.02	0.64	1.37	2.44	3.13	4.54		6.21
2006	0.09	0.7	1.06	2.49	3.57	4.69	5.76	9.55
2007	0.05	0.59	1.60	3.40	4.01	5.69	6.27	8.76
2008	0.07	0.38	1.34	2.69	3.19	5.02	6.32	7.94
2009	0.08	0.41	0.98	2.07	3.88	6.96	6.58	9.46
2010	0.06	0.38	1.09	1.68	2.96	5.38	7.62	9.14

Table 6.- Maturity at age (median values of ogives)

	1	2	3	4	5	6	7	8
1988	0.054	0.099	0.175	0.291	0.441	0.603	0.745	0.879
1989	0.054	0.099	0.175	0.291	0.441	0.603	0.745	0.879
1990	0.054	0.099	0.175	0.291	0.441	0.603	0.745	0.879
1991	0.016	0.044	0.108	0.247	0.462	0.698	0.867	0.962
1992	0.002	0.011	0.048	0.184	0.503	0.819	0.953	0.993
1993	0.001	0.007	0.049	0.282	0.751	0.959	0.994	1.000
1994	0.000	0.001	0.050	0.657	0.986	1.000	1.000	1.000
1995	0.000	0.000	0.006	0.803	1.000	1.000	1.000	1.000
1996	0.000	0.000	0.029	0.666	0.993	1.000	1.000	1.000
1997	0.000	0.008	0.111	0.670	0.971	0.998	1.000	1.000
1998	0.000	0.002	0.096	0.874	0.998	1.000	1.000	1.000
1999	0.000	0.001	0.131	0.902	0.999	1.000	1.000	1.000
2000	0.000	0.001	0.163	0.966	1.000	1.000	1.000	1.000
2001	0.000	0.001	0.315	0.998	1.000	1.000	1.000	1.000
2002	0.000	0.010	0.636	0.997	1.000	1.000	1.000	1.000
2003	0.001	0.024	0.513	0.978	0.999	1.000	1.000	1.000
2004	0.000	0.000	0.100	0.967	1.000	1.000	1.000	1.000
2005	0.041	0.171	0.502	0.830	0.959	0.991	0.998	1.000
2006	0.000	0.014	0.365	0.959	0.999	1.000	1.000	1.000
2007	0.000	0.014	0.365	0.959	0.999	1.000	1.000	1.000
2008	0.000	0.012	0.231	0.882	0.995	1.000	1.000	1.000
2009	0.000	0.010	0.181	0.830	0.991	1.000	1.000	1.000
2010	0.000	0.009	0.167	0.812	0.989	1.000	1.000	1.000

Table 7.- Posterior results: total biomass, SSB, recruitment (tons) and F_{bar}.

	B quantiles			**SSB quantiles**			**R quantiles**			**F_{bar} quantiles**		
Year	**50%**	**5%**	**95%**	**50%**	**5%**	**95%**	**50%**	**5%**	**95%**	**50%**	**5%**	**95%**
1988	64272	59672	70682	19171	15344	23905	13985	11689	17801	0.516	0.472	0.550
1989	104105	98317	112194	33479	27446	40865	18790	16120	23110	0.872	0.813	0.915
1990	64070	60573	68922	25460	21751	29548	23785	20680	28700	0.910	0.853	0.954
1991	44017	40920	48685	17828	15020	21552	60410	53460	71300	0.500	0.467	0.527
1992	57678	54759	62008	21001	18460	23939	54720	47950	65350	1.555	1.476	1.614
1993	45718	42792	49862	10647	8966	13419	2978	2615	3566	1.038	0.968	1.093
1994	49645	46327	55310	21735	18782	27069	4219	3204	6167	0.958	0.912	0.994
1995	22578	21333	24480	19301	18124	21000	2166	1788	2827	1.397	1.254	1.504
1996	5892	5197	6935	3560	3137	4267	135	89	215	0.643	0.528	0.742
1997	5082	4259	6383	3459	2817	4506	130	85	209	0.709	0.565	0.856
1998	3893	2817	5633	3673	2623	5394	196	141	291	0.284	0.205	0.385
1999	2812	1895	4400	2669	1760	4237	33	24	49	0.270	0.200	0.361
2000	2631	1633	4452	2477	1478	4274	332	207	528	0.184	0.126	0.258
2001	2136	1465	3093	1930	1272	2859	586	370	943	0.033	0.023	0.047
2002	2499	1827	3457	2183	1531	3116	69	44	111	0.014	0.007	0.029
2003	2798	2137	3707	2511	1877	3404	1252	817	1901	0.010	0.006	0.017
2004	4490	3613	5645	3727	2921	4831	79	58	115	0.003	0.002	0.005
2005	4883	4040	5944	4047	3323	4984	3955	2491	6512	0.006	0.004	0.010
2006	7680	6139	9764	4333	3470	5438	8808	5318	14951	0.209	0.159	0.267
2007	14618	11334	19210	6600	5042	8528	9226	5668	15891	0.028	0.021	0.037
2008	22688	17301	30081	11359	8658	15186	7550	4455	13100	0.069	0.052	0.092
2009	34003	26227	43828	22233	16698	29759	12950	6235	27790	0.038	0.027	0.052
2010	50204	39520	64172	36278	27730	47189	26510	9706	73585	0.275	0.196	0.397
2011				50291	35132	71833						

Table 8.- F at age (posterior median)

	F at age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8+**
1988	0.000	0.068	0.439	0.557	0.555	0.746	1.258	1.258
1989	0.000	0.005	0.443	0.870	1.308	0.878	1.160	1.160
1990	0.000	0.017	0.258	1.086	1.388	1.463	1.069	1.069
1991	0.000	0.030	0.525	0.368	0.611	0.790	0.967	0.967
1992	0.000	0.388	1.024	1.391	2.257	1.491	2.525	2.525
1993	0.000	0.063	0.724	1.279	1.117	1.794	1.163	1.163
1994	0.000	0.720	1.266	1.212	0.398	0.648	0.341	0.341
1995	0.000	0.000	0.309	1.448	2.452	3.213	1.486	1.486
1996	0.000	0.048	0.284	0.686	0.966	0.503	0.000	0.000
1997	0.000	0.000	0.845	0.525	0.750	0.703	0.539	0.539
1998	0.000	0.000	0.090	0.392	0.358	0.319	0.082	0.082
1999	0.000	0.000	0.184	0.232	0.379	0.111	0.045	0.045
2000	0.000	0.478	0.513	0.016	0.020	0.023	0.002	0.002
2001	0.000	0.035	0.000	0.059	0.038	0.000	0.013	0.013
2002	0.000	0.006	0.014	0.010	0.011	0.005	0.013	0.013
2003	0.000	0.005	0.009	0.009	0.010	0.005	0.004	0.004
2004	0.000	0.001	0.005	0.002	0.002	0.004	0.001	0.001
2005	0.000	0.005	0.004	0.009	0.005	0.004	0.003	0.003
2006	0.000	0.007	0.441	0.118	0.064	0.043	0.015	0.015
2007	0.000	0.000	0.011	0.022	0.050	0.046	0.071	0.071
2008	0.000	0.012	0.023	0.060	0.122	0.092	0.058	0.058
2009	0.000	0.004	0.008	0.042	0.060	0.000	0.092	0.092
2010	0.001	0.045	0.250	0.330	0.214	0.301	0.266	0.266

Table 9.- N at age (posterior median), with the total number and number of matures by year.

	N at age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8+**	**Total**	**Matures**
1988	13985	57580	77620	28150	3545	851	474	240	182445	31190
1989	18790	12040	46330	43100	13875	1742	346	317	136540	30781
1990	23785	16180	10320	25625	15550	3217	621	190	95488	21776
1991	60410	20480	13700	6866	7441	3340	639	130	113006	11936
1992	54720	52020	17120	6981	4095	3462	1299	538	140235	9617
1993	2978	47130	30400	5296	1494	368	667	329	88662	5858
1994	4219	2561	38120	12700	1269	419	52	678	60018	12812
1995	2166	3629	1072	9249	3251	733	188	317	20605	11970
1996	135	1862	3121	675	1869	240	25	1	7928	2699
1997	130	116	1529	2018	292	610	124	1	4820	2605
1998	196	112	100	565	1026	119	260	27	2405	1996
1999	33	168	96	78	328	616	74	25	1418	1160
2000	332	28	145	69	53	193	474	1	1295	845
2001	586	285	15	75	58	45	162	162	1388	514
2002	69	504	237	13	61	48	39	275	1246	602
2003	1252	59	432	200	11	51	41	267	2313	807
2004	79	1076	51	368	170	9	44	265	2062	864
2005	3955	68	926	43	316	146	8	267	5729	1433
2006	8808	3406	58	792	37	270	125	23	13519	1303
2007	9226	7583	2909	32	603	30	221	74	20678	2157
2008	7550	7922	6536	2466	27	493	24	66	25084	4464
2009	12950	6476	6726	5486	1990	20	388	88	34124	8461
2010	26510	11130	5560	5741	4516	1612	18	473	55560	12672
2011		22697	9132	3720	3551	3140	1025	324	43589	13824

Table 10.- N-at-age in prediction years (medians) with F_{bar}=F_{bar}(mean 2008-2010)=0.128 including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2011	8913	22697	9132	3720	3551	3140	1025	324	52502	13912
2012	9718	7632	18701	6445	2476	2570	2100	949	50591	18480
2013	12718	8364	6411	14284	4697	1902	1895	2310	52581	27879
2014	19481	10901	7003	4862	10406	3616	1401	3253	60923	32999

Table 11.- Projections results with F_{bar}=F_{bar}(mean 2008-2010)=0.128.

	Total Biomass quantiles			**SSB quantiles**			**P(SSB<B_{lim})**	**Yield quantiles**		
Year	5%	50%	95%	5%	50%	95%		5%	50%	95%
2011	52407	73656	102909	35487	50433	71249	0.0000	5854	9726	16046
2012	64930	96560	148302	46501	65390	91634	0.0000	5115	9238	16902
2013	76780	127015	219135	63934	95531	150208	0.0000	6644	13137	26994
2014	88274	164001	309443	73481	126165	229654	0.0000	6935	15579	35000

Table 12.- N-at-age in prediction years (medians) with F_{bar}=$F_{0.1}$=0.13 including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2011	8495	22697	9132	3720	3551	3140	1025	324	52084	13873
2012	9598	7369	18732	6415	2459	2566	2104	943	50186	18563
2013	13412	8267	6184	14163	4705	1894	1879	2322	52826	27412
2014	19942	11588	6946	4624	10282	3632	1403	3247	61664	32414

Table 13.- Projections results with F_{bar}=$F_{0.1}$=0.13.

	Total Biomass quantiles			**SSB quantiles**			**P(SSB<B_{lim})**	**Yield quantiles**		
Year	5%	50%	95%	5%	50%	95%		5%	50%	95%
2011	52295	73217	102422	35207	50337	71531	0.0000	5796	9651	15961
2012	65139	96289	149544	46314	65654	92007	0.0000	4809	9265	17924
2013	77306	125412	218815	63949	95245	151422	0.0000	6029	13056	27766
2014	87812	161853	298153	73254	123460	228973	0.0000	6388	15249	36664

Table 14.- N-at-age in prediction years (medians) with F_{bar}=F_{bar}(mean 1988-1995)=0.967 including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2011	8622	22697	9132	3720	3551	3140	1025	324	52211	13838
2012	9840	7450	18750	6417	2456	2572	2104	948	50537	18561
2013	13212	8449	5418	6553	1681	960	739	1017	38029	13468
2014	9345	11380	6080	1885	1706	661	278	585	31920	10060

Table 15.- Projections results with F_{bar}=F_{bar}(mean 1988-1995)=0.967.

	Total Biomass quantiles			**SSB quantiles**			**P(SSB<B_{lim})**	**Yield quantiles**		
Year	5%	50%	95%	5%	50%	95%		5%	50%	95%
2011	52409	73420	102984	35387	50598	71865	0.0000	5805	9652	15539
2012	64849	96398	148878	46575	65230	91072	0.0000	29320	47053	79249
2013	35989	68109	136462	27300	43662	71484	0.0000	16452	33265	73596
2014	20967	58160	139639	14179	29488	66578	0.0452	8959	26540	74026

Table 16.- N-at-age in prediction years (medians) with F_{max}=0.21 including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2011	9037	22697	9132	3720	3551	3140	1025	324	52626	13896
2012	9946	7727	18742	6429	2473	2575	2101	944	50937	18490
2013	13196	8536	6367	13038	4221	1775	1713	2122	50968	25669
2014	19028	11401	7086	4431	8575	3055	1186	2699	57461	28722

Table 17.- Projections results with F_{bar}=F_{max}=0.21.

	Total Biomass quantiles			**SSB quantiles**			**P(SSB<B_{lim})**	**Yield quantiles**		
Year	5%	50%	95%	5%	50%	95%		5%	50%	95%
2011	52245	73236	102759	35232	50487	71767	0.0000	5908	9754	15813
2012	65395	96949	148571	46559	65429	91648	0.0000	7608	14728	28224
2013	71000	118180	210371	57748	88166	138854	0.0000	9098	19104	41108
2014	74024	143509	277413	60717	107377	200648	0.0000	8544	21304	51887

Table 18.- N-at-age in prediction years (medians) with F_{bar}=0 including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2011	9393	22697	9132	3720	3551	3140	1025	324	52982	13886
2012	10333	7974	18754	6422	2462	2570	2101	939	51555	18584
2013	13656	8879	6855	16107	5506	2119	2204	2653	57979	31284
2014	22453	11807	7643	5930	13815	4729	1822	4288	72487	41294

Table 19.- Projections results with F_{bar}= 0.

	Total Biomass quantiles			**SSB quantiles**			**P(SSB<B_{lim})**	**Yield quantiles**		
Year	5%	50%	95%	5%	50%	95%		5%	50%	95%
2011	52443	73210	102536	35247	50523	71519	0.0000	5960	9787	15744
2012	65526	97227	148814	46608	65420	91988	0.0000	0	0	0
2013	88196	141681	243396	73240	108592	170287	0.0000	0	0	0
2014	114783	201914	373663	96374	161204	292897	0.0000	0	0	0

Table 20.- N-at-age in prediction years (medians) with F_{bar}=$F_{statusquo}$=0.28 including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2011	9016	22697	9132	3720	3551	3140	1025	324	52605	13878
2012	9632	7678	18754	6471	2466	2569	2110	944	50624	18521
2013	13326	8154	6307	12311	3911	1682	1591	1993	49275	24242
2014	16586	11395	6655	4189	7453	2665	1042	2362	52347	25852

Table 21.- Projections results with F_{bar}= $F_{statusquo}$=0.28.

	Total Biomass quantiles			**SSB quantiles**			**P(SSB<B_{lim})**	**Yield quantiles**		
Year	5%	50%	95%	5%	50%	95%		5%	50%	95%
2011	52485	73302	102483	35342	50380	71937	0.0000	5879	9687	16104
2012	65349	97325	148155	46408	65464	91009	0.0000	11221	18971	32165
2013	67067	112039	200162	54681	82354	130366	0.0000	12390	23568	47545
2014	67777	129300	248623	54409	94154	179882	0.0000	11194	24735	56994

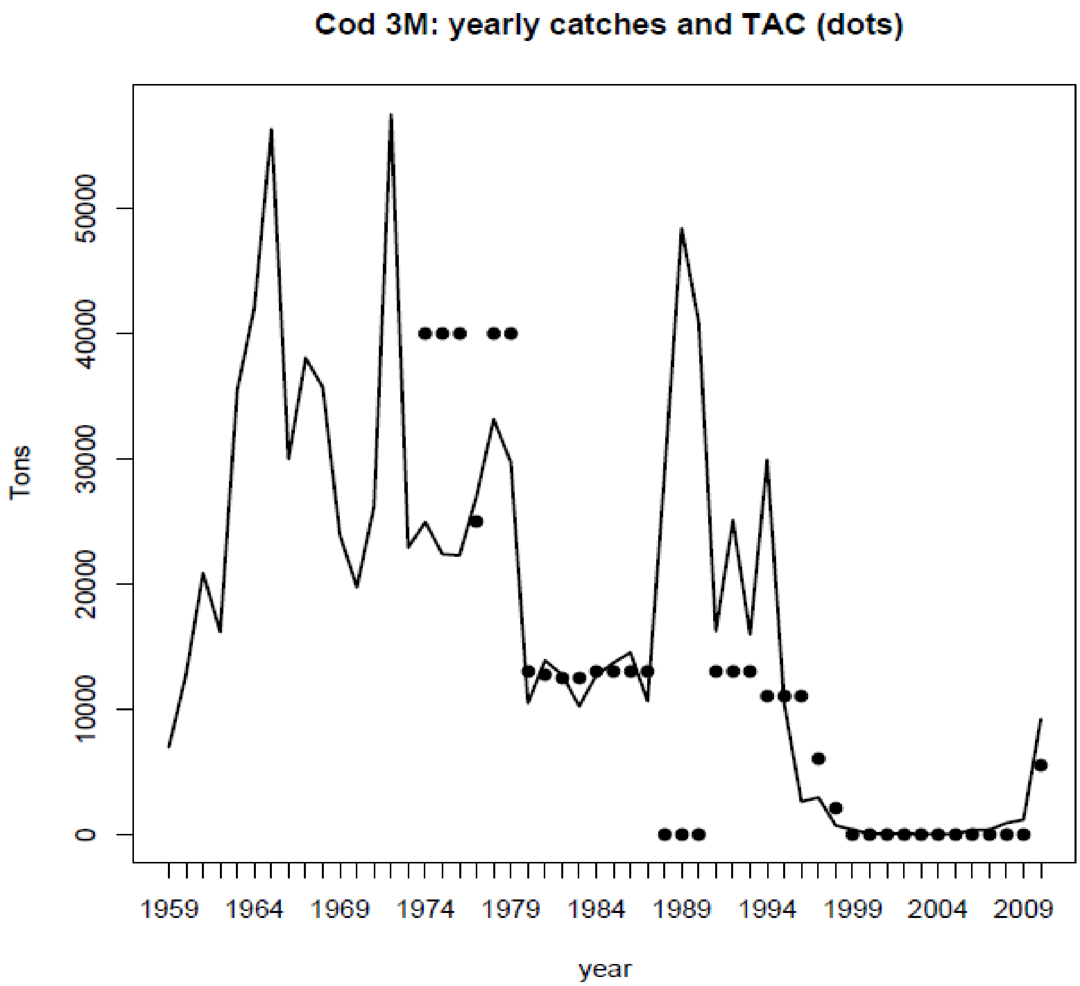

Figure 1.- Catch and TAC of the 3M cod for the period 1959-2010

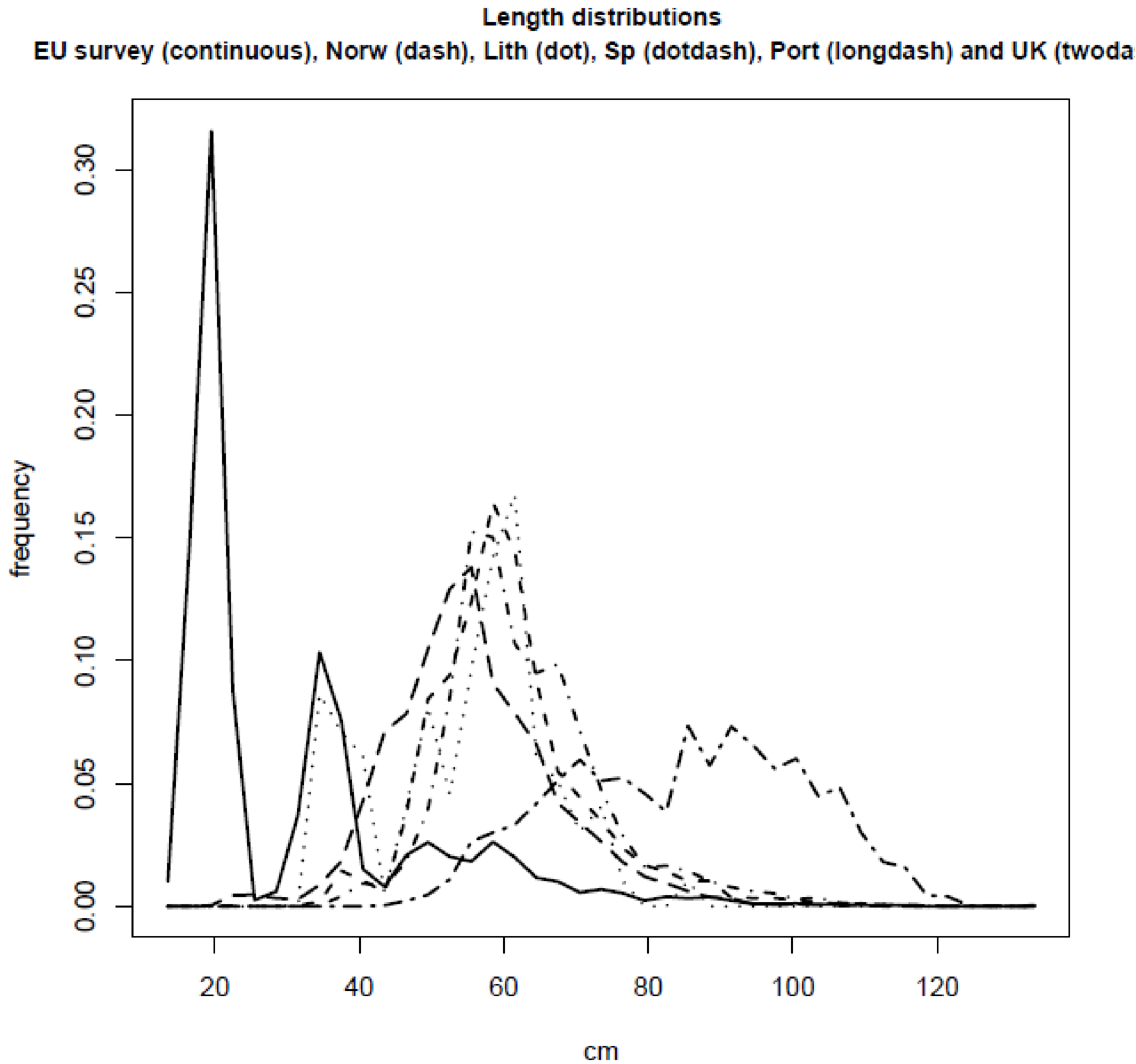

Figure 2.- Length frequencies in 2010. Nw: Norway; Lt: Lithuania; Sp: Spain; Pt: Portugal; UK: United Kingdom

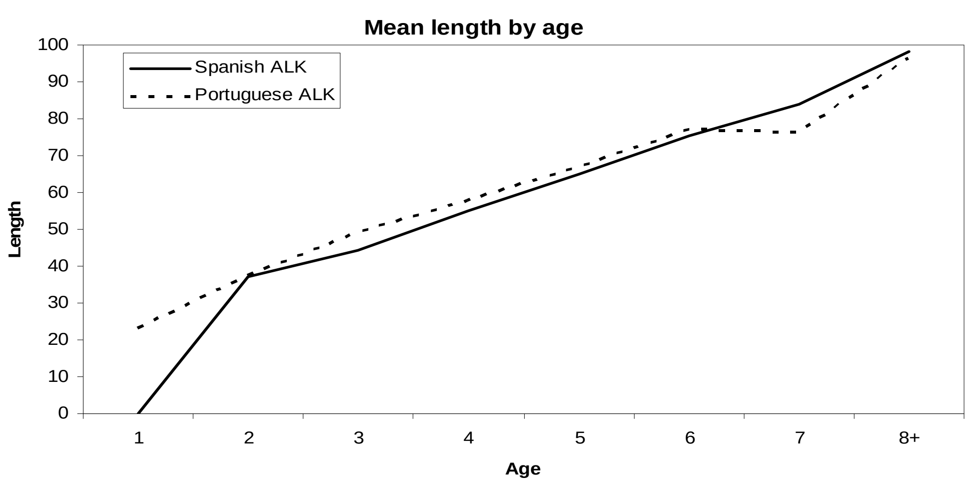

Figure 3.- Mean length at age for the two different ALKs

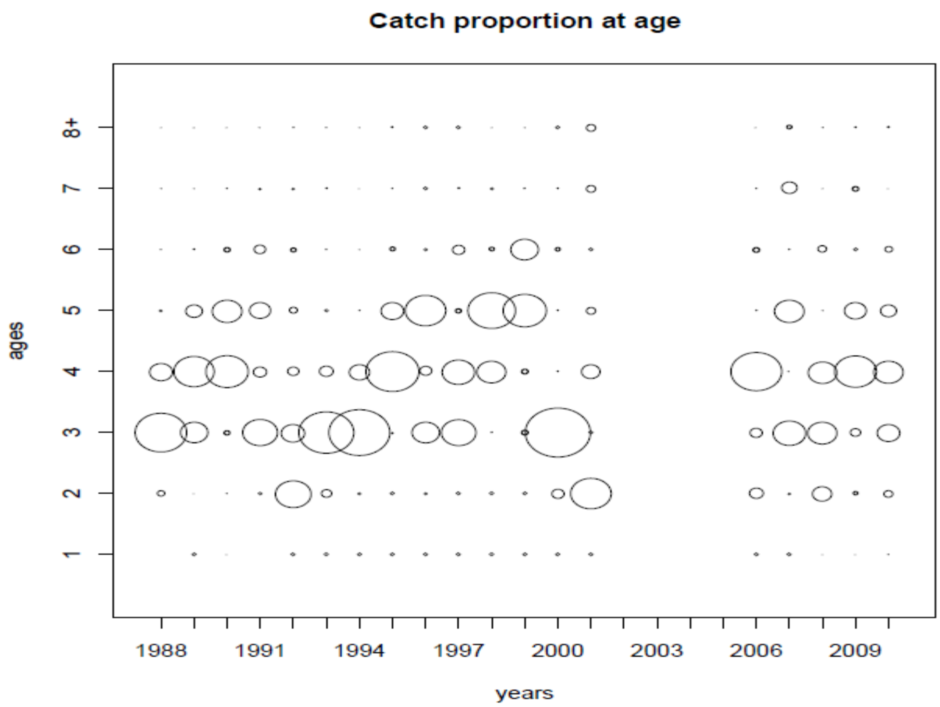

Figure 4.- Commercial catch proportions at age

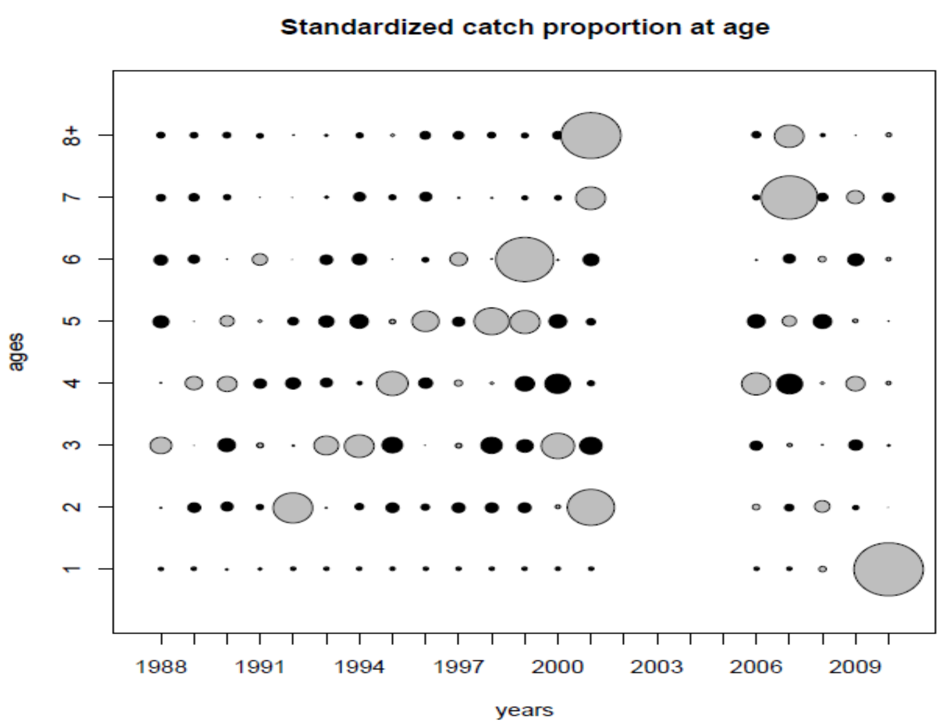

Figure 5.- Commercial catch standardised proportions at age. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

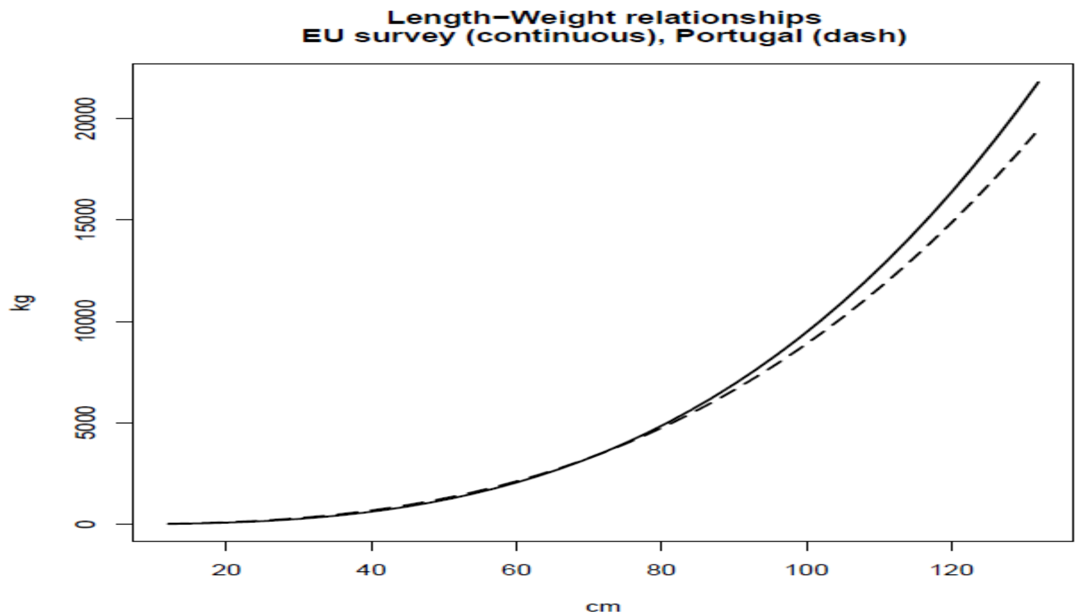

Figure 6.- Length-weight relationships for commercial and survey catches

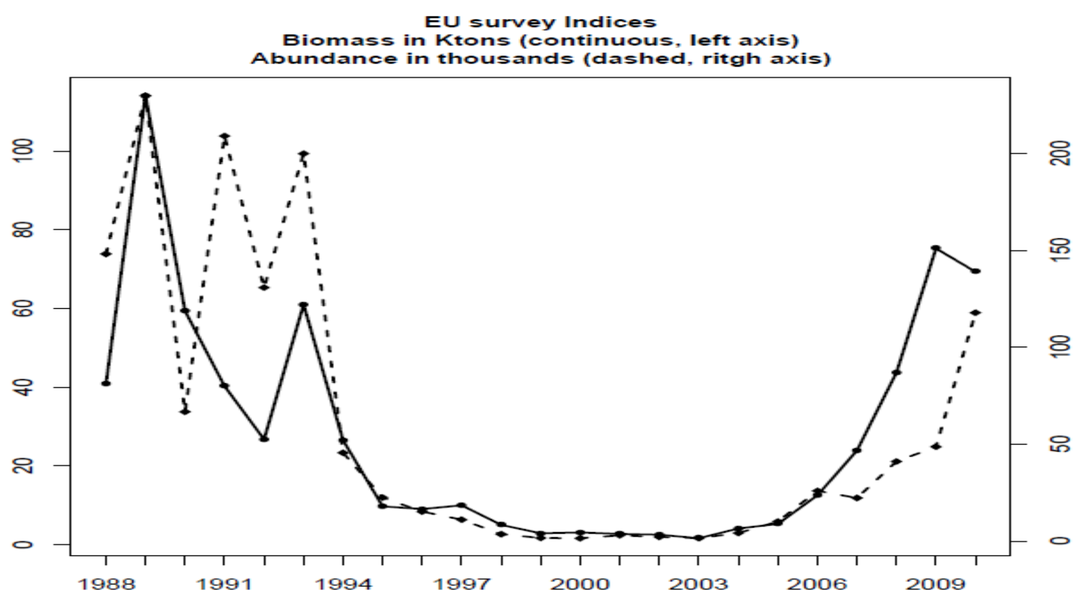

Figure 7.- Biomass and abundance from EU survey

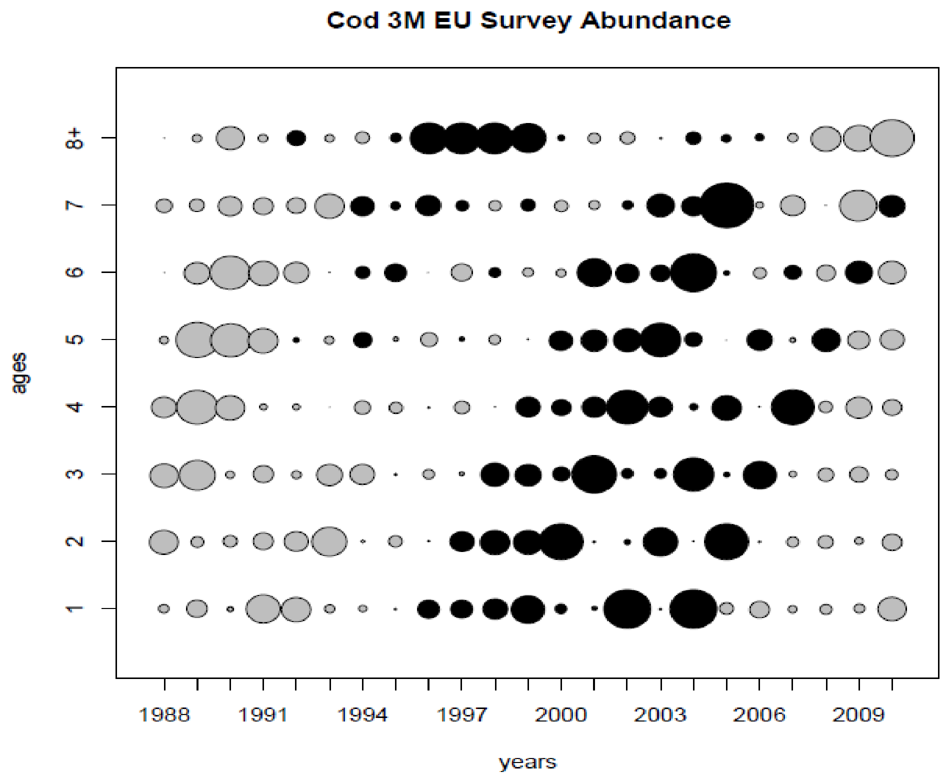

Figure 8.- Standardised log(1+Abundance at age) indices from EU survey. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

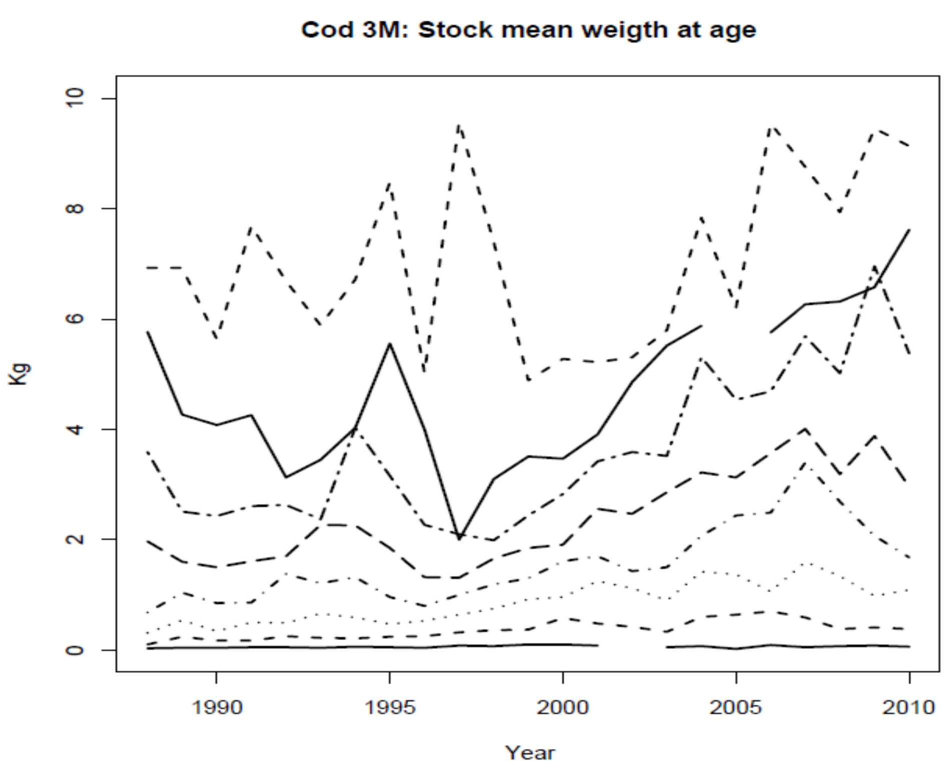

Figure 9.- Stock mean weight at age

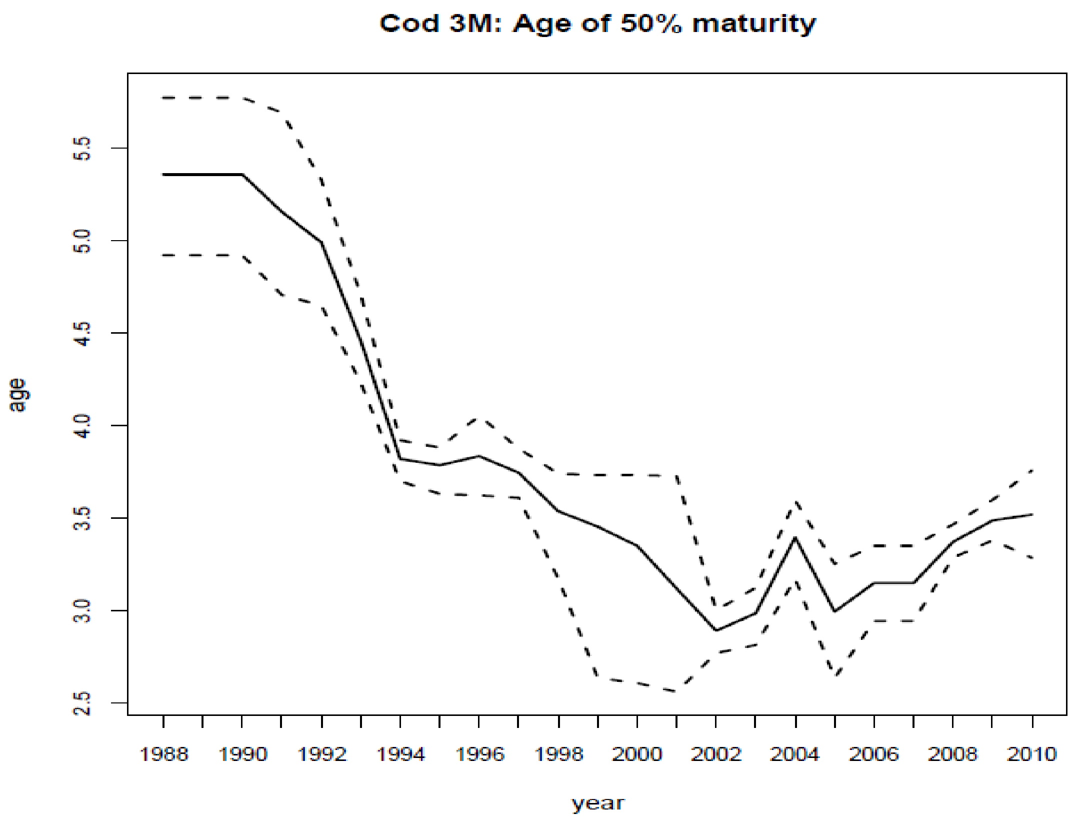

Figure 10.- Age at which 50% of fish are mature

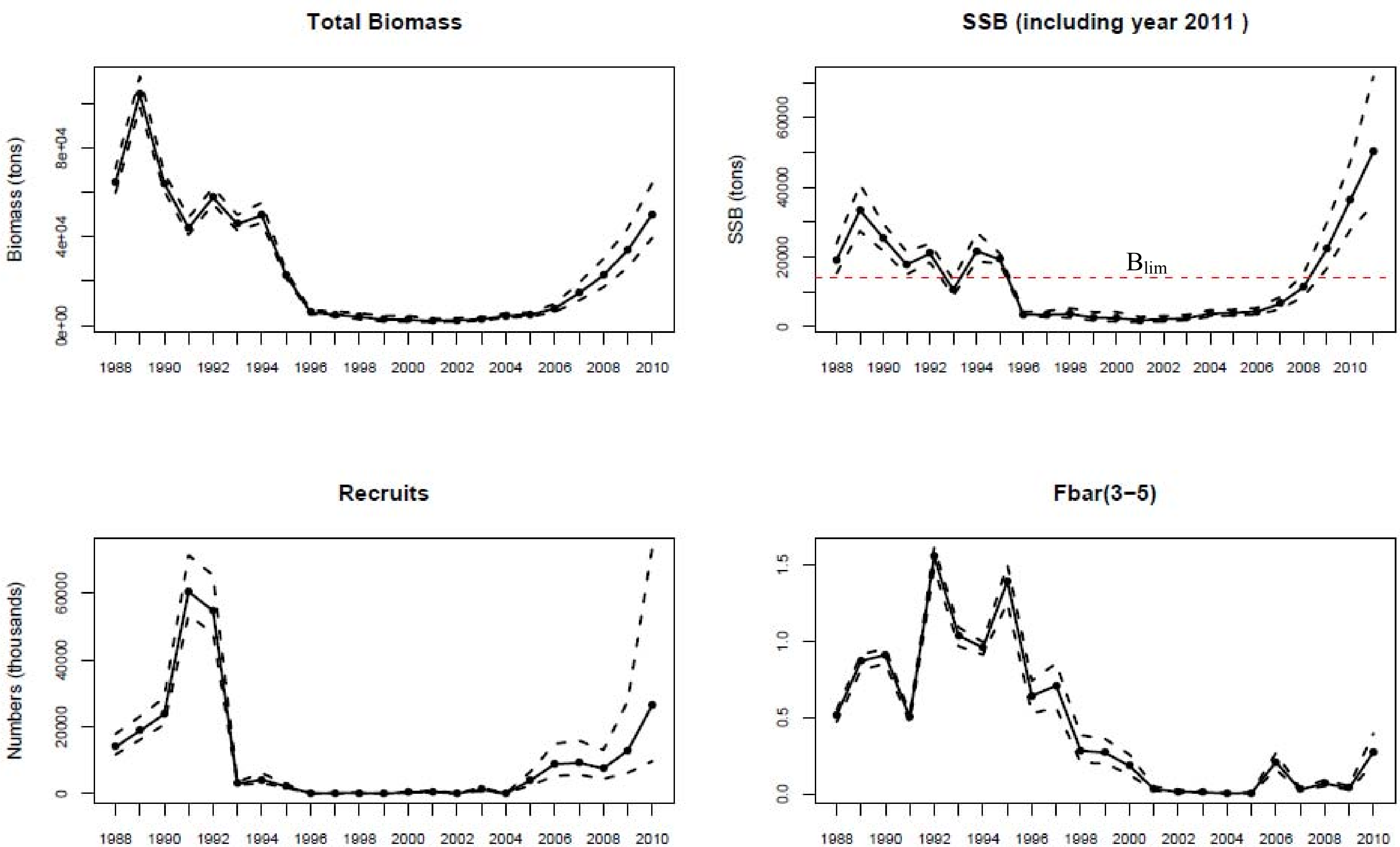

Figure 11.- Estimated trends in biomass, SSB, recruitment and Fbar. The solid lines are the posterior medians and the dashed lines show the limits of 90% posterior credible intervals. Red horizontal line in the SSB graph represents B_{lim} = 14000.

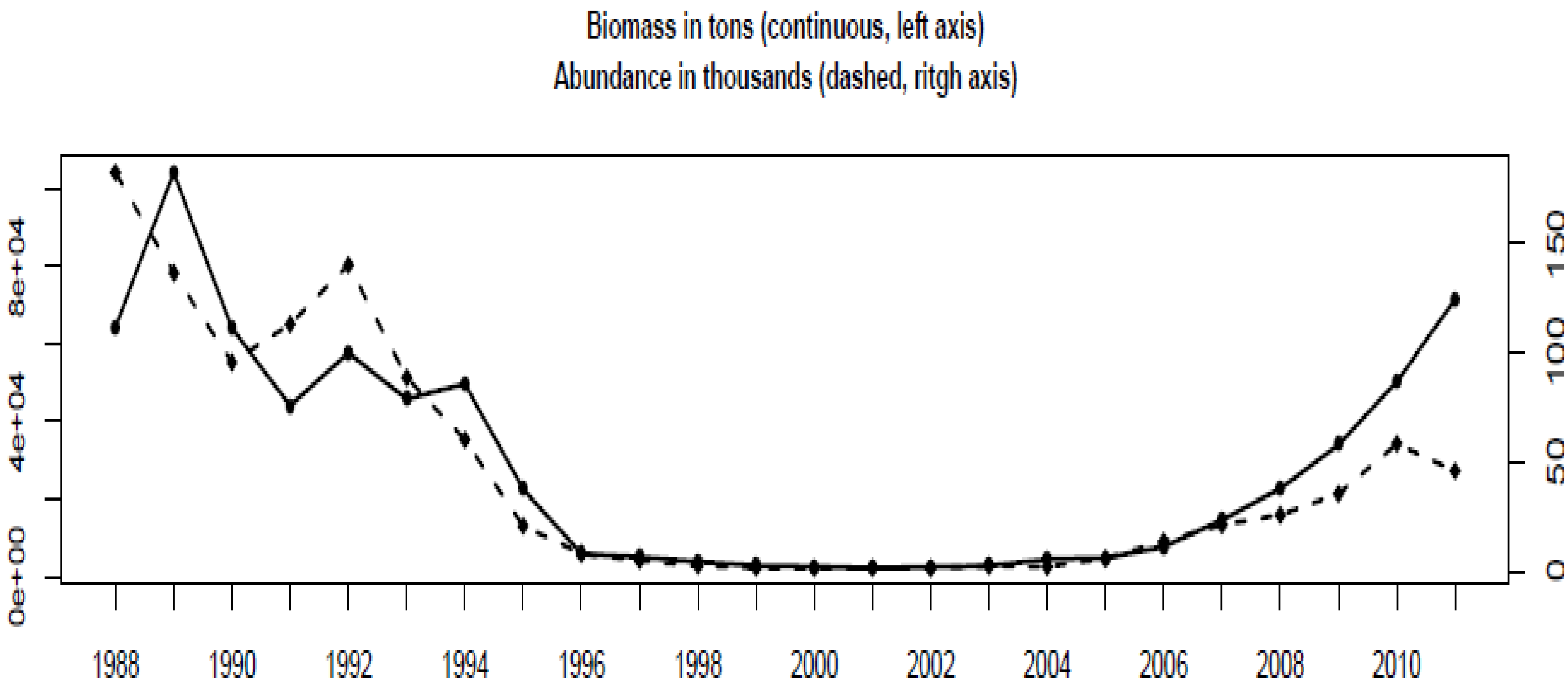

Figure 12.- Estimated trends in biomass and abundance.

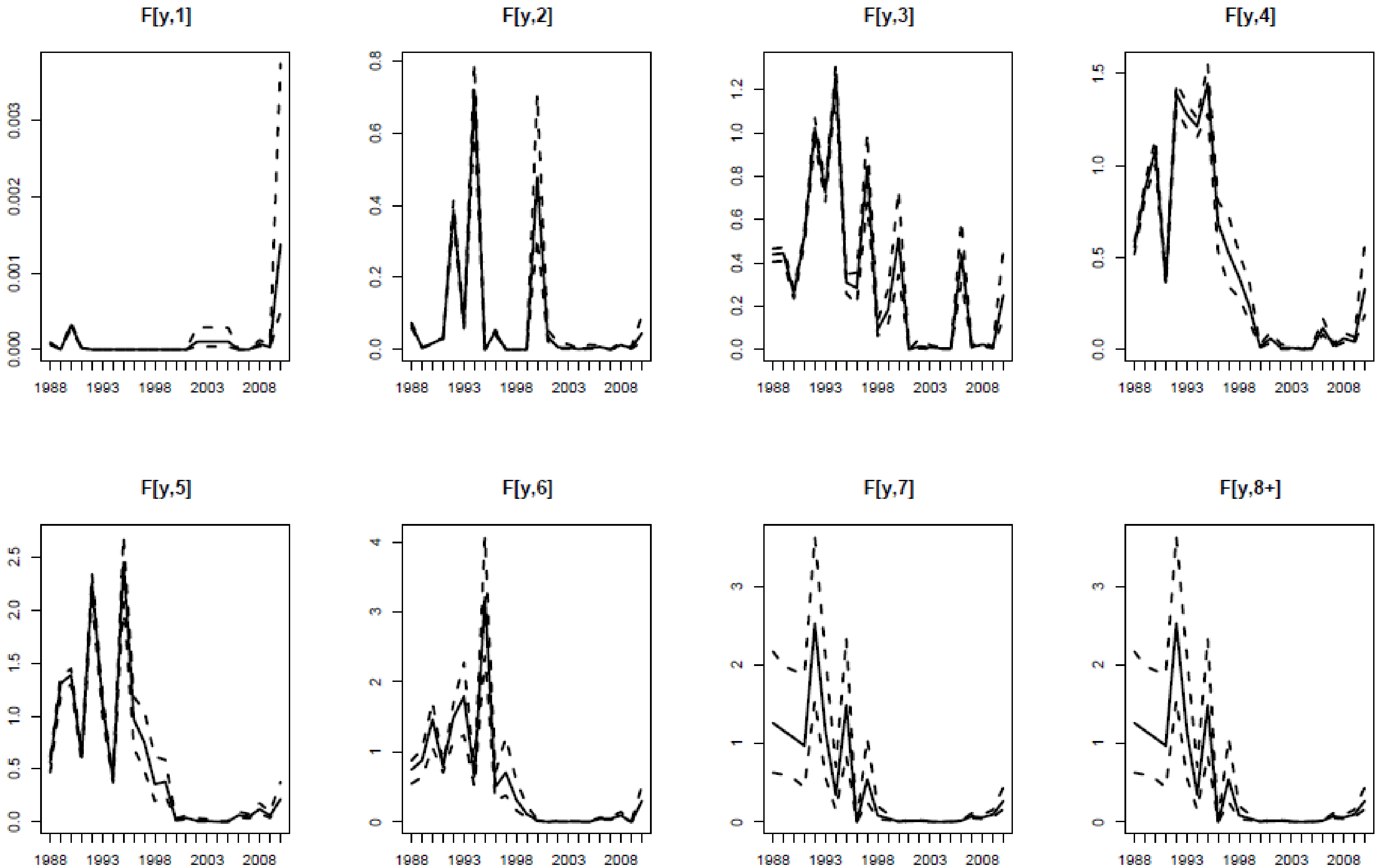

Figure 13.- Estimated fishing mortality at age.

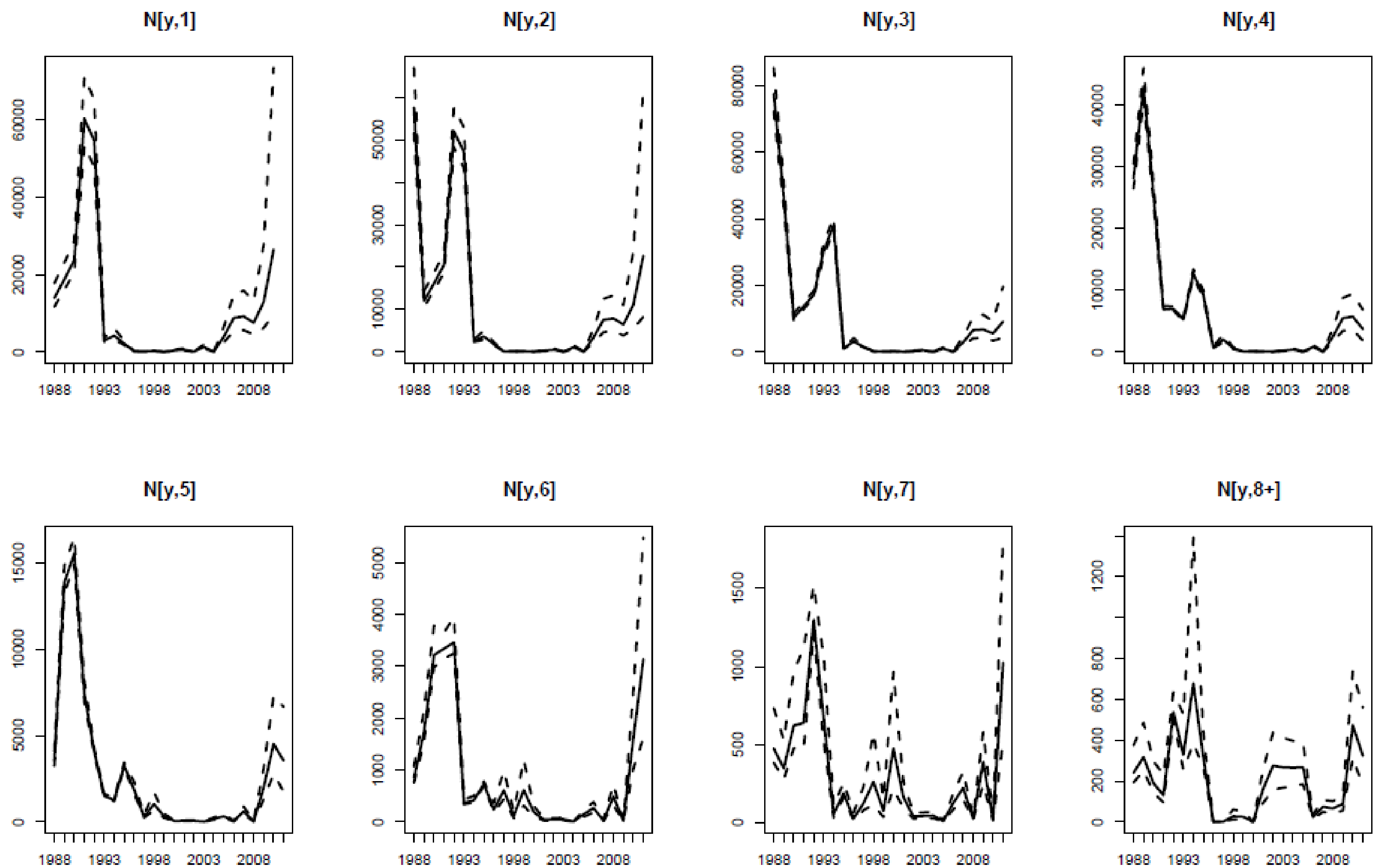

Figure 14.- Estimated numbers at age.

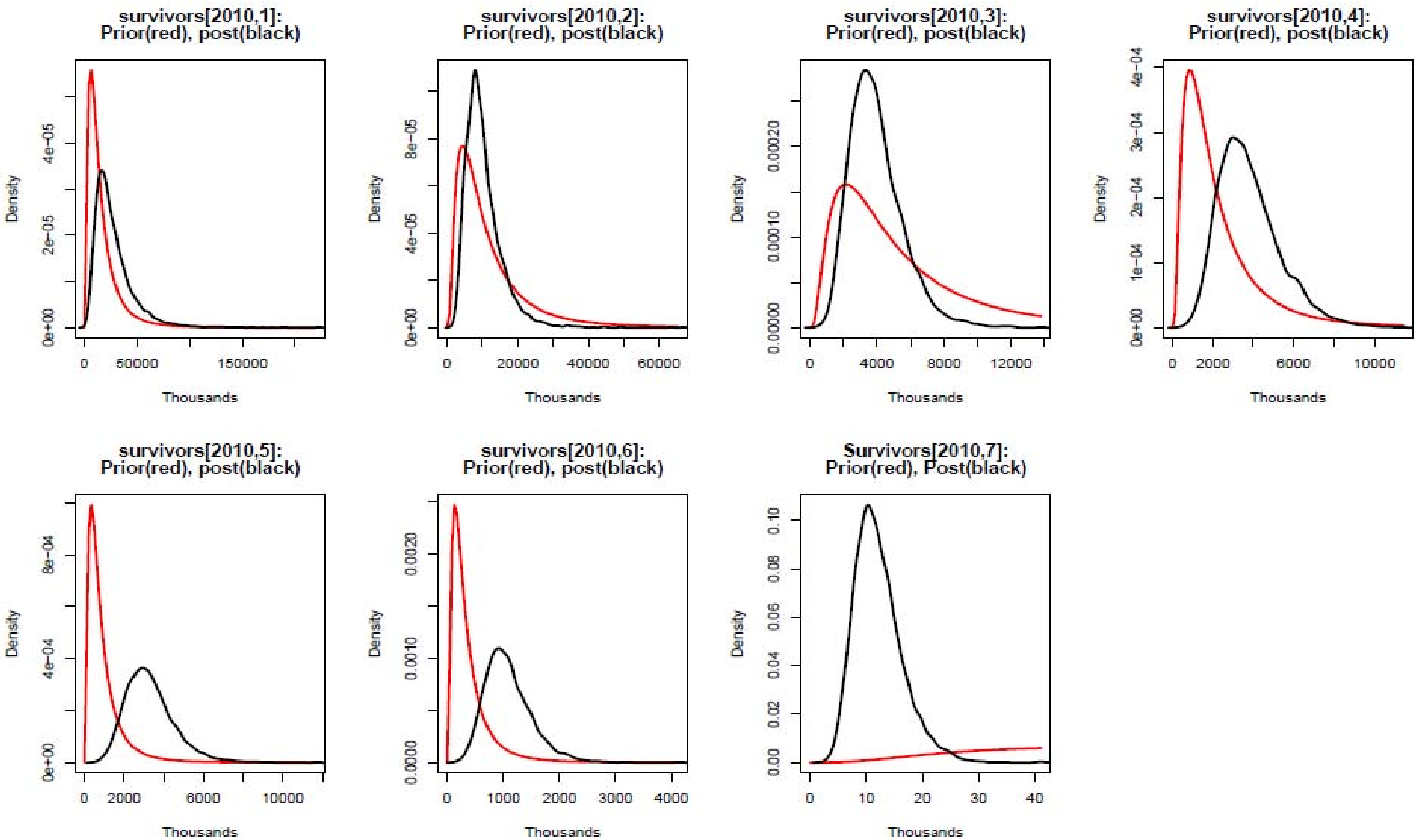

Figure 15.- Survivors at age at the end of 2010 (*survivors* (2010,a) are the number of individuals of age a+1 at the beginning of 2011).

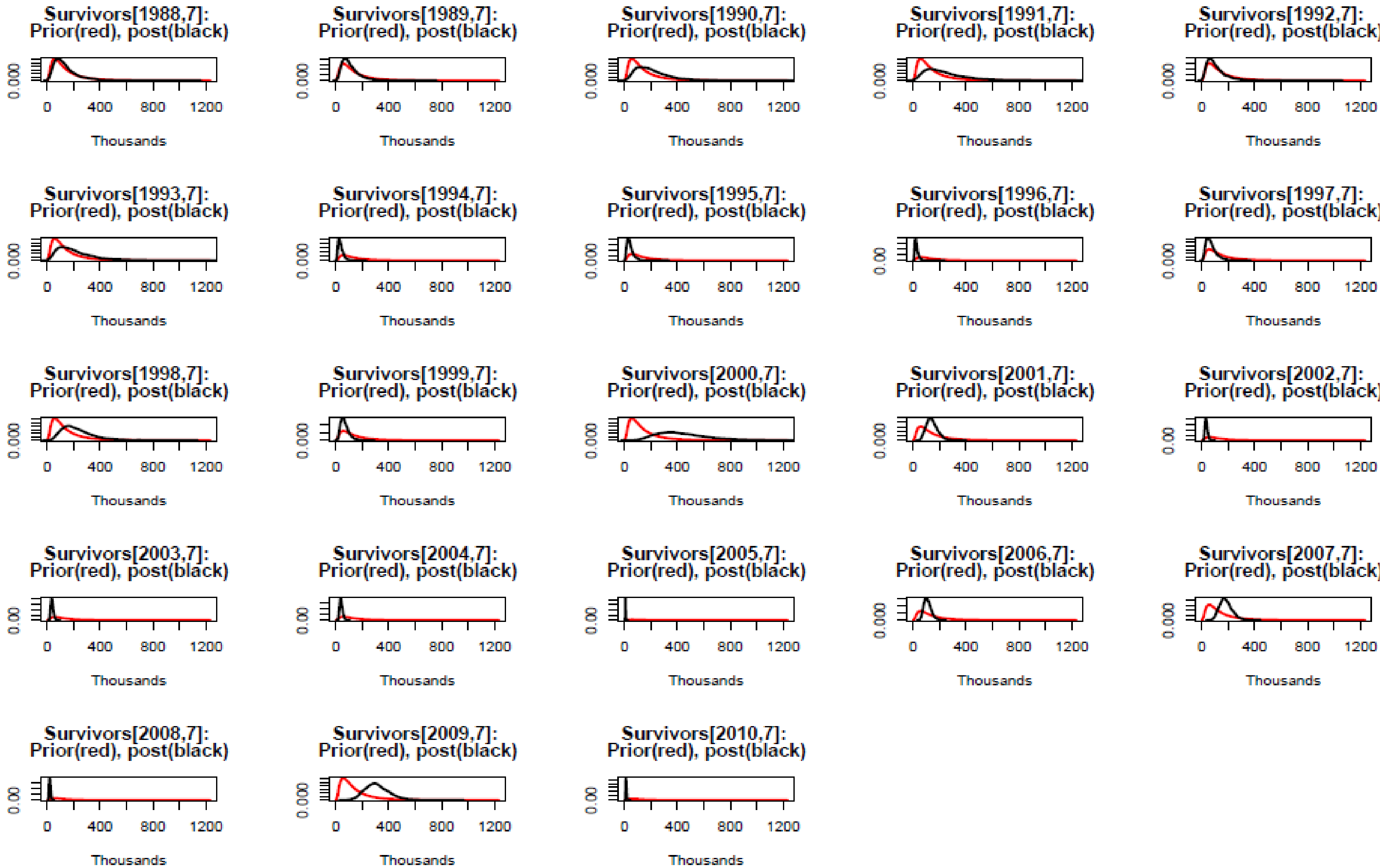

Figure 16.- Survivors from age 7 in each year (*survivors* (y,7) are the individuals of age 8 at the beginning of year y+1).

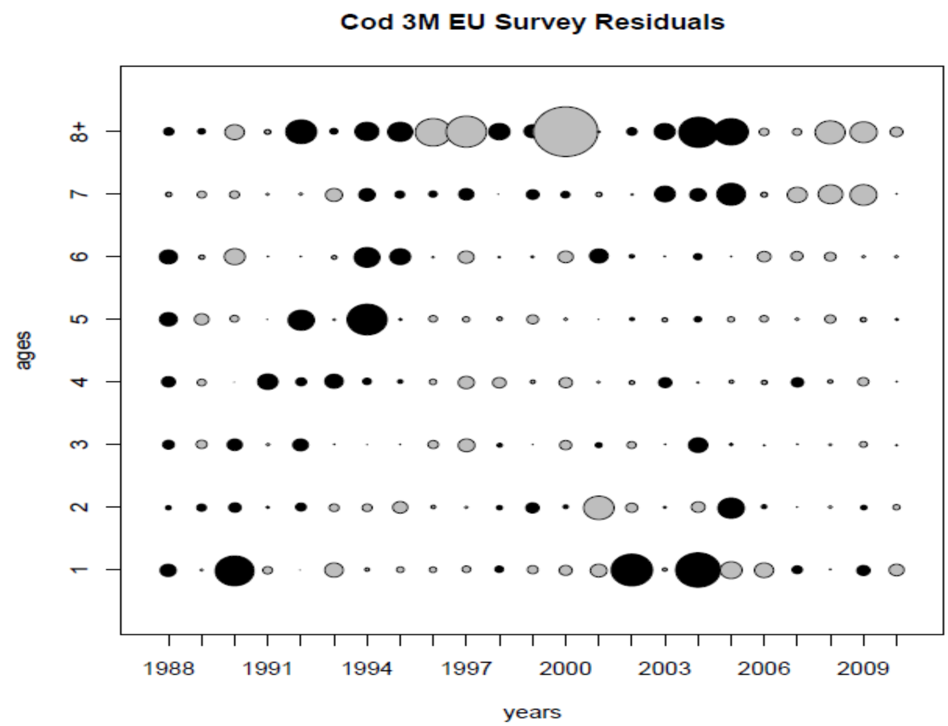

Figure 17.- Raw residuals (observed minus fitted value) in logarithmic scale of EU survey abundance indices at age. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

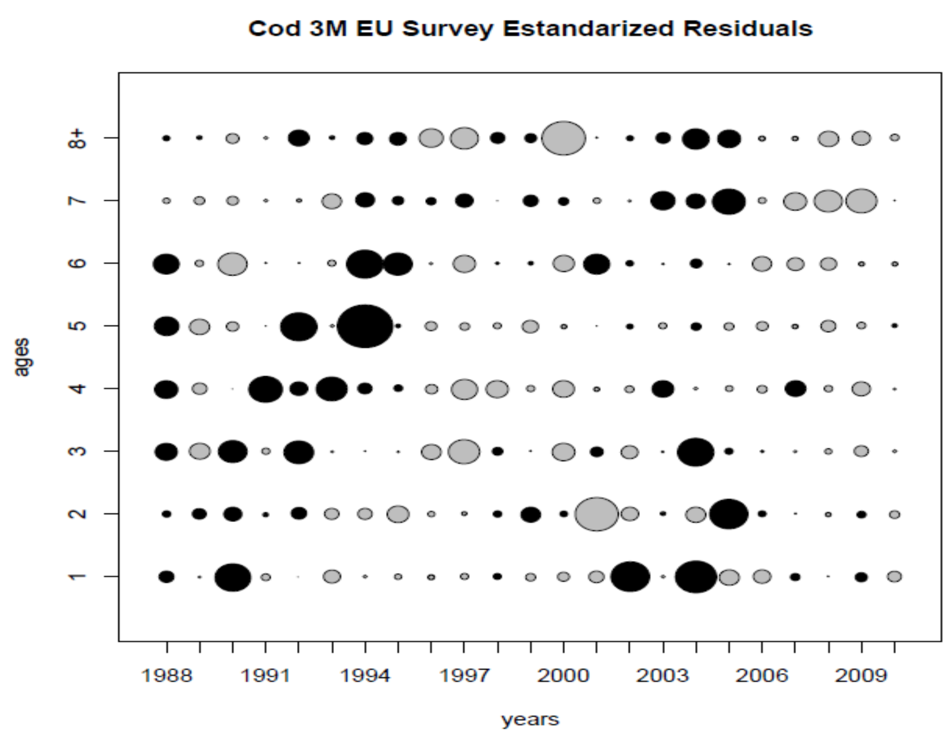

Figure 18.- Standardised residuals (observed minus fitted value) in logarithmic scale of EU survey abundance indices at age. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

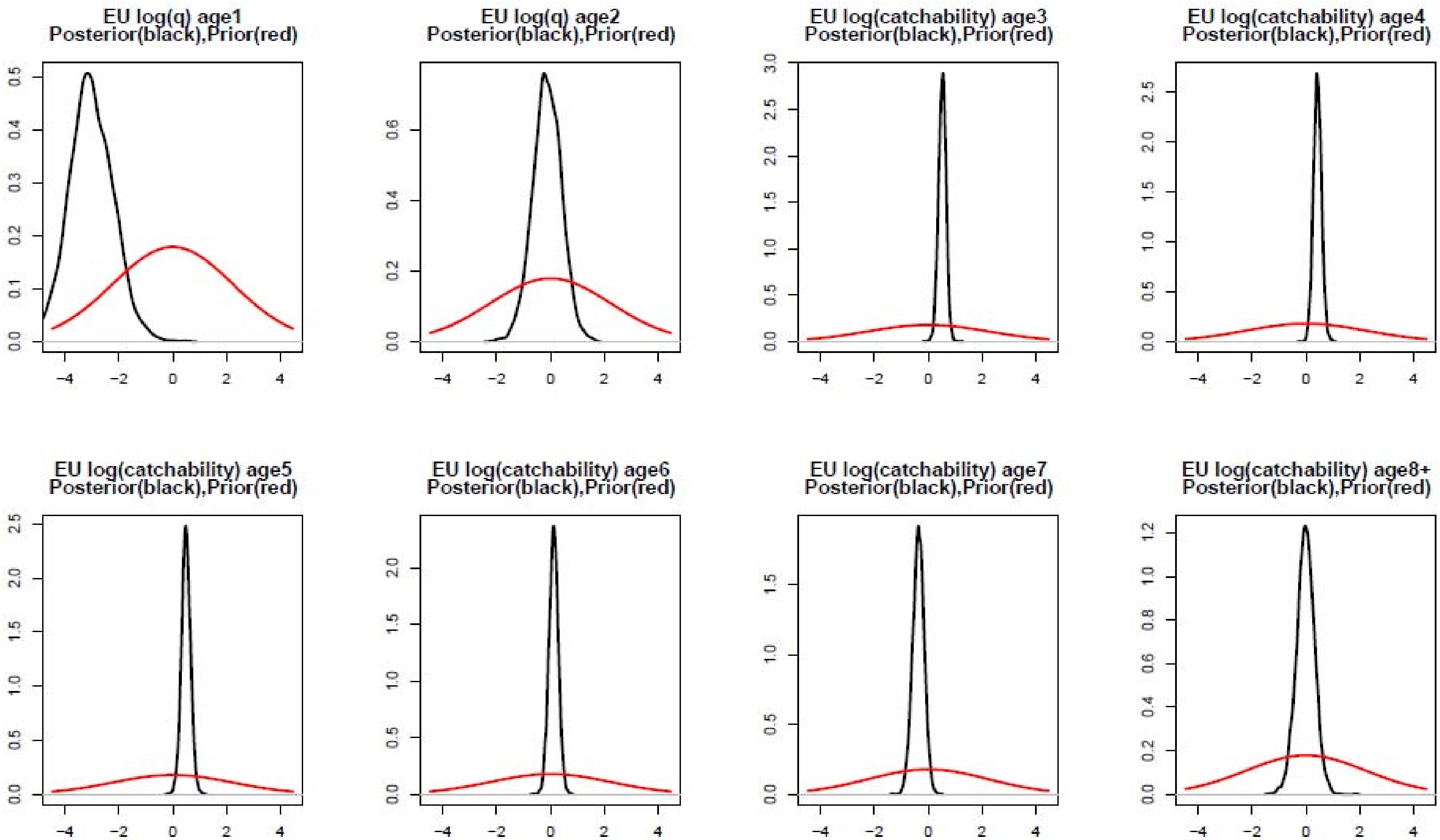

Figure 19.- Results for log(q(a)) of EU abundance at age indices.

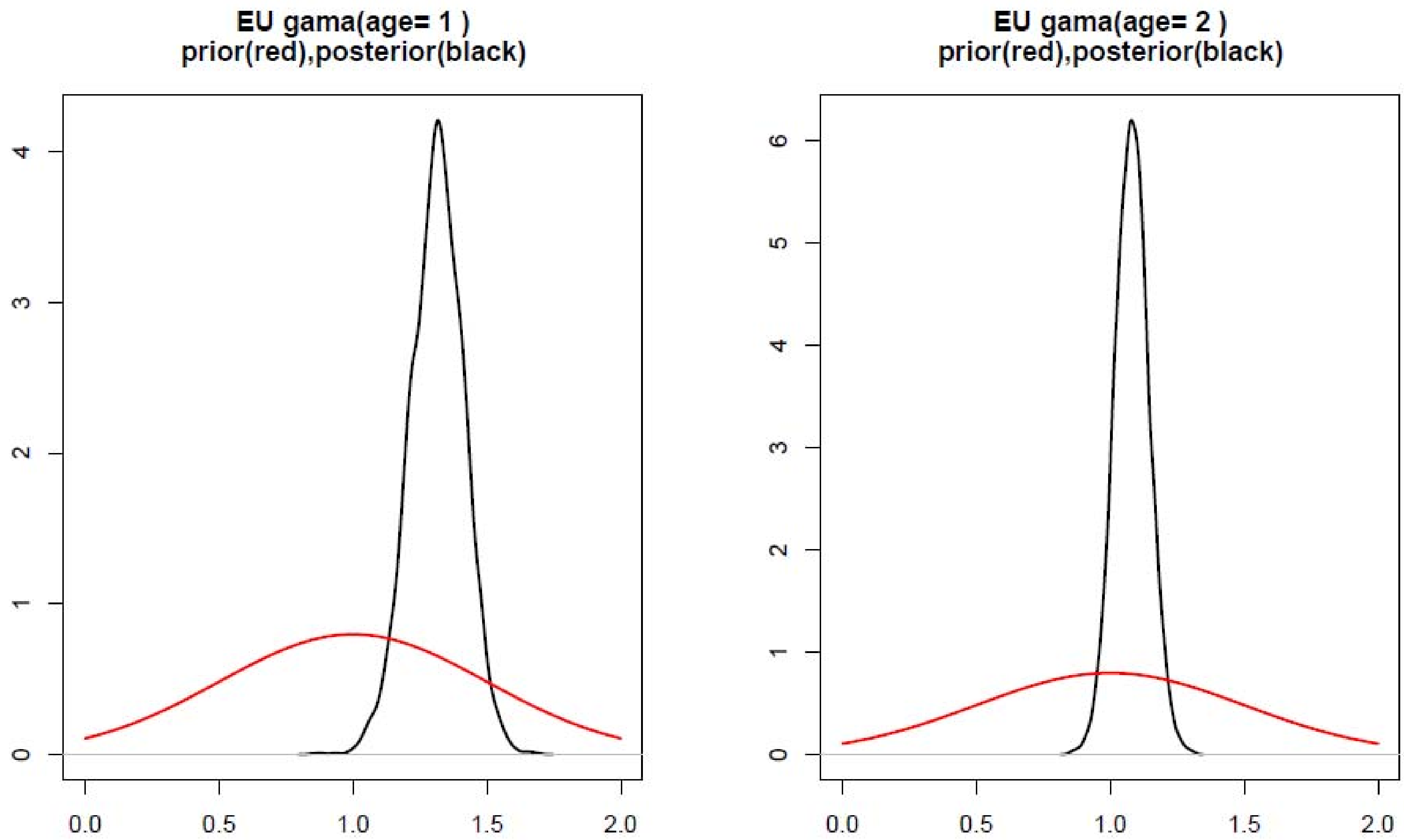

Figure 20.- Results for γ(a) of EU abundance at age indices.

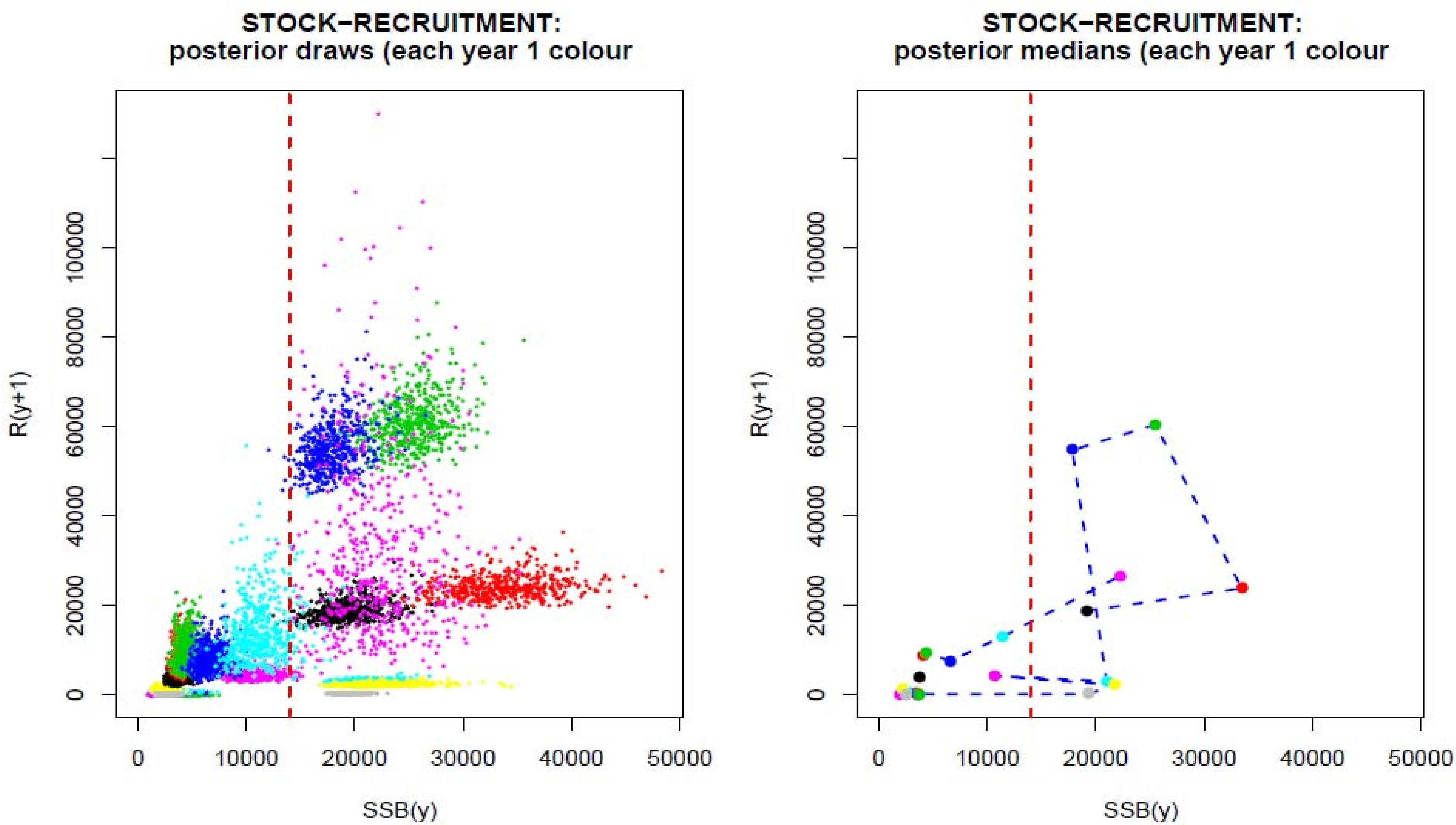

Figure 21a.- Stock-Recruitment plots. B_{lim}=14000 is shown as the red vertical line.

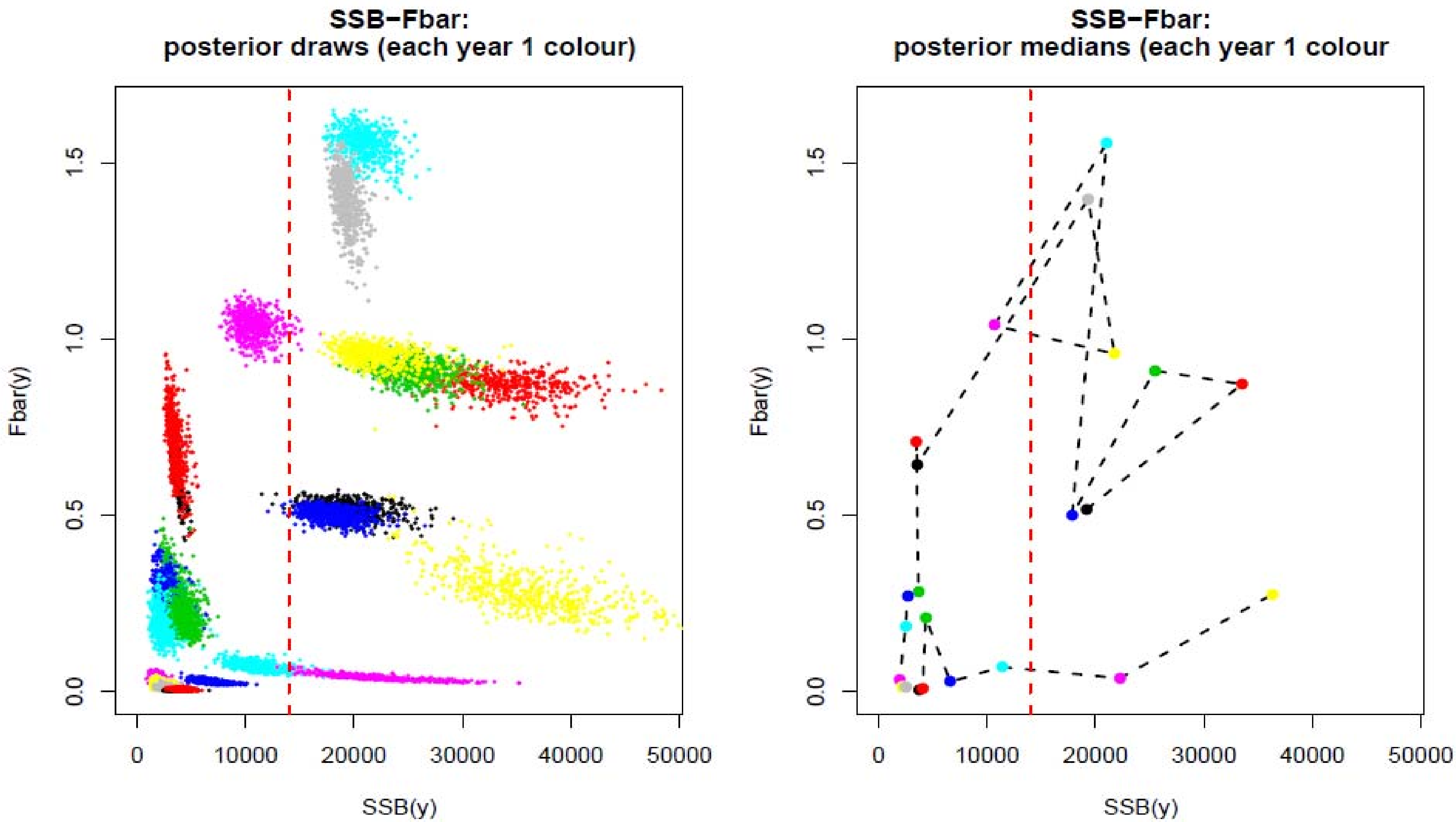

Figure 21b.- F_{bar} versus SSB plots. B_{lim}=14000 is shown as the red vertical line.

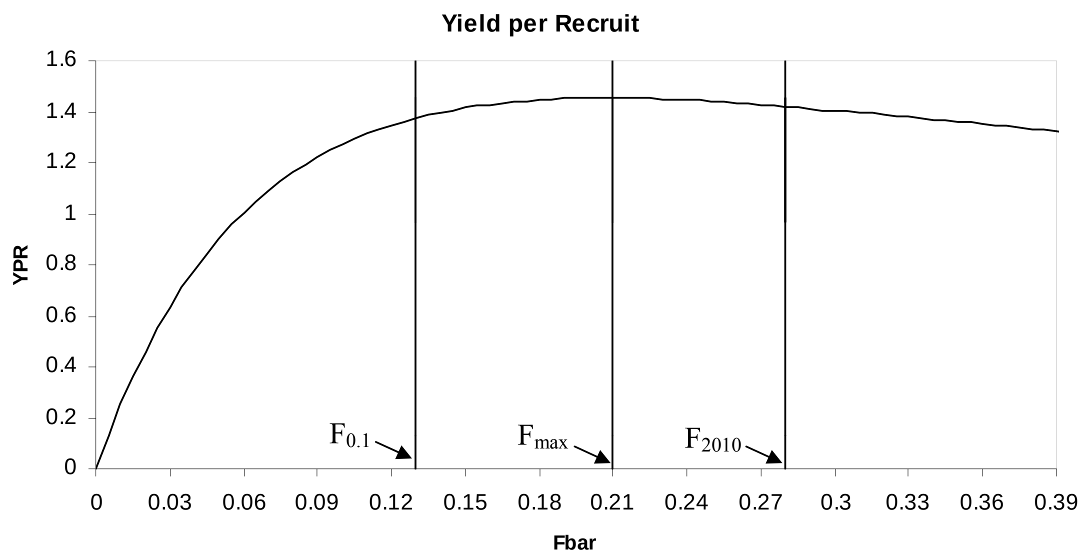

Figure 22.- Bayesian Yield per Recruit versus F_{bar}. The values of $F_{0.1}$, F_{max} and F_{2010} are indicated

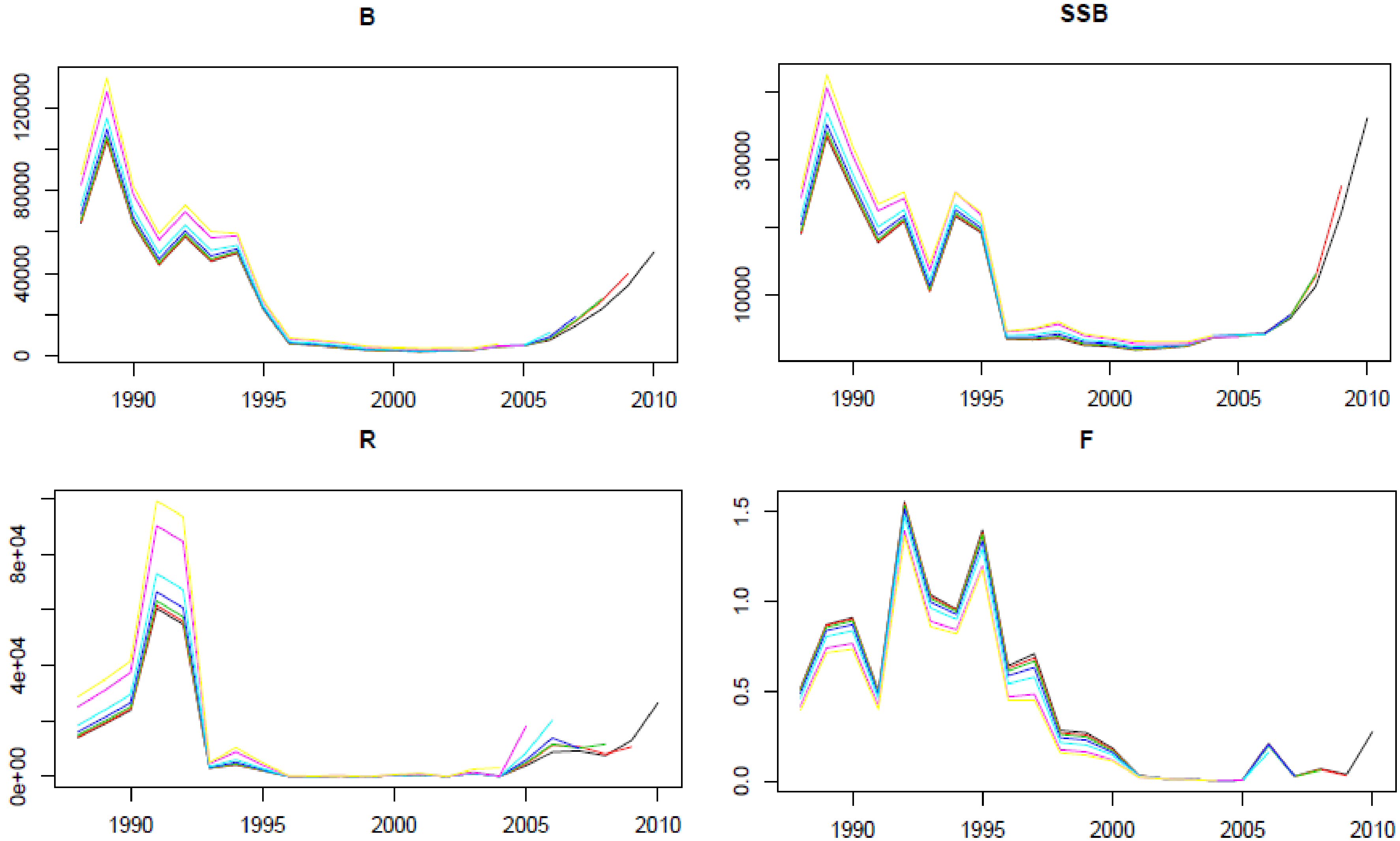

Figure 23.- Retrospective patterns.

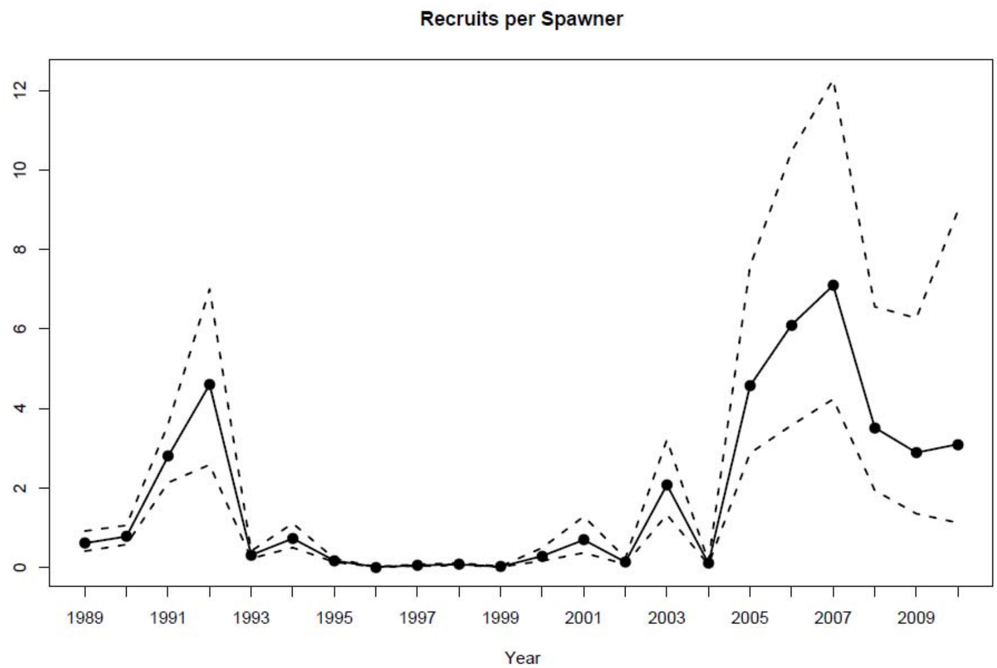

Figure 24.- Estimated recruits (age 1) per spawner.

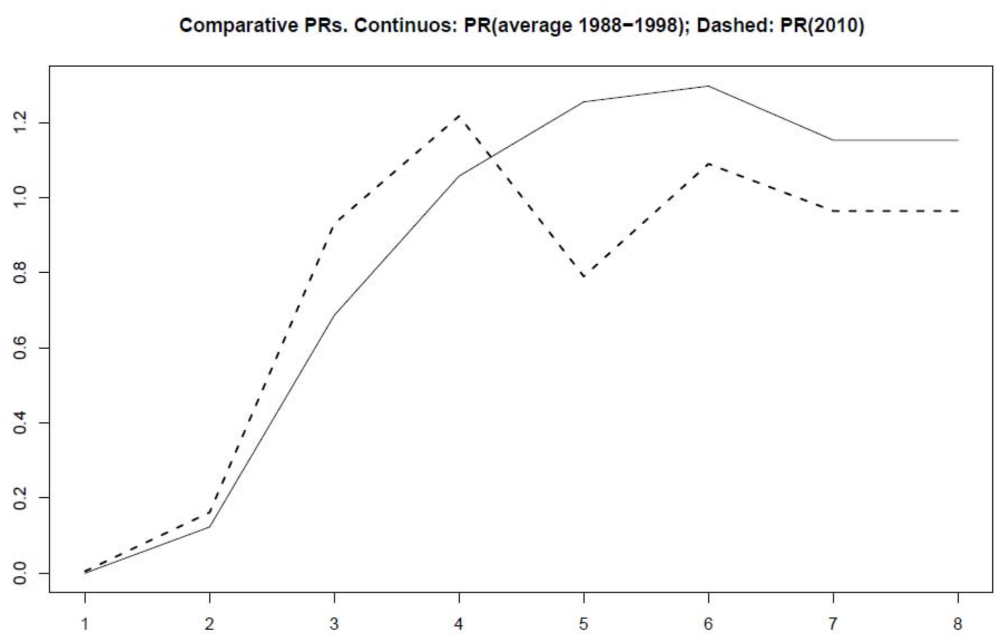

Figure 25.- Estimated PRs. Comparative: PR like the mean over the years 1988-1998 and PR as in 2010.

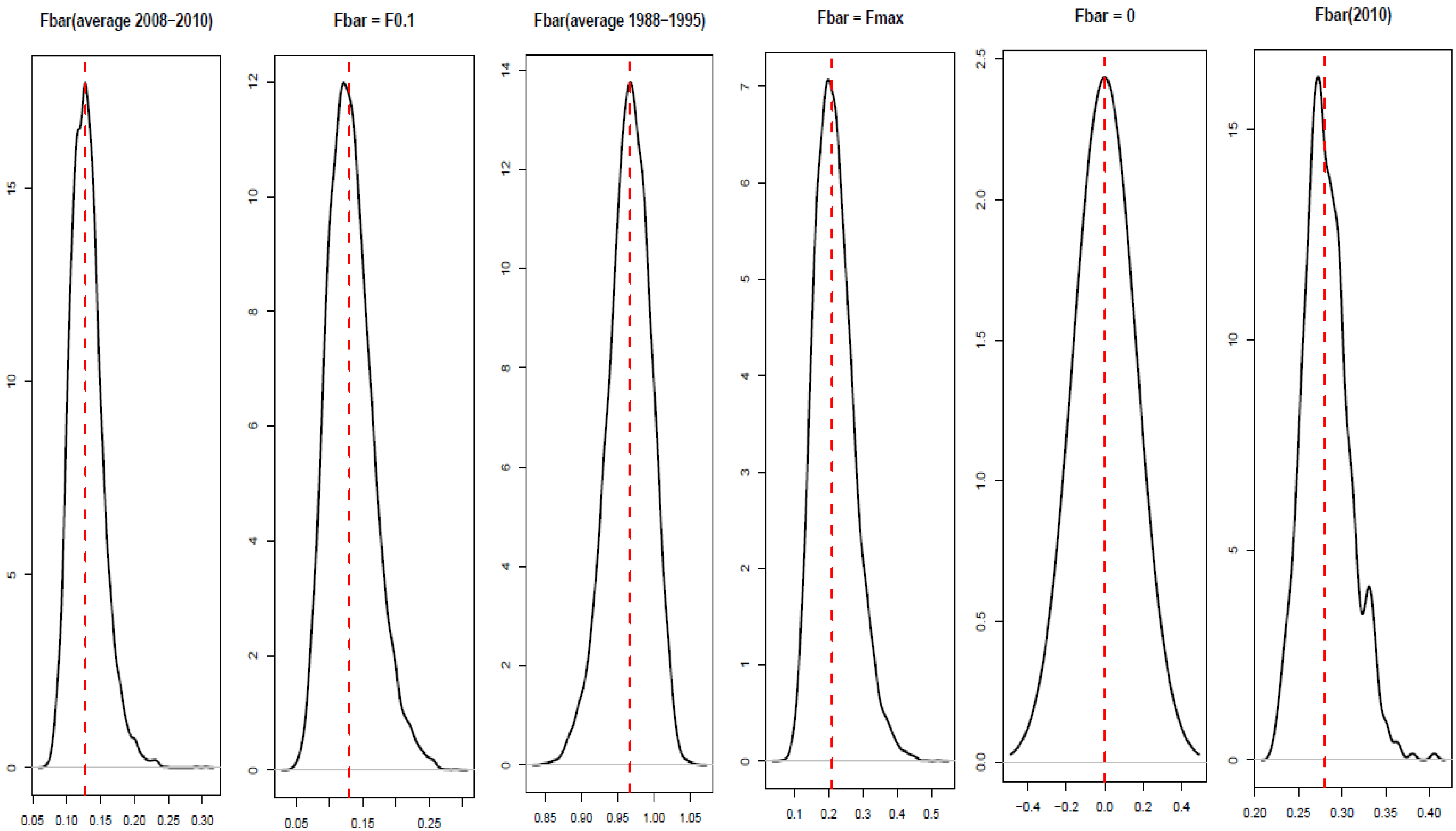

Figure 26.- Distribution and median values of F_{bar} over the different scenarios.

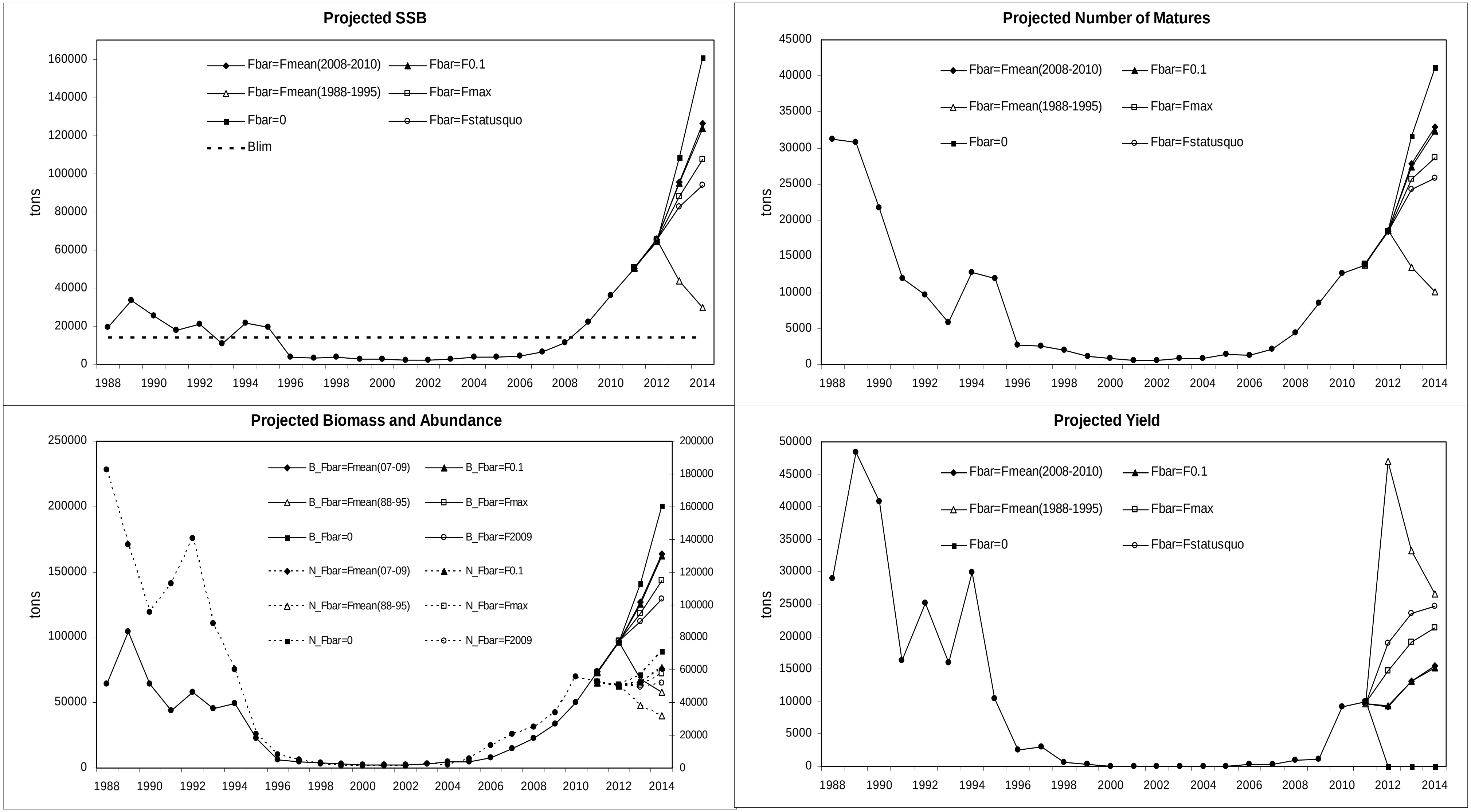

Figure 27.- Projections for SSB, number of matures, Total Biomass and Abundance and Yield with different scenarios.