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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. Due to inconsistencies with total catch in the last four years, a prior was added for 2011 and 2012 catch, the Daily Catch Report data were used in 2013 and several sources (STATLANT 21A (provisional for Faroe Islands and DCR) in 2014. Results indicate a general increase in SSB since 2005, reaching a value well above B_{lim} since 2009.

Introduction

This stock had been on fishing moratorium from 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, the Spawning Stock Biomass (SSB) was estimated to increase slightly from 2004 to 2006 (Fernández, *et al.*, 2007) while recruitment was estimated above the historical average in 2005 and 2006 which in turn caused an increase of SSB in the 2007-2009 period. Recruitment estimates from 2010 to 2012 (2009-2011 year-classes) are the highest since 1992 (González-Troncoso *et al.*, 2014).

Since 1974, when a TAC was established for the first time, estimated catches ranged from 48 000 tons in 1989 to a minimum value of 5 tons in 2004. Annual catches were about 30 000 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 below 1 000 tons and from 2000 to 2005 they were lower than 100 tons, mainly attributed to by-catches from other fisheries. Estimated commercial catches in 2006-2009 were between 339 and 1 161 tons (Table 1 and Figure 1), 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 5 500 tons of catch in 2010. With the results of the 2010-2014 assessments TACs of 10 000 tons in 2011, 9 280 tons in 2012, 14 113 tons in 2013, 14 521 tons in 2014 and 13 795 tons in 2015 were established. The estimated catch by the Scientific Council for 2010 was 9 291 tons, which almost doubled the TAC. No additional estimated catches are available to the Scientific Council since 2011. The STATLANT 21A catch was 9 794 for 2011, 9 003 for 2012, 13 544 for 2013 and 14 290 for 2014.

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, catches between 2002 and 2005 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 was 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), having been used since then in the assessment of this stock.

An assessment of this stock using the Bayesian model used last years is presented. A B_{lim} of 14 000 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

<u>Used data</u>

<u>Commercial data</u>

<u>Total Catch</u>
In 2014 there were catches of 3M cod from Canada, EU-Estonia, EU-Lithuania, EU-Poland, EU-Portugal, EU-Spain, Faroe Islands (Denmark), Norway, Russia and United States with a total amount of 14 290 tons from the STATLANT21A data (Table 1, Figure 1). To 2010 scientific catches were used; in 2011 and 2012, a prior over the total catch was applied. In 2013 the DCR data was used, and in 2014 several sources were used to set the best available information (see Assessment Methodology).

<u>Length distributions</u>
In 2014 length sampling of catch was conducted by EU-Estonia (SCS 15/04), EU-Lithuania (R. Statkus, Personal Communication), EU-Portugal (SCS 15/16), EU-Spain (SCS 15/05), Faroe Islands (L. Ridao, Personal Communication) and Russia (SCS 15/07). Length frequency distributions from the commercial catch and from the EU survey (Casas and González-Troncoso, 2015) are shown in Figure 2a.

EU-Estonia has measured 398 individuals in a range of 38-91 cm and a mode in 52 cm. EU-Lithuania has measured 100 individuals between 30 and 88 cm with a mode at 48 cm. The sample of EU-Portugal contains 10488 individuals measured within 21-111 cm with a mode in 39-41 cm. EU-Spain has a 7822 individuals sample in a range of 17-117. The modal length is 52 cm. Faroe Islands have two different types of vessels in this fishery, trawlers and longliners. For the trawlers a total of 800 individuals were measured between 38 and 122, whit a mode of 50 cm. The longliners measured 200 individuals with lengths among 31-104 cm, reaching the mode at 85 cm, quite highest than for the rest of the fleets. The number of sampled individuals for Russia was 2849. The mode of this length distribution is at 54 cm. The EU survey has a well-defined mode between 30-35 cm, followed with another mode in 48-53. The range is from 9 to 126 cm.

In Figure 2b we can see the evolution of the commercial length distribution since 2010, year in which the fishery was reopened. While during the period 2010-2012 the mode of the commercial length distribution was around 54 cm, in 2013 that mode was decreased substantially, being around 42 cm. In 2014 the first mode is about 51 cm, and there is a second mode between 39-42 cm. This suggests a change in the fish strategy as was pointed out by Iriondo *et al.*, 2014.

<u>Catch-at-age</u>
Catch-at-age is presented in Table 2. Data from 1972 to 1987 were taken from the 1999 assessment, in which a review of those data were made (Vázquez *et. al*, 1999). 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 2009-2011 only from the Portuguese commercial data and was applied to the total commercial length distribution. In 2012 otoliths were no collected by the Portuguese fleet, and although a commercial ALK from the Spanish fleet was available, it was not used because it was no validated, so the commercial 2011 ALK was applied to the total commercial length distribution. In 2013 and 2014 there were two available ALKs for commercial length distribution, one from Portugal and the other from Spain, but as they have not been validated yet, the 2013 and 2014 survey ALKs were used respectively. In 2011 and 2012, as no consistent catch is available, the percentage of each age is presented.

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 3 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 2014 catch) is comprised of 3-5 years age cod. In years 2006, 2009 and 2014 catches containing mostly age 4 individuals and age 3 in years 2011, 2012 and 2013. In 2007 the greatest presence was at ages 3 and 5 and at ages 3 and 4 in 2008 and 2010.

Figure 4 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. Figure 5 shows the same figure for the last complete cohort taking into account that the plus group is at age 8 (2007-2014). Some strong and weak cohorts can be followed, although the pattern is not too evident. The biggest circle corresponds to the recruitment (age 1) of year 1987, the biggest caught, by far, of the entire series. But the corresponding cohort was weak. It is remarkable the catch over the recruitment in some of the last years. In 2013, all the values are negative except age 3, with a quite large positive value. In 2014 the biggest value is at age 4, being the values at ages 1-3 large and negative and at ages 5-8 very small and positive.

Mean weight-at-age

There are available data of mean weight-at-age in catch for years 1972-1987 from the 1999 assessment (Vázquez *et. al*, 1999). For 1988-2013, the same data as last year assessment were taken.

For 2014, mean weight-at-age has been computed separately for the catch and for the stock, using length-weight relationships from the commercial sampling and from the EU survey, respectively. In the commercial case, there are six length-weight relationships available in 2014: EU-Estonian, EU-Lithuanian, EU-Portuguese, EU-Spanish, Faroese trawl and Faroese longliner. All of them are presenting in Figure 6 with the survey one. There are no significant differences between them, although the Portuguese one gives higher weight to the same lengths and the Lithuanian one smaller. The Portuguese length-weight relationship was applied to the commercial data to calculate weight-at-age in the catch as it leads from the biggest sample. Results are showed in Table 3 and Figure 7. Since 2005 there is a general decrease in the trend of the mean-weight for the ages between 2 and 6 years old, especially since 2010. Ages 1, 7 and 8+ present a quite stable trend over these years. It must be noted that all the mean-weight-at-age are now higher than the ones at the beginning of the time series, especially for the oldest ages. In 2013 and 2014 the mean weight of all the ages decreased.

The SOP (sum over ages of the product of catch weight-at-age and numbers at age) for the commercial catch differs in 3.5% from the estimated total catch.

Survey data

Canadian survey

Canada conducted research vessel surveys on Flemish Cap from 1978-1985. Surveys were done with the R/V *Gadus Atlantica*, a stern trawler of 74 m in length, fishing with a lined *Engels 145* otter trawl. The surveys were conducted in January-February of each year from 1978 to 1985, using a stratified random design. Fishing sets were usually of 30 minutes duration, over a distance of 1.75 nautical miles, and covered depths between 130 and 728 m. All strata were surveyed each year, with the exception of 1982, when 4 deeper strata were omitted (Brodie and Bowering, 1992).

Survey indices of abundance at age are presented in Table 4. Figure 8 displays the estimated biomass and abundance indices over the time series. From a high value in 1978, a general decrease in both indices can be seen until 1985. Figure 9 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 was able to detect strength of recruitment and to track cohorts through time very well. It clearly shows a series of consecutive recruitment failures from 1978 to 1980, leading to very weak cohorts, specially the 1979 one (age 1 at 1980). The 1981 cohort was quite good.

EU survey

The EU bottom trawl survey on Flemish Cap has been carried out since 1988 using a *Lofoten* type gear, 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 1988-2014 are presented in Casas and González-Troncoso, 2015.

Survey indices of abundance at age are presented in Table 5. Figure 8 displays the estimated biomass and abundance indices over time. There are differences between the level of biomass and abundance in the Canadian survey and in the EU one, probably due to the difference in the gear. Biomass and abundance show a high increase since 2005, higher in biomass than in abundance except for 2011, following an extremely low period starting in the mid 1990's. The large number in 2011 is due to a big presence of individuals of age 1. It must be noted that 2009-2010 and 2013 biomass is at the level of the first years of the assessment but abundance in these years 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 a new huge increase can be seen in 2011 and 2012. The abundance in 2011-2012 are the highest of the time series of this survey. In 2013 a new decrease in abundance and biomass occurred, both reaching the level of 2009-2010. In 2014 the biomass increased again reaching the maximum of the time series by far. The abundance increased too but much less, being well below the maximum observed during years 2011-2012. The increase in biomass is due to a big increase in the number of individuals of 3 and 4 years old, those from the 2010-2011 cohorts, and the decrease in abundance to a less presence of individuals of ages 1 and 2 (Casas and González-Troncoso, 2015). Figure 10 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. In 2010-2012 a good recruitment can be seen, especially in 2011, lead to two reasonably good cohorts. 2013 and 2014 recruitment are not as good as in the last three years, but it is still at the level of the beginning of the recovery of the stock. Age 8+ in 2014 presented a high value, which indicates the strength of the 2006 cohort.

Mean weight-at-age

Mean weight-at-age in the stock for Canadian survey is not available, so mean weight-at-age in the stock is only available from the EU survey from 1988 to 2014. For the previous years, as the stock change rapidly, it was decided to apply the weight-at-age for catch. As catch has no weight-at-age for the youngest ages (1 and 2), the mean of the EU survey weight-at-age between years 1988-1995 for those ages was taken. The reason for taking those years is that the stock seems to change suddenly its weights-at-age in 1996. The results are showed in Table 6 and Figure 11.

Mean weight-at-age in the stock showed a strong increasing trend from the late 1990's until 2010, although in 2008 all the ages decreased their mean weight-at-age, but still remain much higher than at the beginning of the series. Since 2009-2010 up to 2014 a deceasing trend is observed for all age groups. From 2008 to 2009 youngest and oldest ages increased their mean weight-at-age with respect to 2008, while the ages 3-4 decreased them. In 2011 all ages except 4 and 8+ decreased their mean weight-at-age with respect to 2009-2010. In 2012 the weight-at-age for ages 1-2 increased with respect 2011, but decreased substantially for ages 3-8+. In 2013 and 2014 the weight of all ages decreased except age 8 in 2014. It is remarkable the low value of weight at age 3 (0.35 kg) in 2014, which is among the lowest of the entire times series.

Maturity at age

Maturity ogives from the Canadian survey are available for all the years (1978-1985) and from the EU survey for years 1990-1998, 2001-2006 and 2008-2014. For those years logistic regression models for proportion mature at age have been fitted independently for each year. For years 1983-1985 the fit was no consistent, so those years were omitted for the fit. For 1972 to 1977, the 1978 maturity ogive was applied. The 1982 maturity ogive was taken for 1983 to 1987. 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 7. It can be seen that the percentage of matures in all ages decreased since 2006 to 2011, especially in 2011. This fact, along with the decreasing mean weight at age, is consistent with a stock in a recovery process, with a slower growth and maturing. In 2012 the percentage in ages 4 and 5 increased, as in all ages in 2013 (especially for ages 3 and 4). This is not consistent with the decrease in the mean weight for all ages. Maturity for all age groups declined from 2013 to 2014.

Figure 12 displays the evolution of the a50 (age at which 50% of fish are mature) through the years (estimate and 90% uncertainty limits) and the median value is presented in Table 7. The figure shows a continuous decline of the a50 through time, from above 5 years old in the late 1980's to below 3 years old in 2002 and 2003. An upward trend is present in a50 since 2005. From 2005 to 2011 a50 increased monotonously from 3 to 4.13 years respectively and it declined in 2012 and again in 2013 to 3.39 years due to the increase in the percentage of maturation on all the ages. In 2014 it increased substantially to 4.15 years old close to that of 2010.

Assessment methodology

The Bayesian model used last years was updated with 2014 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 approved assessment.

In years 2011 to 2014 there were a lack of information because estimated catches by the Scientific Council are not available and the available figures (from the STATLANT 21A) are no consistent with 2010 catch. For this reason, Scientific Council decided to incorporate a new prior for the total catch in 2011 and 2012. In 2011, the effort in the major fleets has increased 40% approximately regarding 2010 effort and the 2010 catch was 9 192 tons, so it was decided to fit a prior to 2011 catch with a median value of approximately 12 800 tons and a standard deviation that allows the catch to move between 9 905 and 16 630 tons (95% confidence interval). The chosen prior was a lognormal. In 2012 the TAC was slightly below the 2011 TAC and the effort was virtually the same, so no evidences of change in the catch of 2012 with regards to the catch of 2011 exists, therefore the same prior was taken. The priors for 2011 catch and 2012 catch are independent.

In 2013 some flag states significant in the Div. 3M cod fishery did not submit their 2013 STATLANT 21A data before the start of the meeting, so STATLANT 21A could not be compared to other catch estimates for 2013. Scientific Council analyzed the CPUEs resulting from Daily Catch Reports (DCR) of 3M cod for the period 2011-2013. These CPUEs were compared with the available scientific data. The results of this comparison show significant differences in 2011 and 2012 and a decrease of such differences in 2013. Based on these results, Scientific Council decided to use total catches from the DCR in 2013 (13 985 t), maintaining the model catch estimation for 2011 and 2012.

In 2014 all the significant countries in this fishery submit the STATLANT 21A on time (although it was provisional for Faroe Islands). For the countries with no STATLANT 21A, the DCR data was taken. A total of 14 290 t of catch was set as the best available STACFIS catch to run the assessment.

The inputs of the assessment of this year are as follow:

Catch data for 43 years, from 1972 to 2014

For 2011: $TotalCatch(2011) \sim LN(median = 9.46, sd = 0.1313)$

For 2012: $TotalCatch(2012) \sim LN(median = 9.46, sd = 0.1313)$

Years with catch-at-age: 1972-2001, 2006-2014

Tuning with Canadian survey for 1978 to 1985

EU survey for 1988 to 2014

Ages from 1 to 8+ in all cases

Catchability analysis

Catchability dependent on stock size for ages 1 and 2

Priors over parameters:

Priors over the survivors:

For (2014, a), a=1,…,6 and (y, 7), y=1972,…, 2014

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

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

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

where CW_{mod} is arised from the Baranov equation

cvCW=0.05

Prior over the survey abundance at age indices:

For a=1,…,8 and y=1978,...,1985 (Canadian survey) and y=1988,…,2014 (EU survey)

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

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

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

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

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

where I is the 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.

Projections: NOT YET [Three years projections were made with eight 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 8 and Figure 13.

Total biomass has had an increased trend since 2006, reaching the same level as before the collapse of the stock in the mid 1990´s.

The SSB graph also includes the expected value at the beginning of the year 2015. To calculate it, weight-at-age and maturity-at-age from the last year were used (assuming always that maturity at age 1 is equal to 0, as there is no estimate of recruitment in 2015). 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 since 2010 has been more or less stable around the highest values of the time series, only below the 1972 and 1989 values. This increase is probably due to the increase in the percentage of maturity in all ages, that compensates the decrease in the mean weight in all ages, and to the incorporation of the strong 2010 year class which leads in a higher number of individuals. The SSB at the beginning of 2015 is expected to be the highest of the series, although the uncertainty associated with this value is very high and year by year the projection value is always larger than the actual one.

Recruitment had an increasing trend from 2005 to 2011, being the 2009, 2010 and 2014 values at the level of the mean recruitment of the period and the 2011 and 2012 values above it. In 2013 the recruitment decreased and was around the level at the beginning of the recovery of the stock. Take into account that the actual recruitment levels for last years can not yet be precisely estimated (wide uncertainty limits) (Figure 13 and Table 8).

F_{bar} (mean for ages 3-5) was estimated at very low levels in the period 2001-2009, although an unusual high value has been estimated for 2006. In 2010, when the fishery was reopen, the F_{bar} has increased up to 0.26, although the established 5 500 tons TAC corresponded to a target F_{bar} around 0.14. In 2011, with a TAC of 10 000 tons corresponding to a target F_{bar} around 0.13, a F_{bar} of 0.29 was estimated. In 2012 F_{bar} was estimated at 0.26, while the TAC of 9 280 was established under a F_{bar} of 0.13. In 2013 the TAC was increased almost 50% with respect to 2012 TAC, and the F_{bar}=0.30 is 2.2 times the F_{bar} approved in 2012. For 2014 the TAC remained stable (14 113 tons) corresponding to a F_{bar}=0.14, while the one estimated by the assessment was F_{bar}=0.29. Table 9 and Figure 14 provide more detailed information on the estimated F-at-age values, indicating that the increase in F_{bar} in 2006 is mostly due to a high fishing mortality at age 3 ($F_{3,2006}$=0.449). Since 2010 fishing mortalities have remained stable at around F_{bar}=0.281. In 2010 the highest fishing mortalities are in ages 4 and 6, and from 2011 to 2013 in 6-8+. In 2014 the highest fishing mortality is in ages 7-8+. Figure 15 shows the PR along the years, calculated as the ratio of fishing mortalities to F_{bar}. Figure 16 shows the PR for the years since the reopening of the fishery (2010-2014) and Figure 17 the mean of the three last years (2012-2014) PR *versus* the 2014 PR. In 2014 a decrease in PR for ages 2 and 3 and a rise for ages 4-8+ with regards to the mean of the last three years can be seen.

Figure 18 shows total biomass and abundance by year. Except in the first years of the assessment and the period 1985-1989, in general there is a good concordance between biomass and abundance, although in last years biomass has increased more than abundance. It must be noted that, although SSB in last years is within the maximum of the series (Figure 13), total biomass and abundance have not reached yet the highest historical level.

Estimates of stock abundance at age for 1972-2015 are presented in Table 10 and Figure 19. Abundance at age in 2015 are the survivors of the same cohort in 2014, the last assessment year, so only abundances of ages older than age 1 can be estimated. It can be seen a general increase trend in the abundance for all ages since 2005 and in the total number of matures, especially in 2013, due probably to the decreasing in the age of maturity. In 2014 the number of matures is smaller than the 2013 one but higher than the 2012 one. In 2014 the mode is at age 3 and 4, which corresponds to the 2010 and 2011 cohorts.

Figure 20 depicts the prior and posterior distributions of survivors at age at the end of the final assessment year, where by survivors(2014, a) it is meant individuals of age a + 1 at the beginning of 2015 (in other words, survivors(2014, a) = N(2015, 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 substantial updating of the prior distribution for survivors in almost all ages.

Figure 21 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 in 1996, between 2002 and 2005 and in years 2008 and 2010.

In Figure 22 the priors and posteriors for the total catch in 2011 and 2012 are shown. In both cases, although there is a small update of the total catch, with a posterior value a little greater than the prior value, the update is no important. While the median of the priors is 12 836 tons (exp(9.46)), the posterior medians are 13 650 tons for 2011 and 13 380 tons for 2012. The 2012 value was slightly updated from last year assessment.

Figure 23 shows the prior and the posterior for 2014 of the natural mortality, M. In this case the posterior indicates that an M of value 0.2 is overestimated, as the posterior median is 0.16. This means a slight increase from the median estimated in the last year assessment (0.156).

Bubble plot of standardised residuals (observed minus fitted values divided by estimated standard deviations and in logarithmic scale) for the survey abundance at age indices is displayed in Figure 24 for the Canadian survey and for the EU survey. 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.

For the Canadian survey, a value near -2 is the age 7 of year 1985, so it could be seen that there are a few of values higher than 2 in absolute value. For years 1978-1981 all the ages higher than 3 have positive values while year 1982 has all its residuals except for age 1 negative or near 0, suggesting year effects (i.e. survey catchabilities that are below average in 1982 and above average in 1978-1981).

For the EU survey a value near to -2 is age 2 of year 2005. In the case of this survey almost all residuals are below 2 in absolute value, and all the residuals above 2 in absolute value happened before 2005 except age 2 in 2011. In 1988 all residuals are negative except for the one for age 7, whereas the opposite happens in 1996, 1997 and 2011, suggesting year effects (i.e. survey catchabilities that are below average in 1988 and above average in 1996, 1997 and 2011). From 2008 almost all residuals are positive. In 2012 all the standardized residuals except age 3 are positive. In 2014 all are positive except age 1 and 2. Note that it is the first age 1 negative standardized residual since 2010.

Figure 25 shows another plot of the standardized residuals for the EU surveys for better understanding the patterns. It seems to be a positive pattern in the last years.

Biological Referent Points

Figure 26 shows a SSB-Recruitment plot and Figure 27 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 2014.

F_{lim} (0.131) for this stock is $F_{30\%SPR}$ calculated with the entire historic series (1972-2014). Figure 28 shows the Bayesian Yield per Recruit calculated with the data of years 1972-2014 as well as the value of F_{lim} and $F_{statusquo}$ (as the mean fishing mortality over 2012-2014).

Recruits per Spawner

Figure 29 displays the Recruits per Spawner. The variability over the years of the assessment is very high. Since 2007 a decreasing trend can be seen, reaching in 2013 and 2014 a very low value.

Retrospective pattern

A retrospective analysis of six years was made (Figure 30). Retrospective analysis shows revisions in the recruitment, but no evident patterns can be seen. B, SSB and F show in general a slight overestimation over the years.

Projections

Stochastic projections from 2015 to 2018 have been performed. Variability of input data was taken from the results of the Bayesian assessment. Input data for projections were as follows:

Numbers aged 2 to 8+ in 2015: estimates from the assessment

Recruitments for 2015-2018: Recruits per spawner were estimated for each year (Figure 29). Recruits per spawner were drawn randomly from 2010-2012. The 2013 value was omitted due to uncertainty in estimating the recruitment.

Maturity ogive for 2015-2018: Mean of the last three years (2012-2014) maturity ogive.

Natural mortality for 2015-2017: 2014 natural mortality from the assessment results.

Weight-at-age in stock and weight-at-age in catch for 2015-2018: Mean of the last three years (2012-2014) weights.

PR at age for 2015-2017: Mean of the last three years (2012-2014) PRs.

F_{bar}(ages 3-5): Four options were considered. All Scenarios assumed that the 2015 catch is the TAC (13 795 tons):

(Scenario 1) $F_{bar}=F_{lim}$ (median value = 0.131).
(Scenario 2) $F_{bar}=3/4F_{lim}$ (median value = 0.098).
(Scenario 3) $F_{bar}=F_{statusquo}$ (median value = 0.285).
(Scenario 4) $F_{bar}=3/4F_{statusquo}$ (median value = 0.213).

$F_{statusquo}$ was established as the mean fishing mortality over 2012-2014.

Results for the four options are presented in Tables 11-18 and Figure 31. They indicate that fishing at any of the considered values of F_{bar}, total biomass and abundance during the projected years have high probability of reaching levels near to the highest of all the 1972-2014 estimates. In the case of the SSB, the levels are well above the highest of the assessed period in all the scenarios. The number of matures increases in less proportion than the SSB. The removals associated with the F_{bar} based in $F_{statusquo}$ reach the level seen in 1992, before the collapse of the stock.

A clear trend in the biological parameters of this stock in recent years has led to revisions in estimate numbers from one year assessment to the actual ones in the next assessment. If this pattern continues, the projection results could be biased.

The projected values for the period 2015-2018 are heavily reliant on the relatively abundant most recent cohorts, especially the 2010-2011 cohorts, which are estimated to be extremely large, but with high uncertainty.

References

Brodie, W.B. and W. R. Bowering, 1992. Results for American Plaice from Canadian Surveys in Div. 3M, 1978-85. NAFO SCR Doc. 92/76. Serial Number N2131.

Casas, J.M. and D. González Troncoso, 2015. Results from bottom trawl survey on Flemish Cap of June-July 2014. NAFO SCR Doc. 15/17. Serial Number N6438.

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.

Fomin, K., V. Khlivnoy, T. Mishin and P. Zavoloka, 2015. Russian Research Report for 2014. NAFO SCS Doc. 15/07. Serial Number N6433.

González-Costas, F., G. Ramilo, E. Román, A. Gago, D. González-Troncoso, M. Casas, M. Sacau, E. Guijarro and. J. Lorenzo. Spanish Research Report for 2014. NAFO SCS Doc. 14/05. Serial Number N6423.

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., Fernando González-Costas, Brian Healey, Joanne Morgan and Carsten Hvingel, 2014. Assessment of the 3M Cod Stock in NAFO Division 3M. NAFO SCR Doc. 14/35. Serial Number N6331.

Iriondo A., F. González-Costas, N. Hintzen, M. Machiels, D. González-Troncoso and A. Urtizberea, 2014. Spatial and seasonal fleet activity and cod distribution in Flemish Cap. NAFO SCR Doc. 14-068. Serial Number N6407

Torra, T. and S. Sirp, 2015. Estonian research report for 2014. NAFO SCS Doc. 15/04. Serial Number N6420.

Vázquez, A., L. Motos and J.-C. Mahé, 1999. An Assessment of the Cod Stock in NAFO Division 3M. NAFO SCR Doc. 99/56. Serial Number N4115.

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.

Vargas, J., R. Alpoim, E. Santos and A. M. Ávila de Melo, 2015. Portuguese research report for 2014. NAFO SCS Doc. 15/06. Serial Number N6426.

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Table 1.- Total commercial cod catch in Division 3M. Reported nominal catches since 1960 and estimated total catch from 1988 to 2014 in tons.

Year	Estimated	Portugal	Russia	Spain	France	Faroes	UK	Poland	Norway	Germany	Cuba	Others	Total[1]
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	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				458	34150
1969		7276	283	2681	11831					20		52	22143
1970		9847	494	1324	6239		3	53				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		24	76	29710
1980		3615	1056	706	301	3248		33	1080	355	1	62	10457
1981		3727	927	4100	79	3874			1154			12	13873
1982		3316	1262	4513	119	3121	33		375			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						269	10632
1988	28899	421	39	141		1100					3	14	1718
1989	48373	170	10	378								359	917
1990	40827	551	22	87		1262						840	2762
1991	16229	2838	1	1416		2472	26		897		5	1334	8989
1992	25089	2201	1	4215		747	5				6	51	7226
1993	15958	3132	0	2249		2931						4	8316
1994	29916	2590	0	1952		2249			1			93	6885
1995	10372	1641	0	564		1016						0	3221
1996	2601	1284	0	176		700	129			16		0	2305
1997	2933	1433	0	1			23					0	1457
1998	705	456	0									0	456
1999	353	2	0									0	2
2000	55	30	6									0	36
2001	37	56	0									0	56
2002	33	32	1									0	33
2003	16	7	0									9	16
2004	5	18	2									3	23
2005	19	16	0			7						3	26
2006	339	51	1	16								55	123
2007	345	58	6	33								28	125
2008	889	219	74	42		0						66	401
2009	1161	856	87	85		22						122	1172
2010	9192	1482	374			1183	761		519			85	4404
2011	n.a.	2412	655	1609	200	2211	1063		1117		185	342	9794
2012	n.a.	2663	745	1597		2045	868		826		172	87	9003
2013	n.a.	4709	899	2323		2819	1485		1296			455	13985[2]
2014	n.a.	5251	950	2099		3388		392	1348			862	14290[3]

[1] Recalculated from NAFO Statistical data base using the NAFO 21A Extraction Tool
[2] Daily Catch Report from the NAFO Secretariat [3] STATLANT21A

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

	1	2	3	4	5	6	7	8+
1972	0	0	278	19303	12372	6555	3083	3177
1973	0	0	2035	116	11709	3470	853	1085
1974	0	0	5999	11130	2232	1894	271	257
1975	0	0	7090	2436	1241	238	281	258
1976	0	0	17564	10653	386	100	63	5
1977	0	0	119	17581	8502	436	267	318
1978	0	0	428	3092	18077	3615	329	270
1979	0	0	167	2616	5599	5882	316	137
1980	0	0	551	500	1423	1051	1318	96
1981	0	0	1732	6768	161	326	189	539
1982	0	0	21	3040	1926	310	97	357
1983	0	0	2818	713	765	657	94	131
1984	0	0	9	2229	966	59	90	146
1985	0	0	19	5499	3549	1232	931	218
1986	0	2549	2266	4251	2943	1061	169	162
1987	814	1848	3102	1915	1259	846	313	112
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
2011[1]	0.003	0.098	0.293	0.126	0.198	0.161	0.063	0.056
2012[1]	0.008	0.080	0.297	0.171	0.199	0.136	0.061	0.048
2013	31	894	5624	1236	1158	640	382	252
2014	8	15	809	4554	1581	871	509	341

[1] As there is no total catch available, the proportion of number per age is given

Table 3.- Weight-at-age (kg) in catch.

	1	2	3	4	5	6	7	8+
1972			0.811	0.722	0.981	1.500	1.930	2.296
1973			0.633	0.314	1.300	0.994	0.828	3.430
1974			0.657	0.805	1.769	2.829	3.983	7.701
1975			0.697	1.636	1.798	2.658	3.766	6.497
1976			0.671	1.293	4.192	5.085	5.923	6.298
1977			0.314	0.845	1.400	3.433	5.156	7.722
1978			0.374	0.600	1.102	1.582	2.658	6.351
1979			0.790	1.070	1.480	2.450	4.350	7.079
1980			0.859	1.137	1.747	2.466	3.167	4.676
1981			0.620	1.250	1.880	2.680	3.190	4.747
1982			0.760	1.340	2.450	2.870	4.680	6.146
1983			1.330	1.140	2.240	3.530	4.760	9.163
1984			0.460	1.866	3.695	3.660	6.588	6.655
1985			0.283	0.851	1.605	2.816	4.522	7.978
1986		0.165	0.411	0.784	1.631	2.836	4.317	7.389
1987	0.091	0.133	0.327	1.040	1.890	2.993	4.440	7.630
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			0.920	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
2011	0.086	0.396	0.939	1.523	2.224	3.558	5.979	8.677
2012	0.086	0.374	0.990	1.491	2.135	3.585	6.198	9.041
2013	0.067	0.284	0.758	1.289	2.027	2.868	4.476	8.243
2014	0.108	0.203	0.538	1.108	1.809	2.874	4.087	7.669

Table 4- Canadian bottom trawl survey abundance at age (thousands).

	1	2	3	4	5	6	7	8+
1978	0	95	4757	15531	45688	12135	476	570
1979	0	4675	1067	5619	5465	6676	1706	405
1980	0	1030	19475	2377	2990	2737	3912	224
1981	32	0	5172	15479	975	2108	1041	2211
1982	627	1781	21	1663	978	32	150	377
1983	293	71000	7817	319	2357	958	45	401
1984	43	1527	15834	1897	74	646	427	221
1985	39	520	6212	19955	774	50	105	196

Table 5.- 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
2011	347674	142999	16993	6309	7739	3089	1191	0	215	0	89	0	0	0
2012	103494	128087	10942	11721	4967	4781	1630	832	24	93	30	101	0	17
2013	5525	67521	32339	4776	4185	2782	1807	963	278	40	29	32	5	0
2014	7282	2372	48564	43168	17861	6842	3447	1931	1551	600	79	54	8	0

Table 6.- Weight-at-age (kg) in stock.

	1	2	3	4	5	6	7	8+
1972	0.05	0.20	0.81	0.72	0.98	1.50	1.93	2.30
1973	0.05	0.20	0.63	0.31	1.30	0.99	0.83	3.43
1974	0.05	0.20	0.66	0.81	1.77	2.83	3.98	7.70
1975	0.05	0.20	0.70	1.64	1.80	2.66	3.77	6.50
1976	0.05	0.20	0.67	1.29	4.19	5.09	5.92	6.30
1977	0.05	0.20	0.31	0.85	1.40	3.43	5.16	7.72
1978	0.05	0.20	0.37	0.60	1.10	1.58	2.66	6.35
1979	0.05	0.20	0.79	1.07	1.48	2.45	4.35	7.08
1980	0.05	0.20	0.86	1.14	1.75	2.47	3.17	4.68
1981	0.05	0.20	0.62	1.25	1.88	2.68	3.19	4.75
1982	0.05	0.20	0.76	1.34	2.45	2.87	4.68	6.15
1983	0.05	0.20	1.33	1.14	2.24	3.53	4.76	9.16
1984	0.05	0.20	0.46	1.87	3.70	3.66	6.59	6.66
1985	0.05	0.20	0.28	0.85	1.61	2.82	4.52	7.98
1986	0.05	0.20	0.41	0.78	1.63	2.84	4.32	7.39
1987	0.05	0.20	0.33	1.04	1.89	2.99	4.44	7.63
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
2011	0.04	0.23	0.97	1.70	2.45	3.74	6.26	9.67
2012	0.07	0.37	0.73	1.35	1.99	2.66	4.93	7.81
2013	0.07	0.17	0.69	1.16	2.00	2.75	4.21	7.61
2014	0.05	0.17	0.35	1.06	1.62	2.54	3.85	8.44

Table 7.- Maturity at age and age of first maturation (median values of ogives).

	1	2	3	4	5	6	7	8+	a50
1972	0.000	0.000	0.000	0.002	0.507	0.998	1.000	1.000	5.00
1973	0.000	0.000	0.000	0.002	0.507	0.998	1.000	1.000	5.00
1974	0.000	0.000	0.000	0.002	0.507	0.998	1.000	1.000	5.00
1975	0.000	0.000	0.000	0.002	0.507	0.998	1.000	1.000	5.00
1976	0.000	0.000	0.000	0.002	0.507	0.998	1.000	1.000	5.00
1977	0.000	0.000	0.000	0.002	0.507	0.998	1.000	1.000	5.00
1978	0.000	0.000	0.000	0.002	0.507	0.998	1.000	1.000	5.00
1979	0.000	0.000	0.000	0.008	0.154	0.813	0.991	1.000	5.54
1980	0.000	0.000	0.002	0.029	0.302	0.862	0.989	1.000	5.31
1981	0.000	0.000	0.005	0.104	0.716	0.982	0.999	1.000	4.70
1982	0.000	0.000	0.007	0.146	0.809	0.991	1.000	1.000	4.55
1983	0.000	0.000	0.007	0.146	0.809	0.991	1.000	1.000	4.55
1984	0.000	0.000	0.007	0.146	0.809	0.991	1.000	1.000	4.55
1985	0.000	0.000	0.007	0.146	0.809	0.991	1.000	1.000	4.55
1986	0.000	0.000	0.007	0.146	0.809	0.991	1.000	1.000	4.55
1987	0.000	0.000	0.007	0.146	0.809	0.991	1.000	1.000	4.55
1988	0.054	0.099	0.175	0.291	0.441	0.603	0.745	0.879	5.36
1989	0.054	0.099	0.175	0.291	0.441	0.603	0.745	0.879	5.36
1990	0.054	0.099	0.175	0.291	0.441	0.603	0.745	0.879	5.36
1991	0.018	0.045	0.111	0.247	0.463	0.687	0.849	0.951	5.16
1992	0.002	0.011	0.048	0.184	0.503	0.819	0.953	0.993	4.99
1993	0.001	0.007	0.049	0.282	0.751	0.959	0.994	1.000	4.46
1994	0.000	0.001	0.050	0.657	0.986	1.000	1.000	1.000	3.82
1995	0.000	0.000	0.006	0.803	1.000	1.000	1.000	1.000	3.79
1996	0.000	0.000	0.029	0.666	0.993	1.000	1.000	1.000	3.84
1997	0.000	0.008	0.111	0.670	0.971	0.998	1.000	1.000	3.75
1998	0.000	0.002	0.096	0.874	0.998	1.000	1.000	1.000	3.54
1999	0.000	0.001	0.130	0.902	0.999	1.000	1.000	1.000	3.46
2000	0.000	0.001	0.160	0.971	1.000	1.000	1.000	1.000	3.34
2001	0.000	0.001	0.315	0.998	1.000	1.000	1.000	1.000	3.12
2002	0.000	0.010	0.636	0.997	1.000	1.000	1.000	1.000	2.89
2003	0.001	0.024	0.513	0.978	0.999	1.000	1.000	1.000	2.99
2004	0.000	0.000	0.100	0.967	1.000	1.000	1.000	1.000	3.40
2005	0.041	0.171	0.502	0.830	0.959	0.991	0.998	1.000	3.00
2006	0.000	0.014	0.365	0.959	0.999	1.000	1.000	1.000	3.15
2007	0.000	0.012	0.261	0.920	0.997	1.000	1.000	1.000	3.31
2008	0.000	0.012	0.231	0.882	0.995	1.000	1.000	1.000	3.37
2009	0.000	0.010	0.181	0.830	0.991	1.000	1.000	1.000	3.49
2010	0.000	0.009	0.167	0.812	0.989	1.000	1.000	1.000	3.52
2011	0.001	0.008	0.072	0.428	0.878	0.986	0.999	1.000	4.13
2012	0.000	0.000	0.018	0.578	0.990	1.000	1.000	1.000	3.93
2013	0.004	0.037	0.285	0.804	0.977	0.998	1.000	1.000	3.39
2014	0.000	0.003	0.046	0.400	0.902	0.992	0.999	1.000	4.15

Table 8.- 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%**
1972	83023	78814	89207	36704	33766	40252	16500	13880	20710	0.706	0.666	0.737
1973	49092	46019	53907	20227	17243	23821	57320	46786	74270	0.600	0.550	0.627
1974	52553	47912	59747	15092	13232	19357	113400	92818	147700	1.395	1.214	1.508
1975	66920	59809	77751	7720	6215	11712	21130	16830	28470	0.697	0.575	0.777
1976	108820	99265	123269	8560	6609	12469	9332	7611	12150	0.351	0.316	0.379
1977	83270	77053	92595	20930	17080	27412	2755	2169	3856	0.474	0.441	0.500
1978	56191	52655	61261	28432	23449	33729	18650	15320	24040	0.482	0.443	0.510
1979	49513	45621	55509	24169	21301	28569	12510	10170	16450	0.734	0.669	0.788
1980	30895	27804	35872	11559	9778	15479	7024	5446	9736	0.574	0.520	0.613
1981	33792	29382	40373	13207	9348	19082	19250	15670	25312	0.517	0.478	0.548
1982	29768	27121	33874	13153	11635	15633	19010	15320	25040	0.620	0.570	0.660
1983	39666	35785	45663	12091	10483	14560	11960	9735	15701	0.288	0.256	0.315
1984	45439	41600	51040	19436	17063	22499	13470	10930	17790	0.242	0.221	0.259
1985	38319	35794	42088	20762	19120	22737	53880	44159	69770	0.593	0.540	0.628
1986	40347	36580	46052	15475	13822	18158	111000	93190	139205	0.770	0.706	0.820
1987	53065	47922	60956	12493	11096	15125	70030	59230	87340	0.454	0.405	0.491
1988	64687	60006	71465	19149	15307	24005	14550	11980	18720	0.515	0.472	0.549
1989	104808	98684	113483	33526	27324	41227	19470	16490	24091	0.869	0.815	0.912
1990	64214	60648	69164	25280	21646	29476	24560	21130	29870	0.904	0.847	0.951
1991	44100	40933	48444	17588	14846	21093	62065	54410	73810	0.498	0.465	0.525
1992	58083	54922	62362	20858	18369	23695	56190	48820	67630	1.548	1.472	1.610
1993	45876	42944	50095	10365	8822	12707	3023	2638	3649	1.030	0.960	1.086
1994	49636	46368	54693	21502	18551	26402	4174	3180	6016	0.954	0.906	0.991
1995	22502	21296	24419	19264	18104	20958	2186	1812	2818	1.412	1.266	1.515
1996	5700	5096	6674	3455	3073	4067	132	85	210	0.677	0.565	0.765
1997	4758	4094	5871	3203	2678	4058	129	82	211	0.754	0.608	0.900
1998	3370	2510	4792	3159	2316	4561	198	142	305	0.313	0.230	0.428
1999	2414	1647	3736	2265	1519	3569	33	24	49	0.295	0.221	0.393
2000	2204	1366	3700	2049	1223	3538	316	194	528	0.189	0.128	0.267
2001	1888	1303	2684	1697	1109	2474	542	336	871	0.035	0.024	0.051
2002	2206	1609	2982	1912	1327	2674	65	40	107	0.015	0.007	0.034
2003	2459	1874	3175	2199	1636	2893	1149	752	1813	0.011	0.006	0.019
2004	3956	3183	4835	3253	2537	4113	80	59	116	0.003	0.002	0.005
2005	4304	3562	5130	3551	2909	4275	3594	2457	5641	0.007	0.004	0.011
2006	6791	5521	8558	3848	3096	4796	7401	5322	11330	0.219	0.169	0.278
2007	12618	10246	16117	5426	4195	7085	9996	7486	14520	0.031	0.024	0.041
2008	19935	16409	25257	9715	7860	12453	9672	7406	13601	0.075	0.058	0.097
2009	30481	25687	37344	18671	15444	23369	12150	9095	18010	0.044	0.035	0.053
2010	45365	39256	53775	31991	27096	38713	14230	9820	22912	0.264	0.218	0.310
2011	50194	42190	61074	31862	25731	40752	37020	23570	62662	0.293	0.217	0.382
2012	54216	43766	70416	28897	22228	40843	32945	17859	59701	0.261	0.194	0.339
2013	55475	44177	72012	34988	27577	46087	4613	2129	10512	0.297	0.218	0.387
2014	52813	40384	71330	31264	23723	42330	10670	4036	29410	0.289	0.179	0.488
2015				42514	29111	62438						

Table 9.- F at age (posterior median).

	F at age							
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8+**
1972	0.000	0.000	0.067	0.756	1.298	1.903	3.266	3.266
1973	0.000	0.000	0.122	0.035	1.644	2.140	2.099	2.099
1974	0.000	0.000	0.783	1.786	1.649	1.611	1.167	1.167
1975	0.000	0.000	0.204	0.838	1.061	0.756	1.208	1.208
1976	0.000	0.000	0.262	0.510	0.281	0.198	0.433	0.433
1977	0.000	0.000	0.008	0.435	0.979	0.567	1.170	1.170
1978	0.000	0.000	0.071	0.299	1.076	1.786	1.129	1.129
1979	0.000	0.000	0.095	0.749	1.360	1.364	0.714	0.714
1980	0.000	0.000	0.045	0.430	1.250	1.019	1.457	1.457
1981	0.000	0.000	0.232	1.092	0.228	1.122	0.469	0.469
1982	0.000	0.000	0.004	0.770	1.088	0.864	1.292	1.292
1983	0.000	0.000	0.246	0.198	0.421	1.572	0.674	0.674
1984	0.000	0.000	0.001	0.301	0.428	0.049	0.955	0.955
1985	0.000	0.000	0.002	0.708	1.072	1.637	2.714	2.714
1986	0.000	0.062	0.289	0.978	1.048	1.139	1.103	1.103
1987	0.013	0.021	0.096	0.405	0.866	0.994	1.344	1.344
1988	0.000	0.066	0.433	0.554	0.562	0.765	1.374	1.374
1989	0.000	0.005	0.438	0.862	1.312	0.917	1.271	1.271
1990	0.000	0.017	0.254	1.081	1.380	1.527	1.246	1.246
1991	0.000	0.029	0.519	0.364	0.612	0.790	1.151	1.151
1992	0.000	0.382	1.014	1.381	2.256	1.545	2.702	2.702
1993	0.000	0.062	0.717	1.267	1.111	1.851	1.364	1.364
1994	0.000	0.718	1.263	1.206	0.395	0.650	0.374	0.374
1995	0.000	0.000	0.312	1.468	2.472	3.286	1.552	1.552
1996	0.000	0.048	0.299	0.707	1.032	0.525	0.000	0.000
1997	0.000	0.000	0.870	0.574	0.817	0.834	0.587	0.587
1998	0.000	0.000	0.096	0.420	0.419	0.374	0.108	0.108
1999	0.000	0.000	0.192	0.253	0.423	0.137	0.055	0.055
2000	0.000	0.484	0.523	0.017	0.023	0.026	0.003	0.003
2001	0.000	0.037	0.000	0.062	0.041	0.000	0.016	0.016
2002	0.000	0.005	0.015	0.010	0.012	0.005	0.015	0.015
2003	0.000	0.005	0.010	0.010	0.010	0.005	0.005	0.005
2004	0.000	0.001	0.005	0.002	0.002	0.004	0.001	0.001
2005	0.000	0.005	0.005	0.009	0.005	0.004	0.003	0.003
2006	0.000	0.008	0.449	0.133	0.072	0.050	0.018	0.018
2007	0.000	0.000	0.013	0.022	0.058	0.053	0.084	0.084
2008	0.000	0.011	0.028	0.070	0.128	0.110	0.068	0.068
2009	0.000	0.003	0.008	0.053	0.071	0.000	0.114	0.114
2010	0.003	0.049	0.196	0.314	0.284	0.377	0.290	0.290
2011	0.001	0.053	0.252	0.182	0.445	0.686	0.766	0.766
2012	0.001	0.014	0.184	0.189	0.409	0.543	0.563	0.563
2013	0.007	0.035	0.263	0.218	0.395	0.447	0.544	0.544
2014	0.001	0.004	0.039	0.338	0.454	0.562	0.754	0.754

Table 10.- N at age (posterior median), with the total number and number of matures (posterior median) by year.

	N at age									
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8+**	**Total**	**Matures**
1972	16500	22610	4637	39410	18460	8369	3486	3447	116919	24990
1973	57320	14050	19260	3678	15760	4276	1054	1304	116702	14791
1974	113400	48820	11970	14510	3004	2576	426	398	195104	5130
1975	21130	96655	41580	4659	2063	487	435	392	167401	2509
1976	9332	18010	82395	28890	1711	605	194	15	141152	1908
1977	2755	7948	15340	54010	14760	1095	420	492	96820	9936
1978	18650	2347	6772	12960	29770	4715	528	426	76168	20908
1979	12510	15900	1998	5375	8174	8593	672	288	53510	9318
1980	7024	10660	13550	1549	2165	1781	1861	133	38723	4304
1981	19250	5976	9072	11030	857	526	548	1550	48809	4497
1982	19010	16400	5089	6130	3153	580	145	524	51031	4788
1983	11960	16195	13980	4310	2415	901	208	287	50256	4124
1984	13470	10190	13790	9302	3012	1347	159	254	51524	5708
1985	53880	11470	8684	11740	5863	1664	1084	245	94630	9575
1986	111000	45905	9780	7382	4920	1698	274	259	181218	7475
1987	70030	94555	36760	6238	2360	1461	460	161	212025	5299
1988	14550	58930	78860	28440	3536	841	458	231	185846	31524
1989	19470	12400	46990	43570	13920	1707	332	304	138693	31070
1990	24560	16580	10520	25820	15680	3174	577	176	97087	21906
1991	62065	20915	13890	6954	7461	3356	584	119	115344	12148
1992	56190	52895	17310	7044	4117	3432	1287	530	142805	9620
1993	3023	47900	30760	5350	1506	366	619	304	89828	5806
1994	4174	2577	38355	12790	1283	421	49	629	60278	12838
1995	2186	3545	1069	9240	3262	735	186	313	20536	11963
1996	132	1861	3001	665	1805	234	23	1	7722	2623
1997	129	111	1510	1893	278	548	117	1	4587	2426
1998	198	110	94	538	906	104	202	21	2173	1759
1999	33	169	93	73	301	507	61	20	1257	1000
2000	316	28	144	65	48	168	375	1	1145	709
2001	542	269	15	72	55	40	139	139	1271	458
2002	65	462	221	13	58	44	34	232	1129	541
2003	1149	55	390	184	11	49	37	225	2100	719
2004	80	979	47	328	154	9	41	223	1861	764
2005	3594	68	831	39	278	130	7	228	5175	1277
2006	7401	3044	57	706	33	234	110	21	11606	1159
2007	9996	6303	2563	31	524	26	189	63	19695	1671
2008	9672	8506	5360	2149	26	420	21	57	26211	3818
2009	12150	8222	7153	4420	1701	19	319	72	34056	7247
2010	14230	10320	6972	6032	3557	1344	16	443	42914	11678
2011	37020	12070	8358	4873	3740	2272	782	581	69696	9966
2012	32945	31420	9747	5492	3432	2008	958	875	86877	10978
2013	4613	27950	26370	6866	3861	1924	989	647	73220	22117
2014	10670	3888	22935	17235	4691	2202	1043	692	63356	16776
2015[1]		9091	3285	18826	10415	2526	1064	694	45901	22396

[1] Results without recruitment data

Table 11.- N-at-age in prediction years (medians) with $F_{bar}=F_{lim}=0.131$ including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2015	42069	9091	3285	18826	10415	2526	1064	277	87553	26780
2016	64592	35612	7617	2484	13475	6653	1492	150	132075	25478
2017	62099	55041	29897	6045	1886	9347	4377	92	168784	24780
2018	59678	52672	46137	23324	4552	1313	6060	57	193793	32395

Table 12.- Projections results (median and 90% CI) with $F_{bar}=F_{lim}=0.131$

Year	Total Biomass	SSB	$P(SSB<B_{lim})$	Yield
2015	65670 (44646- 96439)	48340 (31543- 73066)	<1%	13795
2016	73884 (43934-118238)	54691 (31574- 88297)	<1%	12425 (6250-23906)
2017	91376 (48809-158835)	57478 (34419- 91536)	<1%	15436 (7944-27988)
2018	110214 (46833-209350)	60049 (31712-103003)	<1%	

Table 13.- N-at-age in prediction years (medians) with $F_{bar}=3/4F_{lim}=0.098$ including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2015	42069	9091	3285	18826	10415	2526	1064	277	87553	26780
2016	64592	35612	7617	2484	13475	6653	1492	150	132075	25478
2017	62099	55057	29968	6159	1940	9837	4677	100	169837	25778
2018	61886	52693	46286	23897	4789	1422	6781	67	197821	33806

Table 14.- Projections results (median and 90% CI) with $F_{bar}=3/4F_{lim}=0.098$

Year	Total Biomass	SSB	$P(SSB<B_{lim})$	Yield
2015	65670 (44646- 96439)	48340 (31543- 73066)	<1%	13795
2016	73884 (43934-118238)	54691 (31574- 88297)	<1%	9578 (4780-18656)
2017	94576 (50794-163415)	60421 (36089- 96404)	<1%	12486 (6336-23292)
2018	115463 (50233-216608)	64748 (34675-109361)	<1%	

Table 15.- N-at-age in prediction years (medians) with $F_{bar}=F_{2012\text{-}2014}=0.285$ including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2015	42069	9091	3285	18826	10415	2526	1064	277	87553	26780
2016	64592	35612	7617	2484	13475	6653	1492	150	132075	25478
2017	62099	54929	29539	5495	1631	7388	3315	65	164461	20941
2018	49029	52570	45481	20979	3608	896	3642	28	176233	26700

Table 16.- Projections results (median and 90% CI) with $F_{bar}=F_{2012\text{-}2014}=0.285$

Year	Total Biomass	SSB	$P(SSB<B_{lim})$	Yield
2015	65670 (44646- 96439)	48340 (31543-73066)	<1%	13795
2016	73884 (43934-118238)	54691 (31574-88297)	<1%	23435 (14510-37577)
2017	79734 (39947-143720)	46143 (26479-75954)	<1%	23435 (13832-37384)
2018	92346 (34387-185558)	44176 (21238-81238)	<1%	

Table 17.- N-at-age in prediction years (medians) with $F_{bar}=3/4F_{2012\text{-}2014}=0.213$ including total number and number of matures.

Year/Age	1	2	3	4	5	6	7	8+	Total	Matures
2015	42069	9091	3285	18826	10415	2526	1064	277	87553	26780
2016	64592	35612	7617	2484	13475	6653	1492	150	132075	25478
2017	62099	54982	29677	5731	1745	8248	3804	76	166362	22618
2018	53973	52622	45775	22084	4013	1069	4666	39	184241	29059

Table 18.- Projections results (median and 90% CI) with $3/4F_{bar}=F_{2012-2014}=0.213$

Year	Total Biomass	SSB	P(SSB<B_{lim})	Yield
2015	65670 (44646- 96439)	48340 (31543-73066)	<1%	13795
2016	73884 (43934-118238)	54691 (31574-88297)	<1%	18637 (11489-29889)
2017	85044 (43520-150672)	51203 (29423-83238)	<1%	20469 (12052-33209)
2018	100070 (39286-197776)	50823 (25612-90466)	<1%	

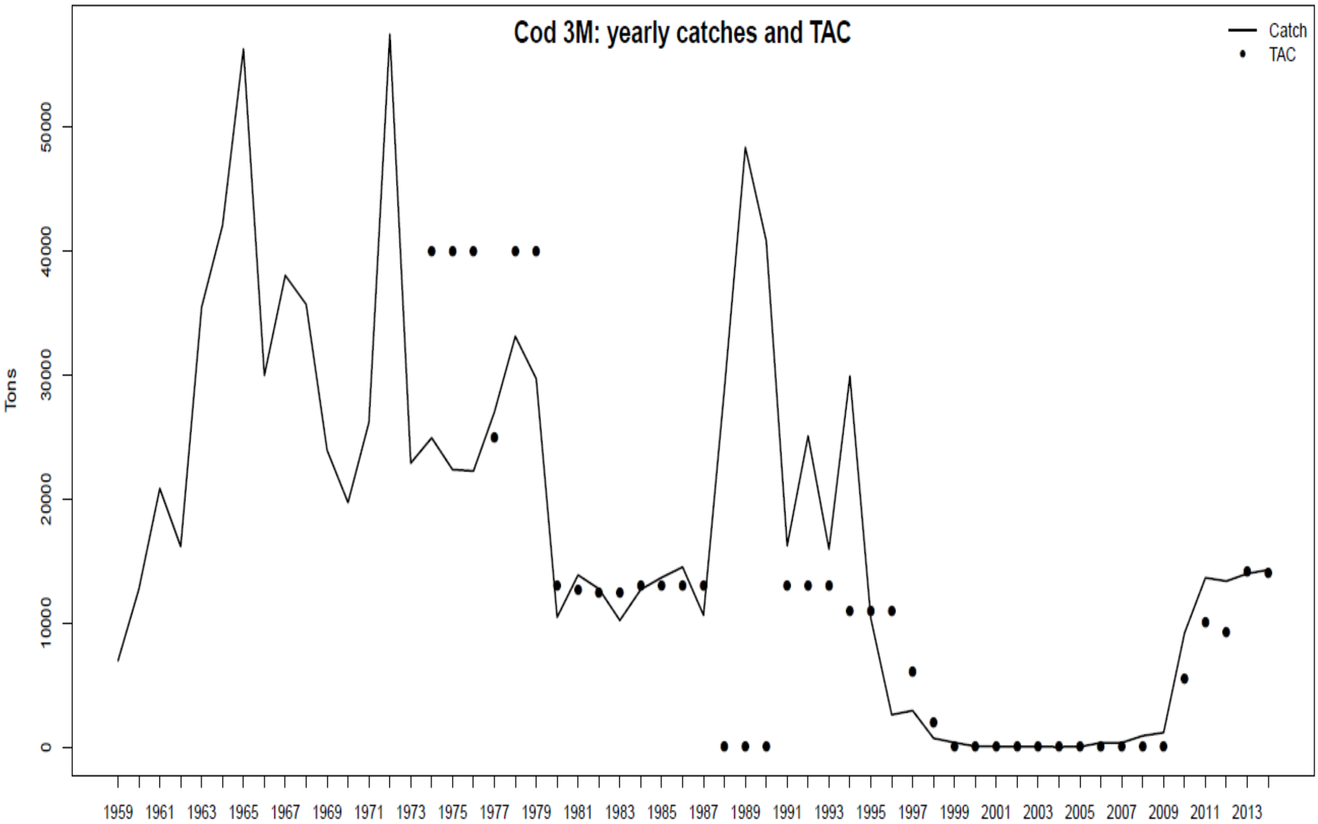


Figure 1.- Catch and TAC of the 3M cod for the period 1959-2014.

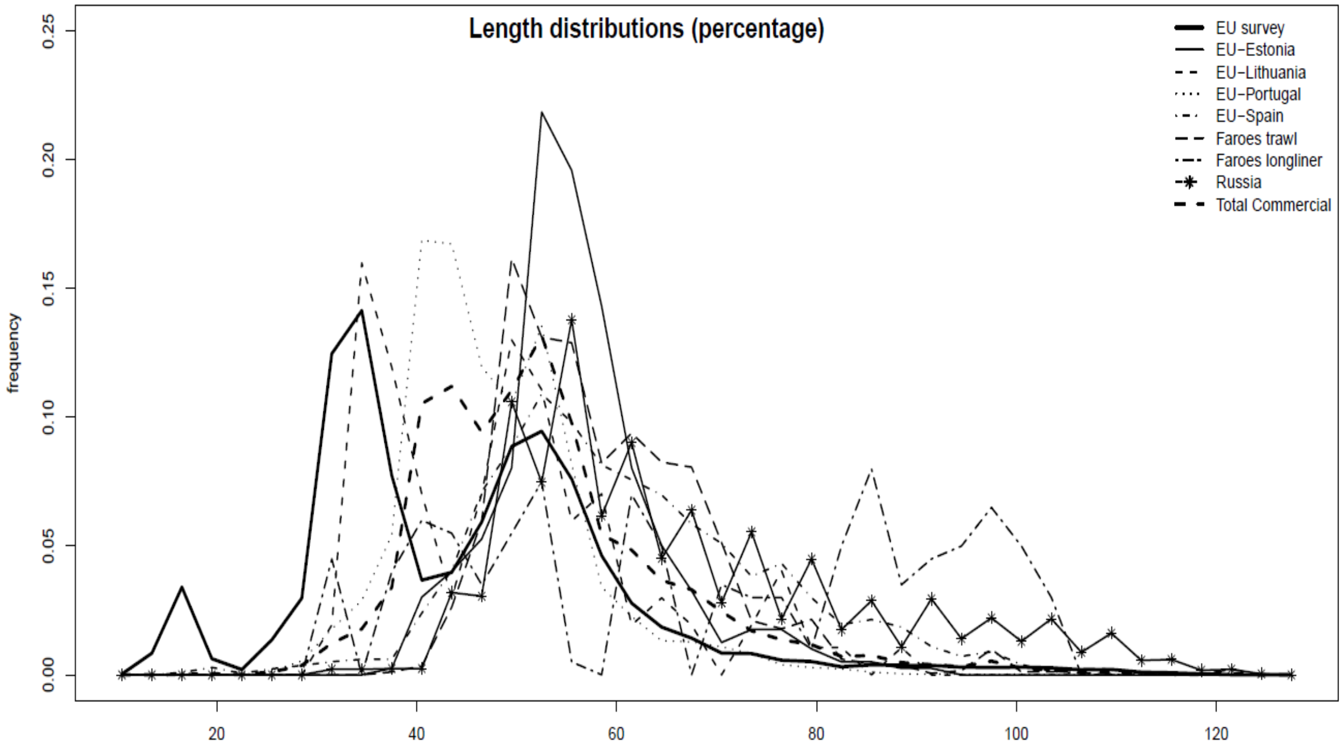


Figure 2a.- Length frequencies in commercial catches and EU survey in 2014.

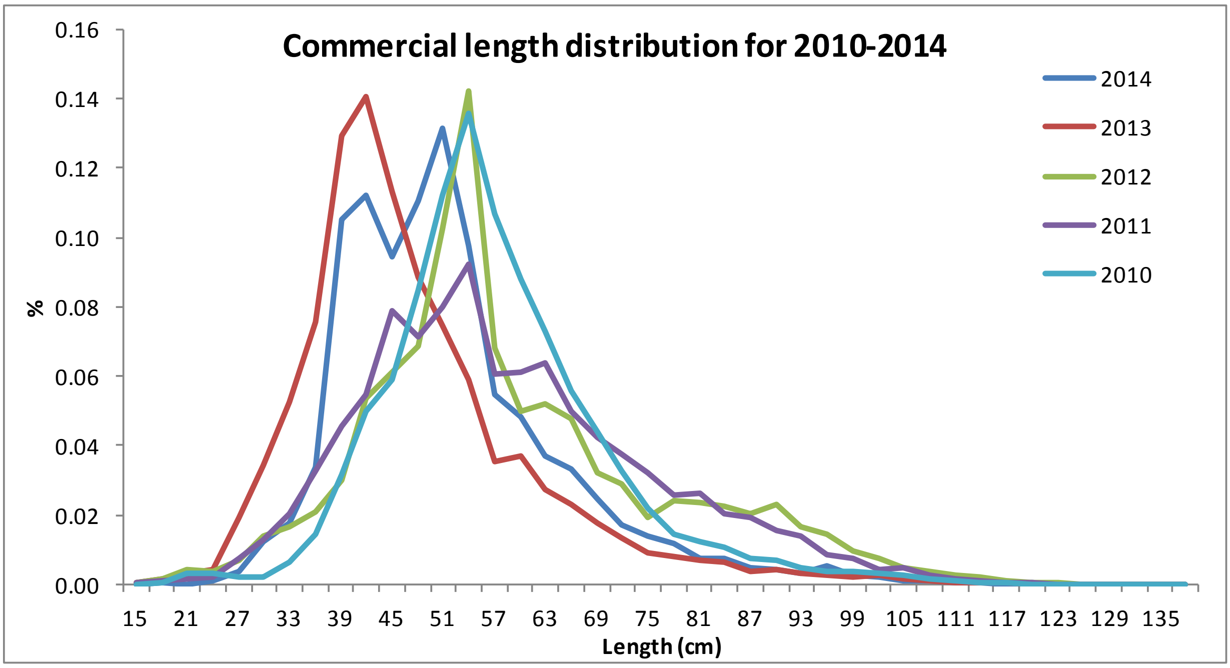


Figure 2b.- Length frequencies in commercial catches in 2010-2014.

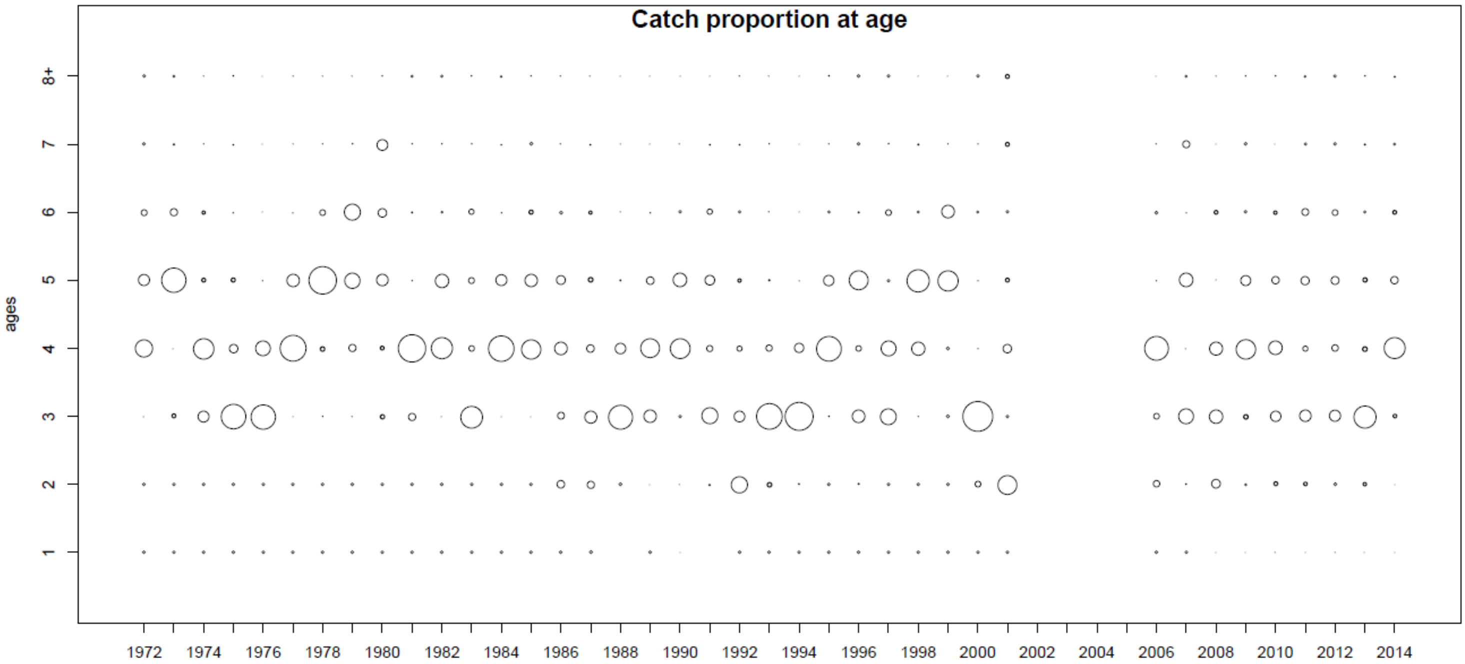


Figure 3.- Commercial catch proportions at age.

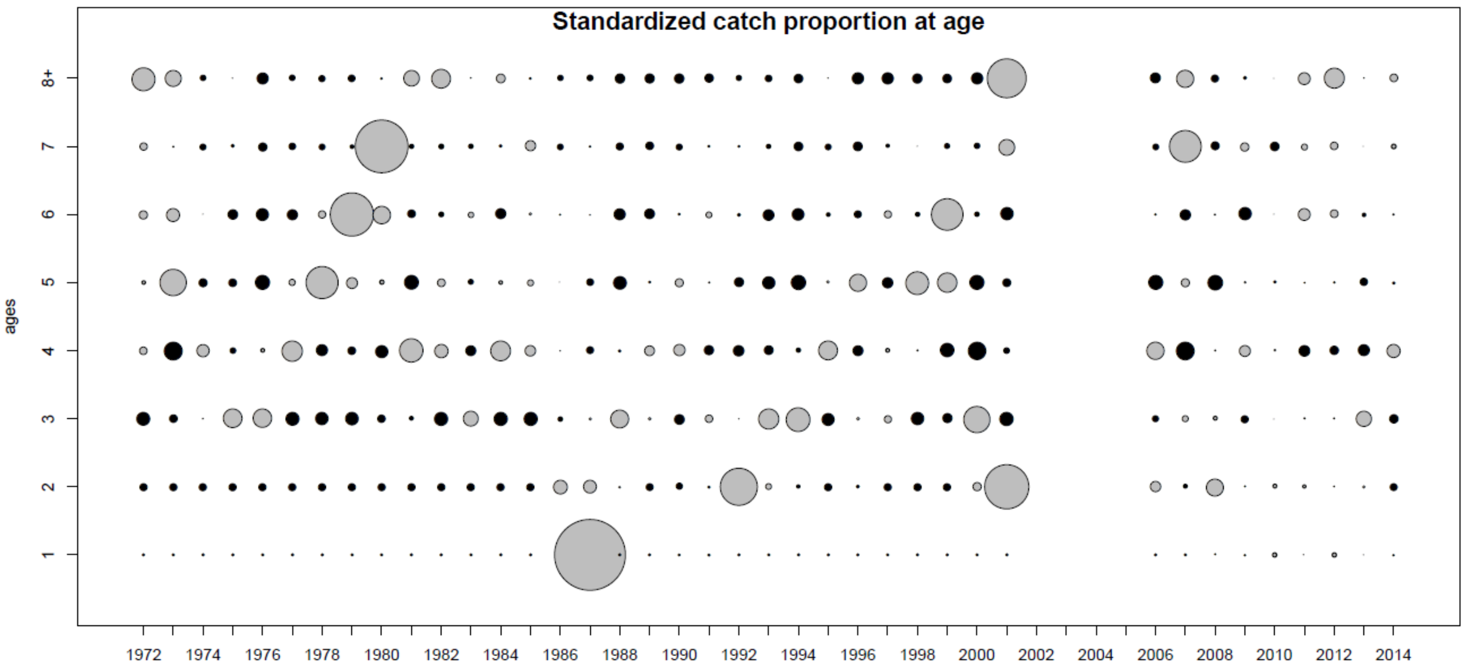


Figure 4.- Commercial catch standardised proportions at age. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

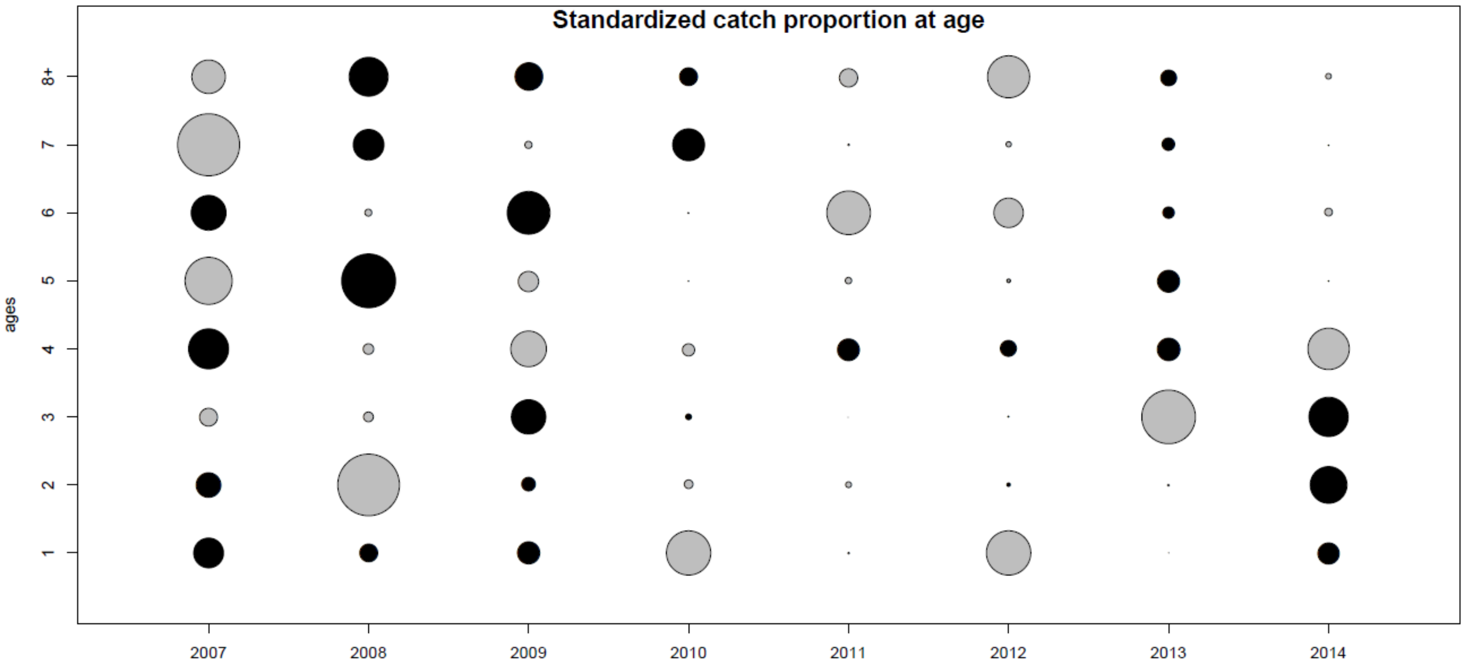


Figure 5.- Commercial catch standardised proportions at age for the last cohort (2007-2014). Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

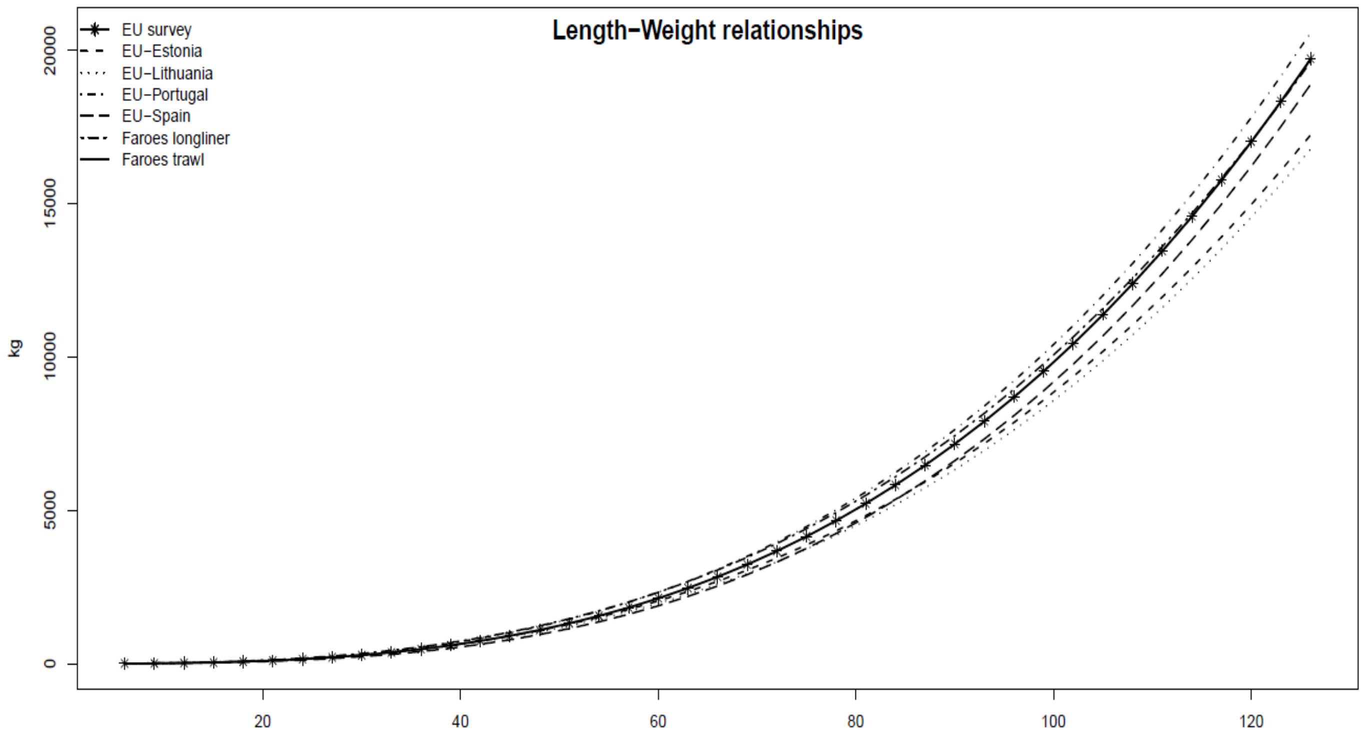


Figure 6.- Length-weight relationships for commercial catches and EU survey in 2014.

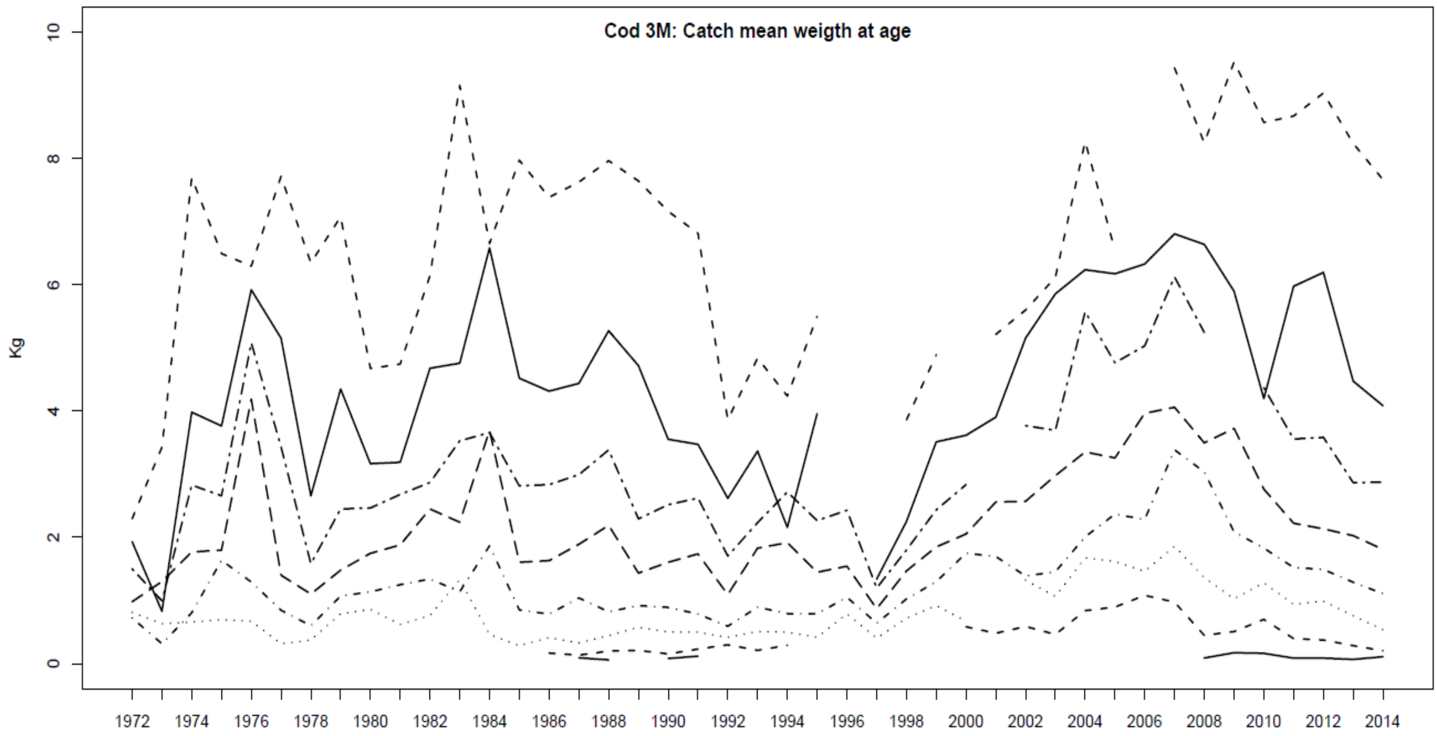


Figure 7.- Catch mean weight at age.

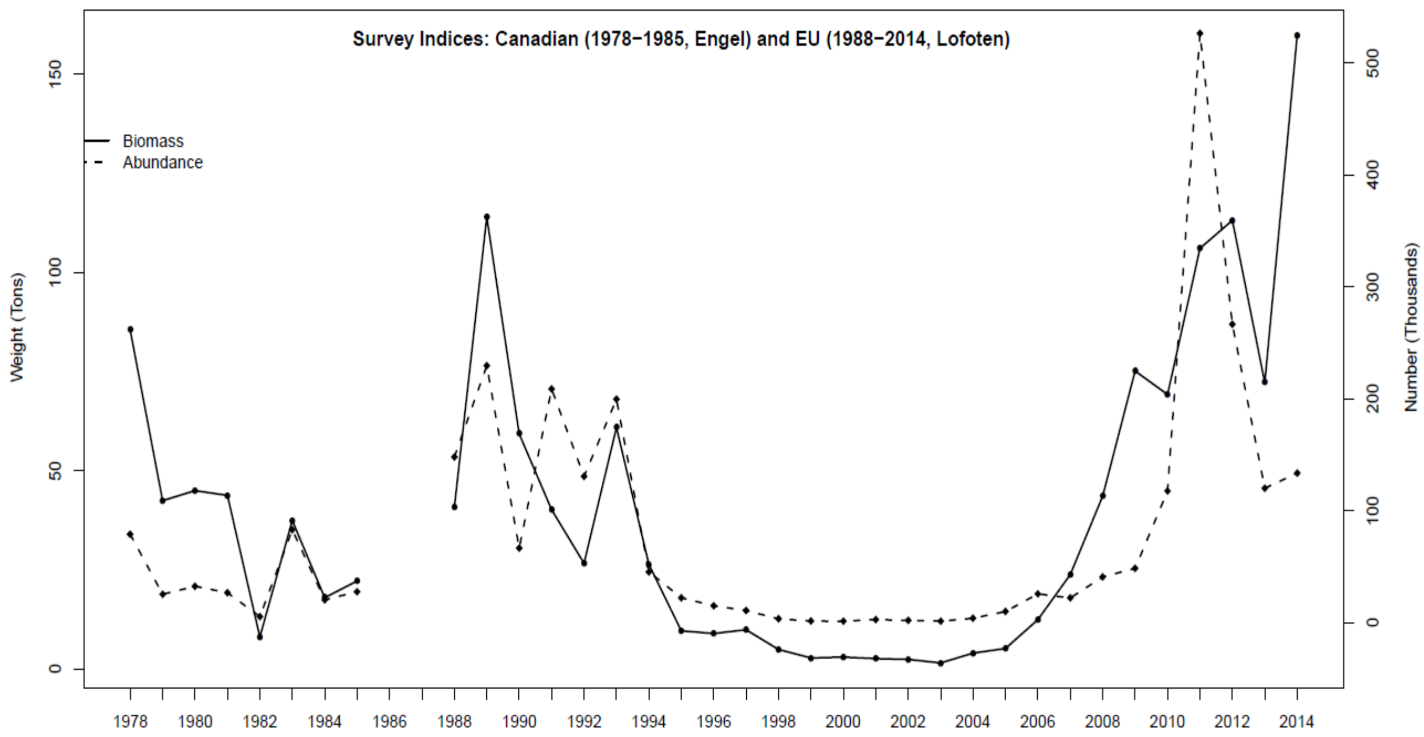


Figure 8.- Biomass and abundance from Canadian and EU surveys.

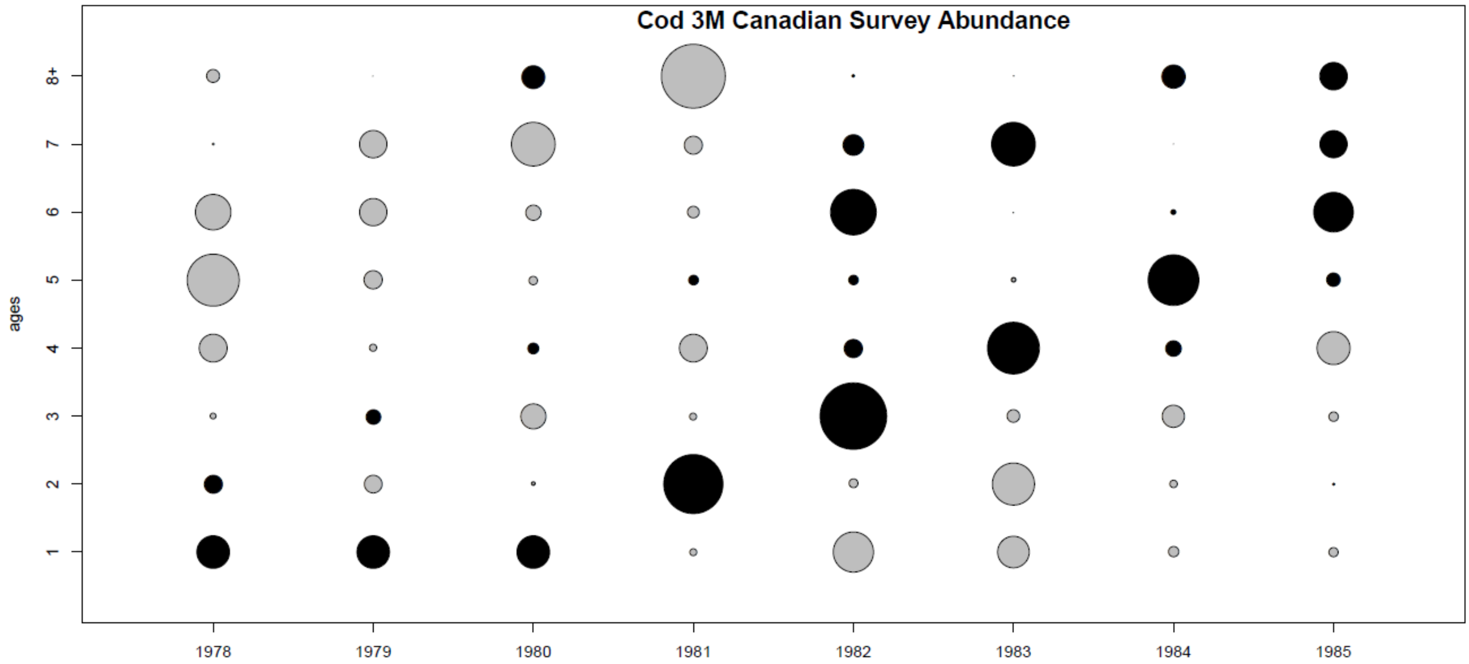


Figure 9.- Standardised log(1+Abundance at age) indices from Canadian survey. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

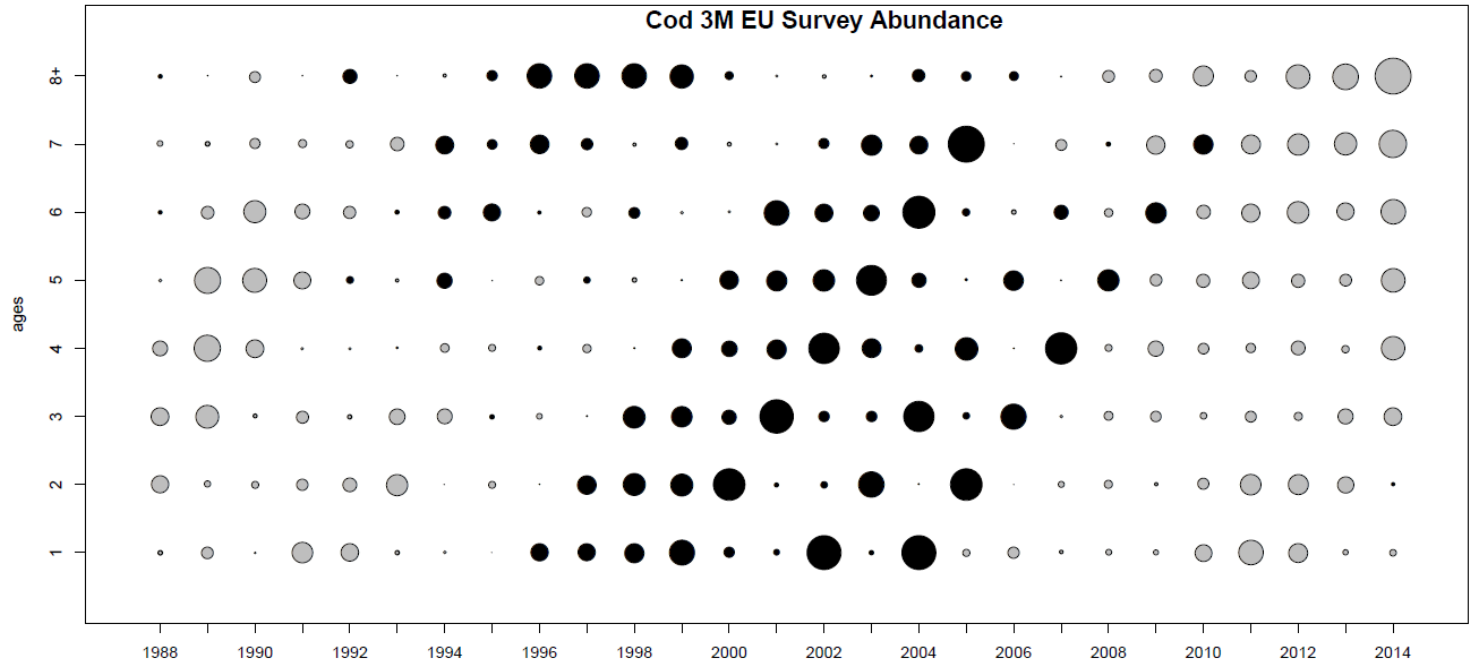


Figure 10.- Standardised log(1+Abundance at age) indices from EU survey. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value.

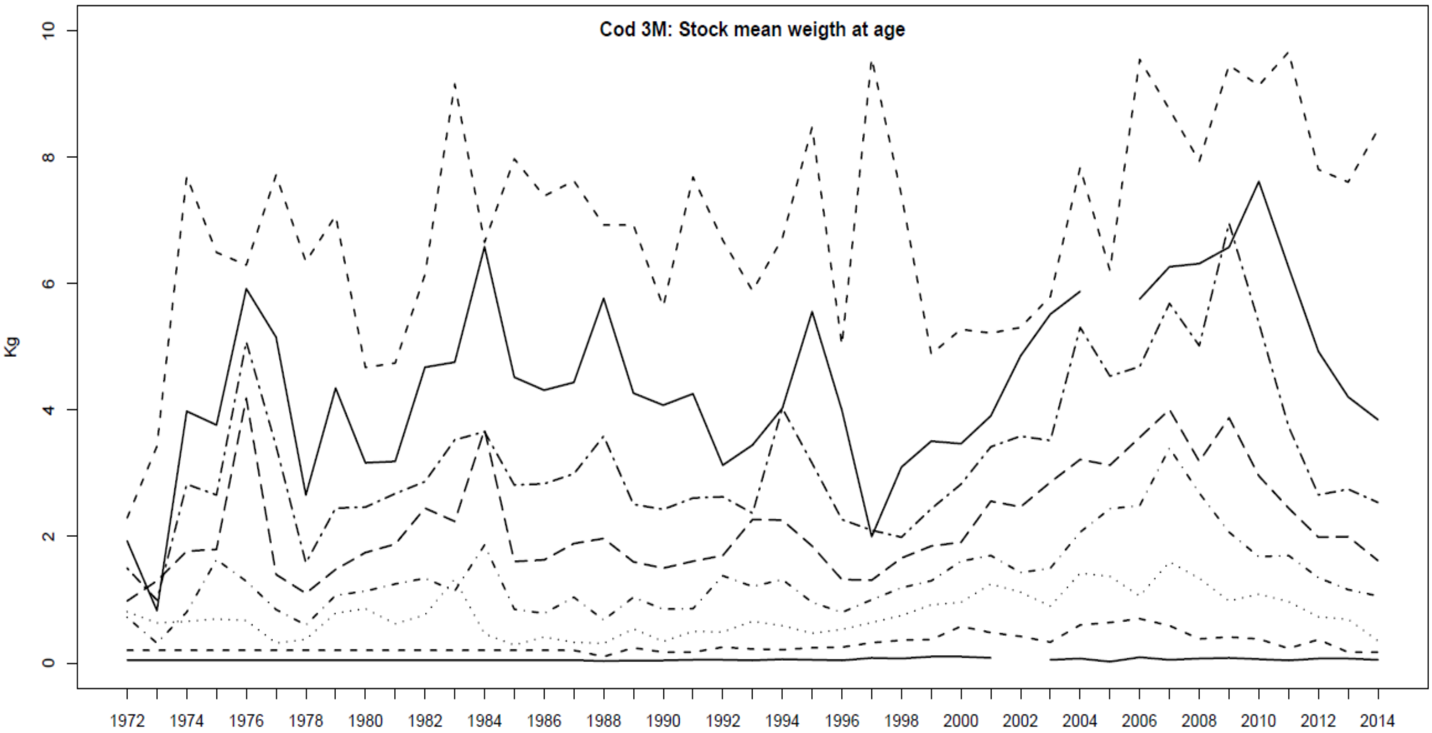


Figure 11.- Stock mean weight at age.

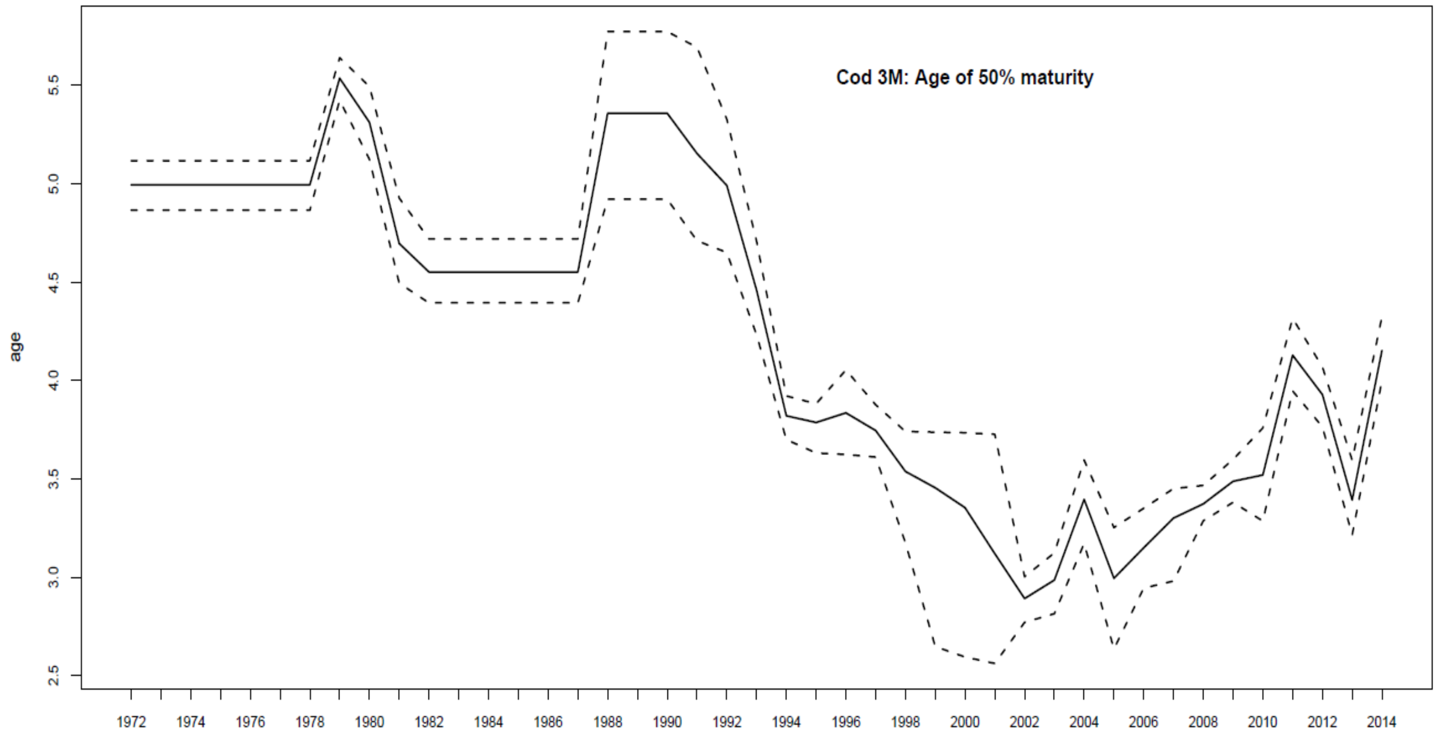


Figure 12.- Age at which 50% of fish are mature.

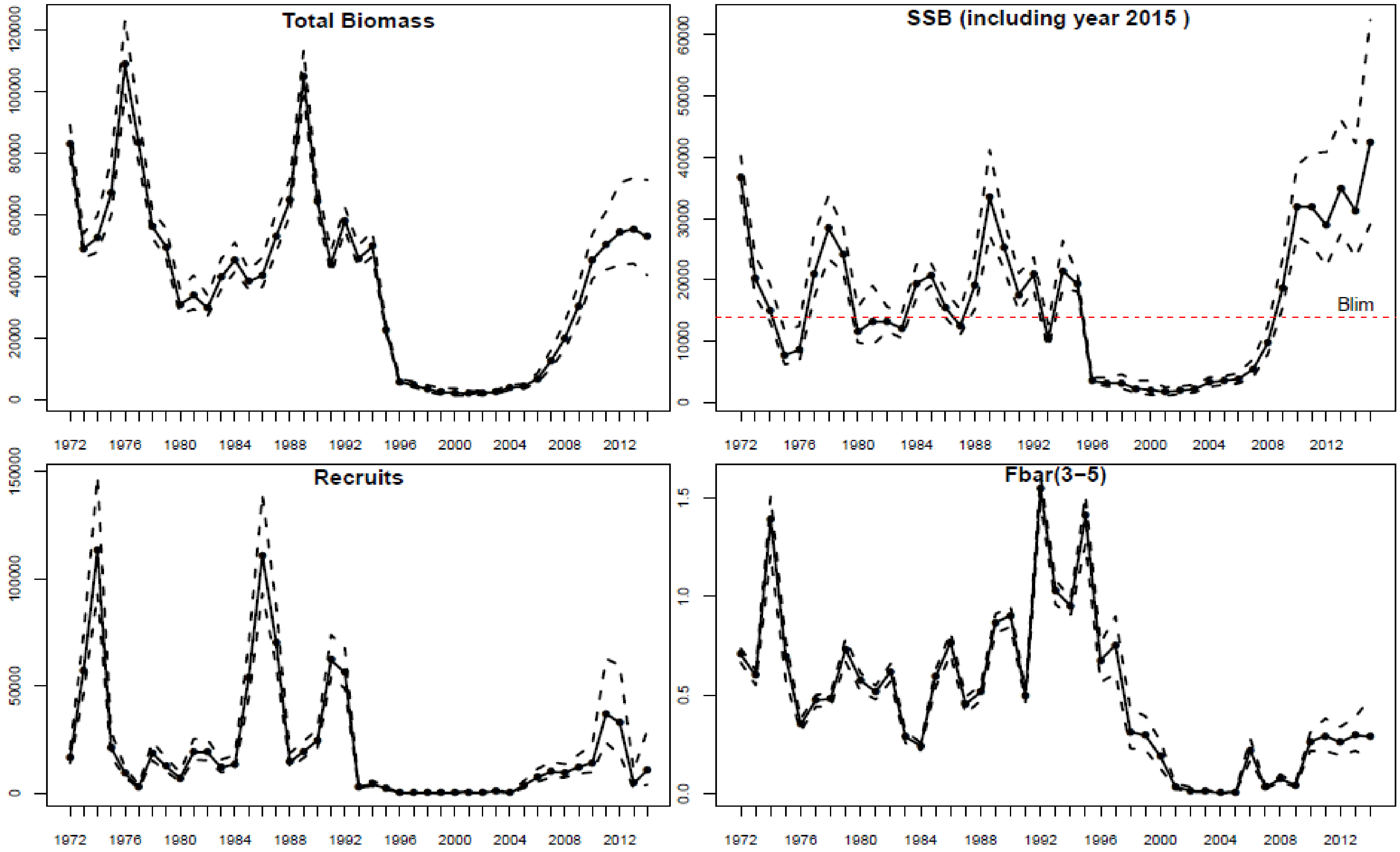


Figure 13.- Estimated trends in biomass, SSB, recruitment and F_{bar}. The solid lines are the posterior medians and the dashed lines show the limits of 90% posterior credible intervals. Red horizontal line in the SSB graph represents B_{lim} = 14 000 tons.

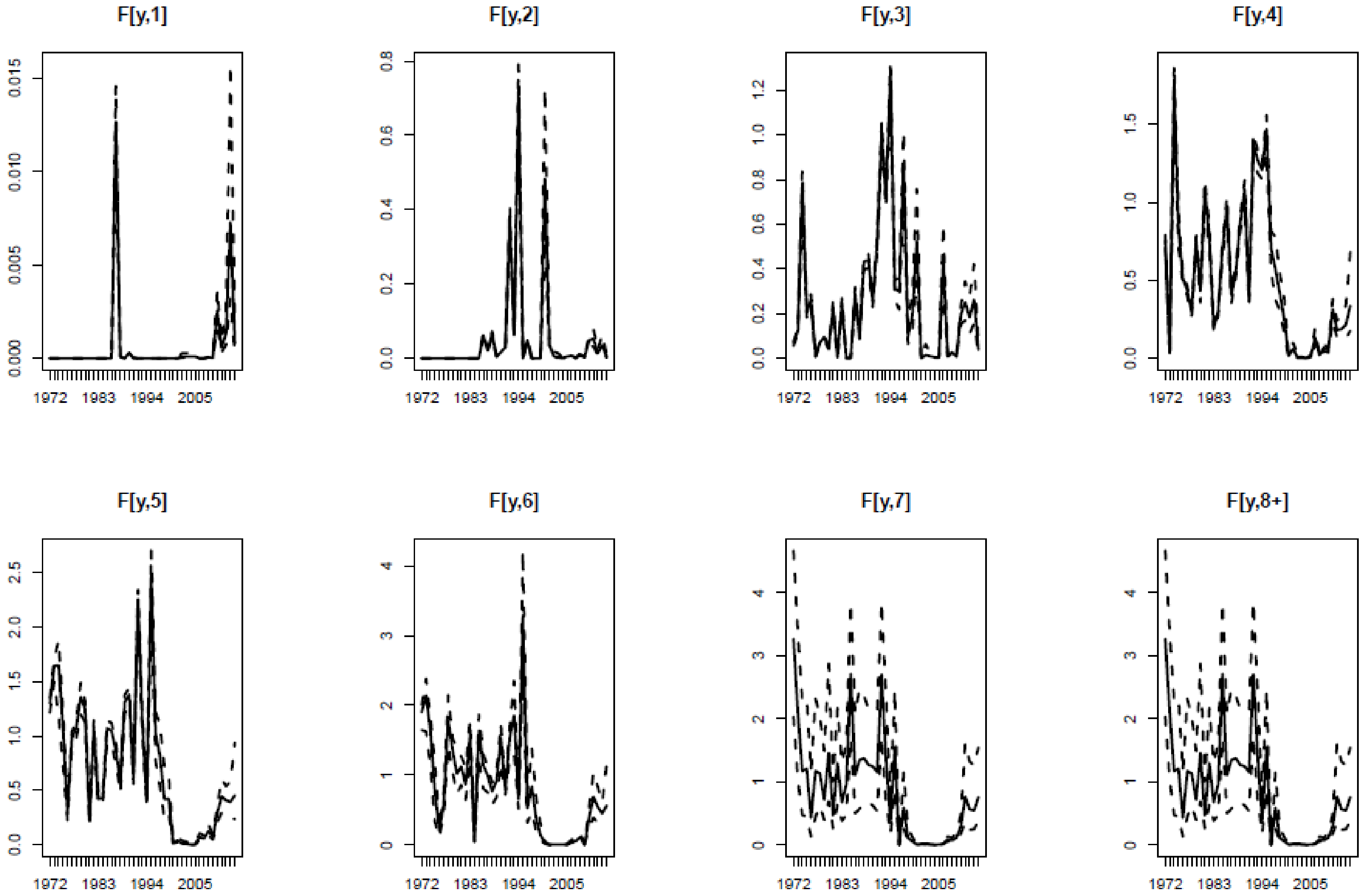


Figure 14.- Estimated fishing mortality at age. The y-axis scale is different in all the graphs.

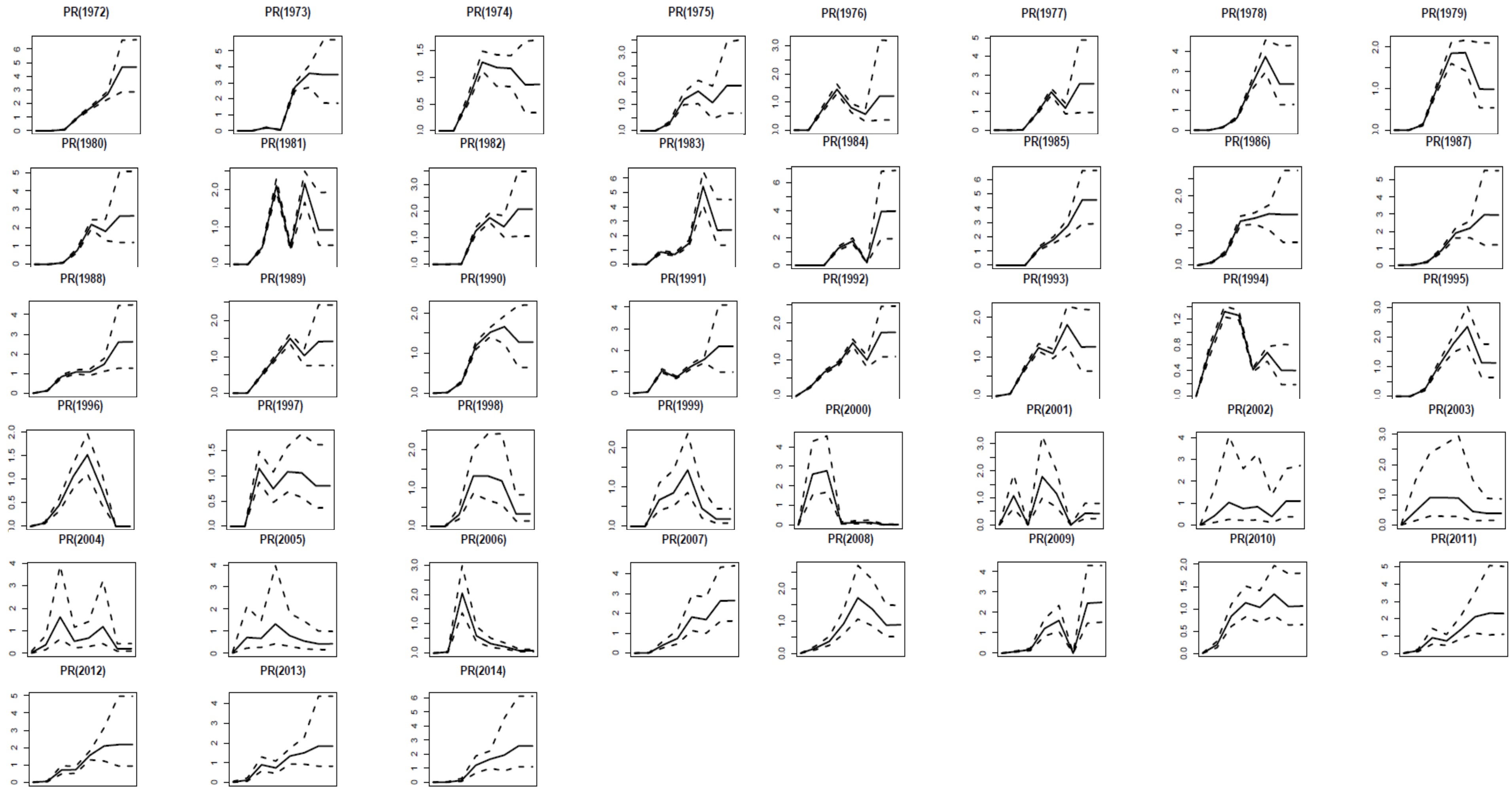


Figure 15.- Estimated PR (F/F_{bar}) per age and year.

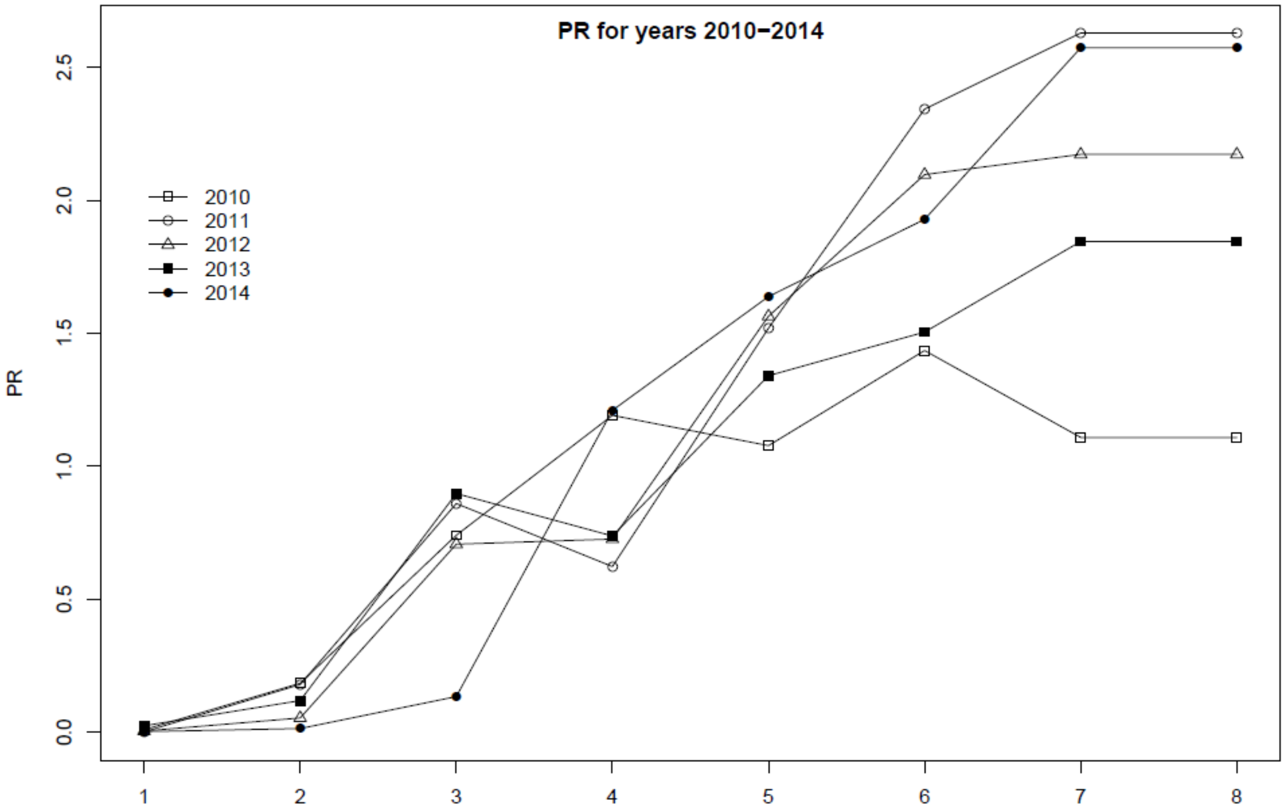


Figure 16.- Estimated PR (F/F_{bar}) per age for the last five years.

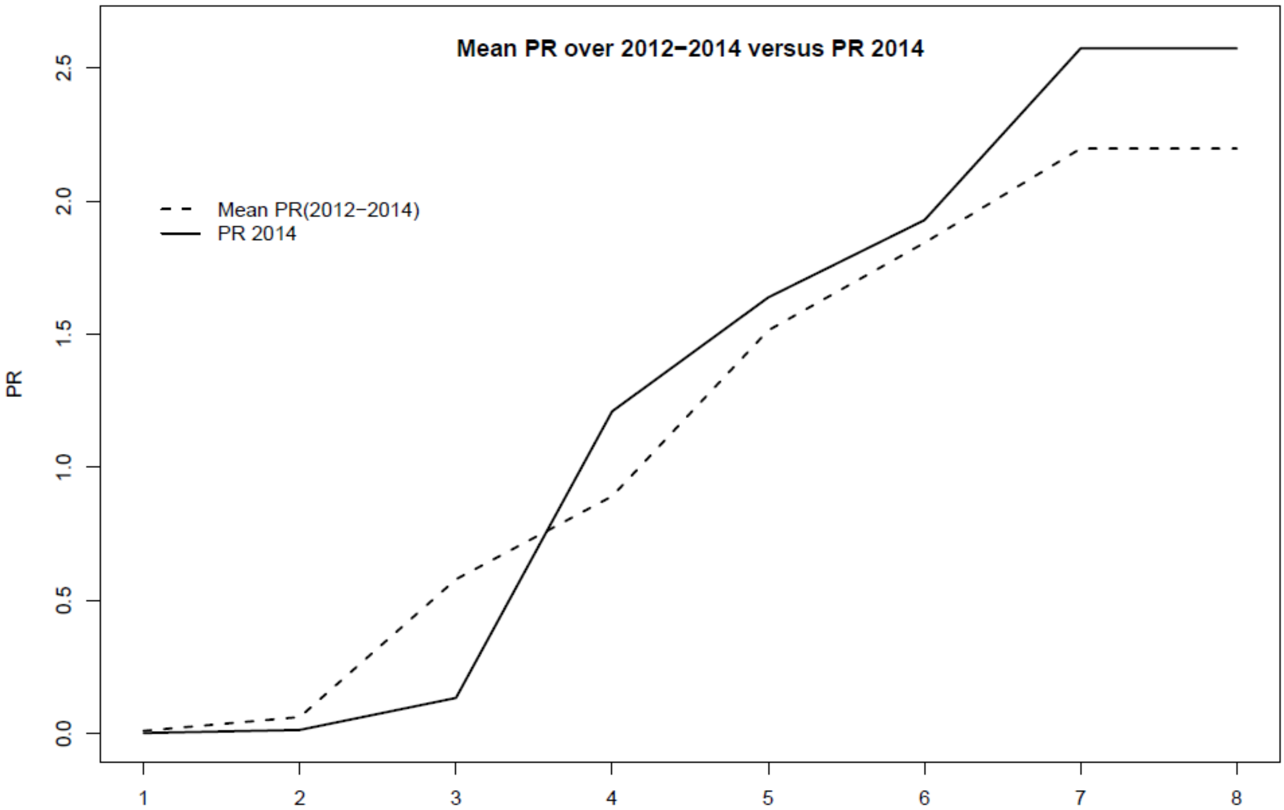


Figure 17.- Mean of 2012-2014 PR versus 2014 PR (posterior medians). Bold line is the mean of the last three years PR.

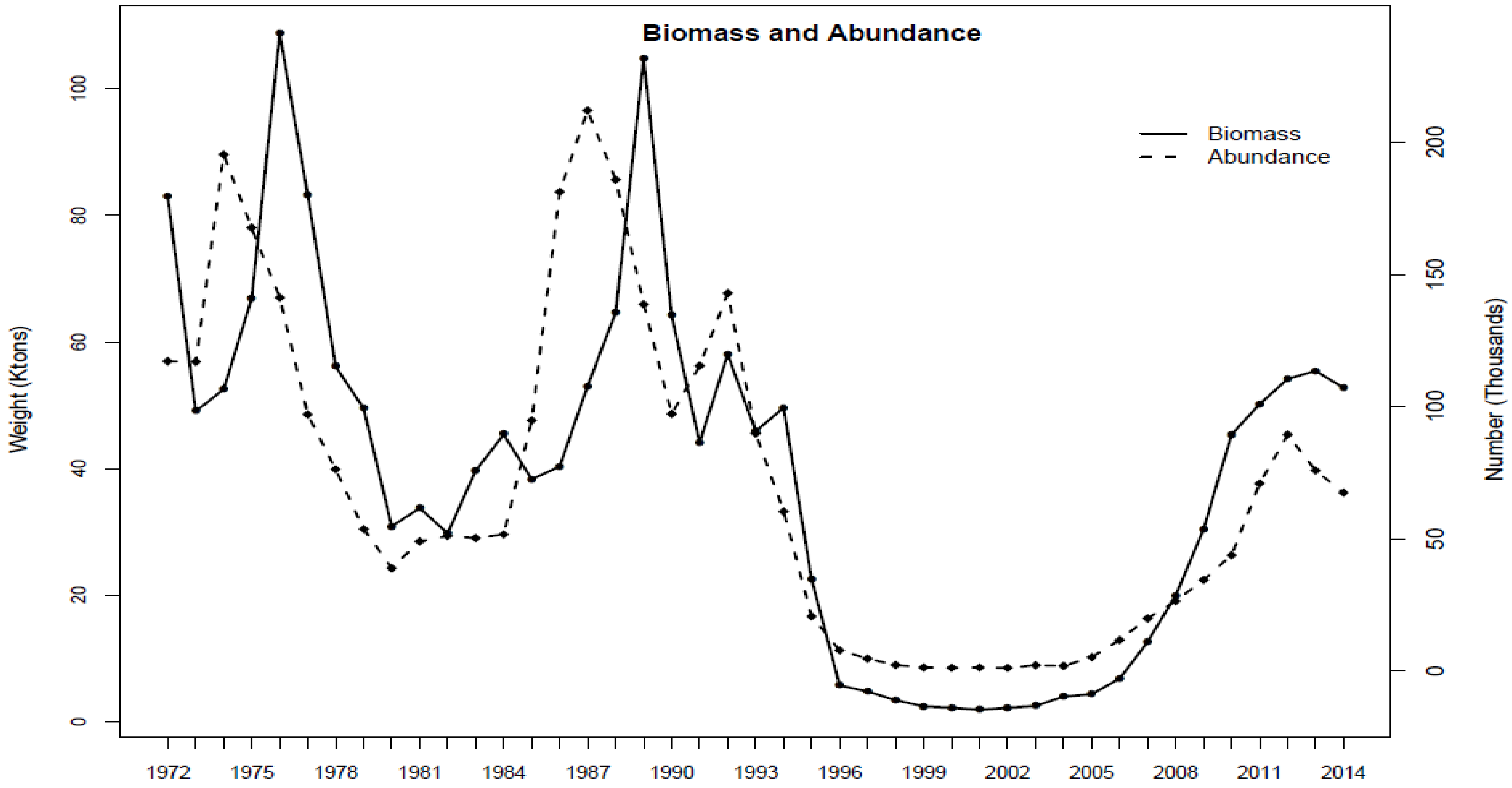


Figure 18.- Estimated trends in biomass and abundance.

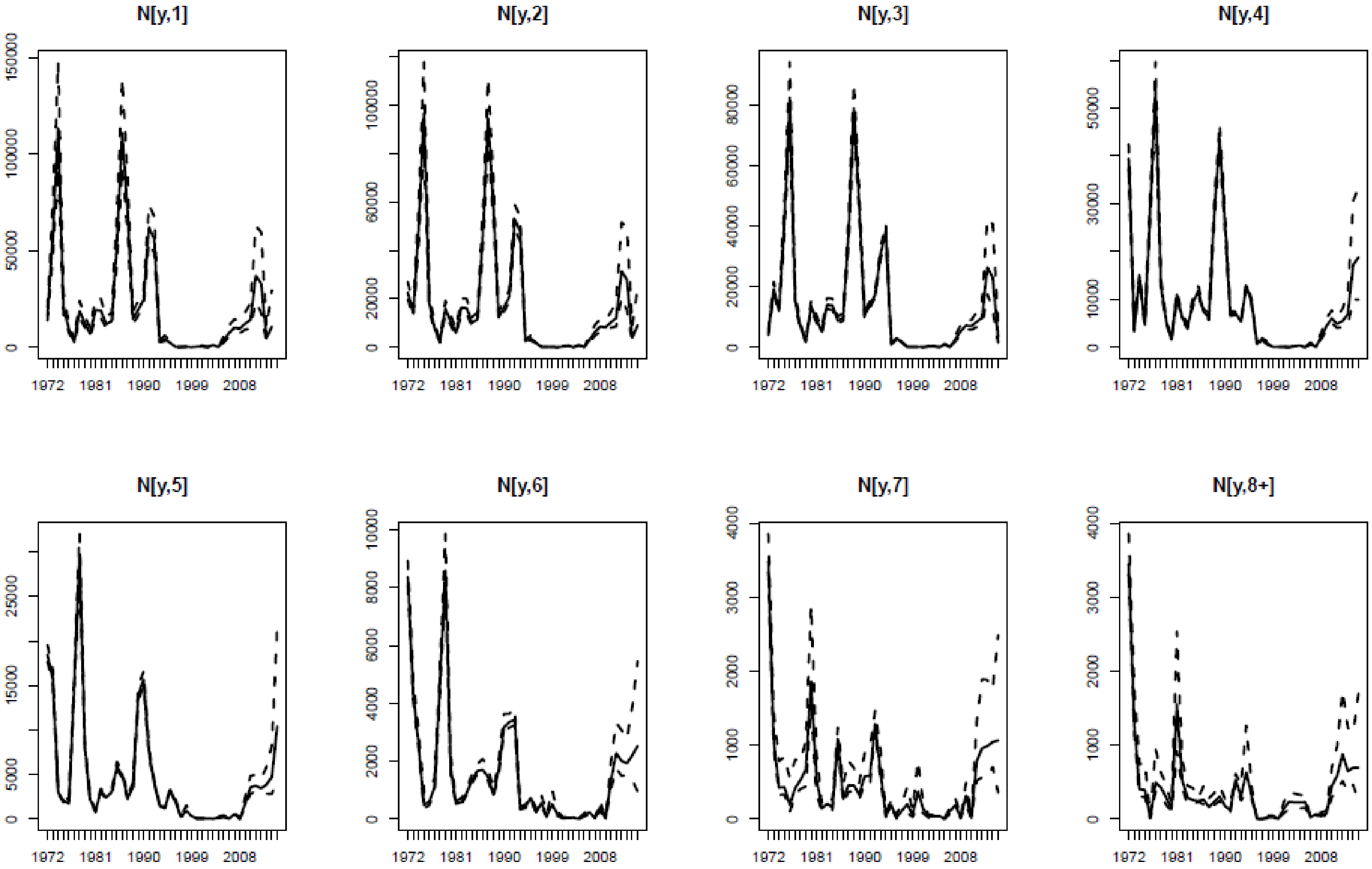


Figure 19.- Estimated numbers at age. The y-axis scale is different in all the graphs.

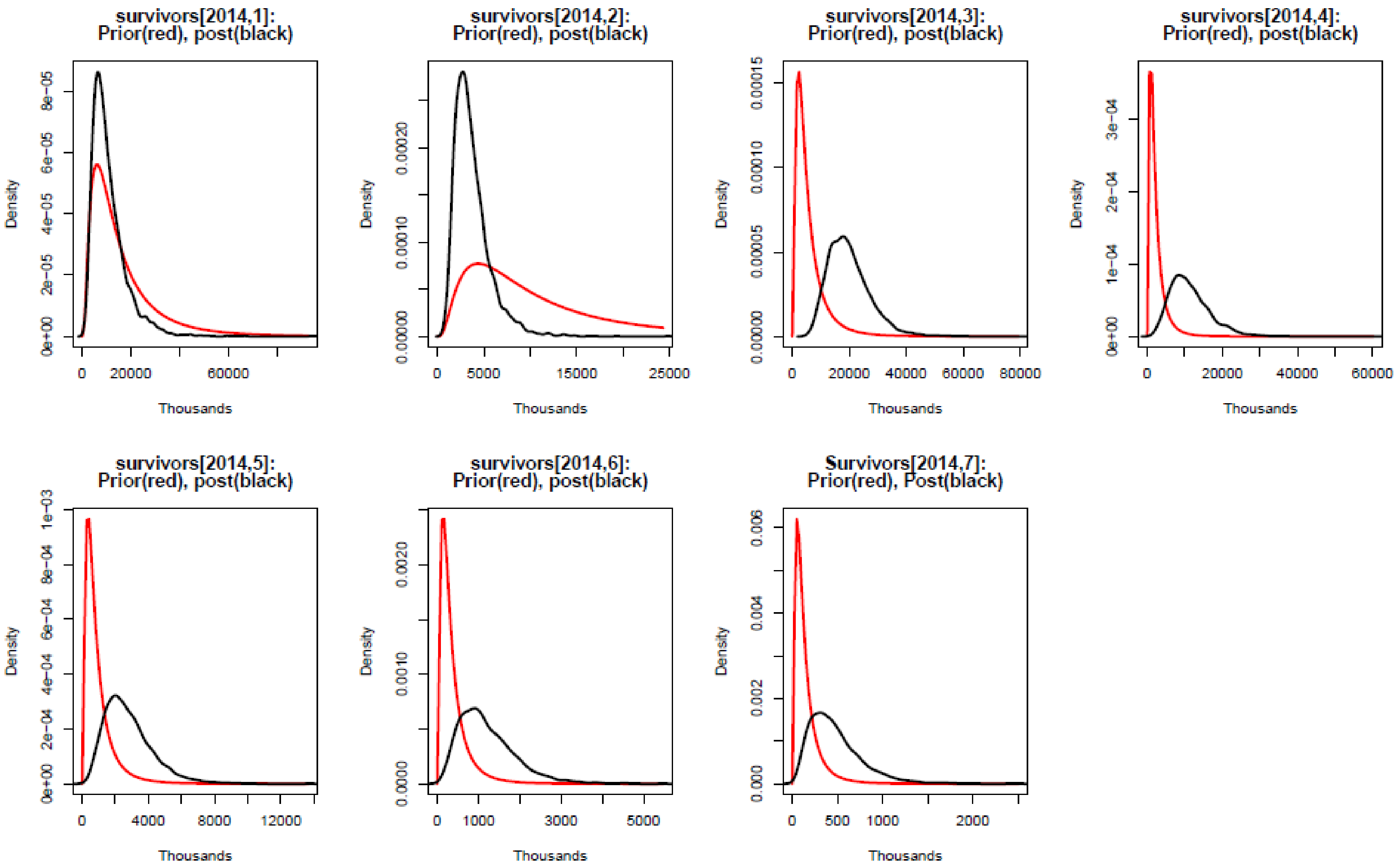


Figure 20.- Survivors at age at the end of 2014 (*survivors* (2014,a) are the number of individuals of age a+1 at the beginning of 2015). The y-axis scale is different in all the graphs.

Figure 21.- Survivors from age 7 in each year (*survivors* (y,7) are the individuals of age 8 at the beginning of year y+1). The y-axis scale is different in all the graphs.

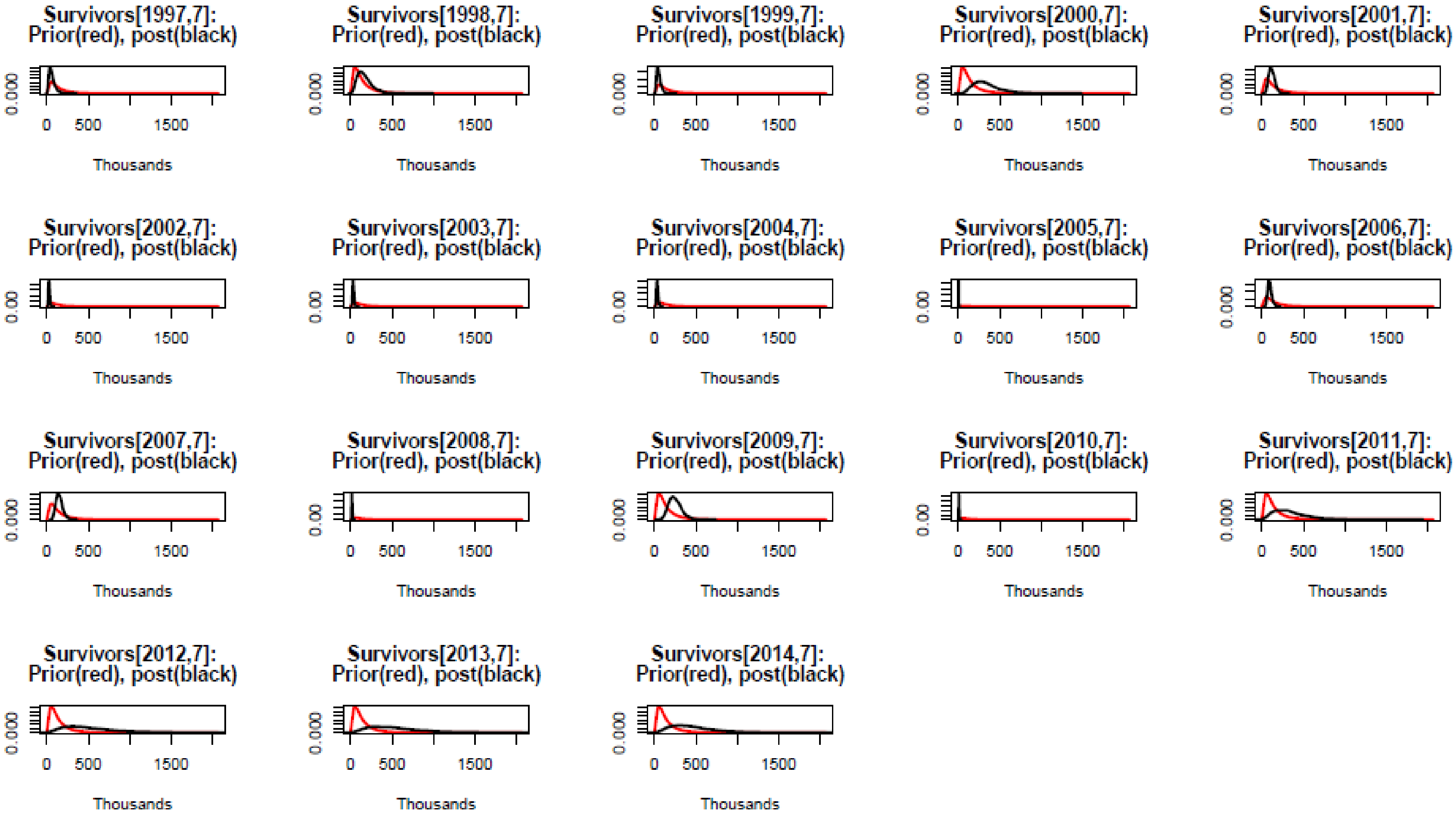


Figure 21 (cont.).- Survivors from age 7 in each year (*survivors* (y,7) are the individuals of age 8 at the beginning of year y+1). The y-axis scale is different in all the graphs.

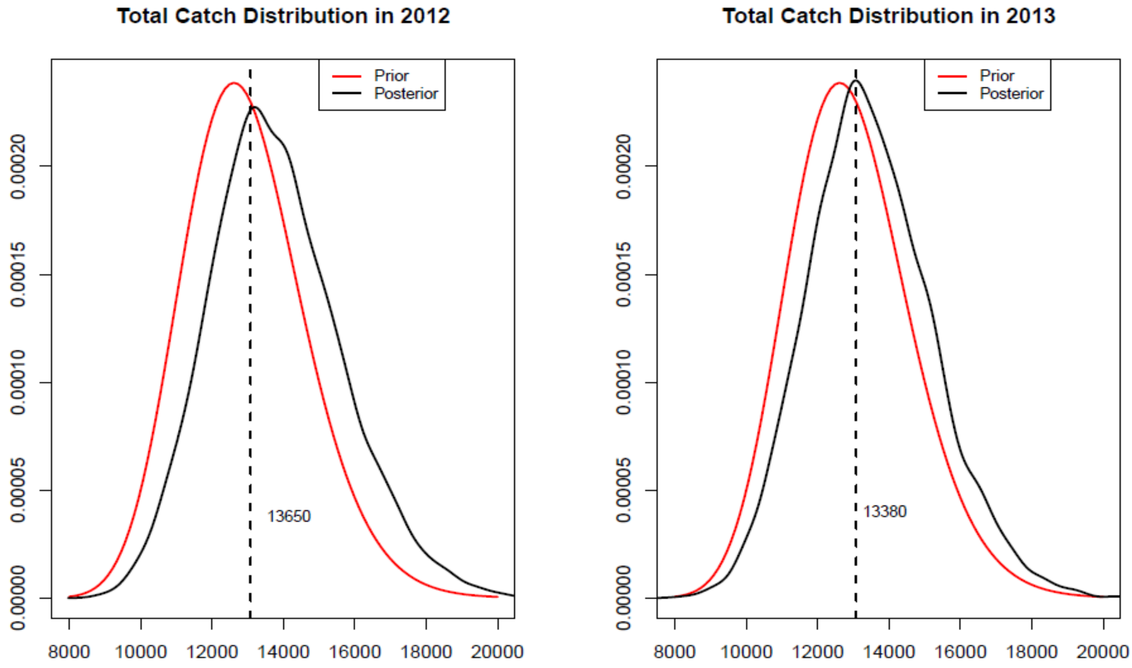


Figure 22.- Estimated total catch in 2011 and 2012.

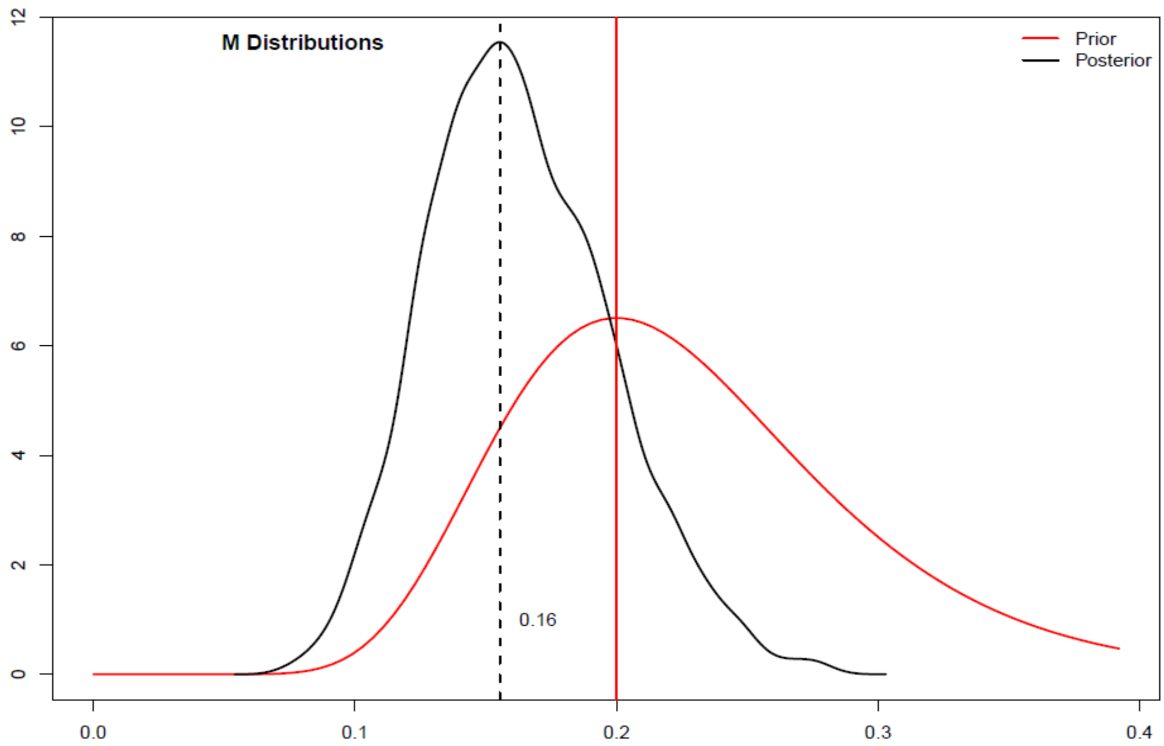
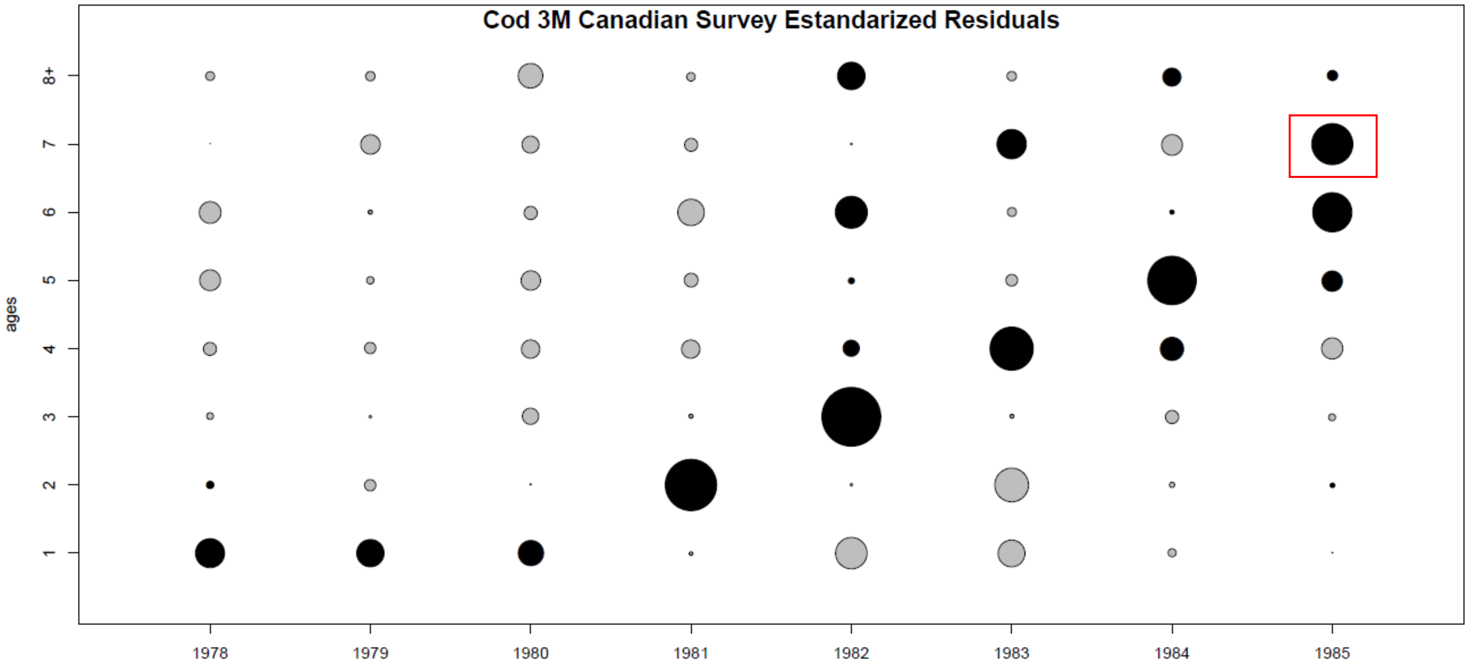


Figure 23.- Estimated natural mortality in 2014.



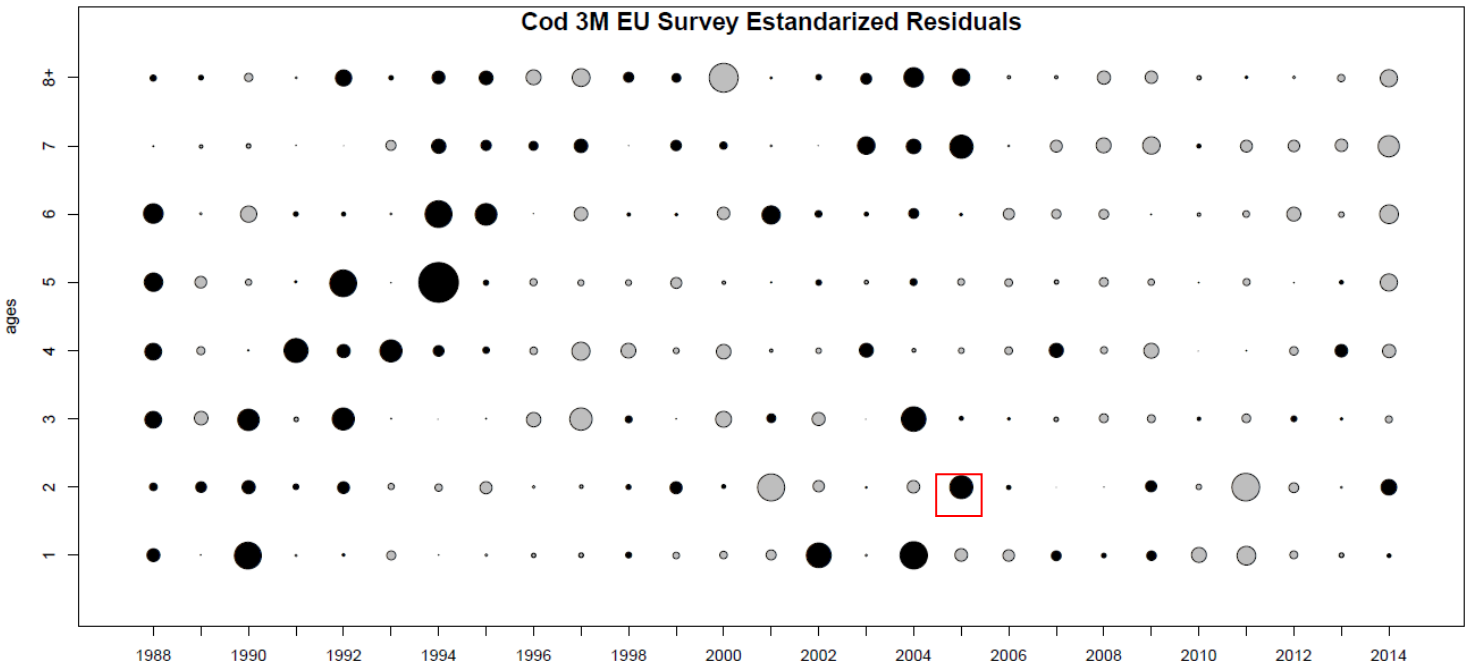


Figure 24.- Standardised residuals (observed minus fitted value) in logarithmic scale of survey abundance indices at age: Canadian and EU surveys. Grey and black values indicate values above and below the average. The larger the bubble size the larger the magnitude of the value. The red square indicates a bubble with a value near 2 (in absolute values).

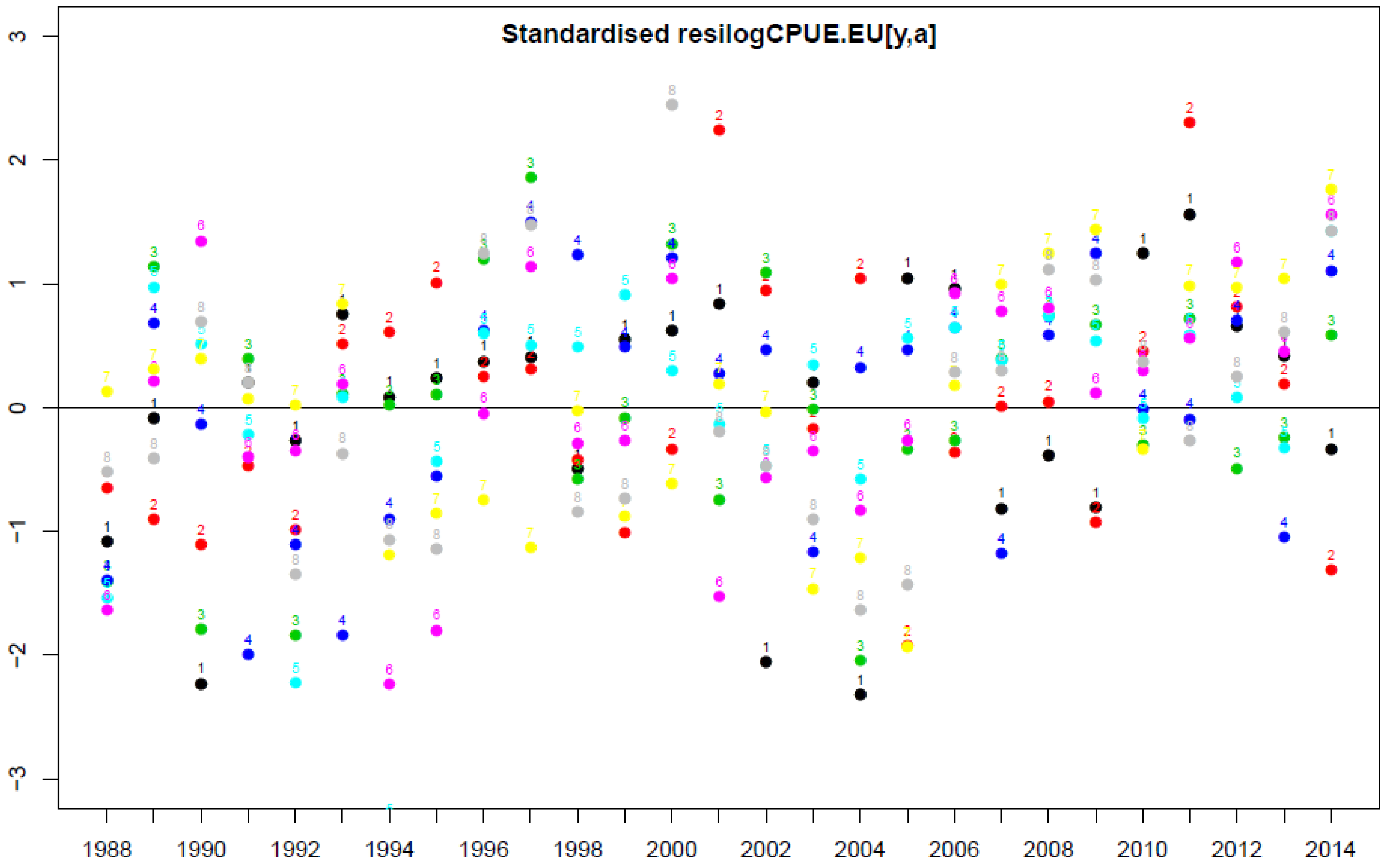
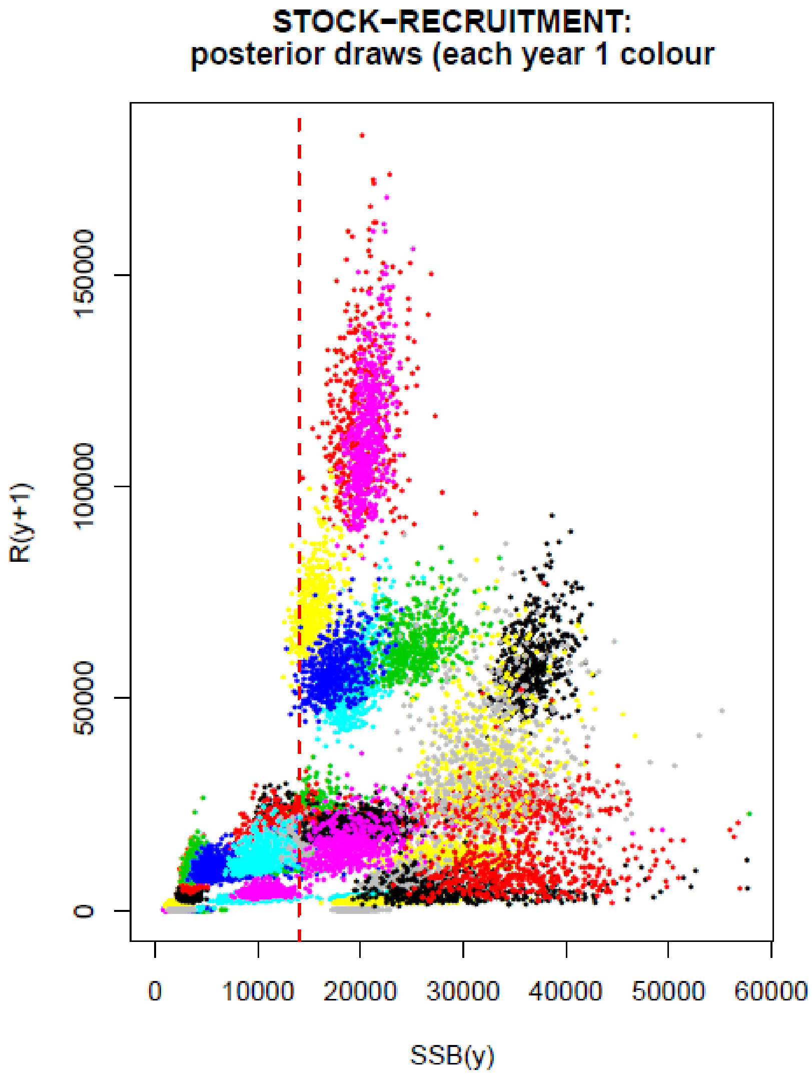


Figure 25.- Standardised residuals (observed minus fitted value) in logarithmic scale of survey abundance indices at age for EU survey by age.



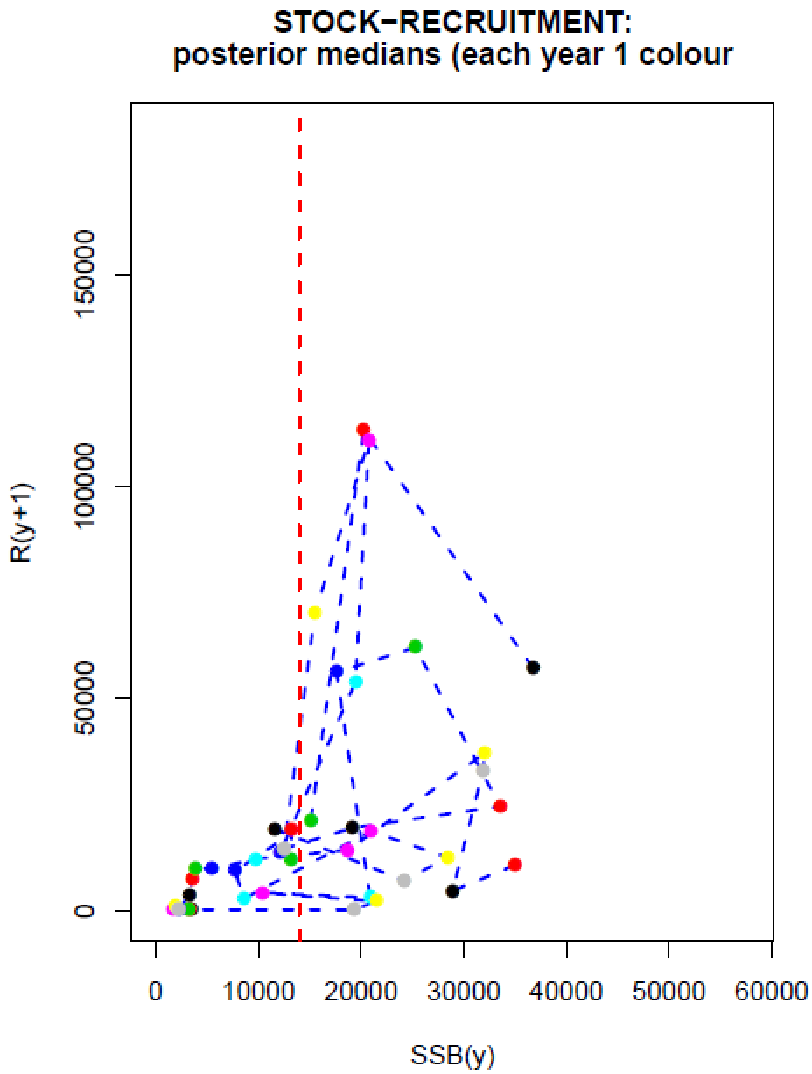


Figure 26.- Stock-Recruitment plots. B_{lim}=14000 is shown as the red vertical line.

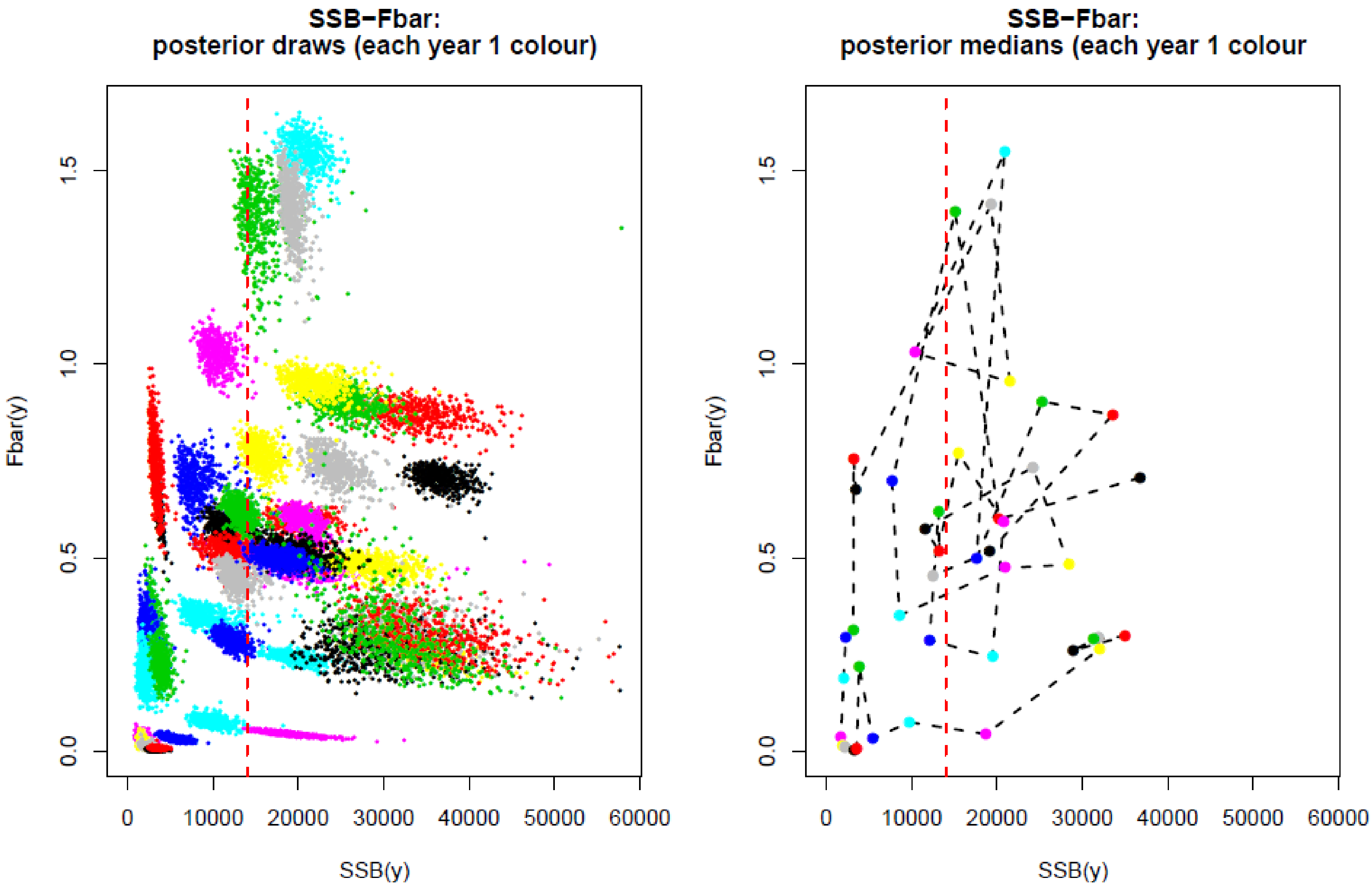


Figure 27.- F_{bar} versus SSB plots. B_{lim}=14000 is shown as the red vertical line.

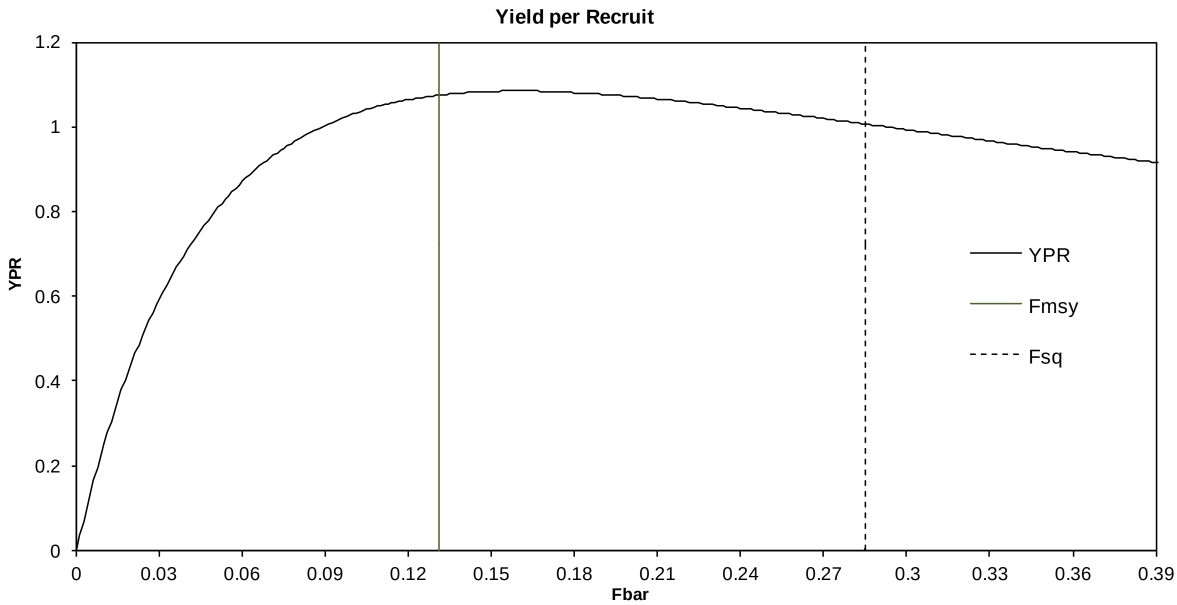


Figure 28.- Bayesian Yield per Recruit (1972-2014) versus F_{bar}. The values of F_{lim} ($F_{30\%SPR}$) and $F_{statusquo}$ (mean F over 2012-2014) are indicated.

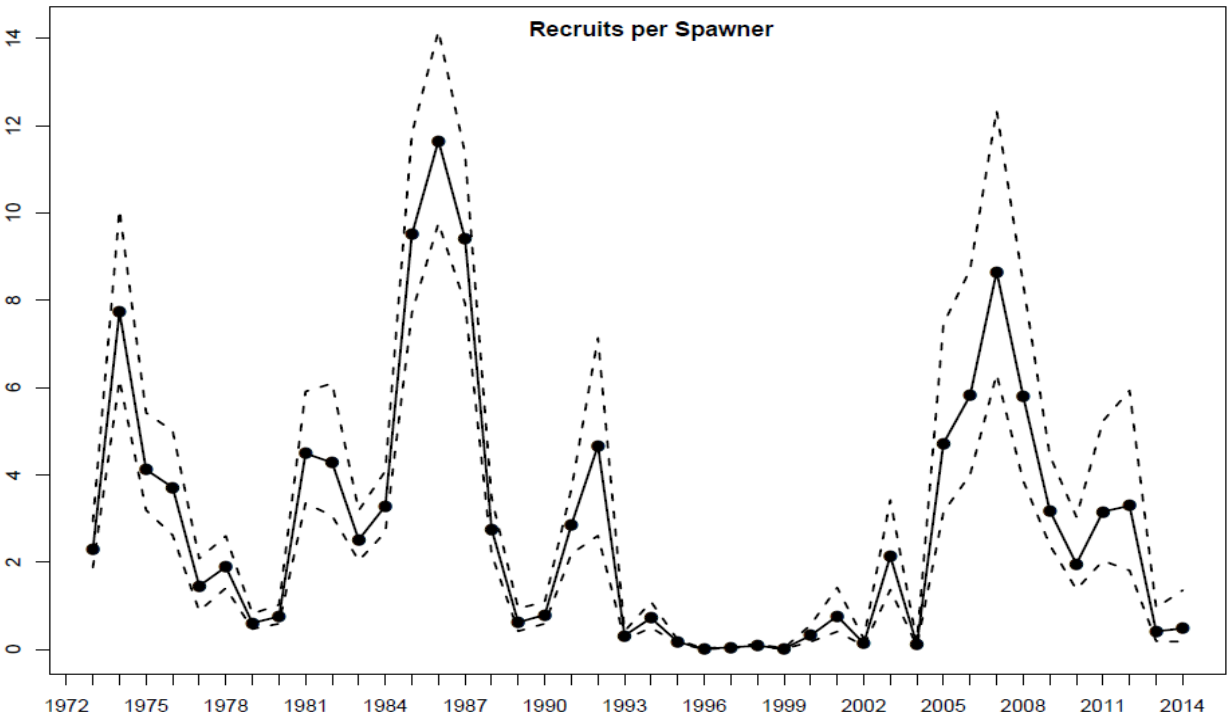


Figure 29.- Estimated recruits (age 1) per spawner.

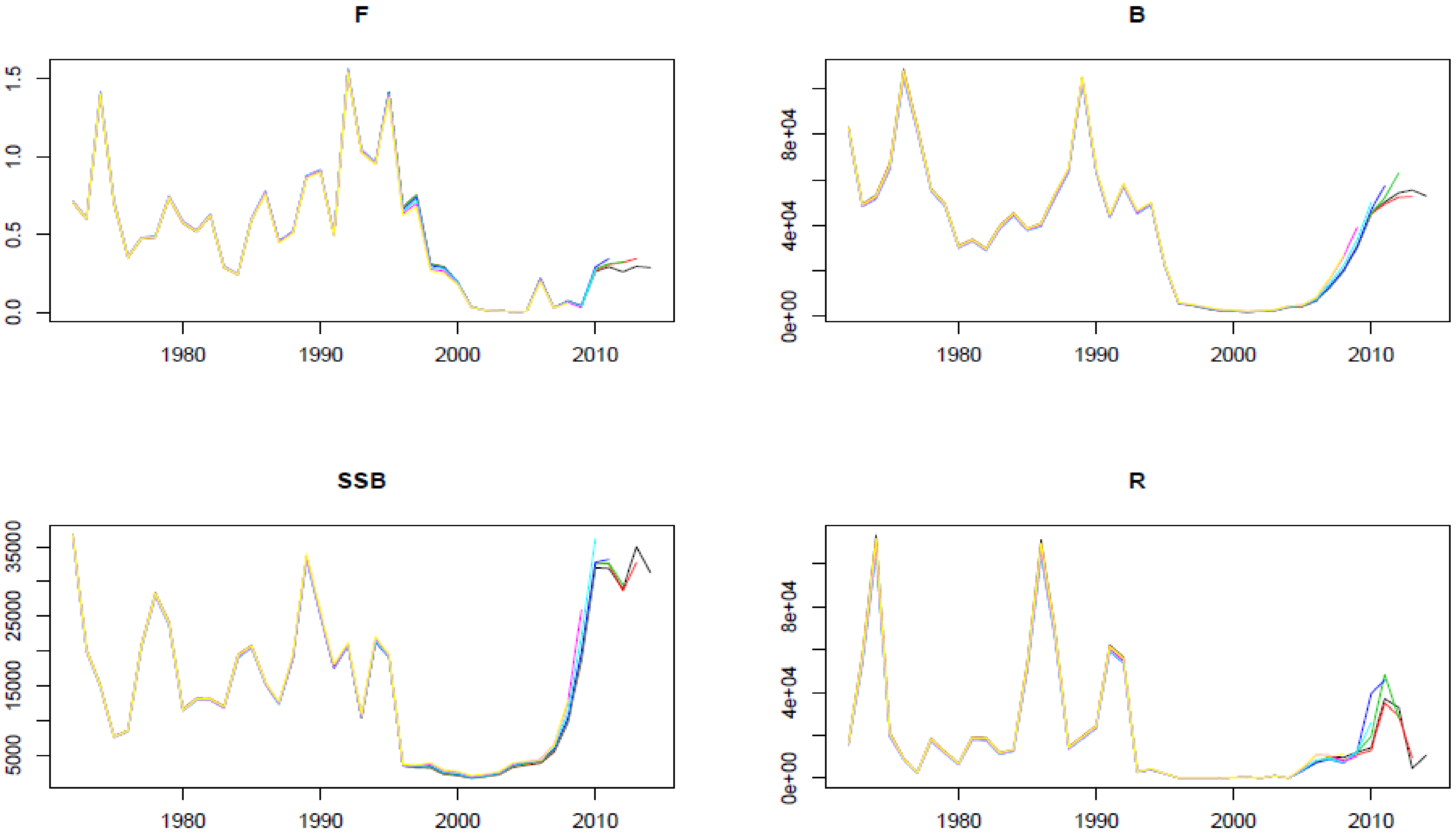


Figure 30.- Retrospective patterns.

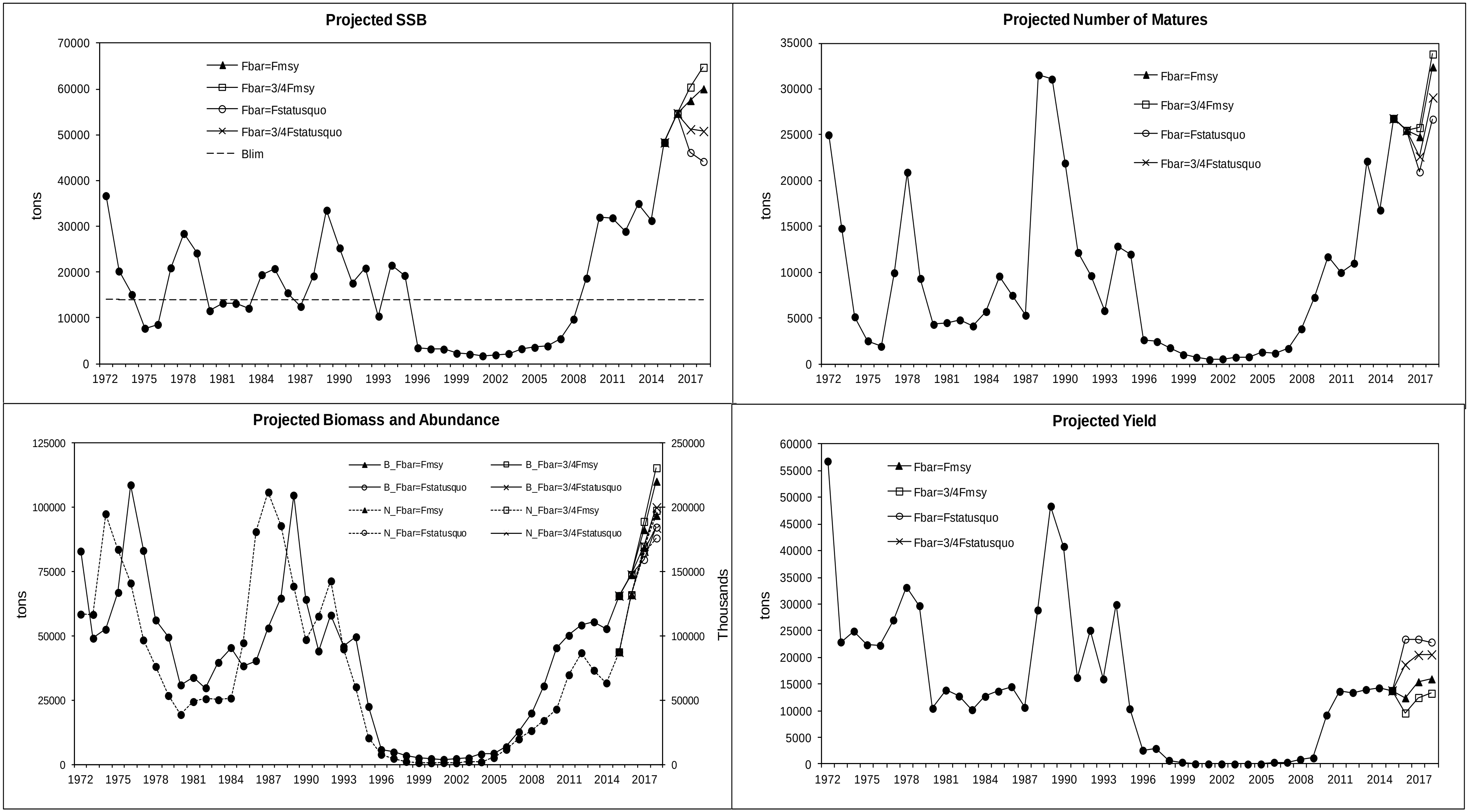


Figure 31.- Projections for SSB, number of matures, total Biomass and Yield with different scenarios.