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Executive summary

Inter-Benchmark Workshop on NEW species (IBPNEW) met in Copenhagen (Denmark) from 1–5 October 2012 to perform a benchmark assessment on the stocks of turbot and sea bass. All the terms of reference were addressed. In hindsight, the five days that were available for this workshop were too short. Although most work regarding the ToRs was finished before the end of the workshop, large parts of the report still needed to be finished at the end of the meeting, and this caused considerable delay in the delivery of the final report.

For turbot in the North Sea ecoregion, the group recommends that turbot from the Skagerrak/Kattegat is not included in the Greater North Sea stock, but treated separately or combined with the Baltic stock. This recommendation is based on considerations of the life-history characteristics of turbot (low larval dispersal, strong spawning site fidelity, limited migrations of the species) and the observed genetic patterns. The western limit of the North Sea stock would remain between IVc and VIId. Further progress on the assessment of turbot in IIIa could be made in WGNEW or WGBFAS.

Landings, effort and survey index data for Turbot in Area IV were collated. These data were made available by earlier working groups and projects, such as ICES WGNEW and the NESPMAN project. Two different stock assessments were performed on the data: ASAP (NOAA toolbox) and a spline-based statistical catch-at age model. The spline-based statistical catch-at-age model was proposed as a model to be used in future WGNSSK groups. The model is run on the landings-at-age data available since 1975 combined with the BTS-ISIS and SNS survey indices and the Dutch beam trawl fleet cpue as tuning indices.

Given the assessment model results, the F_{MAX} reference point on the yield-per-recruit curve was estimated and was well-defined. The assessment results indicate that the fishing mortality in the most recent years has been higher than F_{MAX}. No short-term forecast methodology was proposed, and when used for management advice, WGNSSK should decide on a short-term forecast methodology.

For sea bass in the Northeast Atlantic, the group only had sufficient data to carry out an analytical assessment for populations in the North Sea (IVb&c) and in the Irish Sea, Channel and Celtic Sea (VIIa,d,e,f,g&h). The group concludes that sea bass in the Irish coastal waters of ICES Divisions VIIb,g&j and in VIa, and in the Bay of Biscay (VIIIa&b) and farther south (VIIIc & IXa), should be treated as functionally separate populations, but has insufficient data to develop analytical assessments for these areas. There is no clear basis from fishery data, tagging and genetics studies to subdivide the populations in the Irish Sea, Celtic Sea, Channel and North Sea, although the group acknowledges the existence of fine-scale spatial structuring of immature sea bass, and of adults during the non-spawning period, due to strong site fidelity. The statistical assessment model Stock Synthesis 3 was used to estimate trends in abundance and fishing mortality for sea bass in the combined area using trawl survey indices of abundance-at-age for young bass, fleet-disaggregated length and age compositions for the UK fisheries from 1985 onwards, and length compositions for French fleets. Limited data on UK and French discards were also available for recent years. Insufficient data were available on recreational catches for inclusion in the assessment, although estimates for France and the Netherlands in 2010 indicate that recreational fisheries could account for as much as 20% of the fishing mortality. A wide range of sensitivity runs of the Stock Synthesis model using different combinations of

datasets and model settings indicate a recruitment-driven increase in spawning–stock biomass from the early 1990s up to the mid-2000s, followed by a decline in SSB coincident with increasing fishing mortality during the 2000s. Recent year classes since 2008 appear very weak. A comparative ASAP run (NOAA toolbox) using UK age composition data applied to all other international landings showed similar stock trends to the Stock Synthesis model. Short-term projections were not carried out, although the scenario of increasing F, declining SSB and very poor recruitment since 2008 would lead to an expectation of further SSB decline. The group recommends continued use of Stock Synthesis for provision of trends-based advice by WGNEW and that procedures for carrying out trends-only projections should be developed at WGNEW 2013.

Finally, the group discussed whether trying to control fishing mortality for species such as sea bass and turbot through TACs is an effective strategy: if fishing continues while quota are exhausted, large incentives for overquota discarding are created. Fishing effort reductions on those fleets taking these species as bycatch are probably a more effective measure for reducing fishing mortality. For turbot in the North Sea, such fishing effort reductions are foreseen in the management plans for some of the target species, such as the long-term management plan for sole and plaice in the North Sea, and the management plan for cod. Meanwhile, the assessment results indicate that higher yields for turbot are possible if the gear and fishing patterns of the important fishing fleets taking this species are altered to selectively reduce the catches of small turbot.

1 Introduction

The Inter-Benchmark Protocol for turbot and sea bass (IBPNew) chaired by Jan Jaap Poos, the Netherlands, with invited external experts Arni Magnusson, Iceland, and Chris Legault, US, convened 1–5 October 2012 to (a) review the updates in data analysis and assessment methodology for turbot and sea bass, to (b) prioritize the issues and provide guidance to stock experts on methods with which to solve issues, to (c) describe the choice of preferred method for data analysis and assessment in a concise report, including recommendations on progress to be made in cases where work is not yet finalized. The resulting data analysis procedure and assessment methodology should be described in the stock annex and the management measures in force should be evaluated.

All the terms of reference were addressed, but most attention was on data collation and assessment methods.

The turbot chapter describes how turbot in the North Sea and the Skagerrak was split in two stocks, based on population genetic data. The data available for turbot in ICES Subarea IV was used in two stock assessment methods. A spline based statistical catch-at-age model is proposed to be used in WGNSSK for advice purposes. One of the main issues with the North Sea turbot data is that the landings-at-age data have not been collected consistently in the last few decades. As a result, the data comes from different sources (countries) and has several periods of missing data. The final model uses two periods with different selectivity-at-age estimates, split around the time when the minimum landings size regulations changed. From selectivity patterns given by the final assessment, yield-per-recruit F_{MAX} reference point was estimated. Fishing mortality is higher than F_{MAX}-which can be considered a proxy for F_{MSY}-in recent years. The proposed assessment run and the data suggest that fishing mortality for turbot has been higher than the F_{MSY} proxy. IBPNew suggests that the turbot stock in the North Sea will be evaluated using the proposed stock assessment by ICES WGNSSK in future. That working group could also address some of the outstanding issues that are highlighted in the chapter on turbot. Finally, during the discussions in the working group, one point was raised that was also raised by WGNEW earlier this year: Currently the advice is generally phrased in terms of “reducing catches”. Many of the WGNEW stocks are bycatches in directed or mixed fisheries on other species and this is also true for turbot. By translating ”reducing catches” into setting or reducing TACs in the European fisheries context, the risk is that incentives are created for discarding these species without actually reducing catches. In that context, the effort reductions in management plans for target species in which these species are bycatches should be taken into account. For turbot, which is largely an (economically important) bycatch in bottom-trawl fisheries, the reduction in the bottom-trawl fleets foreseen in the long-term management plan for sole and plaice will likely result in a reduction in fishing mortality.

The sea bass chapter evaluates the stock structure of sea bass in ICES Subareas IV, VI, VII, VIII and IX based on fishery data, genetics studies and results of tagging using conventional and electronic tags. Only the sea bass populations in the Irish Sea, North Sea, Channel and Celtic Sea off SW England were shown by WGNEW (ICES 2012) to have sufficient data to conduct an analytical assessment, and IBPNew treated these as a single population in view of evidence of mixing between areas. The sea bass chapter evaluates the fishery, survey and biological data for this combined area, and describes a process of model building using the Stock Synthesis framework

(Methot, 1990) to evaluate trends in biomass, recruitment and fishing mortality, including a wide range of comparative model runs to examine sensitivity to input data and model structure. It is anticipated that WGNEW 2013 should adopt the baseline Stock Synthesis approach as a basis for providing advice for this stock complex, and develop approaches for forecasting. Available information on sea bass in other areas is provided, including time-series of recreational angling catch rates off southern Ireland, provided by stakeholders attending IBPNew. Sea bass are a very popular target for recreational fishing, and some recent estimates of recreational catches by France and the Netherlands are evaluated although they are currently insufficient for inclusion in any assessment models.

Finally, Stock Annexes for turbot and sea bass were drafted, collating the available information and, where applicable, describing the stock assessment and advice procedure. These stock annexes will have to become part of the regional assessment working group reports.

The invited external experts for the IBPNew meeting were Arni Magnusson (Iceland) and Chris Legault (USA). As per the new ICES benchmark procedures, which were also applied to this inter-benchmark protocol, the experts were not reviewers in the sense of being provided documents and analyses in advance of the meeting, but rather were integrated into the development of the benchmark assessments. Thus, the external experts cannot provide a review of the work which they helped to conduct. The lack of knowledge of specific issues related to each stock made participation by the external experts difficult during the first half of the meeting when data were being compiled. The external experts suggest a separate data meeting could be held with participation by the data experts to develop the basic data for the assessments, followed immediately by the assessment meeting with the external experts. For example, stock structure continues to be an issue for both species, as described in the report. A fair amount of information was presented at the meeting regarding stock structure and the decision of how to split the species into stocks seemed reasonable and pragmatic. Work continues on this issue, especially using genetic approaches, and this topic should be revisited when new information becomes available. However, the external experts did not feel we could contribute meaningfully to the data discussions and would have valued this time to conduct additional analyses during the week.

2 Turbot

2.1 Stock ID and substock structure

So far, fisheries advice on North Sea turbot has always been issued for the combined areas of the North Sea (Subarea IV) and the Skagerrak/Kattegat (Division IIIa). This stock delineation was originally decided upon by managers, and was not supported by biological evidence at the time of defining.

In the working document "Stock structure and status of turbot in IIIa" (supplied to IBPNew 2012), Cardinale *et al*. (2012) summarize the current biological knowledge of turbot that could help delineating biologically meaningful turbot stocks within the North Sea ecoregion. Turbot shows life-history characteristics that make differentiation between biological units likely: low larval dispersal, a strong spawning site fidelity and limited adult migration (thus high residency) (Molander, 1964; Curry-Lindahl, 1985; Aneer and Westin, 1990; Støtterup *et al*., 2002; Voigt, 2002; Iglesias *et al*., 2003; Cardinale *et al*., 2009; Florin and Franzén, 2010). Furthermore, evidence on differences in stock dynamics between the Skagerrak/Kattegat (Cardinale *et al.*, 2009) and the North Sea (ICES 2012) are apparent. Inclusion of the Skagerrak/Kattegat in the "Greater North Sea stock" may lead to the overestimation of the Skagerrak/Kattegat harvest potential and to the consequent depletion of the IIIa stock (component). An analysis of historical survey data indeed shows that the biomass of turbot in IIIa has declined about 86% since 1925, with a decrease in maximum individual body size by around 20 cm compared to the beginning of the time-series (Cardinale *et al*., 2009), while stable abundances (or even an increase in the Tridens Q3 BTS) have been observed in North Sea surveys in recent years (ICES 2012).

Previous genetic studies within restricted geographical areas had already illustrated the presence of distinct turbot populations in the Baltic and Irish Seas using neutral markers (e.g. Delbare and Declerck, 1999; Nielsen, 2004). Over the period 2009–2012, a genetic study of turbot population structure all over the species' distribution area has been conducted using both neutral and gene-associated genetic markers by Vandamme *et al.* (in prep). The neutral marker panel confirmed the break-up between the Baltic and Northeast Atlantic clusters (preliminary results in Figure 2.1.1). Within the latter, a more detailed pattern of genetic differentiation could be observed when gene-associated markers were also included in the analysis; results soon to be consulted on https://fishreg.jrc.ec.europa.eu/web/**fisheries-genetics**). This full analysis suggests a break between the southern and central parts of the North Sea, making turbot from the southern North Sea genetically more similar to those from the Western Waters. However, because it is unknown whether there are also differences in life history within the North Sea, and information on the number and location of spawning aggregations is missing, the break between IVc and VIId is insufficiently supported to be recommended for management purposes. Additionally, it is logistically difficult to split the North Sea into several management and assessment units. The proposed stock structure is represented in Figure 2.1.2. No recommendations are made by IBP New 2012 with reference to the stock structure further west of the North Sea, but Figure 2.1.1 suggests-based on genetics-that the waters around the northern part of Ireland (VIIa + VIIb + VIa) form a separate stock from the rest of the Celtic Seas, Bay of Biscay and Iberian Waters. The western limit of the two 'Western stocks' was set at the borders of the ICES-Divisions, but will be more to the east in reality, given the preference of the species for shallower waters (e.g. the distribution is largely restricted to VIIIabc in the Bay of Biscay).

To conclude, considering the life-history characteristics of turbot (low larval dispersal, strong spawning site fidelity, limited migration of the species) and the observed genetic patterns, it is recommended that turbot from the Skagerrak/Kattegat is not included in the Greater North Sea stock, but treated separately or combined with the Baltic stock. In this scenario, the western limit of the North Sea stock would remain between IVc and VIId. Further progress on the assessment of turbot in IIIa could be made in WGNEW or WGBFAS.

2.2 Issue list

At the start of the benchmark assessment, there was no clearly defined issue list. However, from earlier WGNEW meetings in 2010 and 2012, and from the NESPMAN EU project it was clear that there was data available from different sources that should be brought together. For example, the landings-at-age information was available from different sources in different historic periods. Those sources ranged from ICES CM manuscripts (Weber, 1979) to extracts from databases at national labs (e.g. in Boon and Delbare, 2000). In addition, survey information is available from surveys that sample commercially important flatfish species sole and plaice. The survey information yields important age-structured information about the abundance of especially the young fish. All this information should be brought together and interpreted consistently.

2.3 Scorecard on data quality

The scorecard on data quality was not used explicitly because of time constraints. The main data quality issues perceived by the benchmark group are:

The landings-at-age data are available from different sources in different time periods. This means that the sampling of the landings-at-age is representative for different countries who may have different fisheries on turbot. For example, in the most recent period, landings-at-age data are only available from the Netherlands. In the Netherlands, turbot is mainly caught by trawl fisheries. Discards sampling of this fleet indicates very limited discarding of turbot. This is likely linked to the lack of a minimum landings size for turbot in the Netherlands, since 2000. Other countries may use other fishing techniques in place for turbot, and many do have MLS regulations in place. Selectivities-at-age for those countries may thus be different from the Dutch estimates. However, given that the Netherlands contributes >50% of the landings, a substantial part of the landings is represented by the Dutch landings-at-age matrix.

Turbot in the southeastern part of the North Sea is caught in the surveys for sole and plaice. However, because turbot is a much rarer species, the indices for turbot are likely more noisy than for the more abundant species sole and plaice. This is likely especially true for the older ages, because turbot is characterized by a high L_{MAX} and older individuals may be are able to outswim the gear for the surveys that have low fishing speeds (4 knots).

2.4 Multispecies and mixed fisheries issues

Turbot is an important bycatch species in the Dutch beam trawl fleet (Gillis *et al.*, 2008). Although the landings are small compared to the main target species, the value is high. Currently, TACs have been defined for turbot and brill combined for the EC-waters in Division IIa and Subarea IV. This combined TAC has declined from 9 thousand tonnes in 2000 to 4.6 thousand tonnes in 2012 (See Table 2.4.1).

2.5 Ecosystem drivers

No ecosystem drivers were studied during the benchmark working group.

2.6 Stock Assessment [Subarea IV (North Sea)]

2.6.1 Catch-quality, misreporting, discards

The landings of turbot are available through the EuroStat database. This database holds the officially recorded landings for all countries landing turbot in the North Sea. There are no records for the Dutch landings in the EuroStat database between 1984 and 1987. However, for the North Sea these missing landings have been estimated in a Dutch/Belgian research project, and have been used to fill in the gaps (Boon and Delbare, 2000; Table 2.6.1; Figure 2.6.1). In the 1950s the UK was the biggest contributor to the landings, with almost 50% of the landings. In that early period, the landings fluctuated around 6000 tons per year. Currently, the landings are around 2700 tons per year. Most of the landings stem from the Netherlands that contributes between 50 and 60%. Within the Netherlands most of the landings come from the 80 mm beam trawl fleet fishing for flatfish species sole and plaice. Also in most other countries turbot is caught in mixed fisheries trawls. The second largest contributor to the landings in the last decade is Denmark. In Denmark there is a directed fishery for turbot using gillnets.

Within the Netherlands, most of the landings come from the Southern Bight and the German Bight (Figure 2.6.2). This overlaps with the areas where the research vessel surveys take place.

There is no long-term continuous programme for age sampling of landings in any of the countries. Therefore, the age structure of the landings is estimated using data from different sources in different time periods (Figure 2.6.3). Starting in 1975, there is a four year time period for which the age structure of the landings have been estimated by Weber (1979). The age structure is estimated from market samples taken in Cuxhaven and Hamburg and research vessel surveys. Most of the samples represent landings in the eastern part of IVb. The structure is based on a total of 9360 length and 6389 weight measurements combined with 6788 age samples. Samples are combined with the quarterly landings for England, the Netherlands and Germany and subsequently with the overall landings on an annual basis. The second dataset spans the period 1981–1990, is derived from landings in the Netherlands and available in the "Datubras" project report (Boon and Delbare, 2000). A stratified sampling scheme was used to collect the samples, using quarters, auctions, and market categories as stratification levels. Between 398 and 862 age samples were taken annually for age-determination of fish. Most of the samples represent Areas IVb and IVc. The Dutch data are subsequently raised to the total international landings. The third dataset spans the period 2000–2002. It was supplied by Cefas and based on the UK landings of turbot. These were raised on an annual basis to the total landings. The fourth and final dataset stems again from the Netherlands. It spans the years 1998 and 2004–2011. The age structure is estimated from stratified sampling accounting for auctions, quarters and market categories. These are raised to total Dutch landings by quarter. Between 494 and 1921 age samples were taken per year. The total Dutch landings are subsequently raised to the total international landings per year.

Little information is available about discarding in the different fisheries catching turbot. The only available information comes from the Dutch beam trawl fleet in the period 2002–2007. It indicates very low estimates of discarding (Table 2.6.2). No information is available for the period 1975–2002. In at least part of that period an EU wide minimum landings size (MLS) of 30 cm was enforced. However, this minimum landings size was abandoned and member states have their own MLS rules and regulations. For example, Belgium now has a MLS of 30 cm, while in the Netherlands a minimum size of 25 cm exists, set by the producer organizations. Hence, despite the indications of low discarding in the Dutch fleets in the last decade, more MLS discarding may occur in other fleets, or have occurred in other periods.

Because of the indications of low discarding, we assume the landings-at-age are representative of the catch-at-age (Figure 2.6.4, Table 2.6.3). The resulting catch-at-age matrix has two important characteristics. First, there appear to be some strong cohorts in the data and second, there is an apparent increase in the relative amount of two-year old fish being caught in the last decade. This shift is likely the result of the change in MLS regulations described above, while the recent data come from the Dutch landings only. This fleet has seen a decrease in MLS in the early 2000s. An alternative explanation for the apparent increase in two-year old being caught could be an error in the age-reading. However, no upward shift in the weight of fish at ages 2 and 3 was observed that would result from such an age-reading error.

The sum-of products plot indicates that there is some variation of the sum-of-products around the estimated total landings (Figure 2.6.5). This variation is likely caused by the averaging of the catch weights (see below). The log catch ratios for the years where catch-at-age estimates are available are fairly noisy, as can be expected for a stock with limited age sampling (Figure 2.6.5).

2.6.2 Index series

Four survey series catching turbot are available: the Beam Trawl Survey (BTS; with two research vessels: ISIS and Tridens), the Sole Net Survey (SNS), and the International Bottom-trawl Survey (IBTS) (Figures 2.6.6 and 2.6.7). The IBTS catches very little turbot because the gear is designed to catch roundfish rather than flatfish. Hence, the IBTS was not further evaluated for use in an age-based assessment. The BTS index uses a beam trawl to catch demersal species. The index is based on the catch in one of the two nets. The BTS-ISIS index is based on catches between 52 and 239 individuals per year (Table 2.6.4). The number of individuals used to generate an age–length key can be larger than the number of individuals used for the index, because the index is based on only the catch in one of the two nets, while age samples can be taken from both nets. The BTS Tridens caught between one and 16 individuals per year to base a potential index on. This is too low a sample to give an accurate age-structured index to be used in an age-based assessment. However, the overall index indicates a positive trend, but high interannual variation.

The procedure to create an age structured index series from the BTS-ISIS was updated prior to the working group. Previously, each individual fish caught was linked to an age–length key based on its length. The age–length key was based on all age samples in the BTS survey since 1991. The updated procedure first links the individual fish from which otoliths are taken to the length sample. This allows direct ageing of the fish in the cpue. Those fish for which no direct age sample is available are then assigned to ages using the age–length key based on all fish in the period 1991–2011. The overall index time-series for the BTS-ISIS and SNS is given in Figure 2.6.8. The age structured BTS index is given in Table 2.6.5 and Figure 2.6.9 and the age structured SNS index is given in Table 2.6.6 and Figure 2.6.10.

In addition to the survey based indices, there is also an index based on the Dutch 80 mm beam trawl fleet lpue. The potential bias in this lpue series as an indicator for stock abundances because of spatial targeting of the fleet has been addressed in Hammen *et al.*, 2011. There, a procedure was developed to obtain an age structured index from the lpue, while trying to remove the spatial aspects of targeting (Figure 2.6.11). The resulting index series shows an increase of older ages over time, and a fairly good cohort structure (Table 2.6.7; Figures 2.6.12–2.6.14).

2.6.3 Weights, maturities, growth

Weights

Weight-at-age data in the catch for this stock are available for most but not all of the years during which there is age sampling of the landings (Figure 2.6.15). Data are available for the period 1981–1990 from the DATUBRAS database (Boon and Delbare, 2000), and then again for the years 1998, and 2004 to present from Dutch market sampling. Stock weights are estimated as the catch weights in Q2, coinciding with peak spawning of the stock. Hence stock weights estimates are available for the same time period, but excluding the years 2005 and 2006 where no samples were available in the second quarter. In addition to this average weights-at-age for the stock during the period 1976–1979 are available from Weber (1979). For both the catch and stock weights, estimated values for ages 6 and greater tend to show large interannual fluctuations, due to the limited number of fish sampled at these ages. The vast majority of landings are for ages 4 and younger, and this is reflected in the number of samples for these ages.

Estimated weights-at-age showed an increase during the 1980s up until 1990. From 2004 onwards estimates are stable at a lower level than observed in 1990. With no data except a single year available in the 1990s (1998) to infer the trend in weight-at-age over the period 1991 to 2003, the group decided to use a constant annual weight-at-age vector over the entire period as input to the stock assessment models (Table 2.6.8). This was determined as the mean weight-at-age using all data available over the whole period.

Future work on the use of catch and stock weight is recommended. First, the trends of individual weights in time can be described using a statistical model. Such a model could either describe the trends in time as a function of age only, or describe the growth in a cohort, estimating smooth trends in the parameters describing the growth of each cohort. Second, the variability of weight-at-age that is now removed from the assessment (by taking means of weights by age over the entire study period) could be added to the assessment results, by using the residual variance of the estimates of the means. This information about the variance could be used in combination with the MCMC estimates from the assessment to describe the combined effect of uncertainty in estimated numbers and the uncertainty in estimated weights.

Natural mortality

Natural mortality of exploited fish species is often assumed to be a constant in stock assessments, independent of age and body size. This assumption was questioned by Gislason *et al.*, (2010), who critically reviewed the empirical estimates of natural mortality (M) as a function of the von Bertalanffy growth parameters, L_∞ (cm), K (year $^{-1}$) and length L (cm). In their study, Gislason *et al.* proposed that estimates of M for marine fish could be obtained by the following empirical formula:

$$Ln(M) = 0.55 - 1.61\ Ln(L) + 1.44\ Ln(L_\infty) + Ln\ (K)$$

Several values for the turbot von Bertalanffy growth parameters exist in literature (Table 2.6.9). As can be seen in this table, turbot grows relatively fast and generally reaches a certain length faster and at younger ages compared to other flatfish species in the same areas. This leads to a larger proportion of bigger fish in the younger age classes than in slower growing species such as sole *Solea solea* (males: L_∞ = 24.5 cm, K = 0.58; females: L_∞ = 35.0 cm, K= 0.1).

To get estimates of the natural mortality by age, sex-separated age–length keys were set up for turbot in the North Sea, based on market sampling data of turbot collected by ILVO-fisheries institute during the period 1996–2001. For each age an average length was calculated, corrected for the numbers per length class (Tables 2.6.10 and 2.6.11). Based on these records, natural mortality was calculated for each sex using the equation in Gislason *et al.* (2010). As shown in Table 2.6.12, the results indicate mortalities that are substantially higher than those estimated in for instance North Sea plaice (Beverton, 1964). This natural mortality is especially high in the young age classes, corresponding to the very rapid growth. A slight positive correlation is observed between natural mortality and both K and L_∞, although the effect of a higher K is more pronounced than that of a high L_∞. Due to the higher variability for recorded values of K for male turbot, average natural mortality ranges from 0.34 to 0.53, while for females a more constant value of 0.32 is recorded. Therefore, IBPNew 2012 decided to perform assessment test runs using M's of 0.2 (more relevant to the older females) and 0.3 before deciding on the value that should be used in the end.

Reproductive characteristics and maturity

An extensive set of turbot maturity data from the Netherlands (12 357 individuals; market samples from 1984–1990, 1998 and 2004–2009, survey data from 2005–2009) was used to study some reproductive characteristics of turbot from the North Sea. Figure 2.6.16 depicts the percentages of the four distinguished maturity stages by size class and month, illustrating a spawning season from April to August (confirming the spawning season information compiled by Moreau, 2010, see Table 2.6.13). The proportion of mature individuals smaller than 30 cm is more surprising, as this is exactly the size at which the earliest North Sea turbot were observed to mature in previous studies (Moreau, 2010 and references therein). In the context of Minimum Landing Sizes, this means that still a lot of immature individuals can legally be caught in regions where such MLS's have been installed by the local authorities (e.g. 30 cm in Belgium, 25 cm for the Dutch Producers Organisations).

Based on the same dataset from the Netherlands, sex-separated maturity ogives were constructed for two parts of the time-series, 1984–1995 and 1996–2009, to see whether the maturation pattern has stayed constant over time (Figure 2.6.17). This analysis clearly shows that higher percentages mature at younger ages in the recent time period, especially for females. For males, this trend is much less clear, mainly due to the small number of individuals at age 1 that were all scored to be mature. Due to these differences, IBP New 2012 decided to only use the maturity data from the recent time period for the construction of maturity ogives, and only the data on females. The final maturity ogive that will be used in the assessment was subsequently derived from a General Linear Model, and is shown in Figure 2.6.18. Table 2.6.14 contains the corresponding numbers of individuals (mature vs. immature), averages maturities, and the maturity ogive in numbers.

Growth parameters of turbot in relation to other species

As the overall values of natural mortality of turbot are very high in comparison to what is normally used in stock assessments for flatfish in the same ecoregions (e.g. WGNSSK, WGCSE), these were integrated in the plots based on the supplementary table of Gislason *et al.* (2010). In this table, values of L, Linf, K and M were obtained from a literature survey. Additional data were added on brill (*Scophthalmus rhombus*), as this is a sister species of turbot. Data on Atlantic halibut (*Hippoglossus hippoglossus*) was added as this is known to be the only flatfish which grows faster than turbot (Imsland and Jonassen, 2003). Both brill and turbot are bycatch species in a mixed fisheries in the North Sea aiming for sole and plaice. For this purpose, data were added on sole growth characteristics, plaice was already provided in Gislason *et al.* (2010). Data were obtained for sole and halibut from www.fishbase.org and for brill average length was based on market sampling by ILVO-fisheries institute during the period 1996–2001. Von Bertalanffy growth characteristics were obtained from Ongenae and De Clerck (1998).

Figures 2.6.19 and 2.6.20 show the relation between M and K for a range of species, to which turbot was added. According to Figure 1B, values for turbot are within the range of the observed values for other species. However, in Figure 1A values of M calculated for all species using equation (1) are at the bottom of the scatterplot.

Plots of natural mortality vs. L_∞ (Figure 2.6. A,B) show values for turbot in the center of the observation cloud. Observations for turbot and sole are of the same magnitude, while brill and halibut are situated at both ends of the distribution. Overall this means that the high values of natural mortality for turbot can not only be attributed to the used equation but also to the life-history characteristics of turbot, being a fast growing fish. Especially in the first years of their life, they are subjected to large mortality rates.

2.6.4 Assessment model

The benchmark group made two different stock assessments. Firstly, a statistical catch-at-age model using splines, based on the concepts in Aarts and Poos (2009), and secondly the ASAP model available in the NOAA toolbox.

ASAP exploration of turbot data

ASAP data and model formulation

The dimensions for turbot were years 1975–2011, ages 1–9, and one fleet encompassing all catch information together. A single matrix of catch-at-age was used to generate the proportions of catch-at-age, which contained a number of years with missing information. Two weights-at-age matrices were provided, one for use with catch and the other for use with stock biomass estimates. Both of the weights-at-age matrices were constant over all years. The time-series of annual total catch in metric tons was also provided for all years. The combination of weights-at-age in kg and total catch in tons means that ASAP estimates the population abundance-at-age in thousands of fish. Three indices were used for tuning the model: ISIS, Dutch beam trawl, and SNS each of which only had information for ages 1–7. The ISIS data ranged from 1985–2011, the Tridens data ranged from 2002–2011, and the SNS data ranged from 1975–2011 except for 2003. Each index was entered as an aggregate index in numbers of fish and as proportions-at-age computed from the number caught-at-age. The ISIS and Tridens surveys were tuned to month 9, while the SNS survey was tuned to month 6, meaning that $^9/_{12}$ or $^6/_{12}$ of the annual mortality had occurred when computing predicted indices. Natural mortality was set to 0.2 for all years and ages. Maturity-at-age was held constant over all years and followed the logistic curve at age fit during the meeting.

There were two selectivity blocks for the fleet: 1975–2002 and 2003–2011. Both fleet selectivity blocks were assumed to be flat-topped, with selectivity-at-ages 6–9 all fixed at one, but all younger ages estimated as free parameters. The surveys had selectivity at ages 1–7 estimated as free parameters, except for age 4 which was fixed at one in each survey. All three surveys assumed a logscale CV of 0.4 in each year, while the total catch in weight was fit assuming a logscale CV of 0.05. Both the catch and the surveys assumed effective sample sizes of 100 when computing the multinomial error contribution to the likelihood. A stock–recruitment relationship could not be fit. Instead a Beverton–Holt relationship was assumed with steepness fixed at one. The unexploited recruitment was estimated as a free parameter and recruitment deviations with logscale CV of 0.6 allowed highly variable annual recruitment estimates. No other penalties were employed during the fitting of the model for turbot as all parameters were estimated with reasonable precision.

Results ASAP

The total catch in weight was fit nearly perfectly, as expected, and there were no indications of problems in the catch-at-age residuals (Figure 1.6.21). The signals in the indices were fit reasonably well, with no indication that the assumed CV of 0.4 was inappropriate (Figure 2.6.22). Selectivity-at-age in both fleet blocks showed an early peak, with a decrease at age 5 and full selectivity at the oldest ages, as assumed (Figure 2.6.23). The more recent fleet selectivity block showed higher selectivity-at-ages one and two, as expected given the observed catch-at-age proportions. The survey selectivity patterns were not smooth over age, but showed general patterns of higher selectivity at younger ages for the IBIS and SNS survey and higher selectivity at older ages for the Tridens survey (Figure 2.6.23). The spawning–stock biomass (computed on January 1) showed a declining trend over time while the fishing mortality rate was relatively flat (Figure 2.6.24). There was only a slight retrospective pattern apparent in this assessment (Figure 2.6.25). This retrospective pattern should be considered in light of the fleet selectivity block in years 2003–2011, meaning there is little information to estimate selectivity at the most extreme peels shown.

Spline model exploration of turbot data

The first model uses basis splines (or "B-splines") to describe smooth trends. Given that there are gaps in the catch-at-age matrix, such a smoother can evaluate the trends in fishing mortality in given the availability of surveys in periods where catch-at-age data are lacking. The model uses the available landings-at-age data to represent catches, ignoring the discards-at-age. This choice is supported by the recent information in the Dutch beam trawl fleet that discarding is very limited and that the Dutch beam trawl fleet contributes substantially to the overall landings (>50%, see van der Hammen *et al.*, 2011).

Three different tuning indices are used: The BTS ISIS age structured cpue index, the SNS index, and the commercial lpue from the Dutch beam trawl fleet. The SNS index spans the longest period, and provides information on the stock trends in the early period of missing CAA. Ages 1–7 are included in the assessment for both SNS and BTS ISIS. For the lpue ages 1–9 are included. The two research vessel surveys are conducted in autumn, while the lpue series is collected year-round. The effects of mortality between the timing of the index and 1st of January (when SSB is calculated) is corrected for.

The model is a traditional discrete-time age-structured population model in which the size of annual cohorts of individuals decreases with time as a function of mortality Z. The mortality is split into two components, the natural mortality M and the fishing mortality F. In the absence of information on the trends in natural mortality, we assumed M to be equal for all ages and years. The fishing mortality for each year and age is to be estimated from the data.

The trends in fishing mortality per year and age are assumed to be composed of two components. A component that shapes the differences in fishing mortality over the ages (e.g. because of selectivity of the fishing gears and the overlap between the fishery and the fish stock) and a trend in time (e.g. because of trends in fishing effort). We used basis splines for both components. The spline used over the ages was set to describe the data using 4 knots, covering the younger ages of fish. For ages 7–9, the selectivity was assumed to be constant. This procedure is described extensively in Aarts and Poos (2009). To estimate the selectivity, we used three different model formulations: we compared one model that assumed a single selectivity pattern for the entire time-series, and two models where different selectivity blocks were used for the fleet: 1975–2002 and 2003–2011.

In this model, the trend in fishing mortality over time was also modelled using a spline smoother, and this is where the approach differs from earlier work. The full dataset covers 37 years, and the trend in fishing mortality over this period was modelled using 5 knots. By using splines, the number of parameters to be estimated can be greatly reduced, assuming changes in fishing mortality over time have taken place gradually.

The tuning index is used to give a direct estimate of the changes in abundance over time, assuming the catchability has remained constant over time, and the selectivity can be described by a 4 knot basis spline, similar to the process used in describing F.

Model fitting was done using ADMB (Fournier *et al.*, 2012). Estimates of parameters were made using a log-likelihood function consisting of four components: the landings-at-age data and the three tuning indices. The data are assumed to be lognormally distributed, with means and age-specific standard deviations predicted by the model. There were nine zero values in a total of 765 observations in the three datasets. To accommodate the use of the log transformation of data in the presence of zero-observations we added a small constant to the dataset, equal to half of the smallest observation in each of the separate dataset. Gaps in the catch-at-age data and the indices were not incorporated in the log-likelihood function. This means that in the gaps the mortality and the landings-at-age is inferred from the survey data only.

Residual plots for the initial model runs suggested that the variability of the residuals differed with data source and age. To capture this effect, the standard deviations at age 1 are estimated for each data source separately. The standard deviation for each of the older ages relative to the first age is estimated assuming a pattern that is equal in each of the data sources.

Only those runs were accepted that had positive definite hessian matrices. None of the estimable parameters were bounded. Depending on the exact model formulation, between 75 and 85 parameters were estimated. Estimation of annual recruitment made up for 37 estimable parameters. Uncertainty in model parameters and derived estimates such as spawning–stock biomass were evaluated using the delta method for normal approximation and Hessian based MCMC analysis.

Spline model exploratory runs

A first run of the spline model was done assuming a single selectivity vector for the period 1975–2011. Ages 1–7 were described by a 4 knot spline for each of the data sources. The selectivity-at-age for ages 7 to 9 were assumed to be equal within each data source. The trend of F in time was modelled using a 5 knot spline. Natural mortality was assumed to be equal to 0.2 for all ages and years. The SNS survey was used for ages 1–7 in the period 1975–2011. The BTS-ISIS survey was for ages 1–7 in the period 1985–2011. The Dutch beam trawl lpue series was used as for ages 1–9 in the period 2002–2011.

The log residuals from the four data sources are clearly smaller for the intermediate ages, and higher for the older and younger ages (Figure 2.6.26). In order to capture this effect of larger measurement uncertainty for older and younger ages, the sigmas in the log-likelihood functions are estimated to be a function of age. Log residuals of the catch-at-age matrix indicate that the model underestimates catches of ages 1 and 2 in the last ten years (Figure 2.6.27). The results indicated that fishing mortality increased in the period 1975–2000 and subsequently decreased. Spawning–stock biomass gradually declined in the period before 2005, but increased as a result of a number of strong year classes (Figure 2.6.28). To improve the model fit, two selectivity periods are created, the latter period starting in the early 2000s.

Using two selectivity periods instead of a single period improves the model fit. The residual patterns observed in the model with a single selectivity patterns disappear from the residuals (Figure 2.6.29). As expected, the selectivity for ages 1 and 2 increased in the second period (Figure 2.6.30). Trends in F, SSB and recruitment are overall similar to the model with only a single selectivity pattern (Figure 2.6.31). However, MCMC runs done to estimate parameter uncertainty of the model indicate the selectivity pattern in the final period is very ill-defined when described by a full 4 parameter spline function of age. Hence, in a subsequent exploratory run, the selectivity in the second period is defined by only two additional parameters that describe the difference in the selectivity between the two periods for ages 1 and 2 only. Hence we have a single additional parameter for age 1 and age 2 compared to the model with a single selectivity.

Spline model final runs

The spline model with two selectivity patterns, generated by adding a single additional parameter for age 1 and age 2 compared to the model with a single selectivity proved to be stable. This second setup for the two selectivity periods model yields a substantial increase in the model fit compared to the single selectivity period. The log-likelihood increases from -777.59 to -710.23 by increasing the number of model parameters by 2 (to 80). The selectivity for the two periods show an increase for ages 1 and 2 (Figure 2.6.32). For both periods, selectivity is highest for the oldest ages. However, the uncertainty about the selectivity for those ages is also high (ranging between 0.5 and 1). The selectivities for the two survey tuning indices (SNS and BTS-ISIS) is higher for the younger ages, and lower for the older ages, reflecting the fine mesh gear and the shallow survey area. Only between ages 6 and 7 there is a flat selectivity pattern (Figure 2.6.33). The commercial tuning index on the other hand shows an increasing selectivity with age.

The log residuals from the different data sources do not show conspicuous patterns, except for the SNS survey that shows negative residuals for most of the recent years since 2003 except 2011. The sigma estimates for the different source are lowest for ages 2–4 (Figure 2.6.34). Overall, estimated sigmas for the NL BT tuning index and the catch-at-age matrix are lower than those estimated for the survey tuning indices.

Visual inspection of the traceplot for the MCMC analysis does not indicate severe autocorrelation in the MCMC chain (Figure 2.6.35). This indicates the posterior distribution of the parameters is well estimated. The resulting trend in F (averaged over ages 2–6) indicates that at the beginning of the time-series starting in 1975, F (per year) was roughly between 0.28 and 0.45 (Figure 2.6.36). It increased over the years and peaked in the period around 2000. Since, F has decreased. This decrease in F is also found in sole and plaice, and likely results from the decrease in fishing effort in the beam trawl fleets in the North Sea. The 95% confidence bounds for the most recent F (in 2011) are between 0.35 and 0.57. The SSB has gradually declined until 2004, after which it increased as the result of a number of strong year classes. In 2011, the SSB is estimated to be between 3600 tonnes and 5400 tonnes. Recruitment is estimated to be variable, with peaks in the early part of the time-series, and in the early 2000s. Estimates of the most recent recruitments are very uncertain. Visual inspection of the stock and recruitment relationship does not indicate a clear stock–recruitment relationship (Figure 2.6.37).

The final assessment does exhibit some retrospective bias, in the same direction as was indicated by the ASAP model. This retrospective bias is strongest in the estimation of fishing mortality (Figure 2.6.38). Part of this retrospective pattern is likely caused by the split in the selectivity pattern, and the uncertainty about the selectivity pattern in the most recent period. Future working groups should further study the retrospective pattern and study if increasing the flexibility of some of the spline functions decrease the retrospective pattern.

Finally, to further explore the natural mortality to be used, the final model run was also done assuming a natural mortality of 0.25 and 0.3 per year for all ages and all years. For those runs, the log-likelihood decreased from -710.23 to -710.606 and -711.003, respectively. Hence it seems that the data are very uninformative about the natural mortality, and that using higher estimates of M does not improve the model fit.

2.6.5 Short-term projections

No short-term projections were done during the benchmark.

2.6.6 Appropriate reference points (MSY)

The posterior distribution for the F_{MAX} values of this stock was estimated in the MCMC procedure. This allows estimating the uncertainty in F_{MAX} given the uncertainty in the selection pattern. For the estimation of F_{MAX}, the most recent selection pattern was used. Weights-at-age are taken to be the averages over the entire time-series, as was done in the stock assessment. Natural mortality was assumed to be 0.2 per year, as was done in the assessment. The resulting deterministic yield-per-recruit curve has a fairly well-defined top (F_{MAX}) at F= 0.32 per year (Figure 2.6.39). The deterministic estimate for $F_{0.1}$ is 0.21 per year. In addition to the deterministic estimate for F_{MAX}, a posterior distribution for it was evaluated from the MCMC runs, accounting for the uncertainty in the most recent selectivity pattern. This analysis indicates 95% confidence bounds for F_{MAX} at 0.29 and 0.37 (Figure 2.6.40).

Comparing the yield-per-recruit curve for the second period with that estimated from the first period, reveals that a reduction in the selectivity of the younger ages would lead to a higher yield-per-recruit (Figure 2.6.39). The difference in maximum yield-per-recruit between the two selectivity patterns as estimated in the deterministic YPR curve is approximately 11%. This finding suggests that an increased survival of young fish by reducing the fishery on those ages would lead to higher long-term yields.

2.7 Future research and data requirements

The final assessment we propose uses an lpue series for tuning. For species with strong targeting, this may lead to biased estimates of stock abundance. However, given the low catches of older fish in the survey time-series, the lpue series is probably the best indicator for stock abundance of older fish. The effects of targeting were removed as much as possible by using a method described in van der Hammen *et al*. (2011). Future research should confirm if the age-structured lpue time-series used in the assessment is a reliable indicator for age-structured stock abundance.

The BTS ISIS age-structured survey time-series used in the assessment has been revised prior to the benchmark working group. Previously, the length-structured catch per unit of effort was age-structured using an age–length key that was composed of all sampled individuals in the time-series. The update linked the age estimates to length estimates for individual fish, where possible. The SNS survey is not updated and still uses an age–length key that is composed of all individuals in the time-series. Future research should study if using age–length keys collated by year give better results in the assessments. Using age–length keys by year has the advantage that the information of age structure within a year is better preserved. Such a procedure would also be more like the assessment procedure used for the other flatfish species sole and plaice.

Currently, the average weights-at-age are used in the assessment as an estimate of the weights-at-age within a given year. Hence, the interannual variability of weights is not accounted for in the assessment or the derived reference points. One method of including the variability of weights is to add the weight-at-age estimation as a likelihood component to the assessment model. In that way, the MCMC procedure that is used to estimate confidence bounds in F, SSB, and reference points can be used to show the uncertainties in these properties including the uncertainty in the weight-at-age estimates that are currently accounted for.

There is little known about the natural mortality of this stock. For other flatfish species we have natural mortality estimates that are empirically derived from the cease in fishing during WWII. Using the statistical relationship as estimated by Gislason *et al*. (2010), we derived estimates for natural mortality that are higher than those for sole and plaice. The reason for these high estimates are the high K and L_∞. The benchmark group decided to use M=0.2 per year, as is used for many other fish in the ICES areas. A simple exploration of the assessment model indicated that the model itself is not very informative about M, but that higher M values lead to a slightly lower log likelihood. Further exploration of M for turbot would improve the appropriateness of the ICES advice that will result from using the assessment.

The data collected prior to 2003 clearly shows a lower selectivity for the younger ages in the landings-at-age table compared to the more recent period. By interpreting the landings-at-age data as catch-at-age information, the change in landings of young fish was interpreted by the benchmark working group as an increase in the catchability for those ages. This can be justified, with the knowledge of the abandoning of the 30 cm MLS by the EC. The alternative explanation for the change in catch-at-age table is that those age were discarded previously and hence an unobserved part of the catch-at-age prior to 2000. Having more catch-at-age information available from different countries would provide more insight in the landings-at-age and discards-at age, and possibly give more insight in what caused the changes in the landings-at-age information that is now available from single countries only.

2.8 External reviewers comments

The external reviewers were involved in the model development and decisions that were made regarding data preparation, assumptions, model implementation, and conclusions. They were given access to all data sources and model code, and contributed to the progress made in the working group, both by discussion and direct work. As a result, they agree with everything stated in the above sections.

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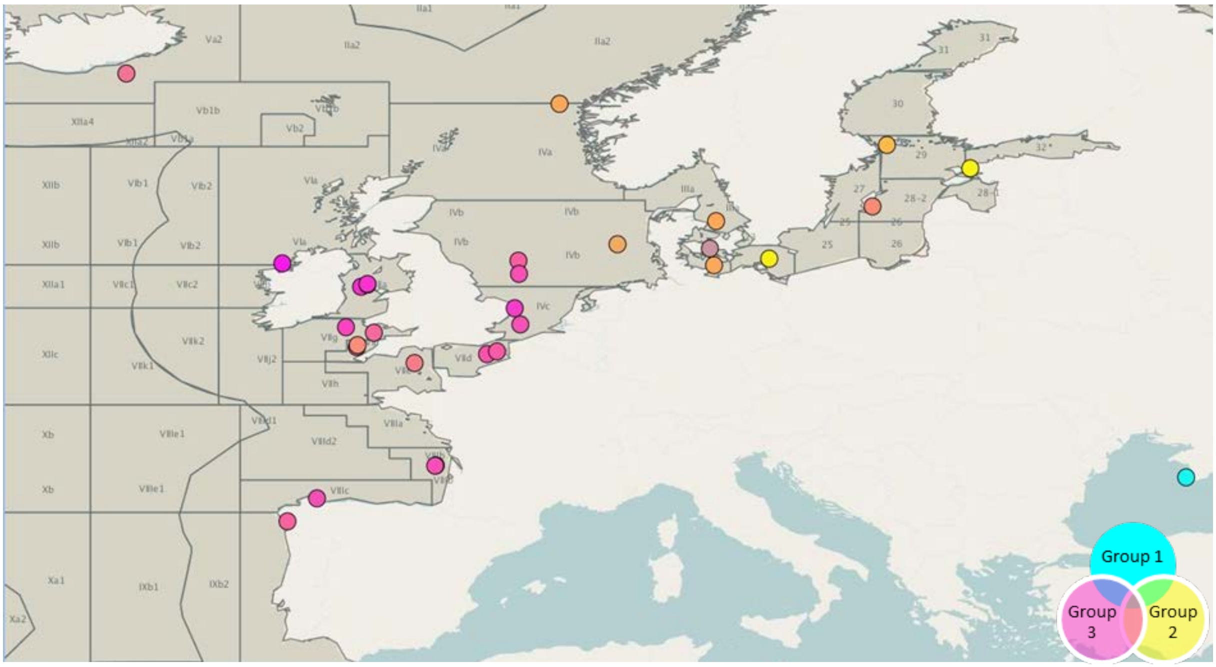


Figure 2.1.1. Assignment probabilities of turbot sampling sites to three genetically distinguishable groups using neutral markers, indicating a break-up between the Baltic and NE-Atlantic clusters. Preliminary results from Vandamme *et al*. (in prep).

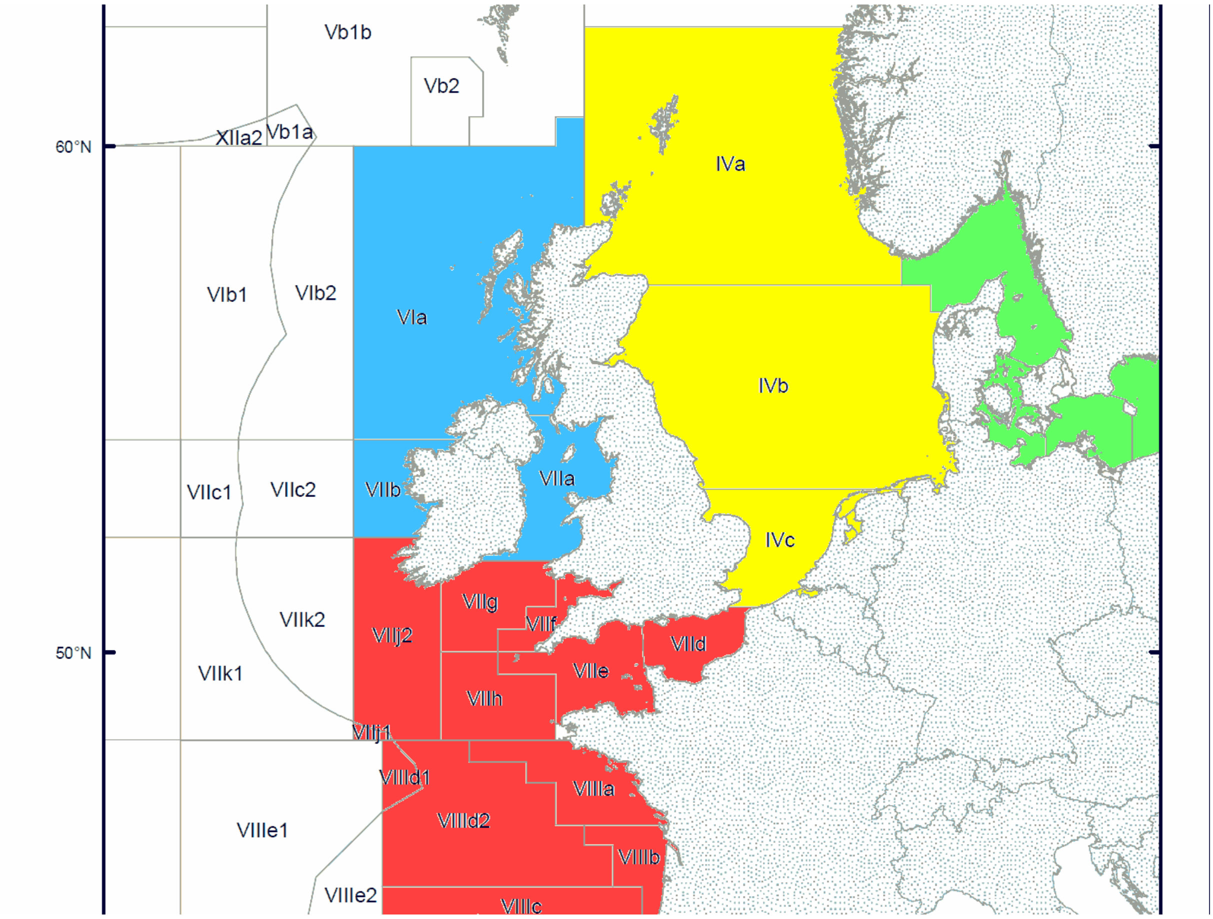


Figure 2.1.2. Stock structure of turbot in the Northeast Atlantic as proposed by IBP New 2012.

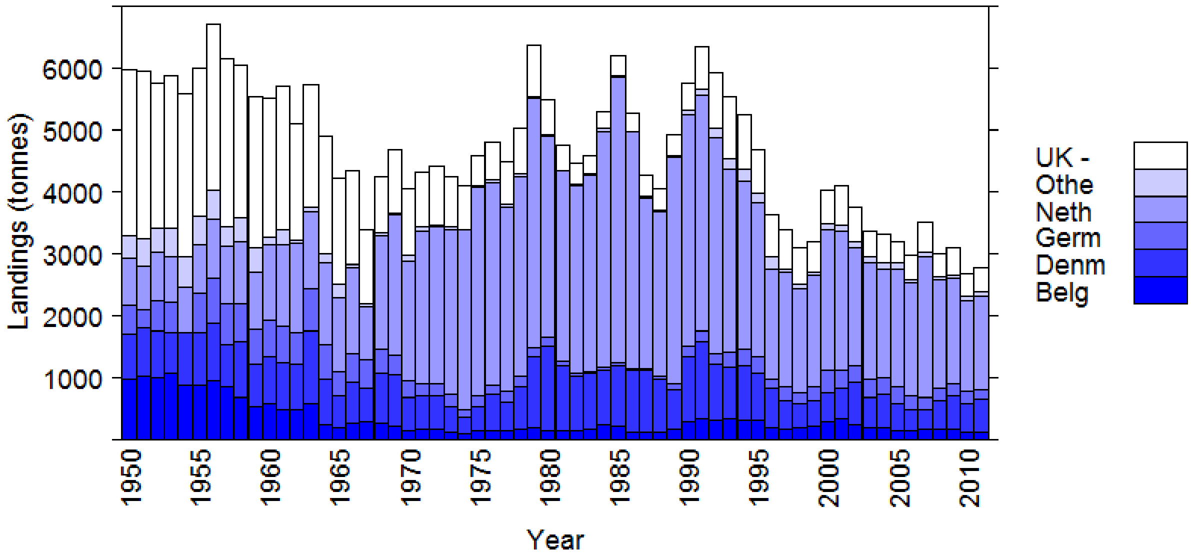


Figure 2.6.1. Landings in IV by different countries from EuroStat.

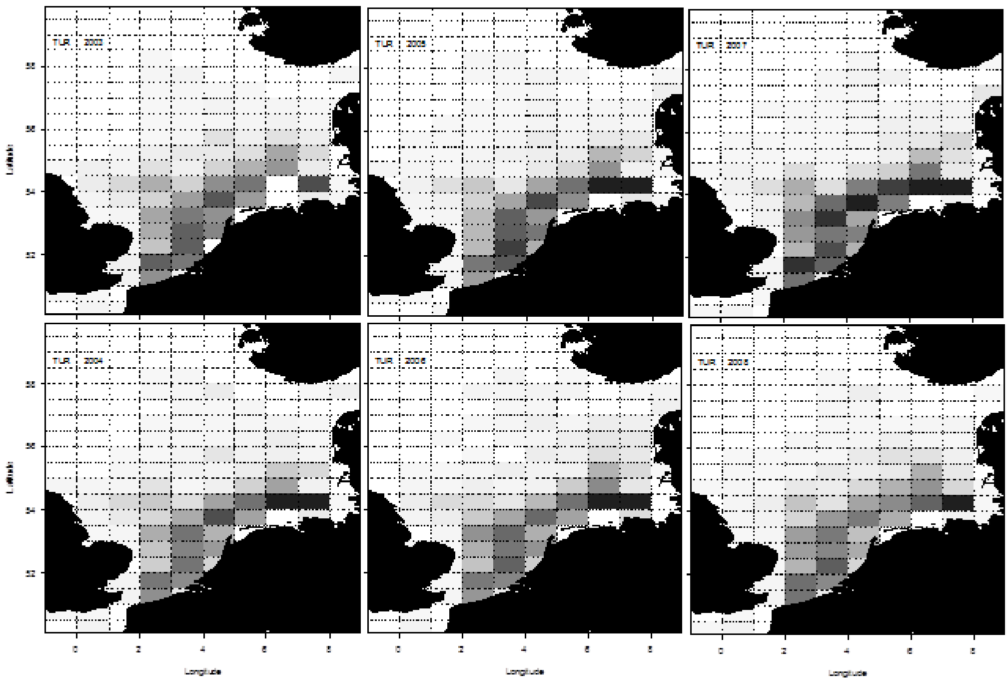


Figure 2.6.2. Spatial distribution of Dutch landings.

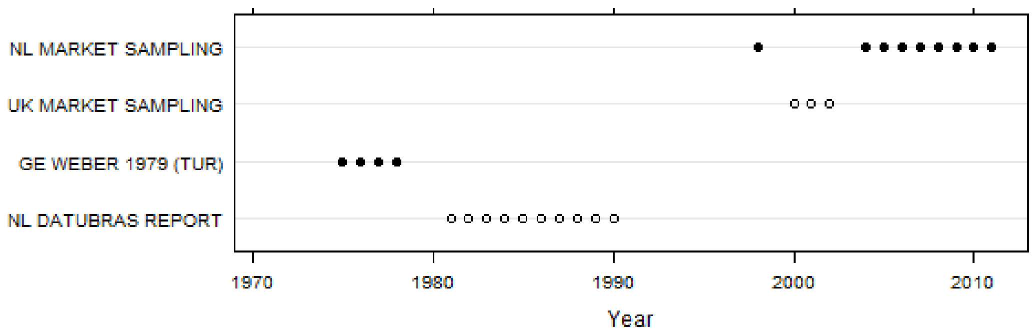


Figure 2.6.3. Source of age data for creating catch-at-age data. The availability of sex separated information is indicated by a closed black dot and sex combined date is indicated by an open circle.

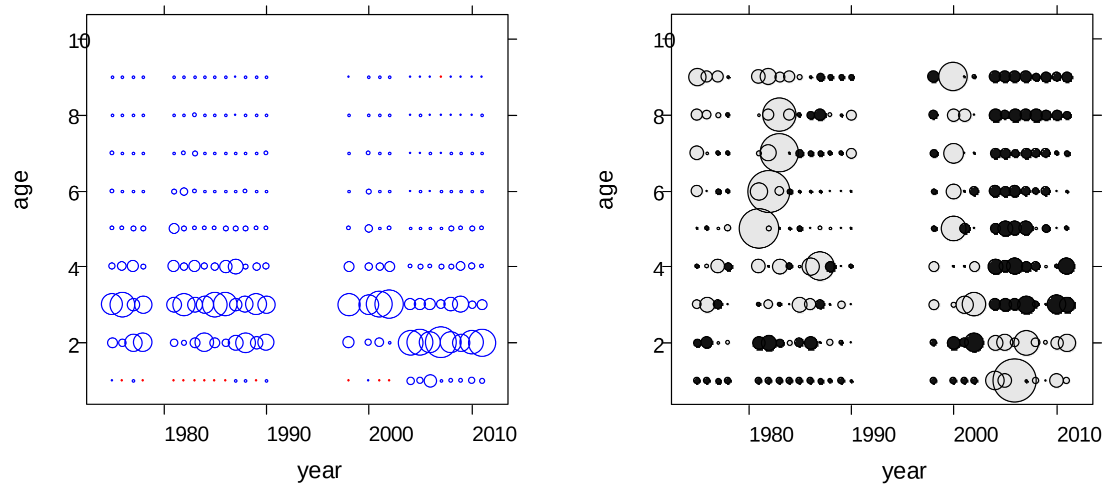


Figure 2.6.4. Age-structured catch-at-age data (left panel) and standardized catch-at-age data (right panel).

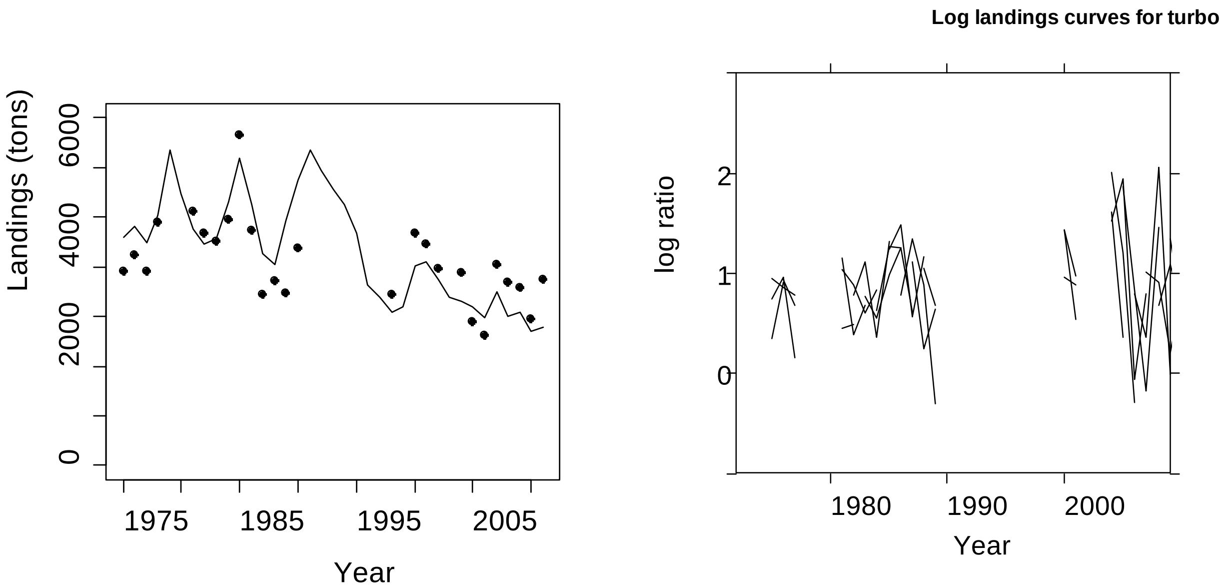


Figure 2.6.5. Sum-of product plot (left panel) and log landings curves (right panel). In the left panel, the drawn line represents the landings, while the dots represent the "sum-of-products". In the right panel catch ratios are plotted for ages 3–7 (where fishery is fully selective).

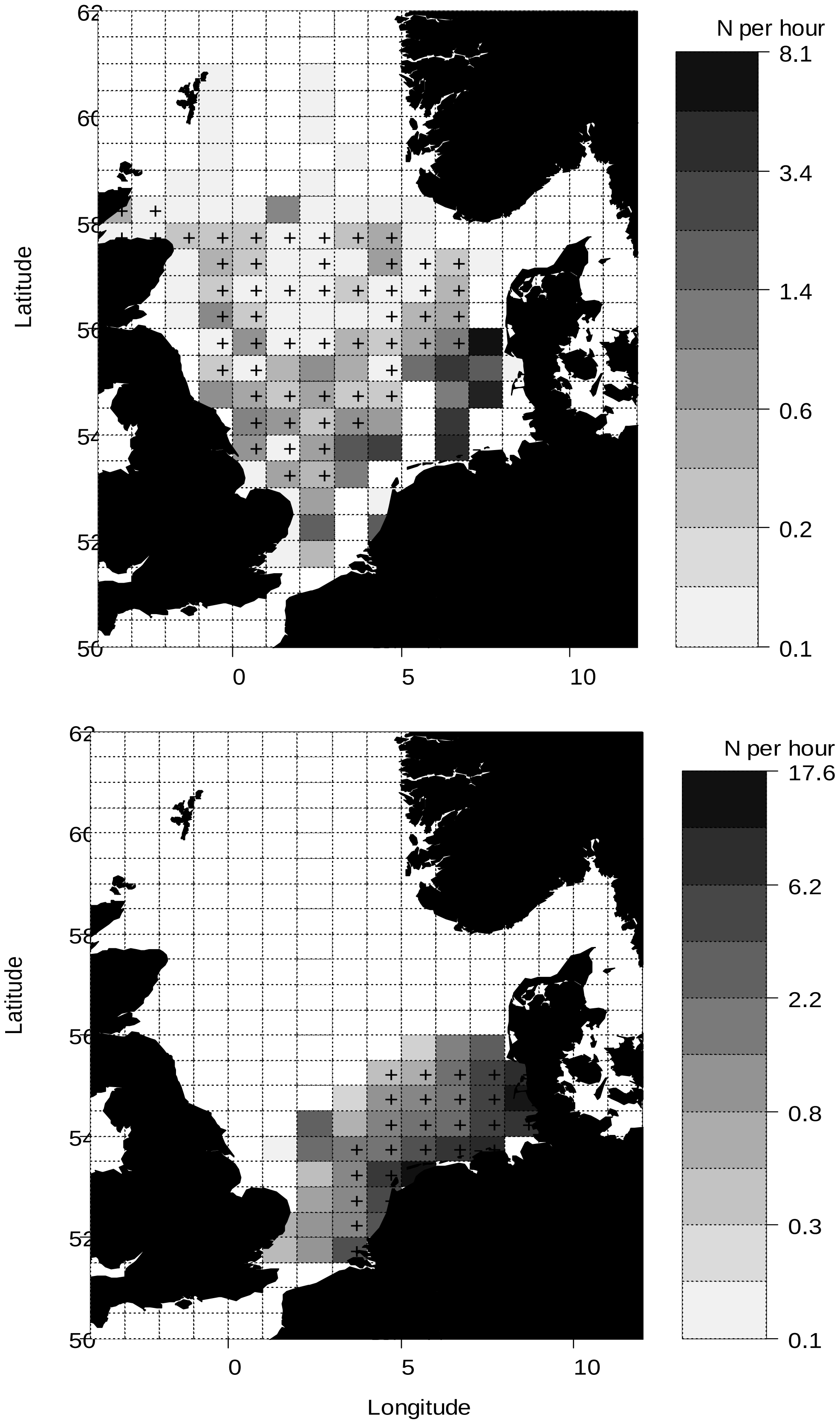


Figure 2.6.6. Spatial distribution of turbot catch per unit of effort in the BTS Tridens (top panel) and BTS ISIS (bottom panel), "+" sign indicates the main survey area where sampling has taken place over all years.

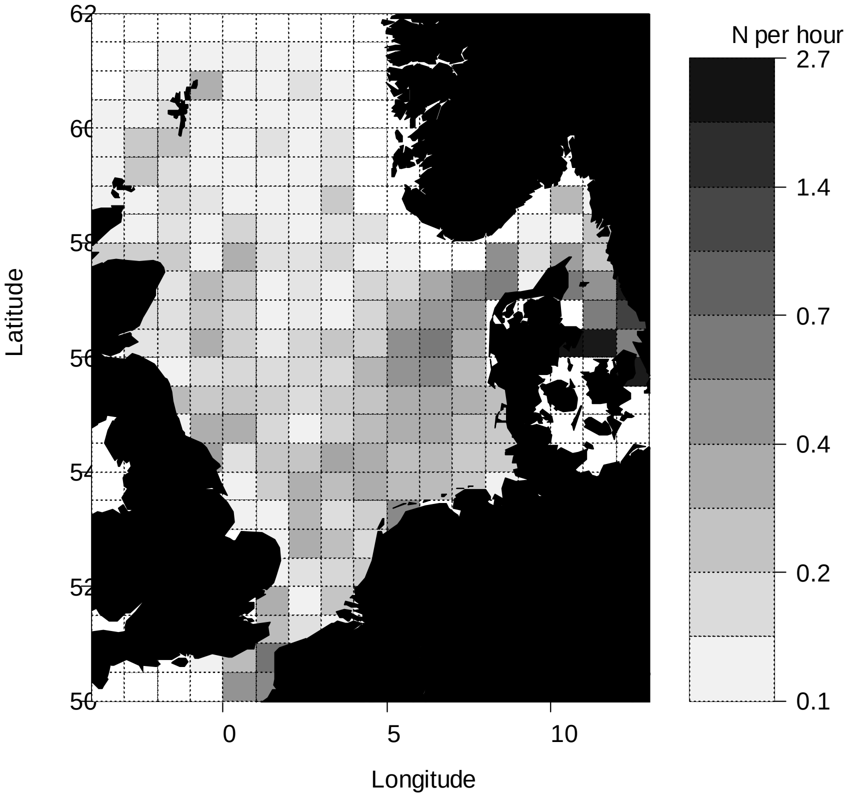


Figure 2.6.7. Spatial distribution of turbot catch per unit of effort in IBTS survey.

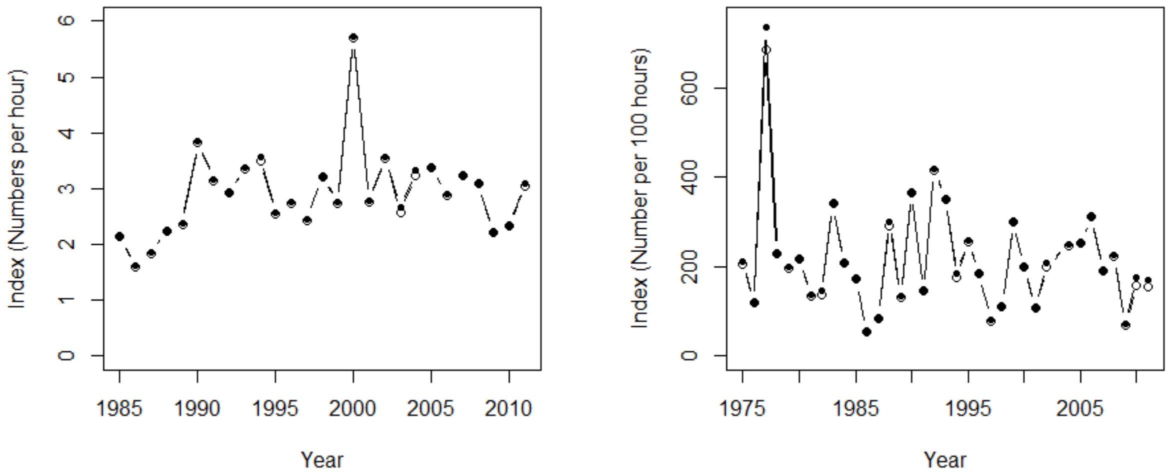


Figure 2.6.8. Time-series of survey indices: BTS-ISIS (left panel) and SNS (right panel). Black symbols indicate total index over ages 0–10, open circles indicate index over ages 1–7, as used in the assessment.

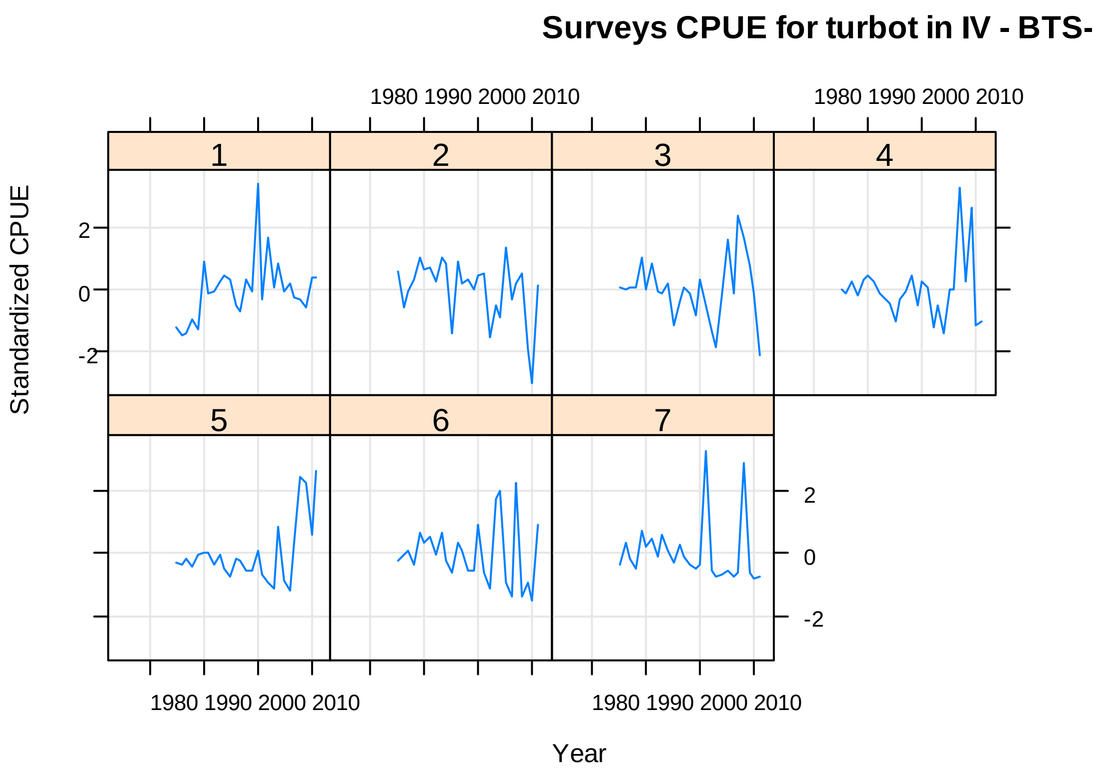


Figure 2.6.9. BTS-ISIS standardized index.

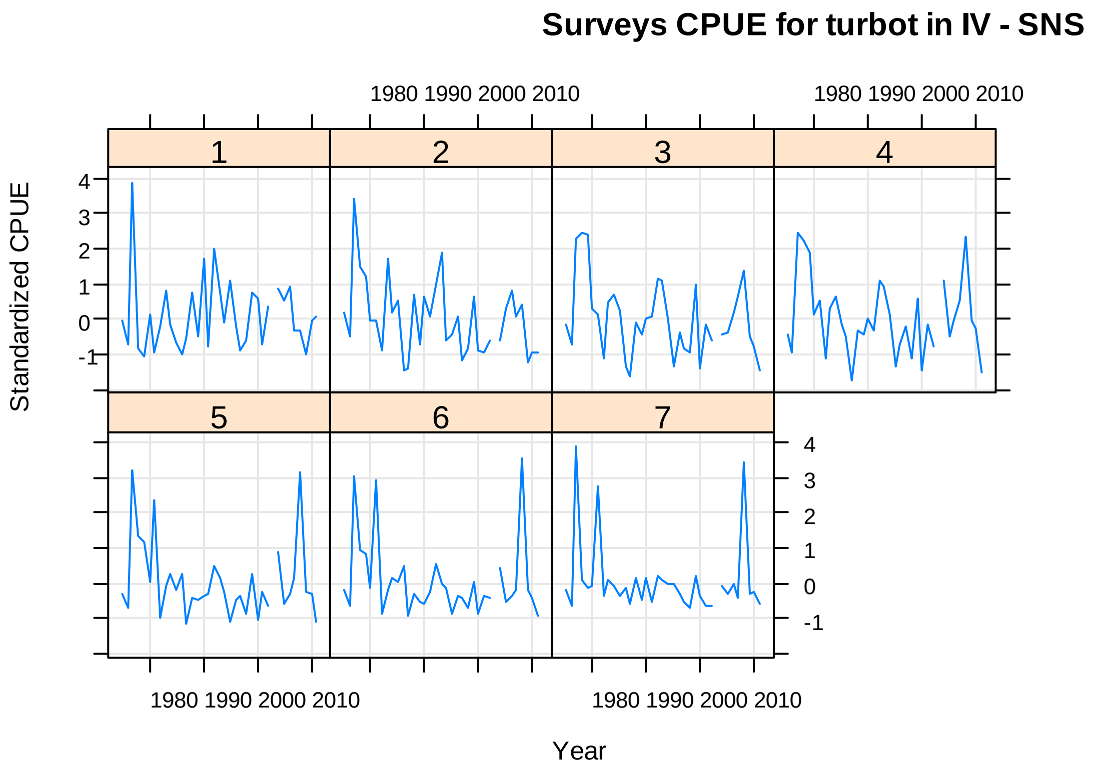


Figure 2.6.10. Standardized SNS index.

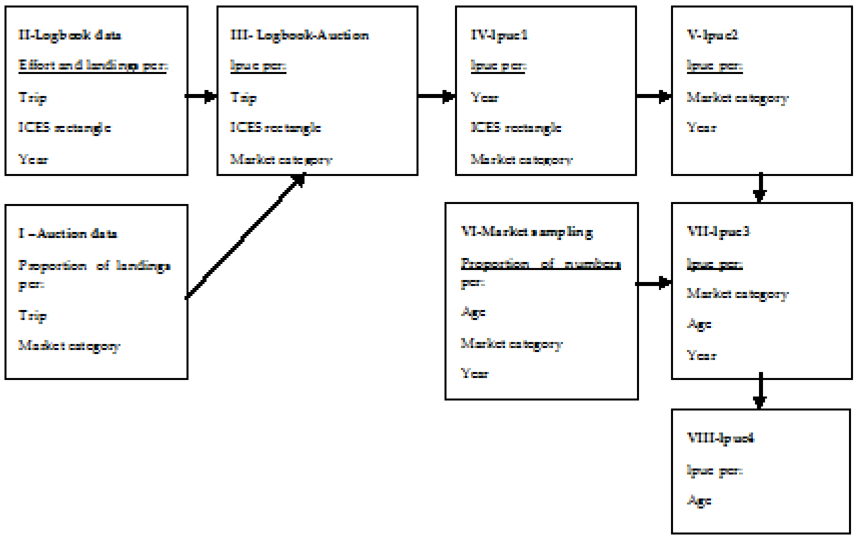


Figure 2.6.11. Procedure for estimating lpue from the Dutch beam trawl fleet. Taken from van der Hammen *et al.*, 2011.

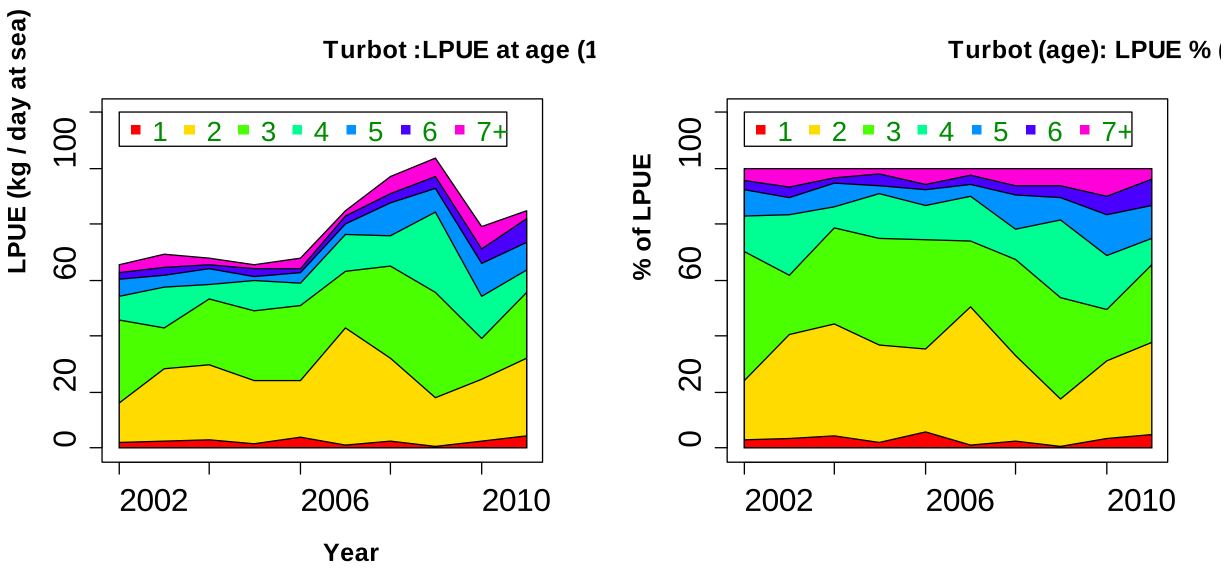


Figure 2.6.12. Lpue time-series per age and age composition.

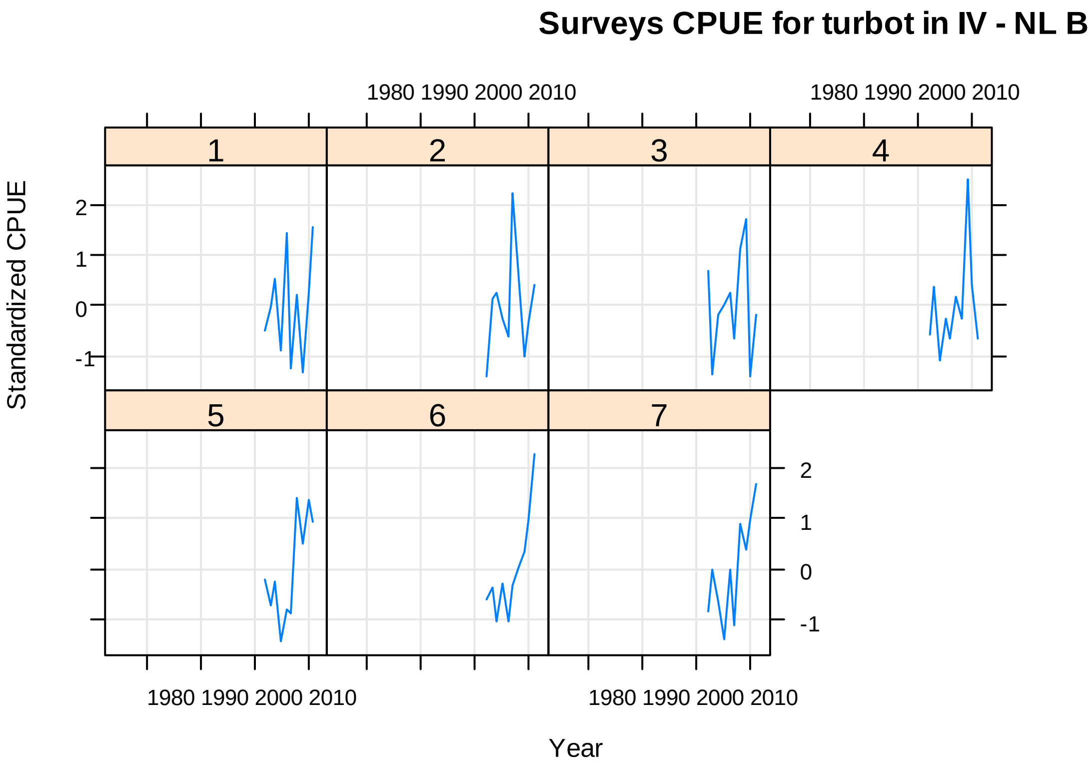


Figure 2.6.13. Standardized index series derived from the Dutch beam trawl fleet lpue.

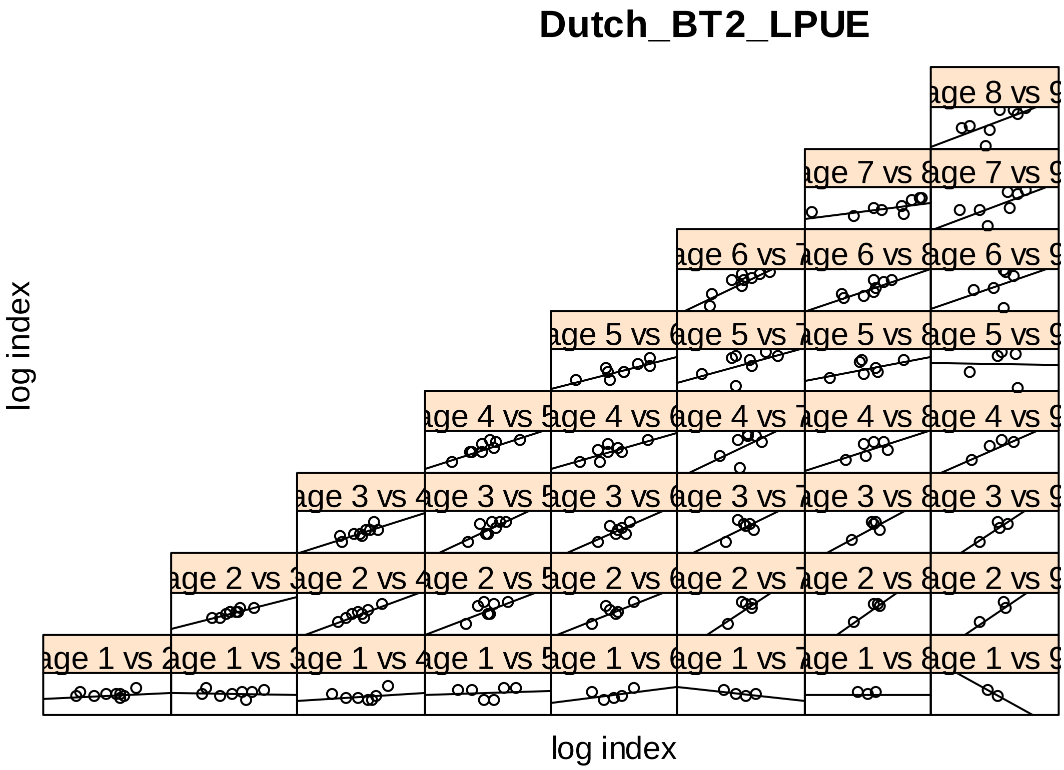


Figure 2.6.14. Internal consistency of NL BT lpue series.

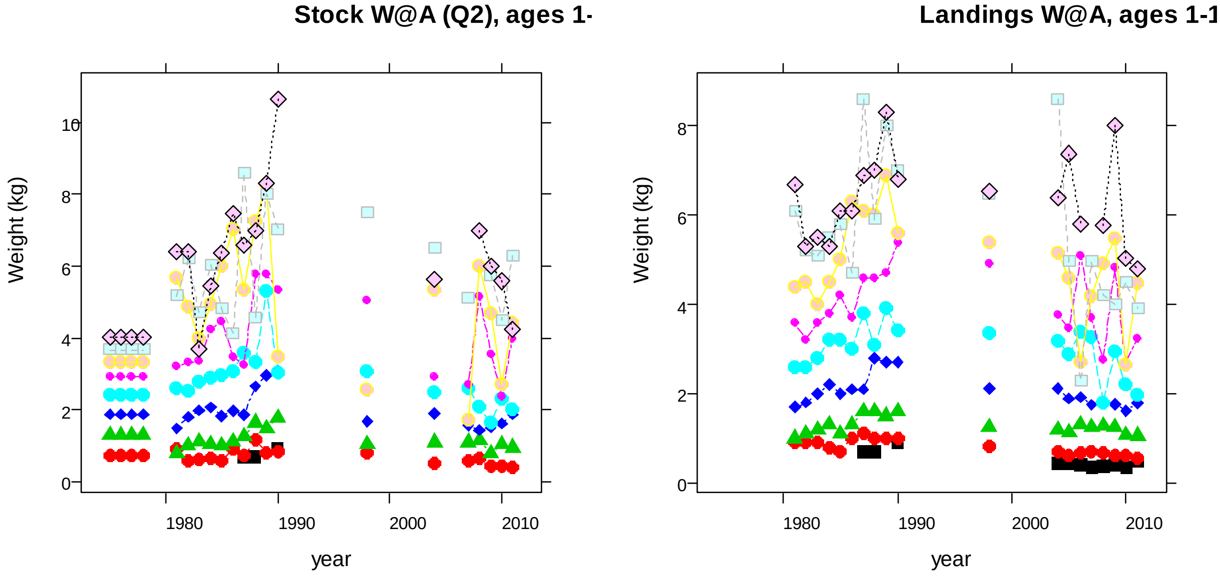


Figure 2.6.15. Weights-at-age. Stock (Q2) and Landings (whole year) weights-at-age for turbot in the North Sea. Sources: pre-1980 data from Weber (1979), 1981–1990 from Boon and Delbare (2000) and >1990 data from Dutch market sampling (FRISBE database).

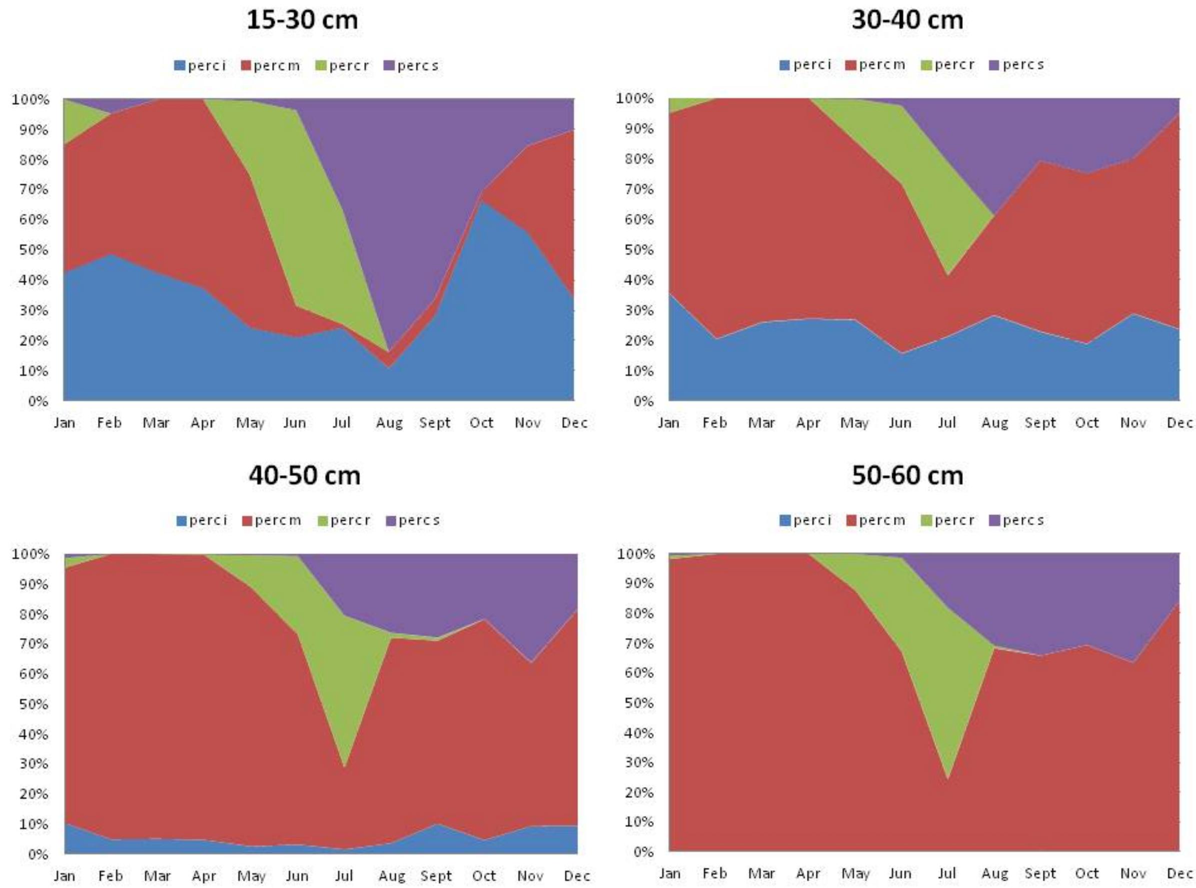


Figure 2.6.16. Percentages of North Sea turbot maturity stages (i = immature, m = maturing, r = running, s = spent) by size class and month (source: Dutch market sampling and surveys, 1984–2009).

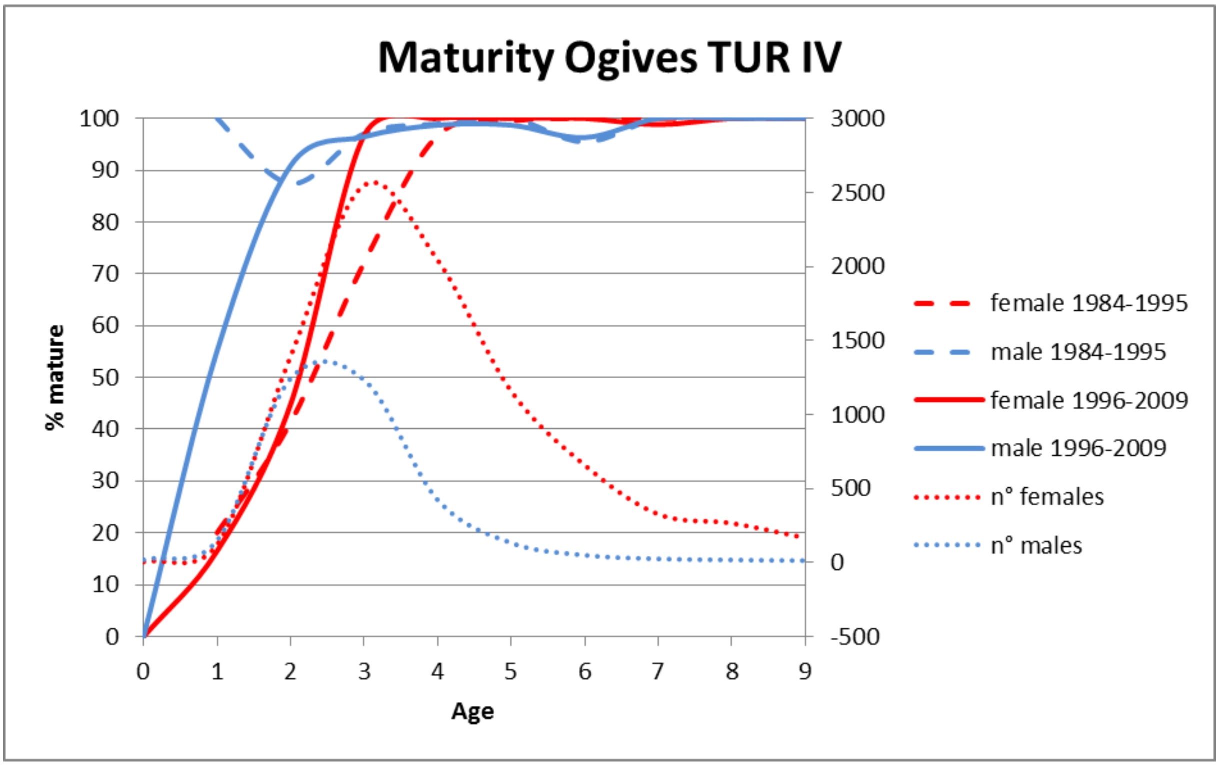


Figure 2.6.17. Sex-separated maturity ogives for North Sea turbot sampled in two periods of time, 1984–1995 and 1996–2009, with addition of the total numbers of individuals for which maturity was scored (source: Dutch market sampling and surveys, 1984–2009).

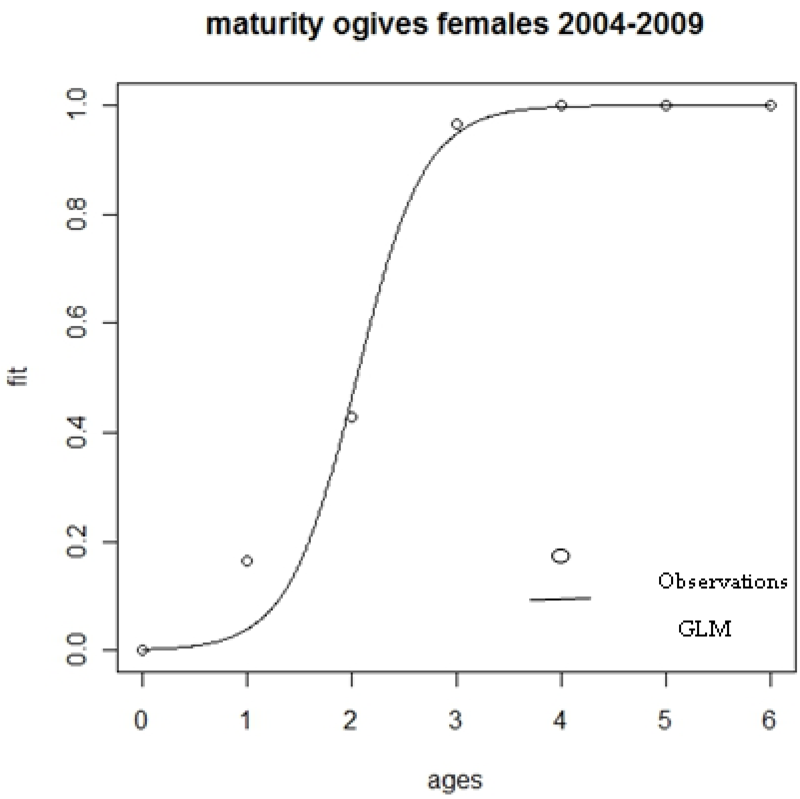


Figure 2.6.18. GLM-derived maturity ogive for female North Sea turbot (source: IMARES market sampling and surveys; 1996–2009).

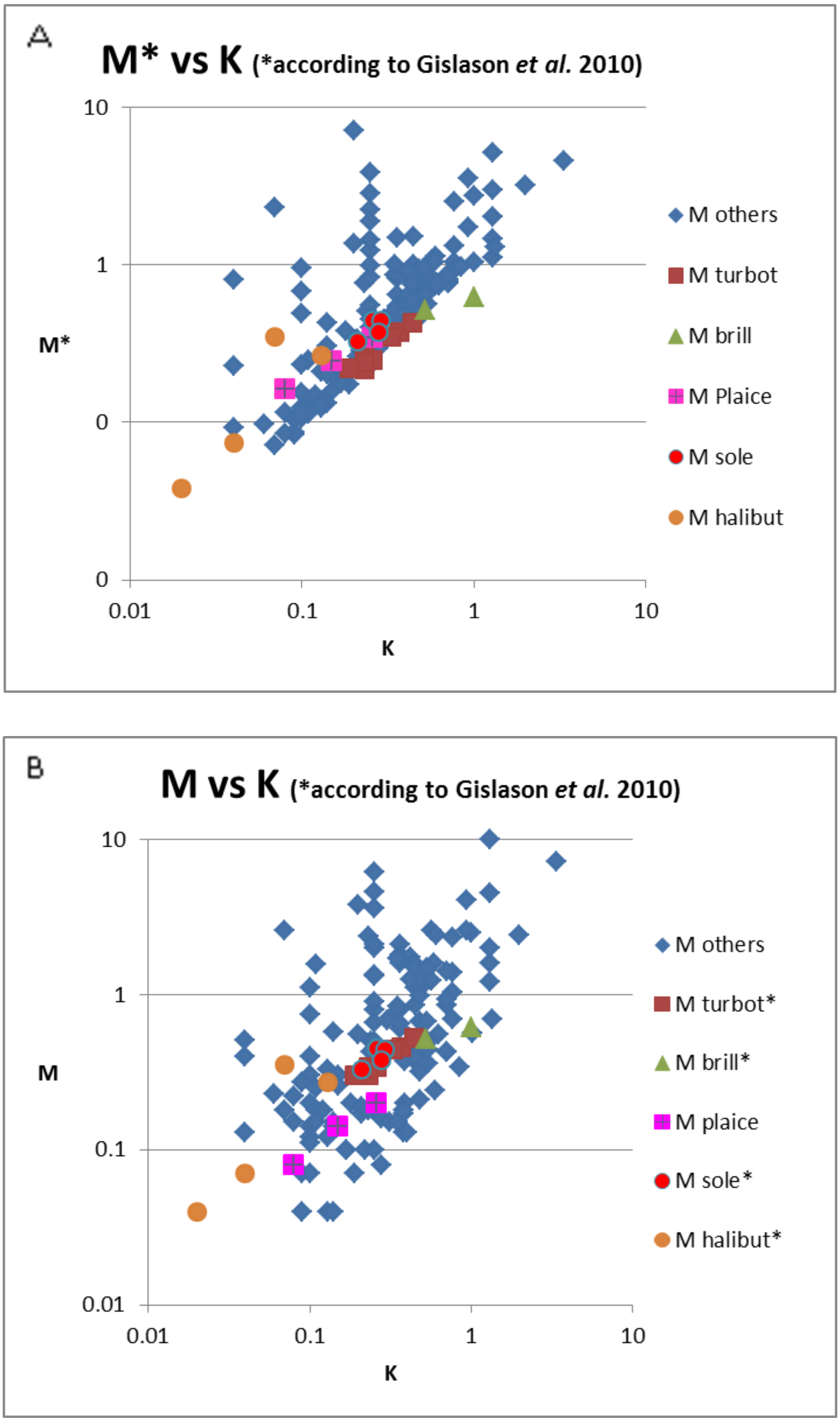
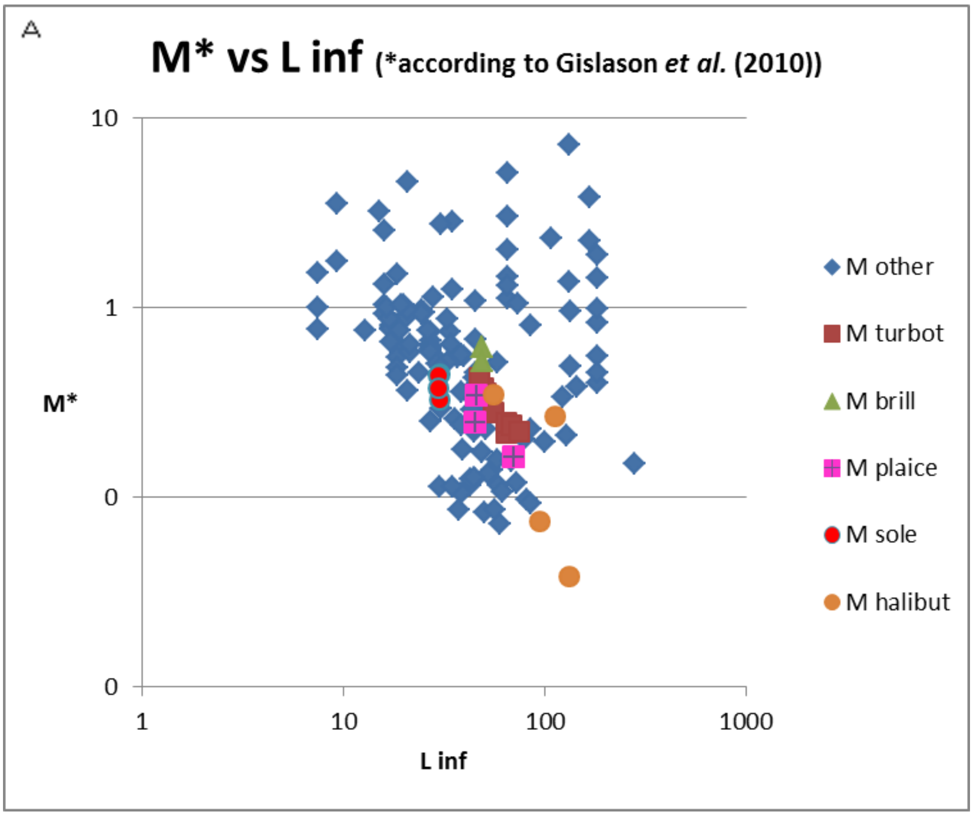


Figure 1.6.19. Representation of natural mortality vs. growth rate. A) represents values of natural mortality calculated for each species according to the equation of Gislason *et al.* (2010), B) natural mortality for all individuals provided in literature, except for turbot, brill, sole and halibut. The latter were calculated according to Gislason *et al.* (2010).



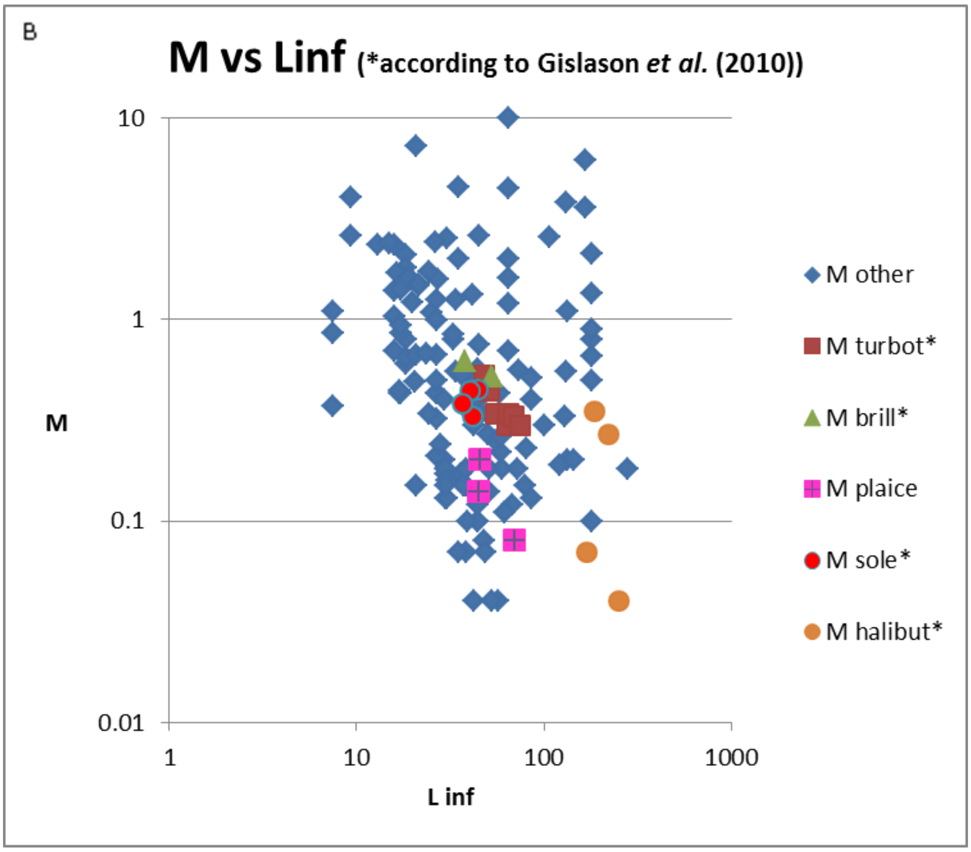


Figure 2.6.20. Representation of natural mortality vs. Linf. A) represents values of natural mortality calculated for each species according to the equation of Gislason *et al.* (2010), B) natural mortality for all individuals provided in literature, except for turbot, brill, sole and halibut. The latter were calculated according to Gislason *et al.* (2010).

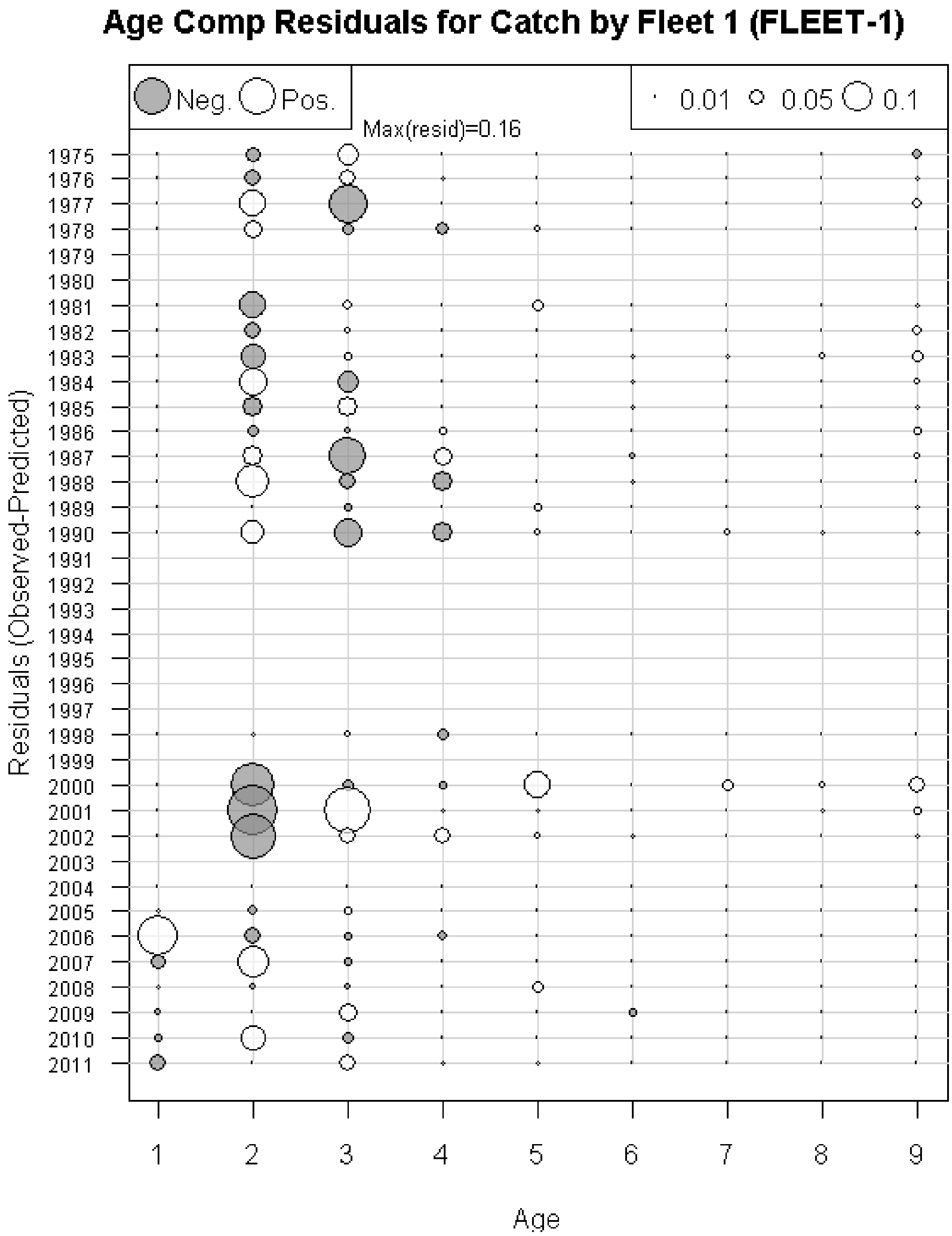


Figure 2.6.21. Residuals of catch-at-age for turbot.

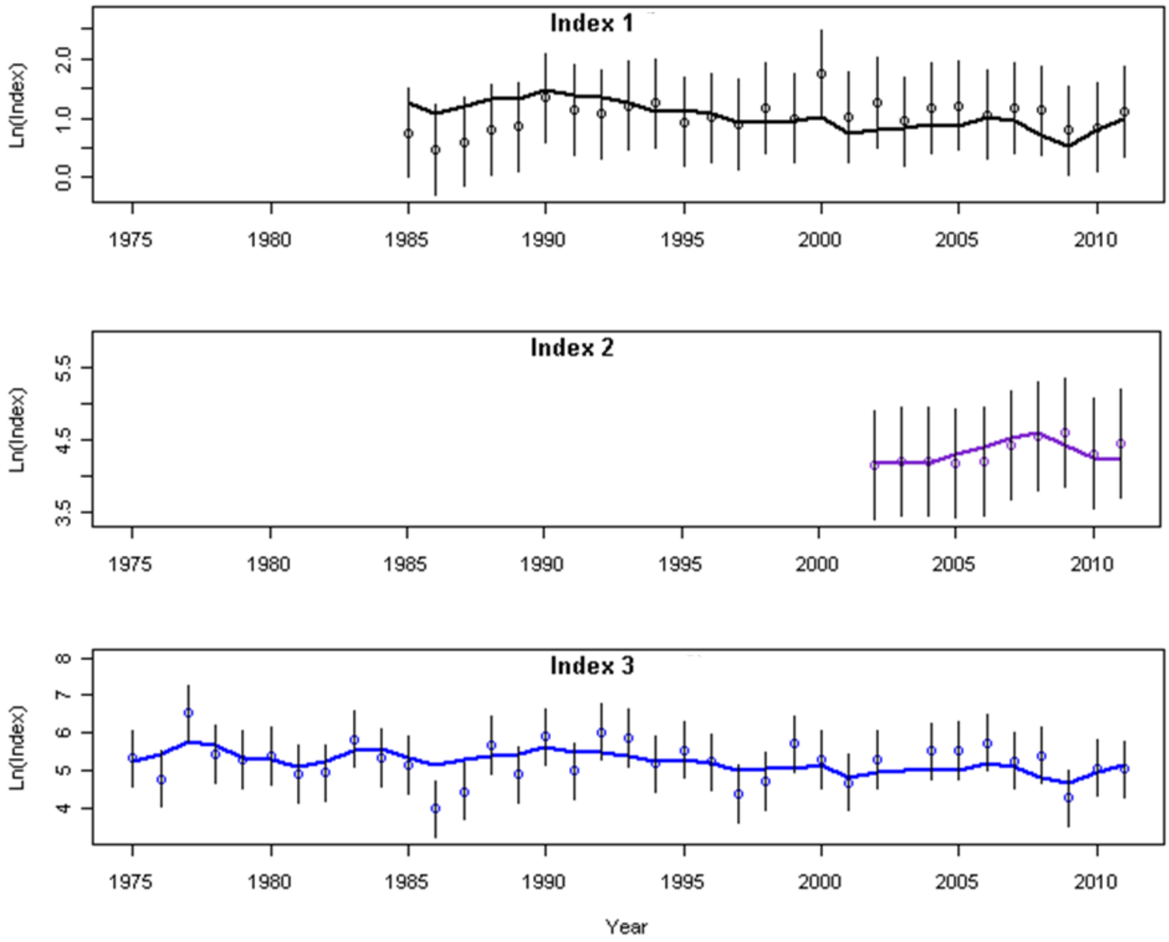


Figure 2.6.22. Fits to turbot surveys.

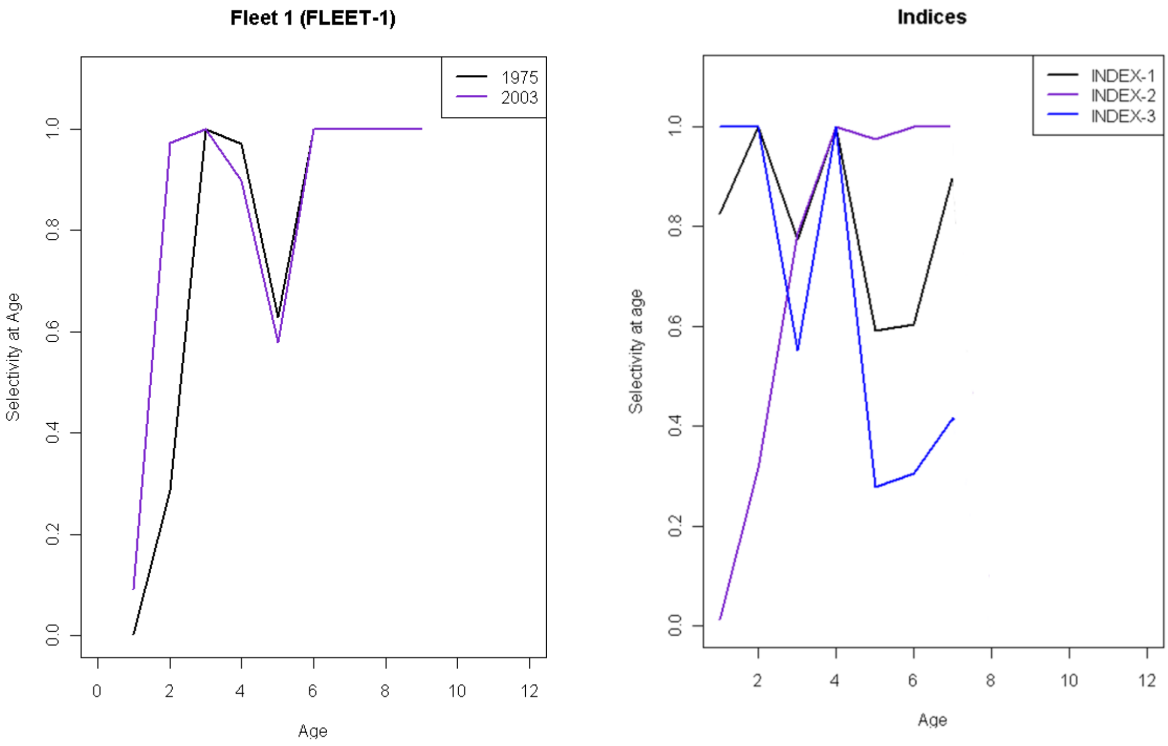


Figure 2.6.23. Fleet selectivity-at-age by block for turbot (left panel) and Survey selectivity-at-age for turbot (right panel). Index 1 = ISIS, Index 2 = Dutch Beam trawl, Index 3 = SNS.

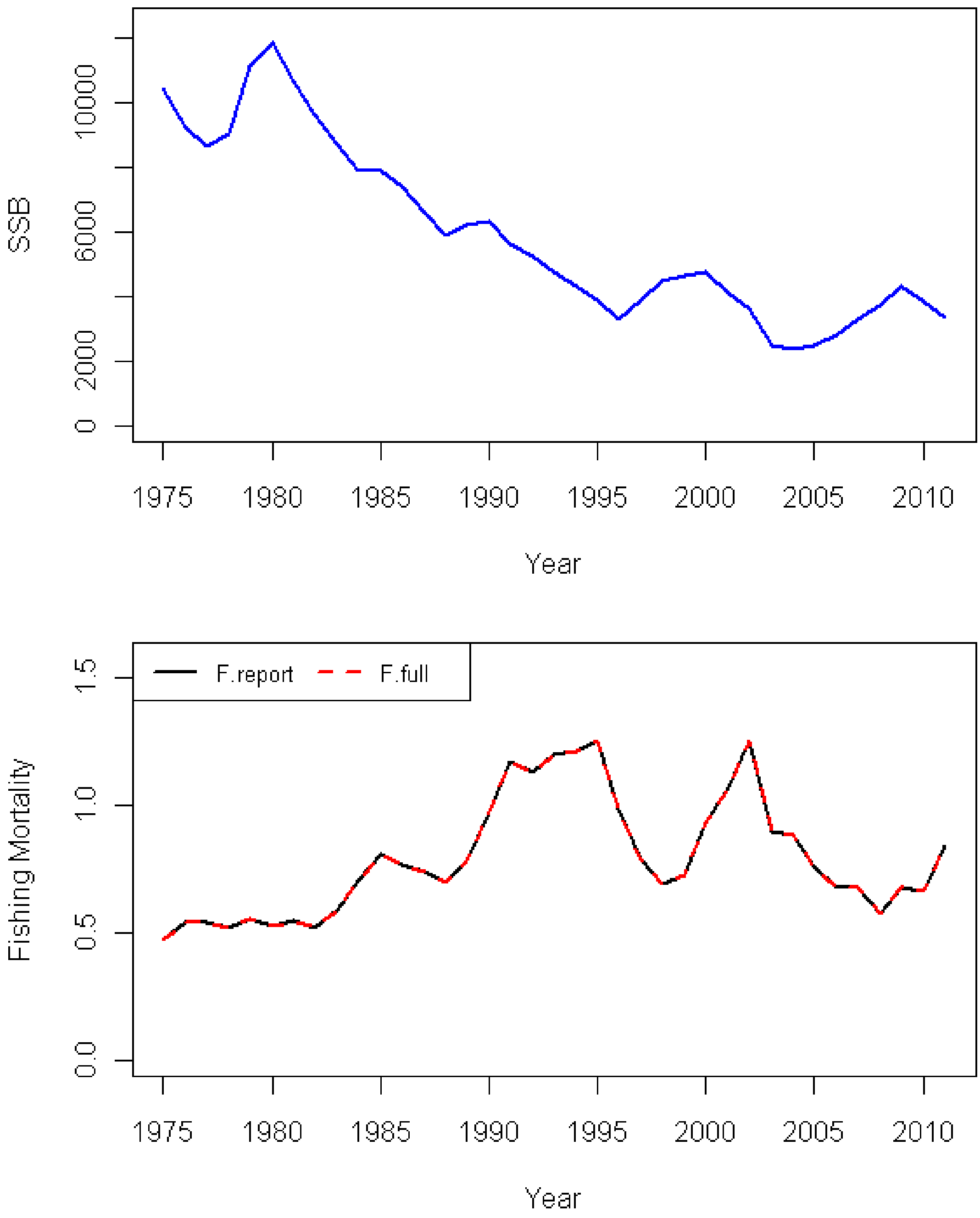


Figure 2.6.24. Spawning–stock biomass and fishing mortality rate by year for turbot.

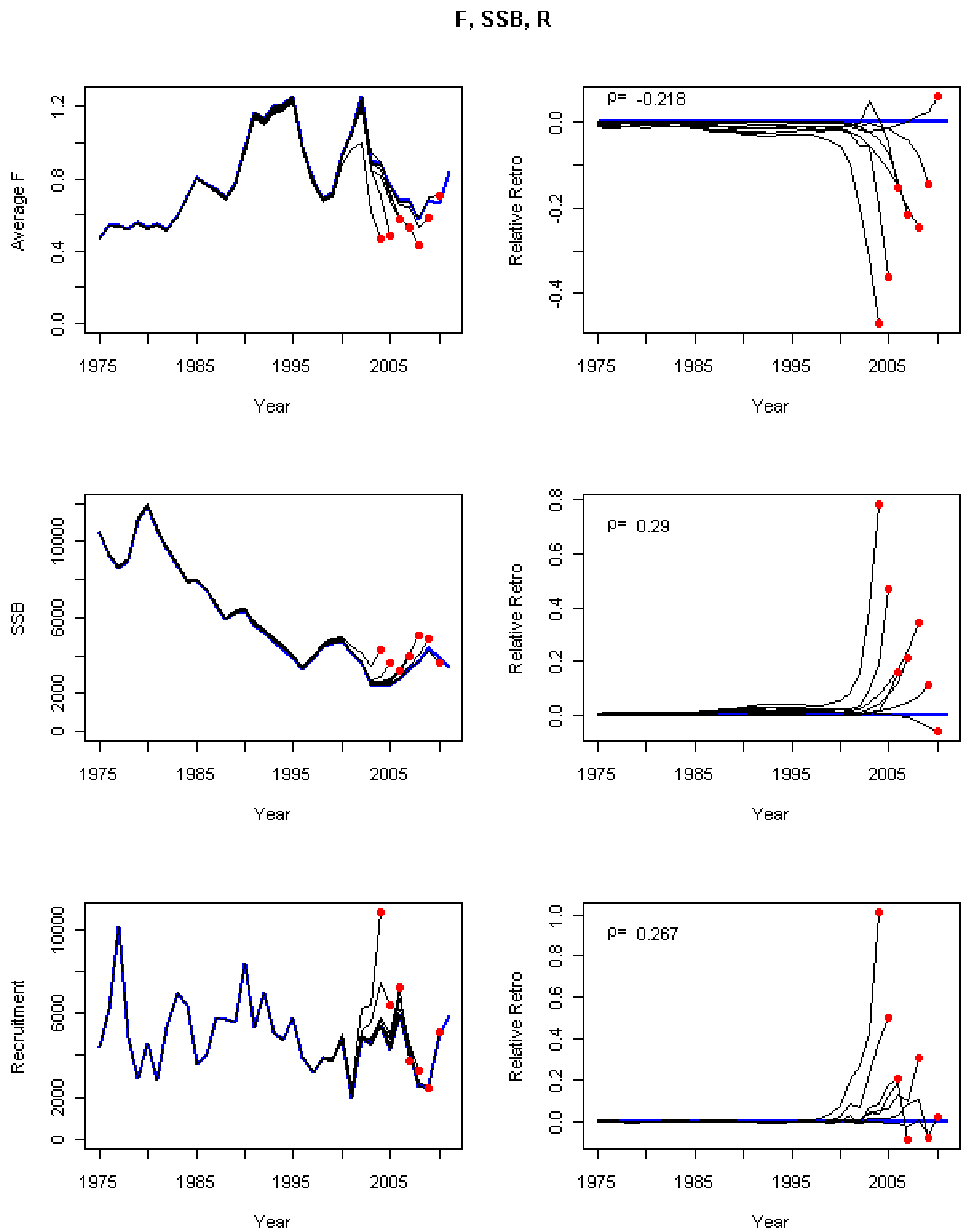


Figure 2.6.25. Retrospective patterns for fishing mortality rate (ages 6–9+), spawning–stock biomass, and recruitment. Left panels show regular scale, right panels show relative differences compared to the final estimates. Rho values denote the average of the endpoints from the seven peels.

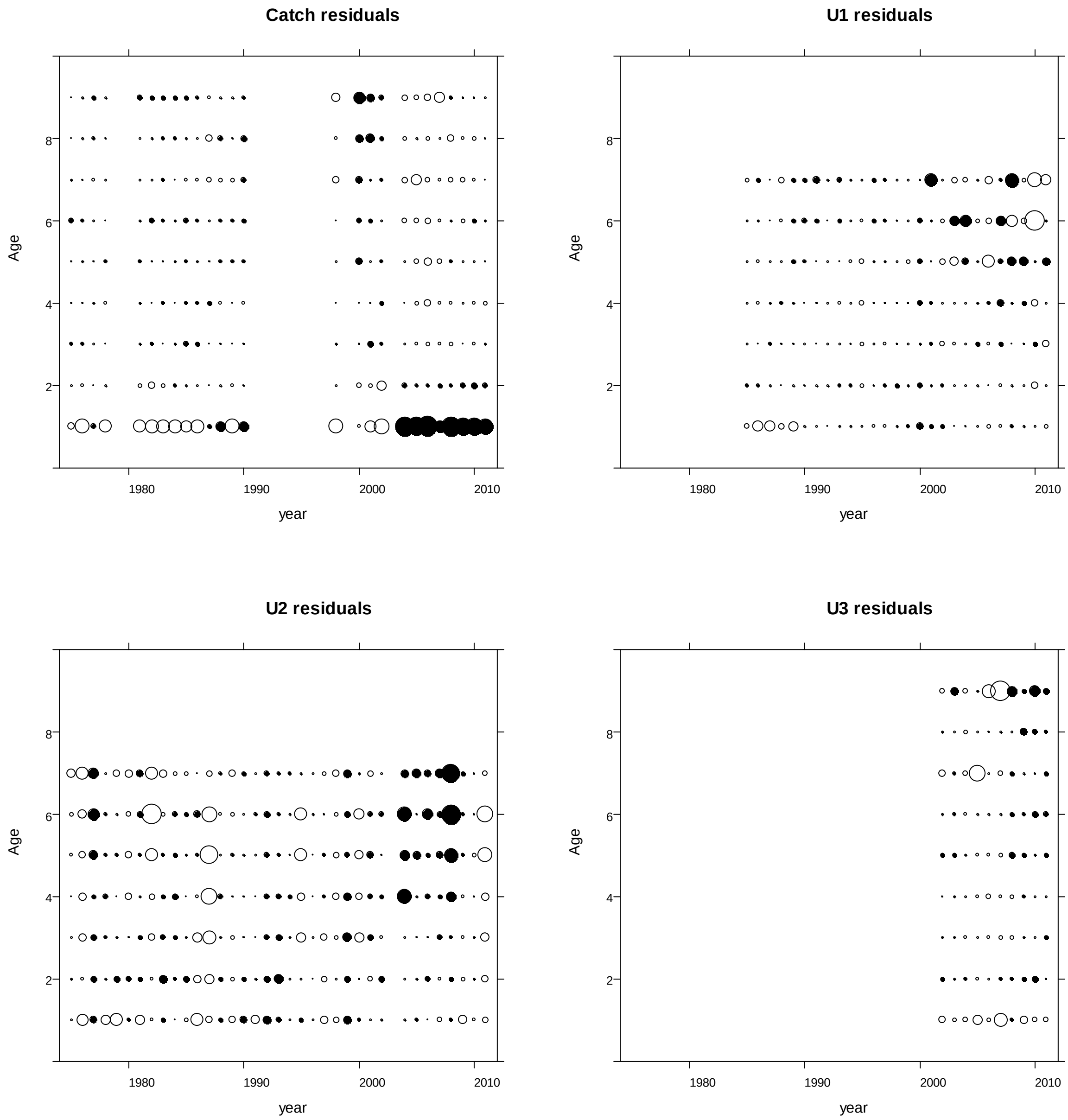


Figure 2.6.26. Residuals from exploratory assessment run with a single selectivity from four data sources.

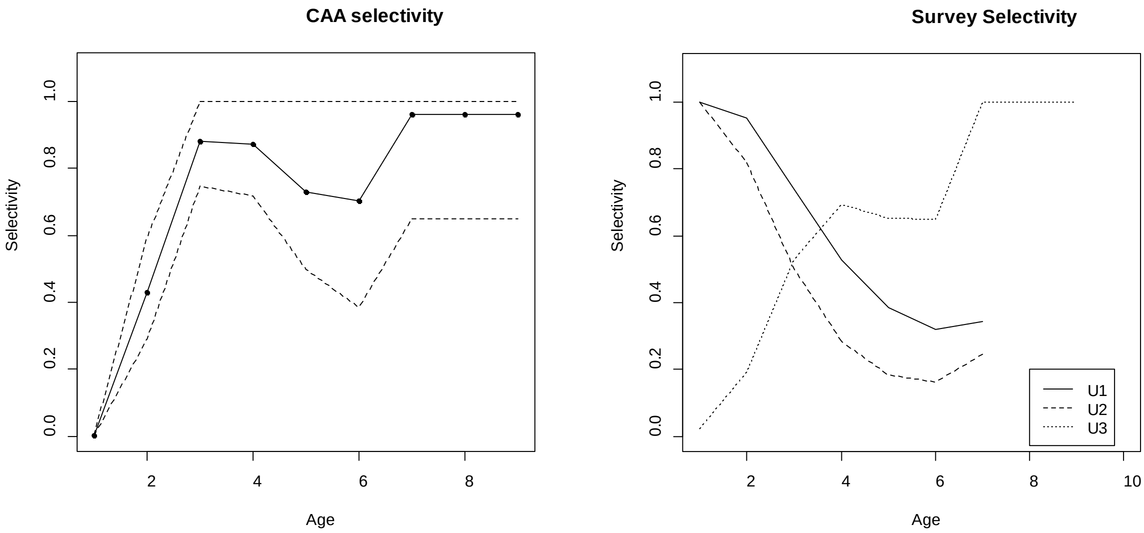


Figure 2.6.27. Estimated selectivity-at-age patterns for the catch-at-age matrix (left panel) and the three tuning indices (right panel), resulting from the exploratory spline run with only a single selectivity period.

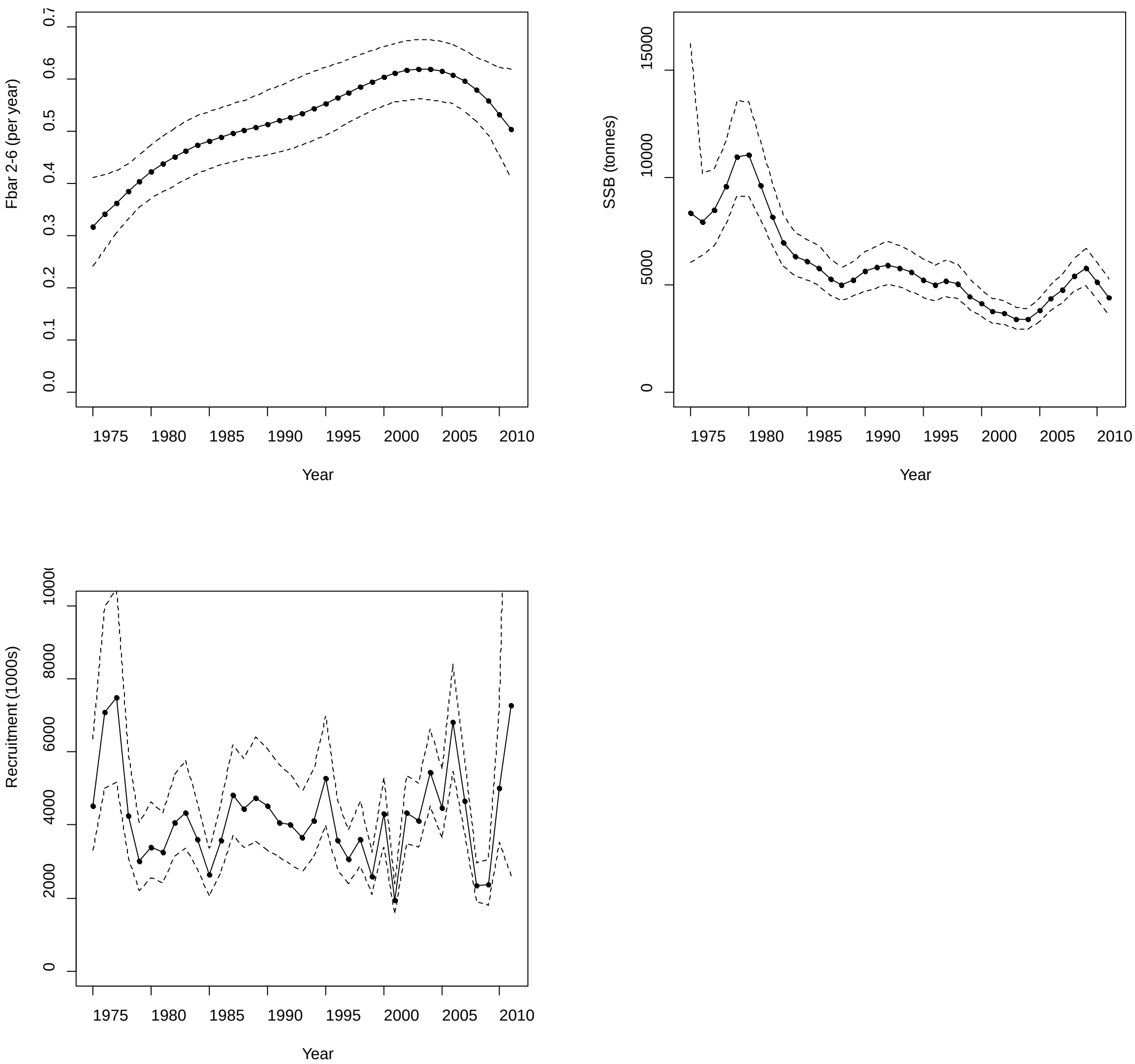


Figure 2.6.28. F, SSB, and R from exploratory runs turbot assessment with a single selectivity.

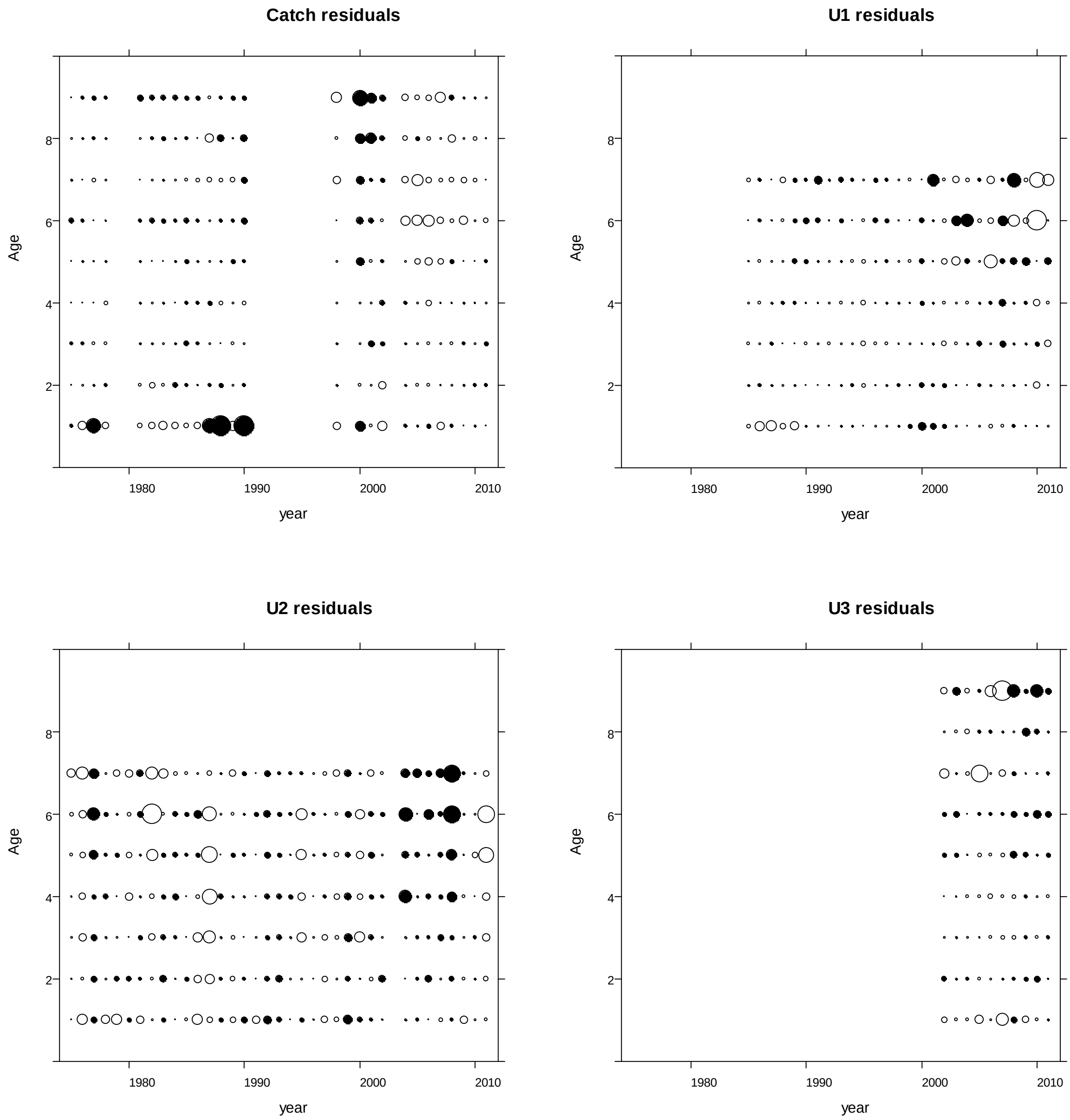


Figure 2.6.29. Residuals for all data sources for the spline model with two separate selectivity patterns.

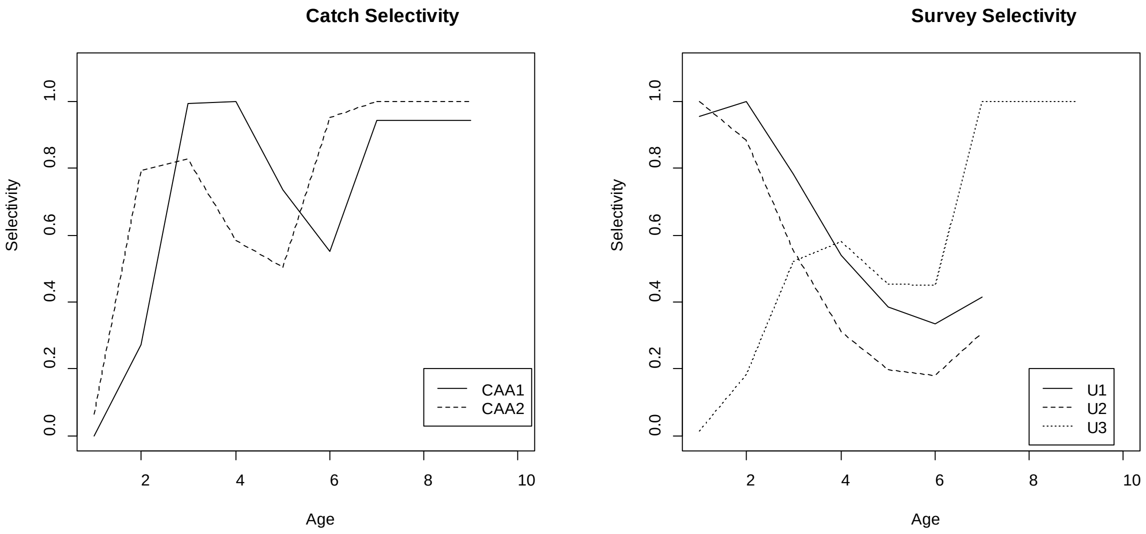


Figure 2.6.30. Selectivity patterns for all data sources for the spline model with two separate selectivity patterns.

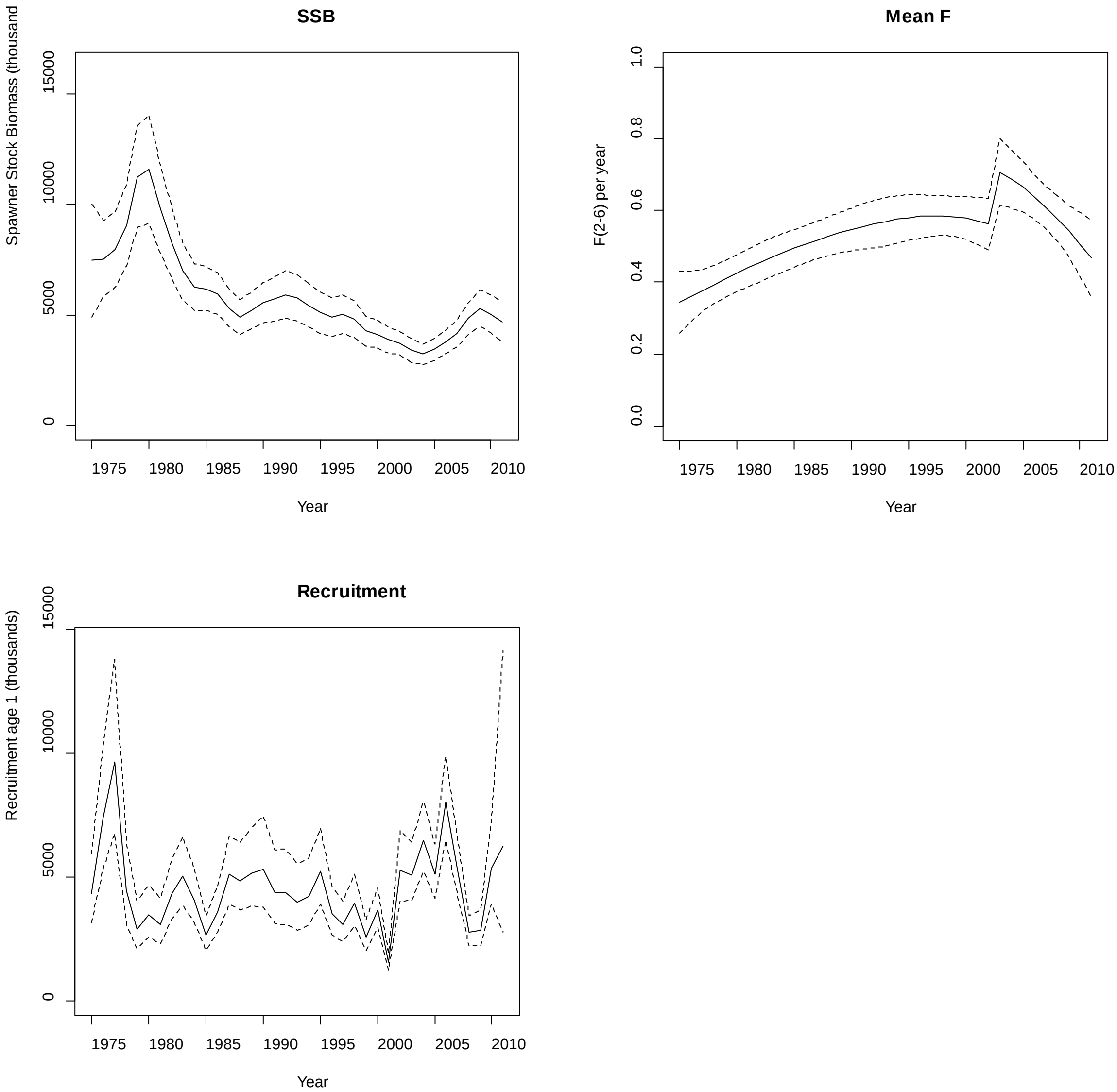


Figure 2.6.31. F, SSB, and R from exploratory runs turbot assessment (two separate selectivity patterns).

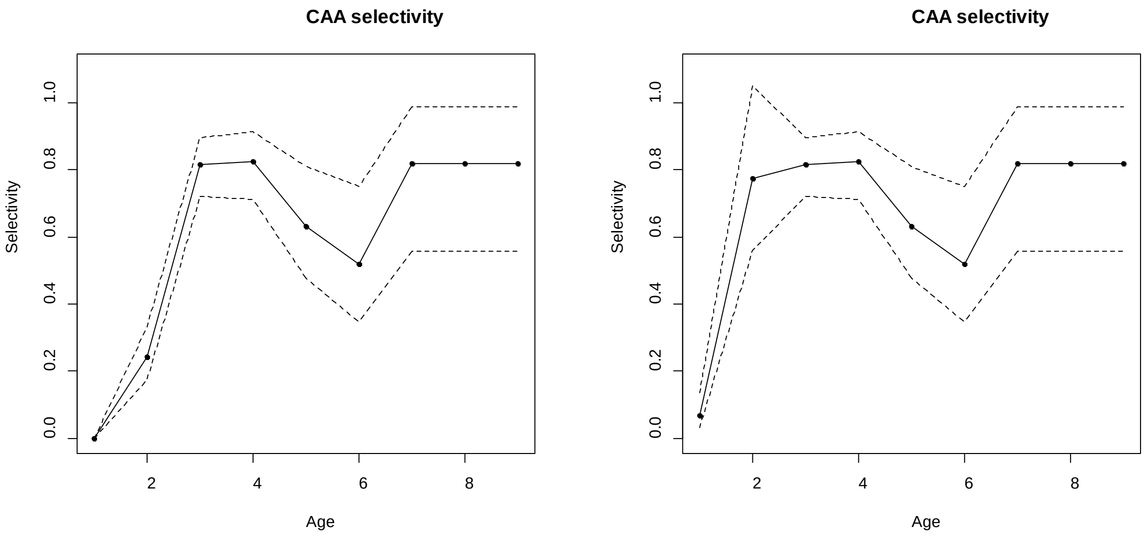


Figure 2.6.31. Fleet selectivities for the two periods 1975–2000 (left panel) and 2000–current (right panel) in run with two selectivities where age 1 and 2 differ. Drawn lines indicate 95% confidence bounds as indicated by MCMC runs.

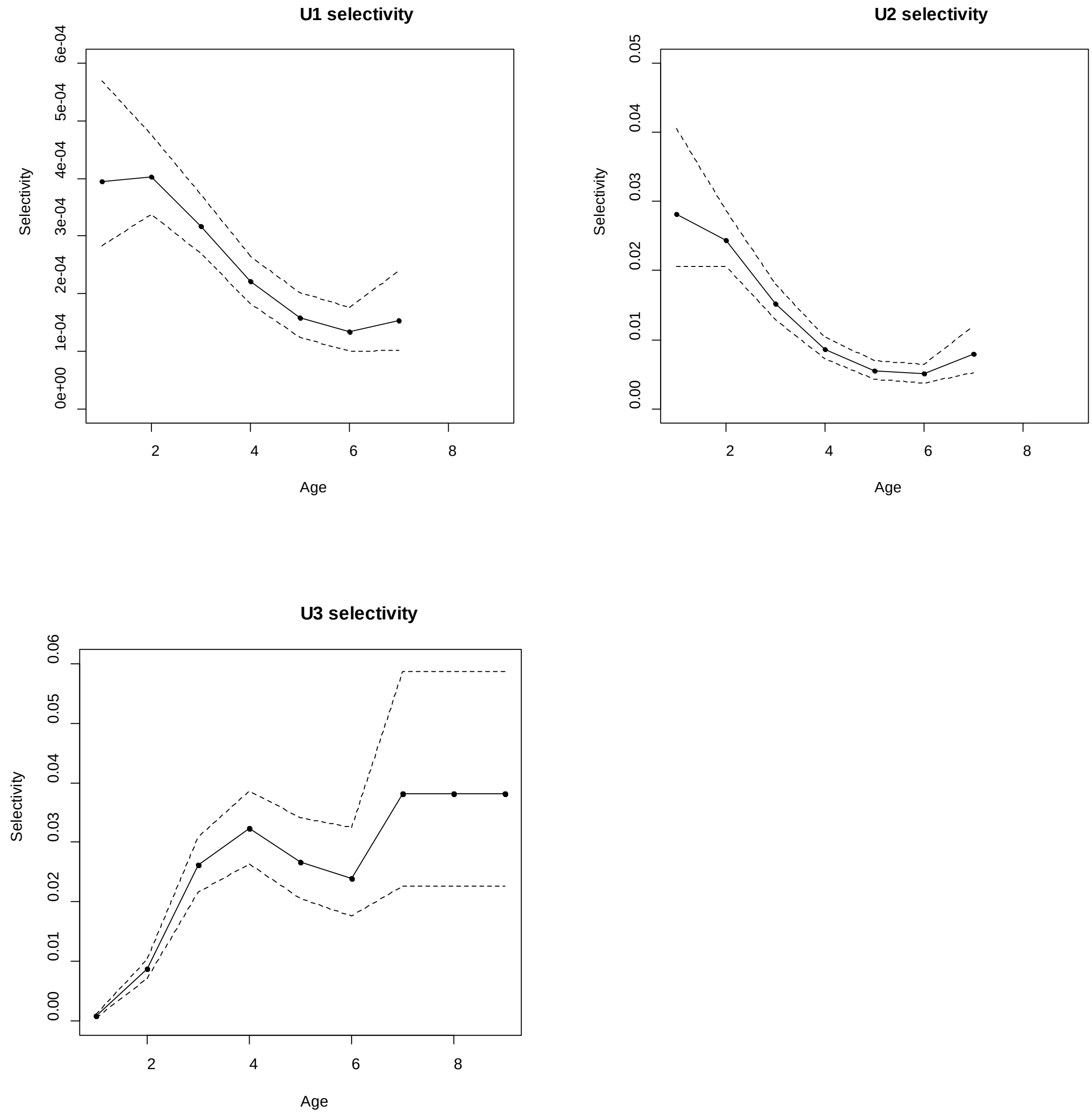


Figure 2.6.32. Selectivities for the tuning-series. Drawn lines are MCMC medians is BTS-Isis, dashed lines represent 96% confidence bounds. U1 is BTS, U2 is SNS, and U3 is Dutch beam trawl lpue tuning-series.

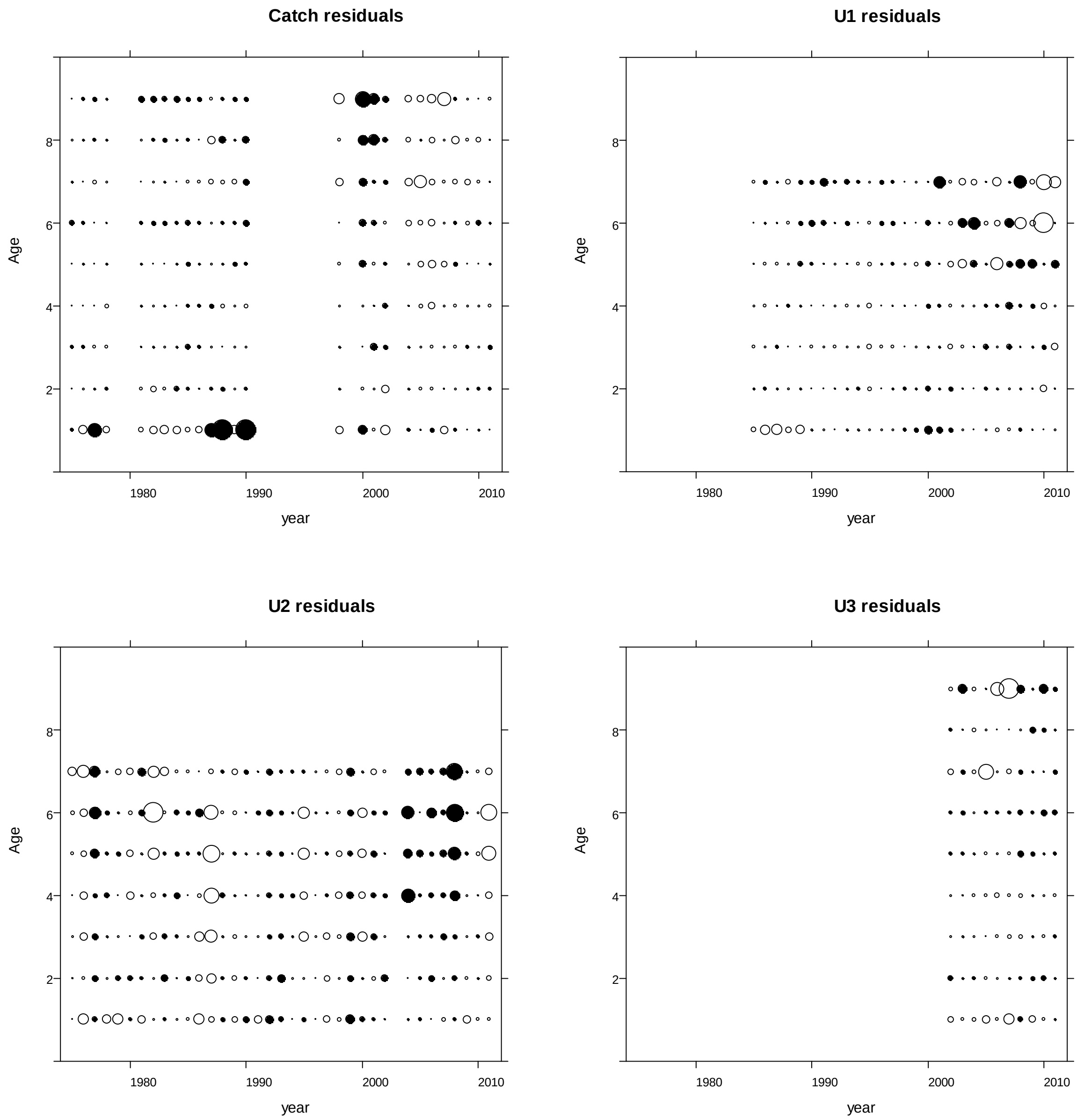


Figure 2.6.33. Residuals from different data sources, for run with two different selectivities, where only age 1 and 2 changing.

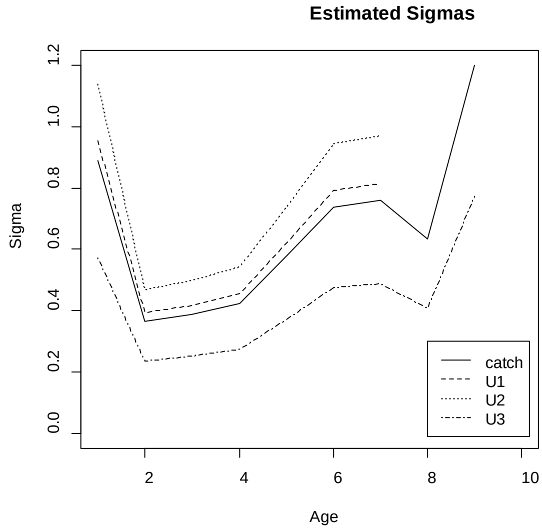


Figure 2.6.34. Age-dependent estimated sigma parameters for the four different data sources.

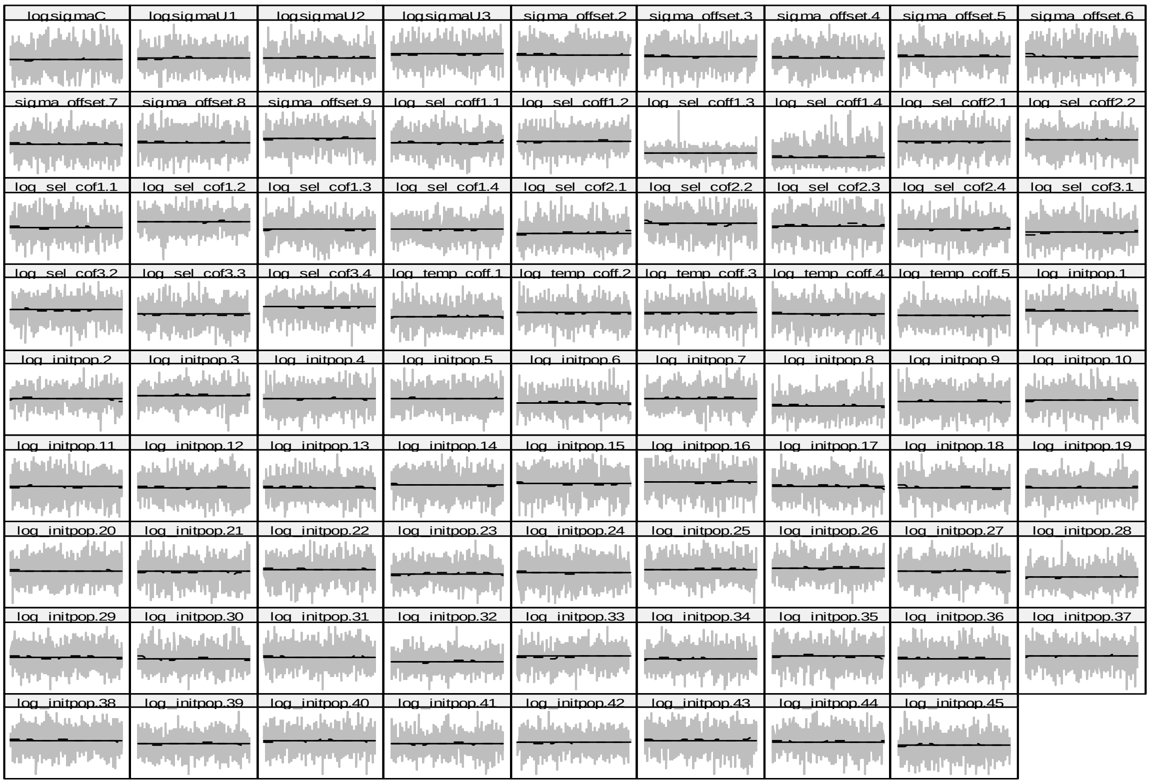


Figure 2.6.35. Traceplot of MCMC runs for final spline model.

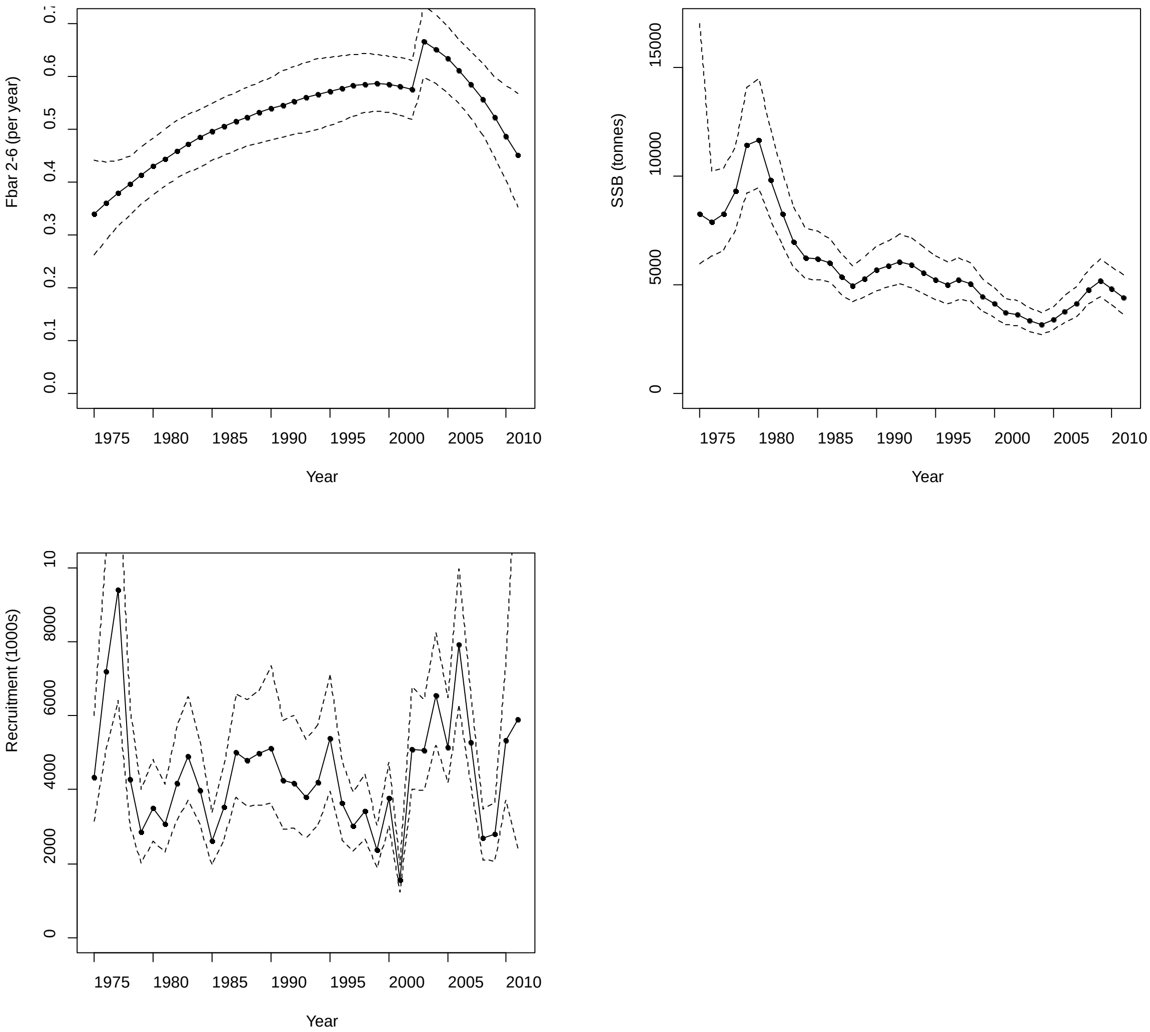


Figure 2.6.36. Final model assessment outcomes for F, SSB, and R.

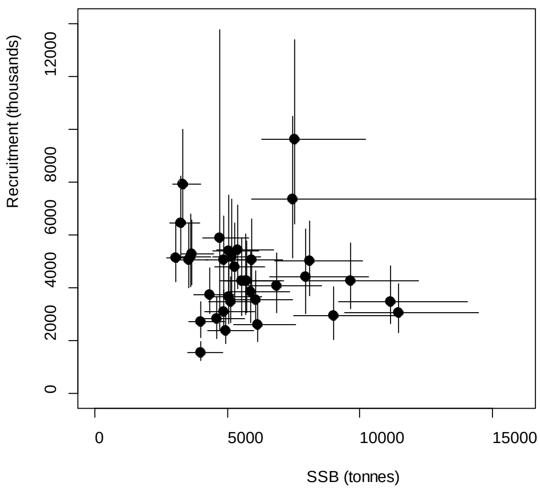


Figure 2.6.37. Stock–recruitment relationship. Horizontal and vertical drawn lines indicate 95% confidence bounds of SSB and R estimates as estimated by MCMC runs.

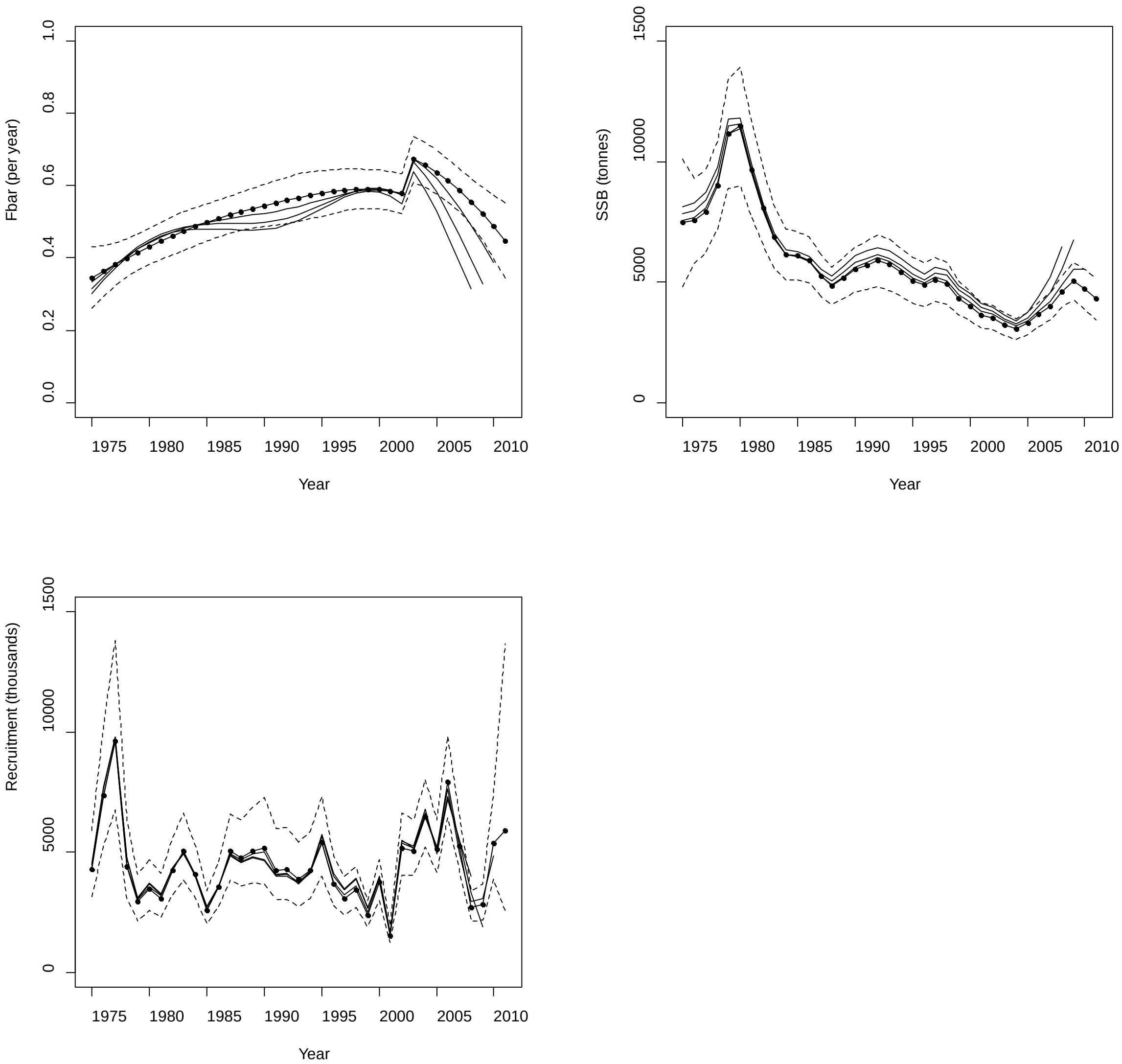


Figure 2.6.38. Retrospective analysis of final spline assessment model.

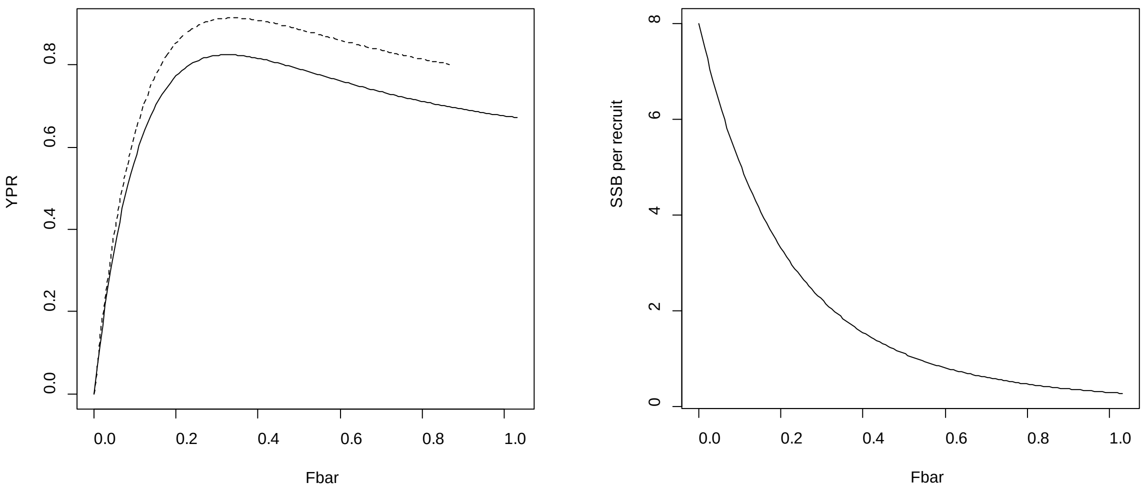


Figure 2.6.39. Deterministic Yield-per-recruit curve (left panel) and SSB per recruit curve (right panel). In the left panel, the drawn line in the YPR curve is derived from the selectivity pattern in the last period, while the dashed line is the selectivity pattern in the first period.

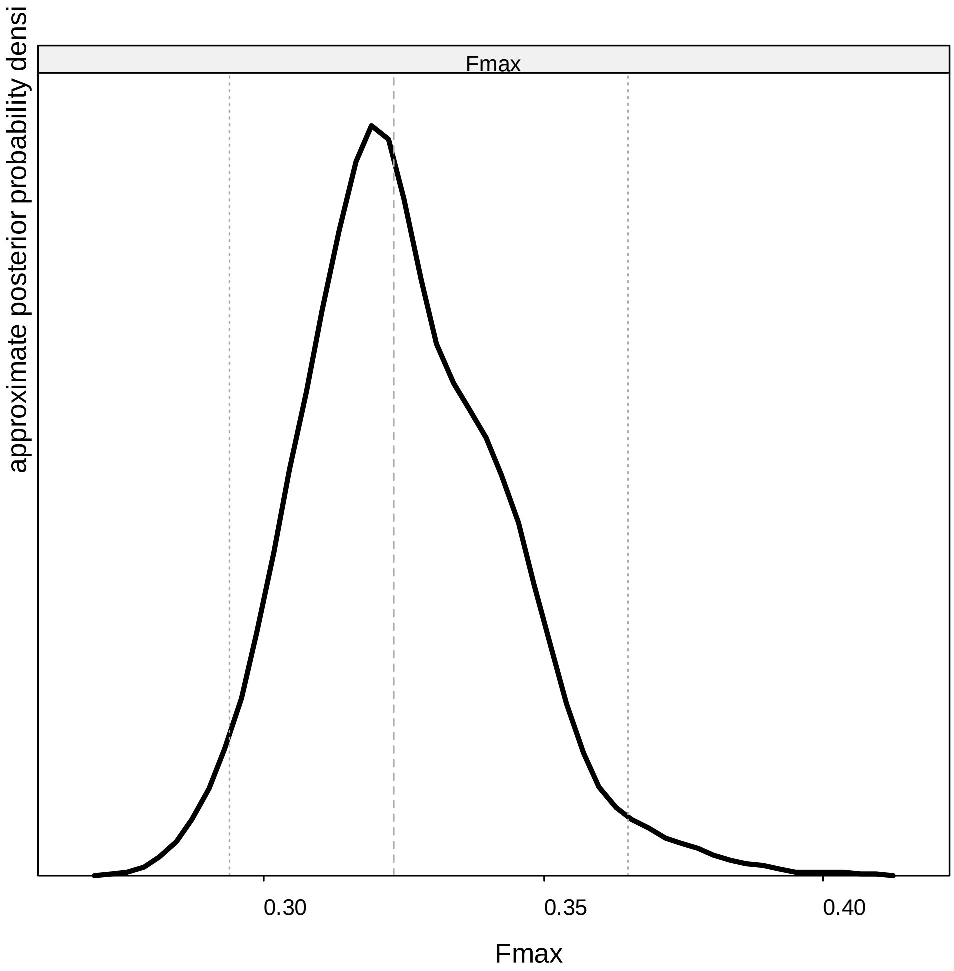


Figure 2.6.40. Posterior probability distribution of F_{MAX} in the second period, as estimated by the MCMC procedure. Outer vertical lines indicate 95% confidence bounds of F_{MAX}.

Table 2.4.1. Combined TAC for Turbot and Brill in Subarea IV and Division IIIa.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
TAC (tonnes)	9000	9000	6750	5738	4877	4550	4323	4323	5263	5263	5263	4642	4642

Table 2.6.1. International landings.

	Country								
Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Others	Total
1960	592	763	91	562	1236	15	2221	21	5501
1961	499	750	239	587	1303	0	2299	20	5697
1962	489	730	66	522	1422	0	1856	0	5085
1963	592	1158	59	693	1246	0	1970	0	5718
1964	244	746	150	537	1329	0	1901	0	4907
1965	201	510	208	393	1199	0	1711	0	4222
1966	267	670	54	467	1384	0	1497	0	4339
1967	293	536	48	457	864	0	1185	0	3383
1968	275	799	30	401	1826	0	917	0	4248
1969	219	830	23	322	2259	0	1017	0	4670
1970	151	538	96	267	1921	0	1070	0	4043
1971	178	529	62	189	2472	0	880	0	4310
1972	164	539	34	203	2523	0	951	0	4414
1973	135	412	50	194	2638	0	824	0	4253
1974	113	247	12	135	2885	0	717	0	4109
1975	158	387	21	169	3349	0	503	1	4588
1976	146	588	38	156	3253	0	631	2	4814
1977	145	474	37	172	2973	0	683	0	4484
1978	170	693	50	173	3196	0	752	0	5034
1979	187	1164	22	151	3999	0	838	3	6364
1980	162	1360	17	146	3241	0	559	0	5485
1981	142	1044	6	86	3073	0	404	0	4755
1982	153	880	14	42	3029	0	335	0	4453
1983	174	893	24	44	3163	0	277	0	4575
1984	242	886	40	46	3800	0	282	1	5297
1985	222	983	37	34	4600	0	312	0	6188
1986	133	997	5	31	3810	0	287	0	5263
1987	130	988	21	27	2760	0	345	0	4271
1988	129	858	24	41	2660	0	328	1	4041
1989	176	637	30	85	3666	0	333	0	4927
1990	292	1046	52	184	3732	0	437	7	5750
1991	350	1233	64	186	3780	30	688	9	6340
1992	317	907	81	163	3495	65	902	3	5933
1993	355	817	123	252	2939	47	1013	0	5546
1994	330	862	141	263	2724	42	882	0	5244
1995	315	761	108	275	2476	33	703	0	4671
1996	210	618	160	157	1776	36	687	0	3644
1997	169	479	1	215	1854	45	619	0	3382

	Country								
Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Others	Total
1998	198	392	22	164	1695	33	582	0	3086
1999	224	411	0	224	1808	32	488	0	3187
2000	302	469	21	349	2280	55	549	0	4025
2001	333	506	17	297	2226	79	642	0	4100
2002	243	677	15	280	1898	85	551	0	3749
2003	192	486	18	289	1893	65	431	0	3374
2004	207	518	15	278	1762	74	463	0	3317
2005	159	429	18	274	1903	65	347	0	3195
2006	146	338	22	221	1828	40	381	0	2976
2007	173	310	32	203	2263	43	485	0	3509
2008	182	457	21	199	1744	32	370	0	3005
2009	172	548	24	197	1698	29	421	0	3089
2010	118	466	37	191	1469	26	385	0	2692
2011	122	547	31	144	1518	28	381	0	2771

Table 2.6.2. Discards information since 2002 for the Dutch beam trawl fleet including sources.

Year	Turbot (N per hour)	Source
2002	NA	CVO report Number: 04.010
2003	<1	CVO report Number: 04.024
2004	0.3	CVO report Number: 05.006
2005	NA	IMARES Report C061/06
2006	NA	CVO report Number: 07.011
2007	<0.1	CVO report Number: 08.008

Table 2.6.3. Catch-at-age matrix.

	age								
year	1	2	3	4	5	6	7	8	9
1975	0.8	427	1012	239	108	124.2	90	46.9	41.7
1976	0	350	1346	392	114	75.9	57.4	50.2	38.2
1977	18.2	895	644	531	166	43.8	30.5	42	36.6
1978	0	1324	1273	309	268	76	37.6	29	20.4
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	0	299	755	532	458	175	67	35	40
1982	0	169	1046	267	167	292	98	49	41
1983	0	402	673	479	110	113	180	91	31
1984	0	1296	1223	311	157	60	57	74	51
1985	0	795	2415	654	179	109	26	38	48
1986	0	371	1470	697	183	67	29	16	18
1987	13	648	546	676	158	52	19	5	5
1988	36	1084	897	178	176	90	28	42	10
1989	0	594	1037	315	139	73	28	22	10
1990	43	957	1032	305	160	73	98	58	13
1991	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA
1998	0	540	1158	476	97	39.3	11.3	10.1	0.91
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	4.5	255	938	270	315	144.7	116.1	51.3	58.79
2001	0	478	1642	357	64	75.5	55.1	64.7	21.58
2002	0	67	1565	463	148	24.3	43.8	29.2	11.36
2003	NA	NA	NA	NA	NA	NA	NA	NA	NA
2004	490.8	2234	894	156	93	10.9	8.5	4.1	1.02
2005	291.1	1678	611	195	21	18.5	2.2	11.8	1.03
2006	705.7	1312	644	95	28	6.3	12.9	3.1	0.7
2007	79.9	2829	627	290	41	29.6	8.4	9.5	0
2008	184.5	1404	854	229	203	49	13.4	1.2	6.81
2009	116.9	1076	1005	434	92	25.9	11.4	7.8	1.65
2010	236.8	1193	328	263	146	74.9	26	6	4.48
2011	216.3	1991	618	114	141	79	33	16.1	3.32

Table 2.6.4. Sampling information from BTS survey.

year	numbers caught		index		no. aged	direct age estimate
	ISIS	Tridens	ISIS	Tridens		
1985	61		2.14			
1986	52		1.62			
1987	56		1.86			
1988	164		2.25			
1989	85		2.39			
1990	202		3.85			
1991	146		3.17		178	3
1992	145		2.93		142	2
1993	159		3.38		167	0
1994	207		3.57		169	1
1995	144		2.57		138	0
1996	115	4	2.75	0.22	166	12
1997	107	3	2.45	0.15	141	4
1998	141	2	3.22	0.09	144	26
1999	155	1	2.76	0.04	149	30
2000	239	6	5.72	0.17	188	59
2001	125	9	2.77	0.22	150	44
2002	139	5	3.56	0.13	15	4
2003	125	6	2.66	0.13	196	78
2004	152	10	3.33	0.18	194	89
2005	143	9	3.38	0.32	144	87
2006	125	11	2.90	0.17	120	93
2007	145	14	3.24	0.38	171	97
2008	127	14	3.10	0.26	162	101
2009	98	16	2.22	0.44	121	78
2010	44*	33*	2.34	0.31	114	58
2011	105	14	3.10	0.48	167	87

*** In 2010, the BTS ISIS only finished part of the survey. Part of the survey was taken over by Tridens.**

Table 2.6.5. BTS Isis age-structured survey index (Number per hour). Figures in bold are used in assessment.

		AGE									
YEAR	EFFORT	0	1	2	3	4	5	6	7	8	9
1985	1	0.001	**0.496**	**1.180**	**0.314**	**0.098**	**0.030**	**0.015**	**0.005**	0.001	0.001
1986	1	0.000	**0.273**	**0.861**	**0.310**	**0.093**	**0.029**	**0.016**	**0.013**	0.009	0.007
1987	1	0.001	**0.333**	**1.010**	**0.319**	**0.111**	**0.035**	**0.018**	**0.007**	0.008	0.004
1988	1	0.002	**0.678**	**1.112**	**0.317**	**0.090**	**0.027**	**0.013**	**0.004**	0.001	0.001
1989	1	0.010	**0.435**	**1.299**	**0.425**	**0.114**	**0.040**	**0.024**	**0.016**	0.011	0.007
1990	1	0.011	**2.120**	**1.199**	**0.313**	**0.121**	**0.041**	**0.021**	**0.011**	0.005	0.003
1991	1	0.005	**1.333**	**1.219**	**0.403**	**0.113**	**0.041**	**0.023**	**0.014**	0.007	0.004
1992	1	0.005	**1.380**	**1.087**	**0.302**	**0.093**	**0.030**	**0.017**	**0.007**	0.003	0.002
1993	1	0.005	**1.603**	**1.301**	**0.296**	**0.085**	**0.039**	**0.024**	**0.015**	0.006	0.003
1994	1	0.061	**1.782**	**1.256**	**0.332**	**0.077**	**0.026**	**0.015**	**0.009**	0.006	0.004
1995	1	0.014	**1.653**	**0.639**	**0.180**	**0.049**	**0.017**	**0.010**	**0.006**	0.003	0.001
1996	1	0.002	**1.045**	**1.272**	**0.268**	**0.083**	**0.034**	**0.021**	**0.011**	0.006	0.003
1997	1	0.003	**0.898**	**1.071**	**0.317**	**0.096**	**0.033**	**0.018**	**0.008**	0.003	0.002
1998	1	0.004	**1.653**	**1.108**	**0.293**	**0.120**	**0.023**	**0.011**	**0.005**	0.001	0.001
1999	1	0.026	**1.374**	**1.025**	**0.216**	**0.074**	**0.022**	**0.010**	**0.004**	0.001	0.001
2000	1	0.020	**4.015**	**1.146**	**0.346**	**0.112**	**0.042**	**0.028**	**0.005**	0.002	0.001
2001	1	0.007	**1.179**	**1.156**	**0.252**	**0.104**	**0.019**	**0.010**	**0.044**	0.001	0.001
2002	1	0.015	**2.719**	**0.605**	**0.159**	**0.039**	**0.010**	**0.004**	**0.003**	0.001	0.001
2003	1	0.083	**1.472**	**0.884**	**0.100**	**0.074**	**0.004**	**0.038**	**0.001**	0.000	0.000
2004	1	0.071	**2.036**	**0.778**	**0.286**	**0.029**	**0.067**	**0.040**	**0.002**	0.018	0.000
2005	1	0.006	**1.357**	**1.399**	**0.490**	**0.100**	**0.012**	**0.006**	**0.003**	0.001	0.001
2006	1	0.005	**1.551**	**0.939**	**0.294**	**0.101**	**0.003**	**0.002**	**0.001**	0.000	0.000
2007	1	0.001	**1.216**	**1.080**	**0.577**	**0.264**	**0.051**	**0.043**	**0.003**	0.001	0.001
2008	1	0.002	**1.165**	**1.165**	**0.498**	**0.113**	**0.118**	**0.001**	**0.039**	0.000	0.000
2009	1	0.002	**0.979**	**0.495**	**0.397**	**0.229**	**0.112**	**0.006**	**0.002**	0.000	0.000
2010	1	0.011	**1.731**	**0.200**	**0.299**	**0.042**	**0.060**	**0.000**	**0.000**	0.000	0.000
2011	1	0.002	**1.728**	**1.051**	**0.075**	**0.048**	**0.125**	**0.028**	**0.001**	0.040	0.000

Table 2.6.6. SNS age-structured survey index (Number per 100 hour). Figures in bold are used in assessment.

		AGE									
Year	effort	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	8	9
1975	1	6.03	**100.4**	**81.3**	**17.59**	**3.84**	**1.20**	**0.67**	**0.42**	0.01	0.03
1976	1	0.23	**50.0**	**53.6**	**11.43**	**2.53**	**0.71**	**0.33**	**0.19**	0.01	0.03
1977	1	49.53	**414.9**	**206.5**	**41.92**	**10.99**	**5.45**	**3.11**	**2.45**	0.67	0.28
1978	1	0.03	**38.3**	**132.0**	**43.80**	**10.43**	**3.17**	**1.54**	**0.55**	0.07	0.08
1979	1	0.02	**20.1**	**120.3**	**43.55**	**9.59**	**2.97**	**1.42**	**0.43**	0.10	0.10
1980	1	0.77	**115.3**	**71.7**	**22.04**	**5.21**	**1.61**	**0.72**	**0.46**	0.06	0.04
1981	1	0.19	**29.1**	**70.5**	**20.44**	**6.28**	**4.45**	**3.03**	**1.87**	0.85	0.34
1982	1	7.03	**89.6**	**38.7**	**7.74**	**2.06**	**0.42**	**0.16**	**0.31**	0.04	0.02
1983	1	0.57	**168.4**	**140.5**	**23.90**	**5.62**	**1.46**	**0.66**	**0.54**	0.03	0.03
1984	1	0.76	**93.4**	**79.3**	**26.11**	**6.45**	**1.88**	**0.94**	**0.46**	0.08	0.09
1985	1	0.17	**51.0**	**93.0**	**21.45**	**4.47**	**1.35**	**0.85**	**0.31**	0.00	0.02
1986	1	0.14	**23.8**	**17.2**	**5.44**	**3.63**	**1.89**	**1.20**	**0.42**	0.11	0.06
1987	1	0.40	**63.1**	**17.6**	**2.52**	**0.59**	**0.18**	**0.11**	**0.21**	0.00	0.00
1988	1	0.82	**166.6**	**101.4**	**17.84**	**4.14**	**1.10**	**0.59**	**0.58**	0.85	0.45
1989	1	3.68	**66.7**	**45.5**	**14.22**	**3.86**	**1.03**	**0.40**	**0.25**	0.07	0.07
1990	1	1.34	**241.6**	**97.4**	**19.15**	**4.99**	**1.18**	**0.36**	**0.58**	0.07	0.03
1991	1	0.08	**43.8**	**76.1**	**19.40**	**4.10**	**1.23**	**0.63**	**0.23**	0.03	0.03
1992	1	1.63	**262.5**	**111.7**	**30.47**	**7.61**	**2.18**	**1.23**	**0.60**	0.05	0.06
1993	1	0.46	**163.3**	**147.6**	**30.14**	**7.22**	**1.77**	**0.78**	**0.55**	0.09	0.05
1994	1	8.18	**99.5**	**49.8**	**18.97**	**5.29**	**1.30**	**0.69**	**0.50**	0.09	0.06
1995	1	1.38	**194.2**	**55.2**	**5.05**	**1.53**	**0.26**	**0.13**	**0.48**	0.00	0.00
1996	1	0.36	**88.4**	**76.8**	**14.79**	**3.12**	**1.03**	**0.54**	**0.34**	0.00	0.01
1997	1	0.15	**35.4**	**27.3**	**10.64**	**4.41**	**1.17**	**0.47**	**0.22**	0.11	0.06
1998	1	0.33	**57.3**	**41.1**	**9.48**	**2.11**	**0.53**	**0.29**	**0.15**	0.03	0.01
1999	1	1.23	**163.1**	**98.4**	**28.70**	**6.33**	**1.90**	**0.82**	**0.62**	0.08	0.10
2000	1	1.11	**153.7**	**38.5**	**4.43**	**1.26**	**0.30**	**0.17**	**0.32**	0.00	0.00
2001	1	0.28	**47.7**	**36.4**	**17.39**	**4.53**	**1.29**	**0.55**	**0.18**	0.14	0.04
2002	1	8.71	**132.4**	**49.3**	**12.99**	**2.93**	**0.79**	**0.48**	**0.19**	0.03	0.03
2003	1	NA	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	NA	NA
2004	1	1.73	**173.5**	**48.3**	**14.30**	**7.58**	**2.67**	**1.16**	**0.46**	0.07	0.10
2005	1	0.85	**148.0**	**84.9**	**15.19**	**3.73**	**0.87**	**0.39**	**0.35**	0.04	0.01
2006	1	1.08	**179.6**	**104.0**	**20.76**	**4.83**	**1.24**	**0.56**	**0.48**	0.07	0.03
2007	1	0.43	**81.0**	**76.1**	**25.14**	**6.24**	**1.77**	**0.67**	**0.29**	0.12	0.05
2008	1	0.45	**78.3**	**90.0**	**33.13**	**10.82**	**5.42**	**3.49**	**2.20**	0.94	0.44
2009	1	0.11	**25.8**	**24.0**	**14.09**	**4.79**	**1.28**	**0.67**	**0.35**	0.08	0.10
2010	1	16.84	**103.9**	**36.9**	**11.23**	**4.27**	**1.19**	**0.48**	**0.37**	0.08	0.10
2011	1	15.78	**113.1**	**35.5**	**4.03**	**1.04**	**0.24**	**0.12**	**0.21**	0.00	0.00

Table 2.6.7. Standardized Dutch Beam trawl fleet index.

		age								
Year	effort	1	2	3	4	5	6	7	8	9
2002	1	1.85	14.11	29.96	8.6	5.99	2.06	0.73	0.94	0.15
2003	1	2.4	25.82	14.63	14.96	4.14	2.61	1.55	0.51	0.7
2004	1	3.01	26.98	23.44	5.16	5.78	1.18	0.91	0.31	0.12
2005	1	1.38	22.89	24.9	10.66	1.74	2.73	0.15	0.46	0.17
2006	1	4.06	19.98	26.86	8.13	3.96	1.21	1.52	0.37	0.03
2007	1	0.95	42.05	20.13	13.47	3.7	2.67	0.45	0.66	0
2008	1	2.64	29.5	33.14	10.81	11.6	3.43	2.42	0.25	0.7
2009	1	0.88	17.13	37.74	28.76	8.48	4.09	1.94	1.29	0.14
2010	1	2.68	22.15	14.44	15.19	11.47	5.4	2.52	1.07	0.85
2011	1	4.19	27.98	23.53	8.17	9.89	8.13	3.23	1.29	0.51

Table 2.6.8. Stock and catch weight-at-age vectors.

	age								
	1	2	3	4	5	6	7	8	9
Catch weight-at-age	0.5	0.8	1.27	2.04	2.98	3.99	4.88	5.57	6.32
Stock weight-at-age	0.77	0.69	1.17	1.94	2.76	3.80	4.65	5.48	5.94

Table 2.6.9. Von Bertalanffy growth parameters for North Sea turbot from literature: L_∞, asymptotic length (cm); *K*, growth coefficient.

L∞ (males)	L∞ (females)	K (males)	K (females)	Authors
55.50	64.10	0.23	0.23	Mengi (1963)
49.20	64.80	0.37	0.26	Jones (1974)
50.92	68.65	0.33	0.23	Weber (1979)
47.70	74.20	0.44	0.19	Ongenae and De Clerck (1998)

Table 2.6.3.10. Average length for each year class of female turbot (source: ILVO market sampling, 1996–2001).

Age	1	2	3	4	5	6	7+
Average length	34,67	36,53	40,80	47,06	51,26	54,28	60,41
Total number of ind.	15	235	431	394	222	121	92

Table 2.6.3.11. Average length for each year class of male turbot (source: ILVO market sampling, 1996–2001).

Age	1	2	3	4	5	6	7+
Average length	33,67	32,68	35,16	38,61	40,30	41,38	45,48
Total number of ind.	6	225	431	195	73	26	29

Table 2.6.3.12. Estimates of natural mortality by age for turbot in the North Sea using the equation from Gislason *et al*. (2010).

FEMALES								
Mengi (1963)			k= 0,23	Linf= 64,1				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,64	-0,72	-0,90	-1,13	-1,27	-1,36	-1,53	
M	0,53	0,49	0,41	0,32	0,28	0,26	0,22	0,30
Jones (1974)			k=0,26	Linf= 64,8				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,50	-0,58	-0,76	-0,99	-1,13	-1,22	-1,39	
M	0,61	0,56	0,47	0,37	0,32	0,29	0,25	0,34
Weber (1979)			k=0,23	Linf= 68,65				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,54	-0,62	-0,80	-1,03	-1,17	-1,26	-1,43	
M	0,58	0,54	0,45	0,36	0,31	0,28	0,24	0,33
Ongenae and De Clerck (1998)			k= 0,19	Linf= 74,2				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,62	-0,70	-0,88	-1,11	-1,25	-1,34	-1,51	
M	0,54	0,50	0,41	0,33	0,29	0,26	0,22	0,30
MALES								
Mengi (1963)			k= 0,23	Linf= 55,5				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,80	-0,75	-0,87	-1,02	-1,09	-1,13	-1,28	
M	0,45	0,47	0,42	0,36	0,34	0,32	0,28	0,34
Jones (1974)			k= 0,37	Linf = 49,2				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,50	-0,45	-0,57	-0,72	-0,79	-0,83	-0,98	
M	0,61	0,64	0,57	0,49	0,46	0,44	0,38	0,46
Weber (1979)			k= 0,33	Linf= 50,92				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,56	-0,51	-0,63	-0,78	-0,85	-0,89	-1,05	
M	0,57	0,60	0,53	0,46	0,43	0,41	0,35	0,44
Ongenae and De Clerck (1998)			k= 0,44	Linf= 47,7				
Age	1	2	3	4	5	6	7+	avg 3–7+
Ln(M)	-0,37	-0,32	-0,44	-0,59	-0,66	-0,70	-0,85	
M	0,69	0,73	0,65	0,56	0,52	0,50	0,43	0,53

Table 2.6.13. Overview of reproductive characteristics of turbot from different ICES-areas (after Moreau, 2010).

	North Sea/ Skagerrak	English Channel	Celtic Sea	Irish Sea
Proportion females (age 2–5 years)	50–80%	30–50%	40–60%	40–50%
Proportion females (age >5 years)	60–80%	10–100%	35–100%	30–100%
Spawning period	Apr–Aug	May–Sep	Apr–Jul?	May–Aug?
Length at 0% maturity	30 cm	35 cm	35 cm	35 cm
Length at full maturity	47 cm	ND	ND	ND
Age-at-maturity males	3 years	3 years	3 years	3 years
Age-at-maturity females	4–5 years	4–5 years	4–5 years	4–5 years
Monthly variation in condition factor	NO	NO	NO	NO

ND*: not determined.

Table 2.6.14. Maturity ogives for female North Sea Turbot, derived from the data and a General Linear Model, period 1996–2009 (source: Dutch market sampling and surveys). The maturity ogive predicted by the GLM is proposed to be used in the stock assessment by IBPNew 2012.

Age	0	1	2	3	4	5	6	7	8	9	10
number immature	4	96	520	42	0	0	0	2	0	0	0
number mature	0	19	391	1170	890	505	309	160	82	42	32
Mat. ogive (data)	0.0	0.2	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Mat. ogive (GLM)	**0.0**	**0.0**	**0.5**	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**

3 Sea bass in the Northeast Atlantic

3.1 Stock ID and substock structure

Bass *Dicentrarchus labrax* is a widely distributed species in Northeast Atlantic shelf waters with a range from southern Norway, through the North Sea, the Irish Sea, the Bay of Biscay, the Mediterranean and the Black Sea to Northwest Africa. The species is at the northern limits of its range around the British Isles and southern Scandinavia. Stock identity of European sea bass was reviewed by WGNEW 2012 and further considered at ICES IBPNew 2012.

Evidence from genetics studies

Although Child (1992) suggested that there may be genetic differences between immature bass from the Irish Sea and elsewhere, other work (Tobin, Galway University, unpublished manuscript), using samples of 0-group bass from the Camel and Tamar Estuaries (SW England), the Scheldt Estuary in Belgium and two Irish samples, suggests that there is little, if any, sign of population structuring. In addition, work by Durand, Bonhomme and Morizur (2001) on adult bass captured at the main spawning grounds in VIIe, VIIf, VIIIa and VIIIb suggested that the genetic differentiation between spawning grounds is very limited, suggesting that mixing between generations is sufficient to homogenize the genetic make-up of each subpopulation. Fritsch *et al.* (2007) investigated eight microsatellite loci of juvenile and adult bass caught in the Bay of Biscay and the English Channel and of five loci of bass caught in Ireland and Scotland. Genetic data showed no significant population differentiation, indicting substantial gene flow. However, results suggested that Irish and Scottish populations could be separated from the Bay of Biscay and Channel, but the sample size in this case was limited.

Evidence from tagging studies

Since 2001, various proposals have been made to structure the sea bass population and its migrations and to establish stock boundaries based largely on conventional tagging studies. The 2001 ICES Study Group on Sea Bass (SGBASS) proposed four stocks (North Sea and eastern Channel; Biscay and western Channel; west coast of England & Wales, and Ireland (ICES, 2001). The SGBASS 2004 extended this to propose additional stock structuring in the eastern Channel and southern part of the western Channel (ICES 2004; Figure 3.1.1). They considered the eastern and western Channel have a mixture of resident and seasonal visiting sea bass and, although there is little evidence of a "biological" boundary between these stocks, the SGBASS suggested that the boundary between ICES Divisions VIId and VIIe be retained for assessment purposes because the respective fisheries are different in character. Very few sea bass appear to move north or south across the Hurd Deep within VIIe, which suggested to SGBASS (ICES 2004) that fish around North Brittany and the Channel Islands could be separated from UK stocks and possibly included with those in Subarea VIII (Figure 3.1.1d). The Study Group considered that for management purposes the bass population around Ireland could be regarded as a discrete stock. Finally, the bass population in the Bay of Biscay appeared to be relatively self-contained, and the Study Group proposed that this should be treated as a separate stock area.

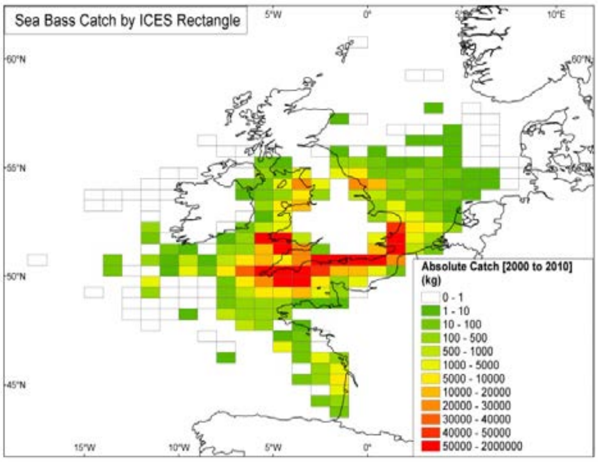
Recent genetic and tagging studies led both Fritsch *et al.* (2007) and Pawson *et al.* (2007), to question the need for six stock areas. While these authors proposed separate stock units in the North Sea and Bay of Biscay, they suggested that the English Channel and Bristol Channel could be treated as a single-stock unit, as could bass in Irish waters. In a recent study conducted by Cefas using electronic data-storage tags (Quayle *et al*., 2009), sea bass tagged near the Channel Islands in VIIe (south of Hurd Deep) moved as far as the southern North Sea, and sea bass tagged on the NE coast of England and the Thames Estuary moved into VIId in the eastern Channel (Figure 3.1.2). An electronic tagging study conducted in France in 2010–2011, presented to IBPNew 2012 (H. de Pontual, Ifremer) showed seasonal movements of bass between tagging sites off NW Brittany and the Bay of Biscay, which supports the idea of a stock in the Bay of Biscay which can mix with sea bass in the North Brittany area (area "F" in Figure 3.1.1d). State–space modelling is being developed to reconstruct individual migration routes. Preliminary results show two different patterns: either winter spawning migration towards "warm" waters (Bay of Biscay) or, more scarcely, towards colder waters (Celtic sea or western Channel).

Tagging studies presented by Pawson *et al*., (2008) show that sea bass show strong site fidelity on feeding areas and after spawning migrations are often recaptured close to the initial tagging site (55% of recaptures within 16 km of tagging site). This prompted Pawson *et al*., (2008) to suggest that management of sea bass could include selected sites designated only for catch & release sea angling to allow survival to larger sizes. The recent French tagging study also showed a high degree of homing for sea bass on summer feeding areas. Whether site fidelity also occurs on spawning grounds needs to be further investigated.

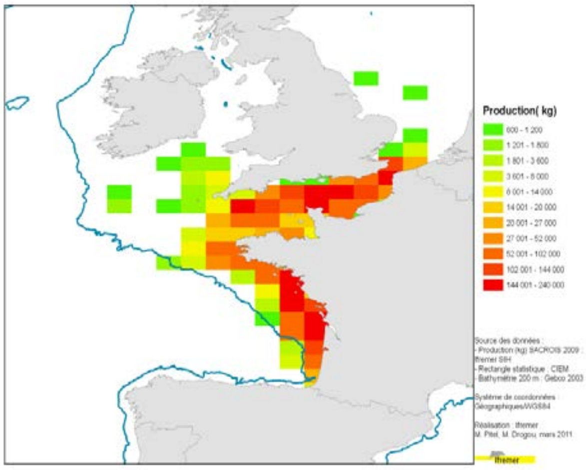
Distribution of commercial fishing catches

The most intensive fishing areas for sea bass by the UK, France and Netherlands in Subareas IV are in the southern North Sea and the fishery spreads across the North Sea–eastern Channel boundary (Figure 3.1.1a–c), which together with tagging results suggests that this is not an appropriate boundary for delimiting separate stocks for assessment purposes. This does not preclude the existence of population components that do not mix between the two areas, or the need for spatial management.

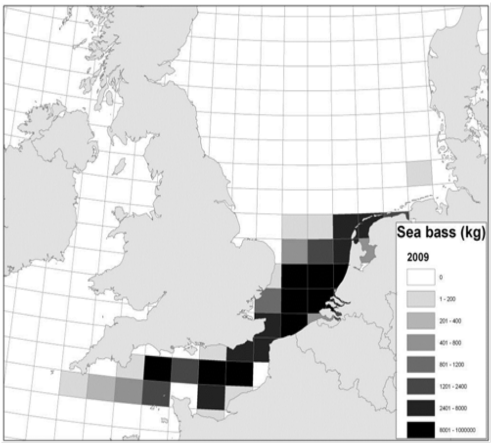
(a) United Kingdom (2001–2010)



(b) France (2009)



(c) Netherlands (2009)



(d) Stock structure proposed by SGBASS (2004)

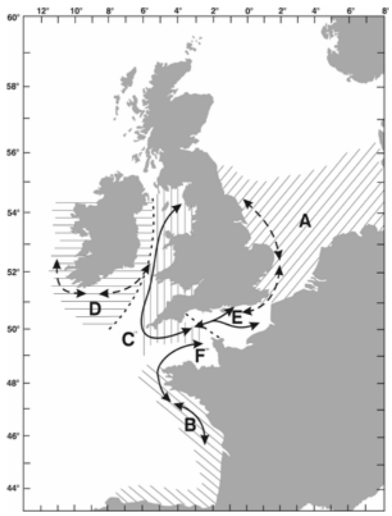


Figure 3.1.1a–d. Distribution of UK landings of bass by ICES rectangle. (a) UK aggregated over 2000–2010 for all gear types; (b) France 2009 all gears; (c) Netherlands 2009 all gears; (d) putative population structure and seasonal movements proposed by ICES SGBASS (2004) based on tagging and other information.

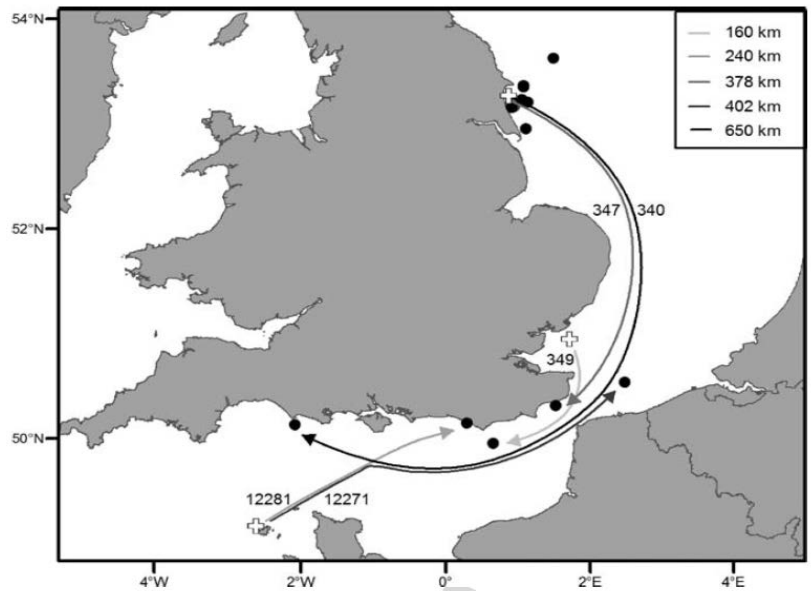


Figure 3.1.2 (a) Release and recapture positions of sea bass tagged with data-storage tags (Quayle *et al.*, 2009). Release positions shown by white crosses and recapture positions shown by black circles.

Similarities in stock trends between ICES areas

Previous WGNEW meetings have attempted to analyse the UK landings-at-age data separately for ICES Divisions IVb&c, VIId, VIIe&h, and VIIa,f&g, using simple approaches such as SURBA, as well as a complex statistical, fleet-disaggregated model (ICES 2008). The age compositions for these areas are derived from independent sampling for length and age. Historical recruitment trends were very similar for the four assessment areas, except for the most recent year classes which were estimated from only partial cohort data and without the use of recruit indices. This could reflect large-scale environmental variables affecting recruitment in all areas, but could also be an effect of stock mixing on the separate catch-at-age matrices.

Stock definitions for benchmark assessment

Further studies are needed on sea bass stock identity, using conventional and electronic tagging, genetics and other individual and population markers (e.g. otolith microchemistry and shape), together with data on spawning distribution, larval transport and VMS data for vessels tracking migrating bass shoals, to confirm and quantify the exchange rate of sea bass between sea areas that could form management units for this stock. Such information is critical to support development of models to describe the spatial dynamic of the species under environmental drivers (e.g. temperature and food). Such a modelling work is being carried out in France in the framework of a PhD study (R. Lopez).

The pragmatic view of IBPNew 2012 is to structure the baseline stock assessments into four units:

- Assessment area 1. Sea bass in ICES Areas IVbc, VIId, VIIe,h and VIIa,f&g (lack of clear genetic evidence; concentration of Area IV bass fisheries in the southern North Sea; seasonal movements of bass across ICES Divisions). This is a relatively data-rich area with data on fishery landings and length–age composition by fleet; discards estimates; growth and maturity parameters; juvenile surveys, fishery lpue trends.

- Assessment area 2. Sea bass in Biscay (ICES Subarea VIIIa,b). Available data are fishery landings, with length compositions from 2000; discards from 2009; some fishery lpue.
- Assessment area 3. Sea bass in VIIIc and IXa (landings, effort).
- Assessment area 4. Sea bass in Irish coastal waters (VIa, VIIb, VIIj). Available data: Recreational fishery catch rates; no commercial fishery operating.

Fishery landings of sea bass are extremely small in Irish coastal waters of VIIa and VIIg and the stock assessment for assessment area 1will not reflect the sea bass populations around the Irish coast, which may be more strongly affiliated to the population in area 4 off southern, western and northern Ireland.

Tagging shows movements of sea bass between VIIIa and southern parts of VIIh/VIIe. A sensitivity analysis of the stock assessment for sea bass includes a combined IV, VII and VIII assessment (assessment areas 1 and 2 excluding Irish populations for which there are no commercial fisheries).

3.2 Issue list

Not available.

3.3 Scorecard on data quality

Data quality is evaluated in relation to precision (relative standard errors or proxies for effective sample size) and critical forms of bias (e.g. coverage of surveys; biases in fishery catch data, natural mortality rate). Where possible, sensitivity analyses are conducted to evaluate the effect of these biases on the assessment results. WGNEW 2012 highlighted blocks of national data using traffic lights colours to indicate potential quality issues, but IBPNew 2012 did not have time to conduct the detailed evaluation of biases in data quality required by the ICES scorecard.

3.4 Multispecies and mixed fisheries issues

No information was available to IBPNew 2012 to evaluate impacts on sea bass populations of predation or competition with other species, or the impacts of sea bass on other ecosystem components.

Although sea bass are caught by many commercial vessels, the bulk of the catch can be taken by relatively few vessels which are more economically dependent on this species. For example in the UK in 2010, sea bass landings were reported by 1480 vessels (including 1207 of 10 m and under), 10% of which were responsible for over 70% of the total UK sea bass landings (Walmsley and Armstrong, 2012). Vessels targeting bass or other species in shallower waters using mesh sizes 80–100 mm can at times have relatively large catches of sea bass below the minimum landing size, which are discarded. An important mixed fishery issue is the competition between commercial and recreational fishers for local populations of sea bass which tagging studies show can have strong site fidelity.

3.5 Ecosystem drivers

Recruitment of sea bass is highly variable, and the fisheries have often in the past been dominated by individual very strong year classes or have been negatively affected by periods of very poor recruitment. Expansion of sea bass populations in the North Sea in the 1990s coincided with a period of ocean warming as well as the growth of the very strong 1989 year class. Temperature appears to be a major driver for bass production and distribution (Pawson, 1992). Reynolds *et al*. (2003) observed a positive relationship between annual seawater temperature during the development phases of eggs and larvae of sea bass and the timing and (possibly) abundance of post-larval recruitment to nursery areas. In addition, early growth is related to summer temperature, and survival of 0-groups through the first winter is affected by body size (and fat reserves) and water temperature (Lancaster, 1991; Pawson, 1992). Prolonged periods of temperatures below 5–6°C may lead to high levels of mortality in 0-groups in estuaries during cold winters, and may be a contributory factor to a recent decline in abundance of young bass shown by surveys included in the benchmark assessment.

A long time-series of seasonal sea temperature data from the Thames estuary (R. Forster, Cefas, pers. comm.) shows extended periods of winter temperatures below 5°C (Figure 3.5.1). Low temperatures in 1996, 1997, 2005, 2006, and 2008–2011, would have affected overwintering 0-gp sea bass from the previous year's spawning, coinciding with very low abundance of juvenile sea bass of those year classes in the Cefas Thames juvenile sea bass survey (Figure 3.5.1).

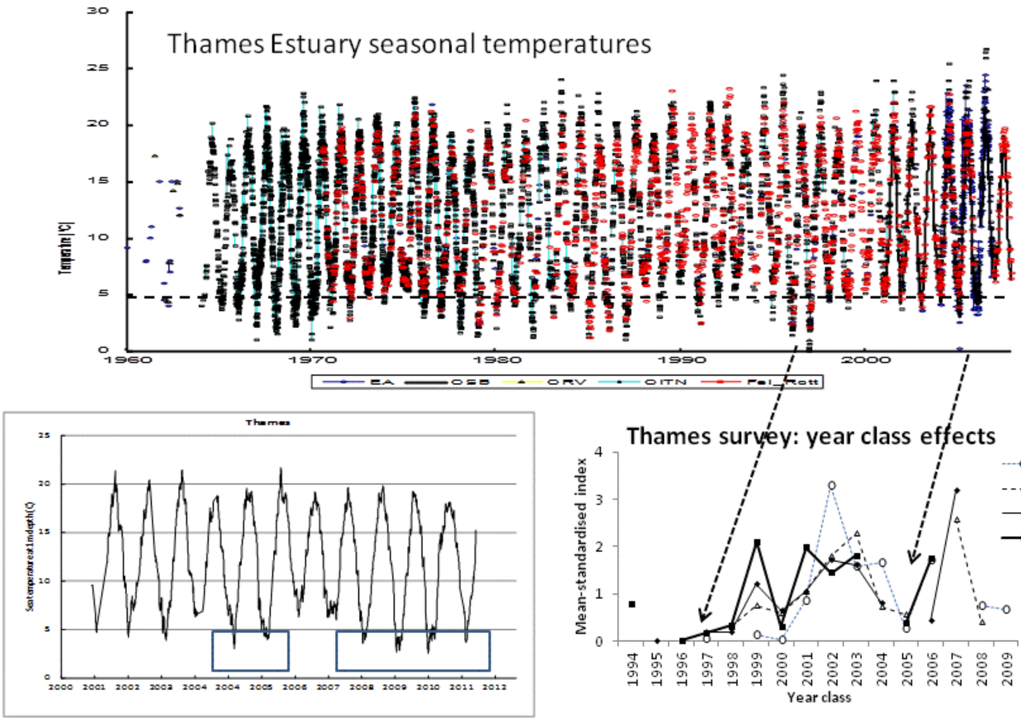


Figure 3.5.1. Top: seasonal sea temperatures in the Thames estuary (ICES Division IVc) since the 1960s, in relation to variations in year-class abundance for sea bass indicated by the Cefas Thames bass survey. Bottom left plot is the temperature series extended to summer 2011. Periods of winter temperature below 5°C are indicated.

Small-fish surveys carried out by the UK Environment Agency at Southampton (ICES Division VIId) from 2007 to 2011, using beach-seines at seven sites and beam trawls at five of the sites, show declining catch-rates of 0-gp sea bass coinciding with declining winter sea temperatures, although these remain above 7.5°C (Longley, 2012; Figure 3.5.2).

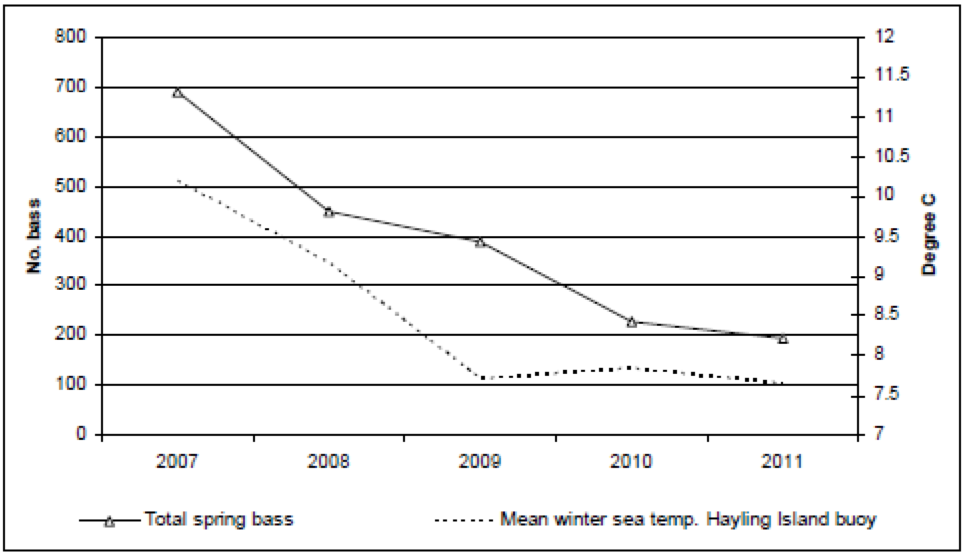


Figure 3.5.2. Declining catch rates of 0-gp bass in annual beach-seine and beam trawl surveys carried out by UK Environment Agency since 2011, in comparison with winter sea temperatures at the same sites (Longley, 2012).

3.6 Stock assessment of sea bass in Areas IV, VII, VIII, IX and X

3.6.1 Catch; quality, misreporting, discards

Commercial landings data

Landings series for use in the assessment are given in Tables 3.6.1.1–3.6.1.8, and are derived from two sources:

1) Official statistics recorded in the FishStat database since around the mid-1970s.

2) French landings for 1999–2010 from a separate analysis by Ifremer of log-book and auction data.

Total international landings from the two sources combined increased from around 2000 t in the late 1970s to over 8000 t by 2006, the bulk coming from Areas IVb,c, VIIe and XIII (Table 3.6.1.1; Figure 3.6.1.1). An important driver of the increase in landings since the 1990s was the increased landings in Divisions IVb,c, VIId and VIIe,h, coinciding with the large 1989 year class and a northward expansion of the sea bass population in the North Sea during a period of increasing sea temperatures. Landings by country from each ICES Area are given in Tables 3.6.1.2–3.6.1.8.

WGNEW has previously given separate (unofficial) estimates of 29–65 t for Spanish Basque countries for Area VIII, but only for 1995–2005. These have not been updated but can be viewed in the WGNEW 2010 report and 2011 advice sheet. Spanish landings and effort for VIIa,b,d and VIIc/IXa from 2007–2011 were supplied to IBPNew (Table 3.6.1.9.)

UK and French landings by gear type and area are shown in Figures 3.6.1.2 and 3.6.1.3. A large fraction of the landings from VIIe,h are from the pelagic trawl fisheries on offshore sea bass.

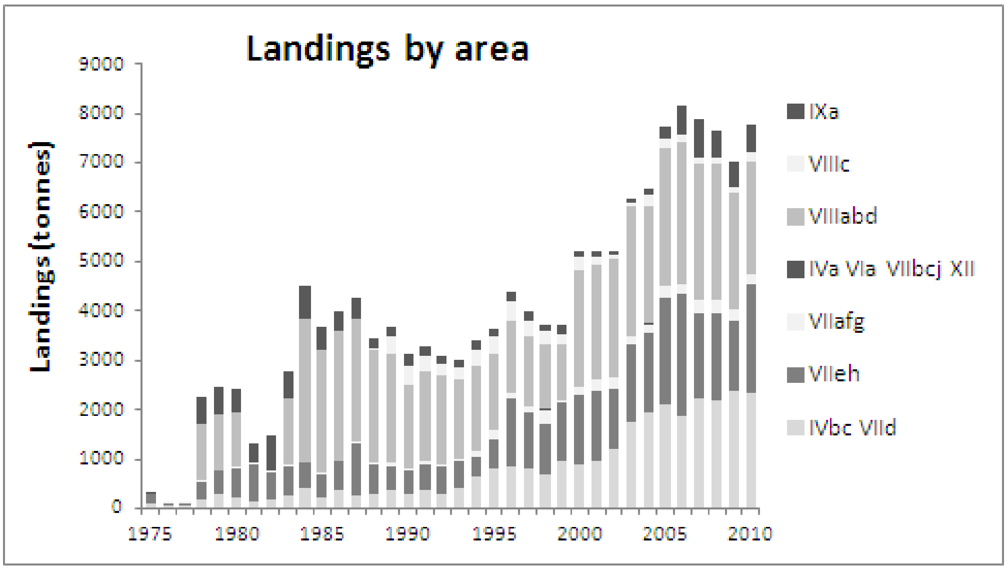


Figure 3.6.1.1. Sea bass in the Northeast Atlantic. ICES landings (tonnes).

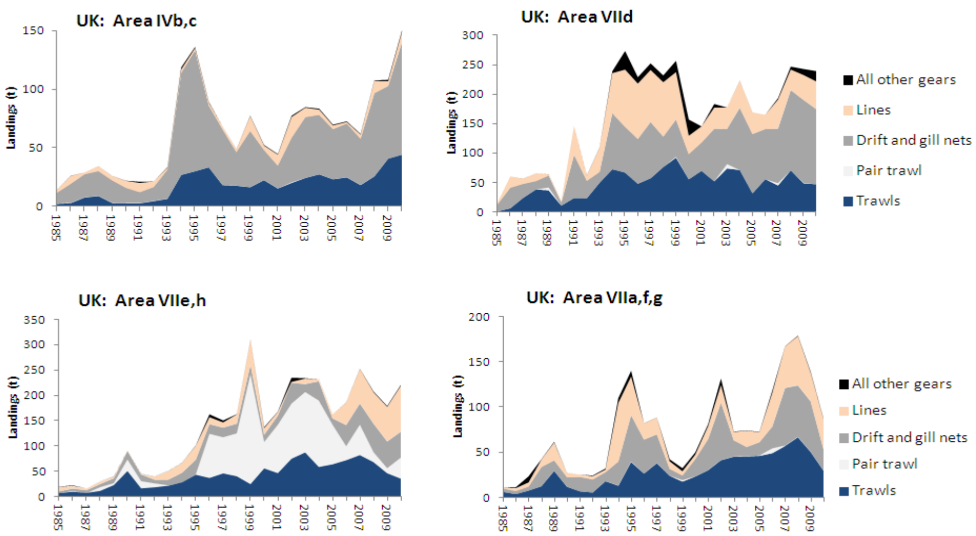


Figure 3.6.1.2. Sea bass in the Northeast Atlantic. Landings by area and gear type for UK commercial fishing fleets (pair trawl = offshore pelagic trawl fishery).

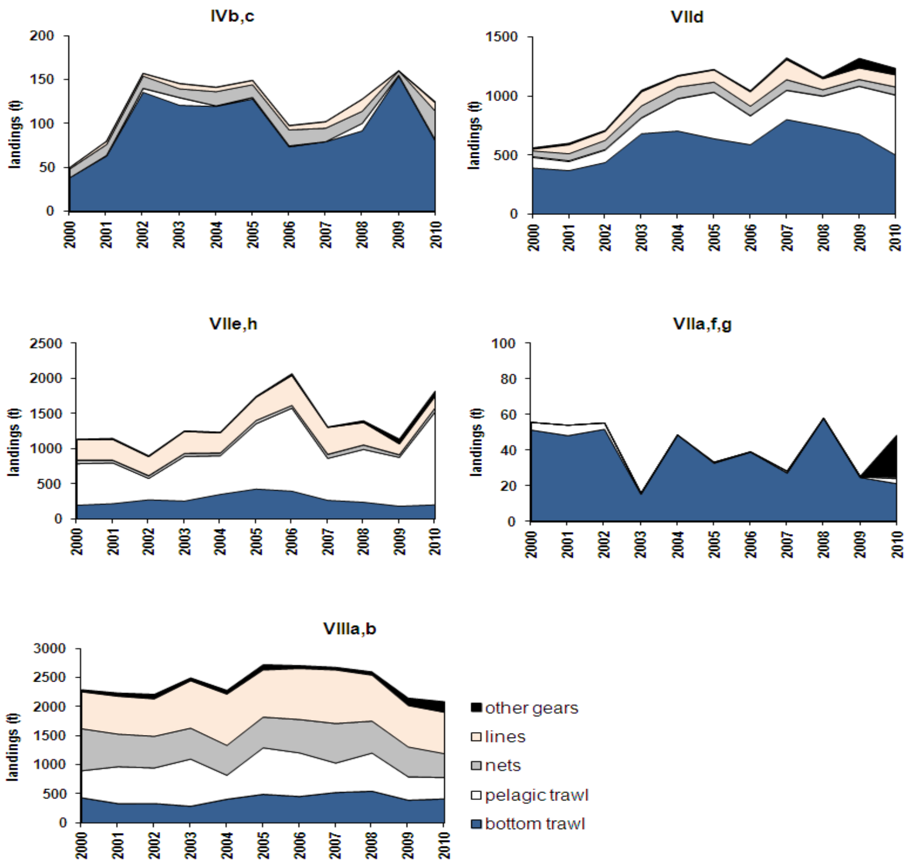


Figure 3.6.1.3. Sea bass in the Northeast Atlantic. Landings by area and gear type for French commercial fishing fleets.

Quality of landings data

The official landings data for sea bass available to IBPNew 2012 are subject to several uncertainties that can affect the accuracy of assessments:

- Incomplete reporting of landings in the 1970s and early 1980s when the fisheries were developing;
- Reporting of official French data by port rather than fishing ground before 2000. (The best landings estimates are from auctions for this period. During IBPNew no fishing grounds could be identified for these landings).
- Poor reporting accuracy for small vessels that do not supply EU logbooks.

From 1999 onwards, Ifremer has provided revised French landings from a separate analysis of logbook and auction data which allocates landings correctly by fishing ground. To generate a consistent series of French landings from 1985 onwards for the Area IV&VII assessment, IBPNew 2012 adjusted pre-1999 official FishStat landings by the average of the Ifremer correction factors by area from 1999–2010:

- IVbc+VIId: 1.04; VIIeh: 1.6; VIIafg: 0.62.

The accuracy of UK landings statistics is expected to have improved since the introduction of the Registration of Buyers and Sellers regulations in 2005, particularly for small vessels that do not have to supply EU logbooks. The UK has previously carried out independent surveys to estimate historical landings data for sea bass, using a voluntary logbook scheme in conjunction with a biennial census of vessels catching sea bass. The census covers different segments of coast in different years (Pickett, 1990). The landings tables in earlier ACOM advice included “unallocated” landings which were the difference between the voluntary logbook estimates and the official UK statistics in each ICES area.

A review of the Cefas logbook scheme in 2012 (Armstrong and Walmsley, 2012a) showed that the previous estimates included recreational charter boats. Landings have now been re-estimated excluding these vessels to allow a direct comparison with official landings data. The Cefas logbook estimates for nets and lines still show substantial differences with official estimates, even for recent years since 2006 when the Registration of Buyers and Sellers has vastly improved recording of landings by 10 m and under vessels (Table 3.6.1.10). Coverage of trawls has been too low to provide estimates. The review concluded that the survey is sensibly spread over a range of vessel types and gears, but is over-stratified and has insufficient (and declining) coverage of the many survey strata while using *ad hoc*, judgment-based vessel selection schemes rather than randomized selection. However, the official data on sea bass for 10 m and under vessels prior to 2006 are also of poor quality and subject to potentially large bias (most likely underestimation). As neither data source for UK 10 m and under vessels is considered reliable historically, the sensitivity of the assessment to the two catch streams could be investigated. The necessary adjustments to official UK landings data by area and gear are given in Table 3.6.1.10. ICES WGNEW (ICES 2008) previously found that the stock trends from a statistical assessment model using UK sea bass data (Pawson *et al*., 2007b) were relatively insensitive to the choice of these two catch histories.

Landings data for the southern population of sea bass in ICES Division IXa have become more accurate since 2006 when *Dicentrarchus labrax* landed into Portugal started to be recorded as the correct species rather than mainly as part of a mixed sea bass category with the spotted sea bass *Dicentrarchus punctatus*. This resulted in a sharp increase in reported landings of *D. Labrax* in 2006 (Figure 3.6.1.4).

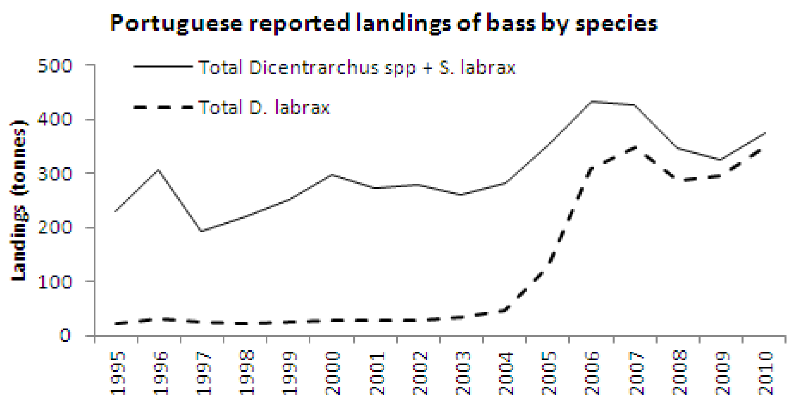


Figure 3.6.1.4. Sea bass in the Northeast Atlantic. Landings by area and gear type for Portuguese commercial fishing fleets.

Commercial discards

Discarding of sea bass by commercial fisheries can occur where fishing takes place in areas with bass smaller than the minimum landing size (36 cm in most European countries), and where mesh sizes <100 mm are in use. Estimates were provided to IBPNew 2012 mainly from sampling in UK and France.

For UK fleets, sample numbers by gear type and area are highest for otter trawls and nets (Table 3.6.11), but of these, a variable and often small number of trips have bass catches. Very little discards sampling has taken place on offshore UK pairtrawlers, however as this fishery targets mature bass, discarding is expected to be low, as observed in the French offshore fishery. No trips were undertaken on vessels using lines, which are a significant component of the sea bass fishery. It is assumed that discards of line-caught sea bass in shallow inshore waters will have a high survival rate.

Estimates of annual numbers and weight of sea bass discarded by UK fleets, and relative standard errors, are given for trawls and gillnets in ICES Divisions IVvc, VIId, VIIeh and VIIafg combined in Tables 3.6.1.12 and 3.6.1.13. Generally the highest discard rates were for trawlers using 80–89 mm mesh are in the eastern Channel (VIId) and southern North Sea. Overall, annual trawl discard rates (by number) ranged from 10–47% during 2002–2011. Discard rates of gillnetters were very low in most sampled years (0–33%; Table 3.6.1.13). Beam trawl catches and discards of sea bass are minor.

Numbers of fishing trips sampled on French vessels in 2009 and 2010, and discard estimates by fleet, are given in Table 3.6.1.14. Discard rates were low in general. As with UK fleets, bottom trawlers had the highest discard rate mainly in the eastern English Channel (VIId) and southern North Sea (IVb,c). The total amount of discards estimated in 2009 and 2010 was 183 t and 157 t, mainly assigned to Division VIId. Data for some fleets and areas are considered indicative only, because of the low rates of sampling.

Observer data from Spanish vessels fishing in Areas VII, VIII, and IX have shown no incidences of sea bass discarding (Table 3.6.1.15)

Quality of discards estimates

Discards estimates for UK and France are from vessel selections that for some areas and gears include relatively limited numbers of observed trips where sea bass is caught and discarded. Precision is therefore very low at current sampling rates. Sampling rates for under-10m vessels, which take the bulk of the UK sea bass catch, has historically been low or absent, and line gears have not been sampled. There is therefore a large potential for bias in the discards estimates.

Recreational catches

Recreational marine fishery surveys in Europe are still at an early stage in development (ICES WGRFS 2012). Methods are described in the Stock Annex.

France

A new study targeting sea bass was conducted between 2009 and 2011. Estimates of sea bass catches were obtained from a panel of 121 recreational fishermen recruited during a random digit dialling screening survey of 15000 households in the targeted districts. The estimated recreational catch of bass in the Bay of Biscay and in the Channel was 3170 t of which 2350 t was kept and 830 t released. The precision of the estimate is relatively low (CV =-51%). Around 60% of the recreational catch estimate was from Bay of Biscay.

The main gears used, in order of total catch, were fishing rod with artificial lure, fishing rod with bait, handline, longline, net and spear fishing. Approximately 80% of the recreational catch was taken by sea angling (rod and line or handline); 2610 t total catch and 1840 t kept (29% release rate).

UK (E&W)

A new survey programme based on a statistically sound survey design commenced in 2012 to estimate fishing effort, catches (kept and released) and fish sizes for shore based and boat angling in England. The survey does not cover other forms of recreational fishing. Results will be available late 2013.

Netherlands

A recent survey investigated the amount of sea bass caught by recreational fishers (van der Hammen and de Graaf, 2012; ICES, 2012). . Estimates of sea bass catches were obtained from a panel of 1043 recreational fishermen recruited during a telephone survey of 109 293 people. Preliminary estimates are that about 360 thousand individual sea bass were caught in 2010. Of these, 218 ± 130 (95% CI) thousands were retained, which is about 61%. In weight, 161 tonnes of sea bass were caught in total. Of this, 96 ± 60 (95% CI) tonnes were retained, which is 60%. These results are mainly applicable to Subarea IV.

Spain

A recreational boat fishing survey was performed in the Basque Country to estimate the total catch of the target species of this fishery in 2009. Sea bass catch data from 555 surveys were modelled with a two-step GLM, using type of boat and total boat length as covariables. The results were extrapolated to the total number of boats using an updated census. The estimated catch for sea bass was in 2009 was 8.2 tons, with an associated standard error of 0.149 tons. This is an underestimate of recreational catches as it excludes shore fishing, which is the subject of a pilot study in 2012.

Ireland

The only time-series of recreational fishery data available to IBPNew 2012 was provided by stakeholders participating in the meeting. Cpue data were collected by the Cork Sea Angling Club (mainly shore anglers on the south coast of Ireland) from approximately ten angling competitions held each year. This series is within assessment area 4 (Irish coastal waters in VIa, VIIb, VIIj). Numbers of sea bass per angler-days declined rapidly from the mid-1960s for a decade, after which it stabilized for a further decade, before declining to its lowest level in the 1980s (Figure 3.6.1.5). Part of the decline in the 1960s was associated with the very strong 1959 year class.

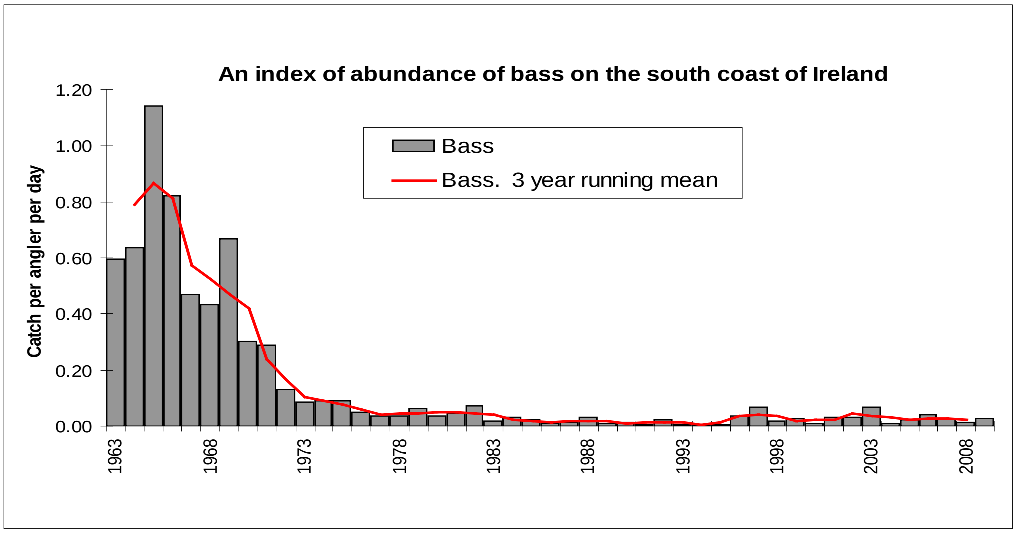


Figure 3.6.1.5. Sea angling cpue data collected by the Cork Sea Angling Club (Ireland) for the period 1963–2009 (courtesy of Ed Fahy, European Anglers Alliance and Irish Bass).

The deterioration in abundance was accompanied by the gradual introduction of regulations. Currently, they are: the prohibition of the sale of bass caught in Irish waters; prohibition on the fishing of bass by commercial fishers in Areas VI and VII; a bag limit of two bass per angler day; a close season from 15 May to 15 June; and a minimum size limit of 40 cm, total length. There is a perceived recovery in the abundance of bass by anglers and in the index of abundance in Figure 3.6.1.5 from the mid-1990s. Age compositions of sea bass caught by sea anglers have extended up to 27 years of age, and in 2011, the 2002 year class was predominant in samples (Figure 3.6.1.6). The number of specimen fish reported to the Irish Specimen Fish Committee has varied without trend since the 1960s, with probably a large contribution from the strong 1959 year class recorded in Irish waters (Figure 3.6.1.6). This is possibly the longest dataseries on marine phenomena in existence in Ireland. Bass was first included in 1959, and the threshold size for bass registered in the scheme has remained the same. This is in contrast to the numbers and average weights of many commercial species, larger individuals of which are similarly recorded in the specimen fish scheme. In many cases their numbers have declined and it has been necessary to reduce their threshold weights in order to ensure that they are still represented in the specimen fish lists.

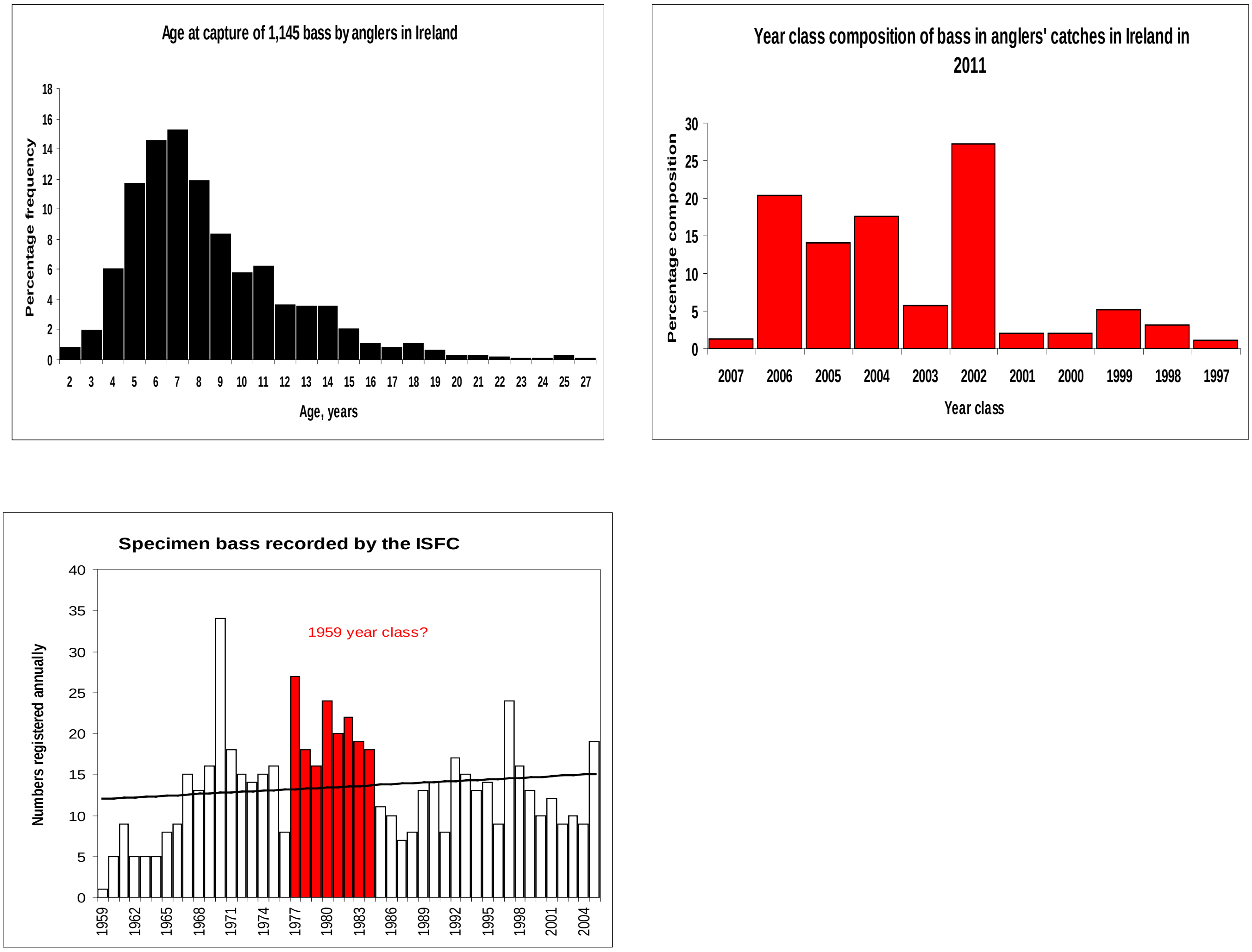


Figure 3.6.1.6. Top left: age compositions of 1145 sea bass caught by recreational sea anglers in southern Ireland. Top right: age compositions in 2011 showing contributions by year class. Bottom: time-series of numbers of specimen sea bass recorded by the Irish Specimen Fish Committee (figures courtesy of Ed Fahy, European Anglers Alliance and Irish Bass).

Quality of recreational catch estimates

Recreational catch estimates from surveys (numbers or tonnes caught per year) are not yet available as time-series. The estimates for France are characterized by relatively poor precision. The 2012 ICES Working Group on Recreational Fisheries initiated the development of data quality indicators for recreational fishery survey estimates; however sources and potential magnitude of bias in available estimates were not provided to IBPNew 2012.

Length and age compositions of commercial landings

Length and age compositions of sea bass landings, in a form suitable for inclusion in assessments, were available from sampling in the UK and France. Shorter time-series of length compositions were supplied by Spain for Areas VIII and IX.

Sampling rates

Length and age compositions are supplied by the UK since 1985 for IVb&c, VIId, VIIe,h and VIIa,f&g, disaggregated by five gear types: otter trawl, pelagic pair trawl, drift and gillnets, lines, and other gears.

UK Sampling rates for length compositions have been very variable between area, gear and year strata (Tables 3.6.1.16–3.6.1.19). Most strata have some sampling coverage with the exception of pair trawls which have had zero or very low coverage in many years despite large catches. The sampling rate (trips sampled per tonne landed) has declined for all gears since the mid-2000s (Figure 3.6.7).

Although separate ALKs are derived by the UK for the five areas, the same ALK is applied to all gear groups meaning that the age composition estimates for the different gears are not independent. Annual sampling rates for age compositions are given in Tables 3.6.1.20 and 3.6.1.21).

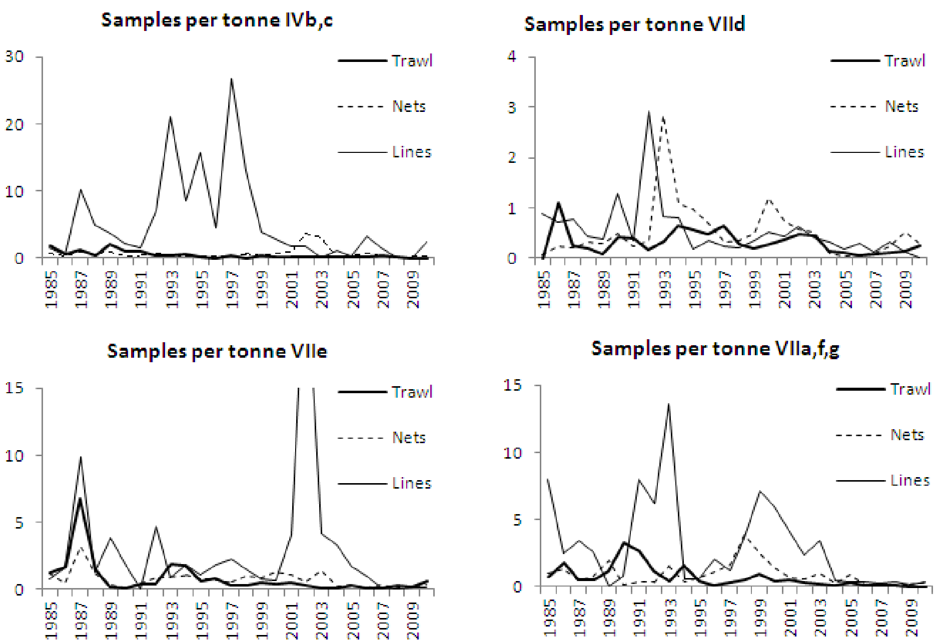


Figure 3.6.1.7. Sea bass in the Northeast Atlantic. Annual sampling of UK (E&W) sea bass landings for length compositions: nos. trips sampled per tonne of bass landed, by area and gear.

Sampling of sea bass in France has also been very variable between areas and gears, with greatest consistency between years in VIIIa,b. There has been a general increase in numbers of trips sampled for length since 2009 (Tables 3.6.1.22–3.6.1.25 and Figure 3.6.1.8). Sampling rates for sea bass length compositions in Spain are shown in Table 3.6.1.38).

Length and age compositions for UK and France

Annual landings by "fleet" (UK trawl, UK midwater trawl, UK nets, UK lines, France all, other fleets) for input to assessment model for Areas IV and VII are given in Table 3.6.1.26. The landings age compositions and mean weights-at-age for the UK fleets are given in Tables 3.6.1.27 to 3.6.1.34. Length compositions for UK midwater trawlers, which have low sampling rates for age, are given in Table 3.6.1.35). French length compositions for landings of all gears combined in Areas IVbc, VIId, VIIeh and VIIafg are given in Table 3.6.1.36, and for Area VIIIab in Table 3.6.1.37. Length and age compositions by gear type and fishing ground are given for UK and France by WGNEW 2012.

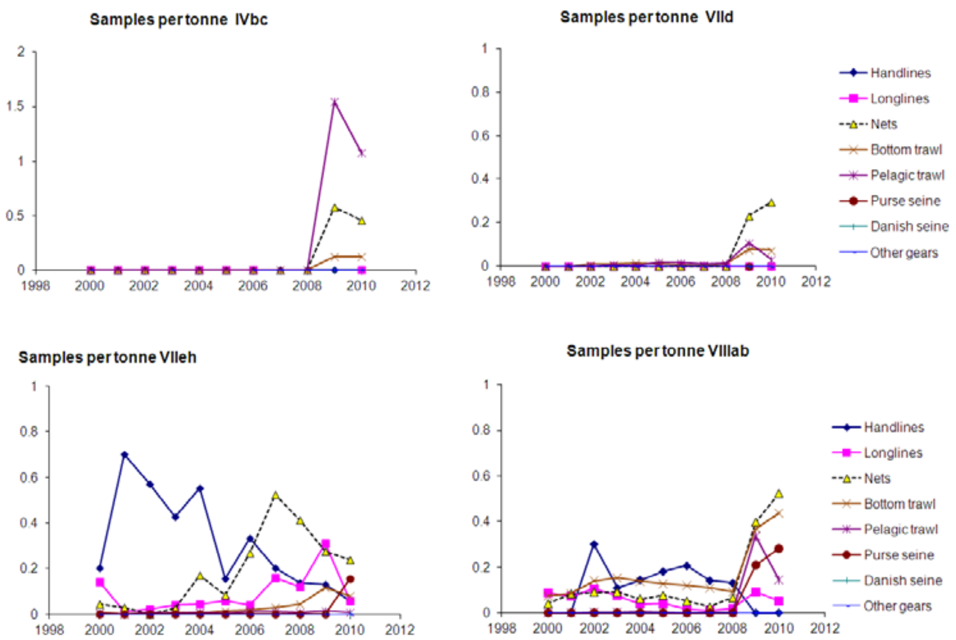


Figure 3.6.1.8. Sea bass in the Northeast Atlantic. Annual sampling of bass landings in France for length compositions: nos. trips sampled per tonne of bass landed, by area and gear.

Length and age compositions: other countries

Spanish landings of *Dicentrarchus labrax*, which is not a target species for any Spanish fleet, were not sampled for length structure before the implementation of concurrent sampling in 2009. Length information is scarce for most part of the Spanish métiers. For this reason length structure is presented only for bottom-trawl activity in the Bay of Biscay in 2010 and 2011 where enough individuals have been sampled to allow an adequate extrapolation (Table 3.6.1.38).

The Netherlands has collected age samples of sea bass every year from 2005 to 2008. From 2010 onwards, age samples were collected only once every three years. Otoliths and scales that are retrieved from the fish are sent to Cefas in the UK for age reading. Length samples are collected every year. All samples are collected in the auctions where most sea bass is landed, in the south of the Netherlands. The quality of the data is good enough to use them in assessments. However, both the length and age data need processing before they can be inserted in an assessment.

Comparison of age and length compositions for UK and French fisheries by area and gear

Age compositions of sea bass landings in the UK and French fisheries in VIIe–h for the years 2000–2010 are compared in Figures 3.6.1.9 to 3.6.1.11. The compositions of bottom-trawl landings are quite similar in most years (Figure 3.6.1.9) with some exceptions such as 2008 and 2010. Age compositions in the net fisheries differ substantially in some years (Figure 3.6.1.10). The French longline fishery appears to take younger sea bass than the handline fishery which has a very high component in the 12+ group in some years (Figure 3.6.1.11). The UK line fishery age compositions (combined line gears) are more similar to the French handline fishery than the longline fishery.

Length compositions of UK and French fleets are compared for 2010 in Figures 3.6.1.12 and 3.6.1.13. The length compositions For IVbc nets and lines and VIId bottom trawl were very similar (Figure 3.6.1.12), as were bottom trawls and pair trawls in VIIe,h (Figure 3.6.1.13). Samples from the UK and French line fisheries in VIIe,h had very different length compositions.

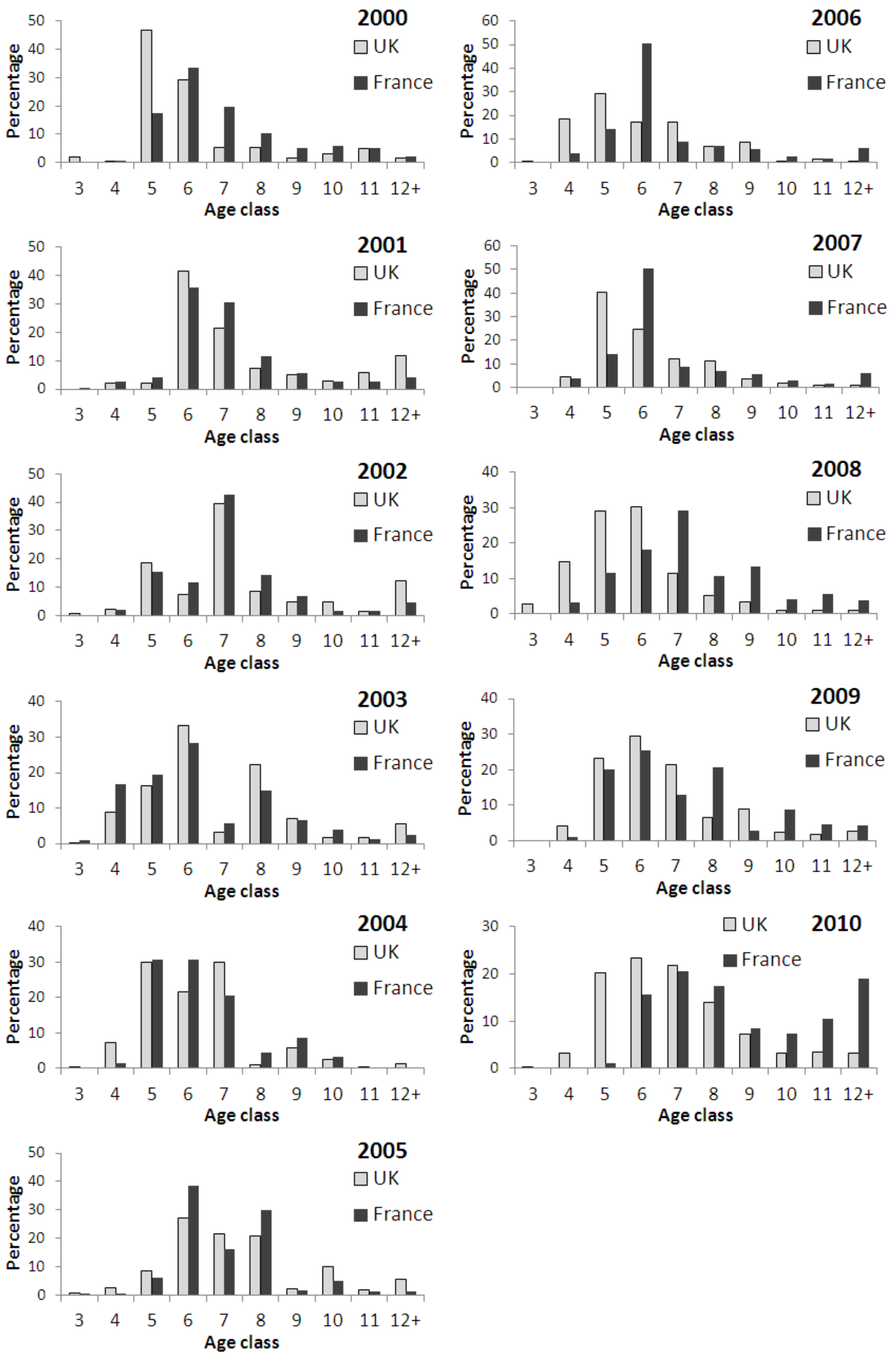


Figure 3.6.1.9. Sea bass in the Northeast Atlantic. Sea bass in Divisions VIIe,h: Comparison between percentage age composition of annual landings of UK and French bottom trawlers.

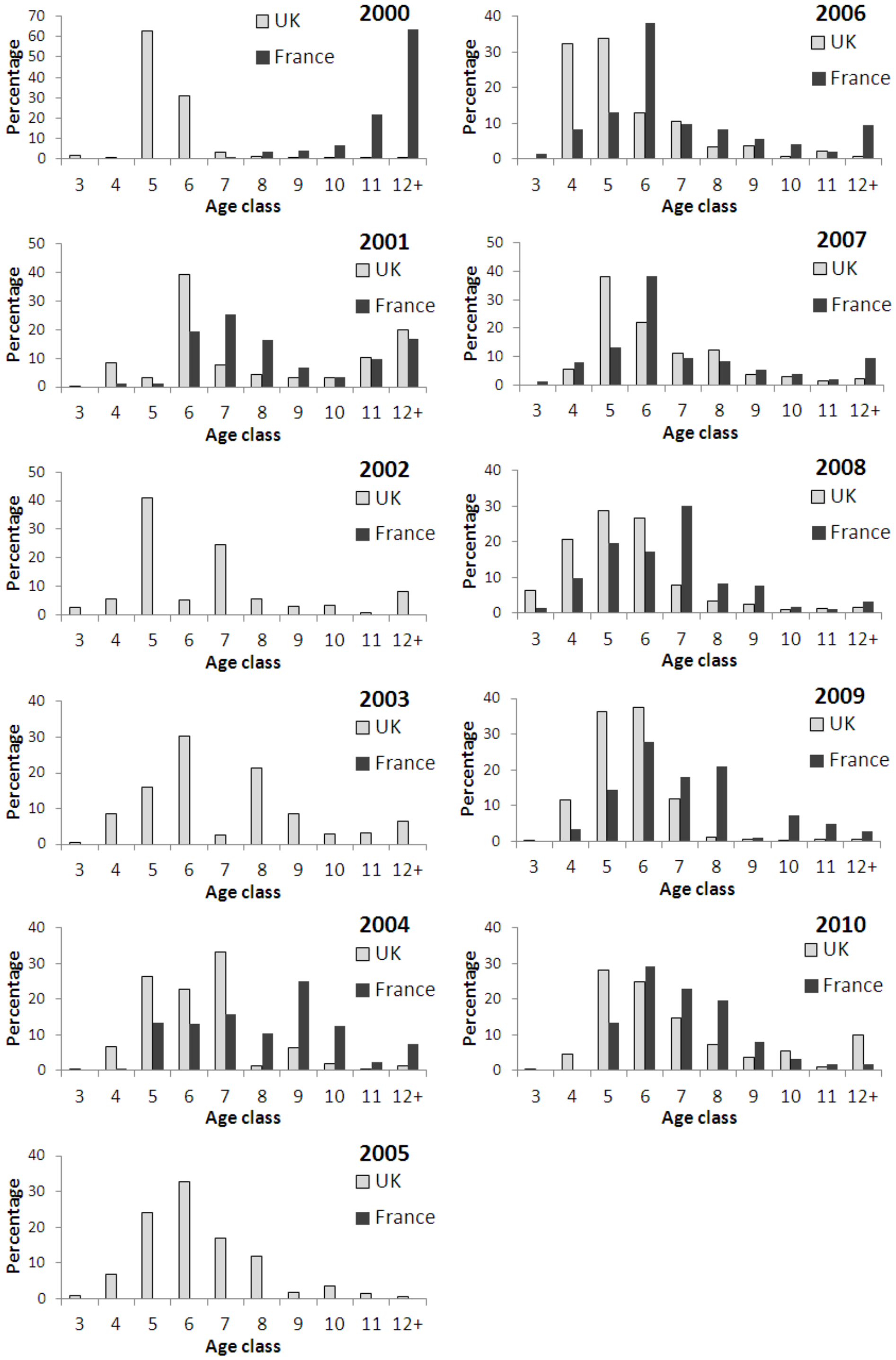


Figure 3.6.1.10. Sea bass in the Northeast Atlantic. Sea bass in Divisions VIIe,h: Comparison between percentage age composition of annual landings of UK and French vessels using fixed/driftnets.

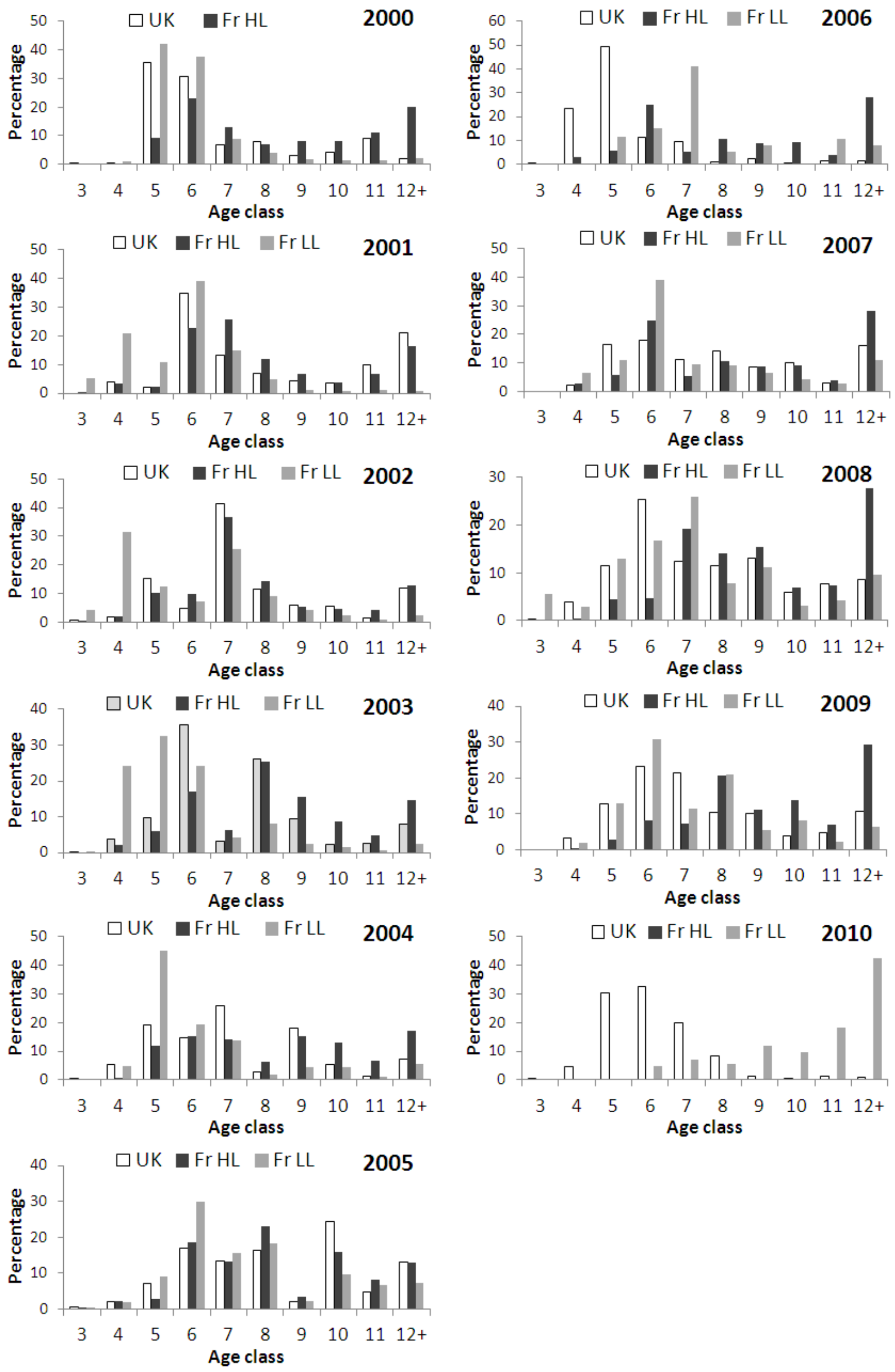


Figure 3.6.1.11. Sea bass in the Northeast Atlantic. Sea bass in Divisions VIIe,h: Comparison between percentage age composition of annual landings of UK and French vessels using lines. French data are given separately for handlines (Fr HL) and longlines (Fr LL).

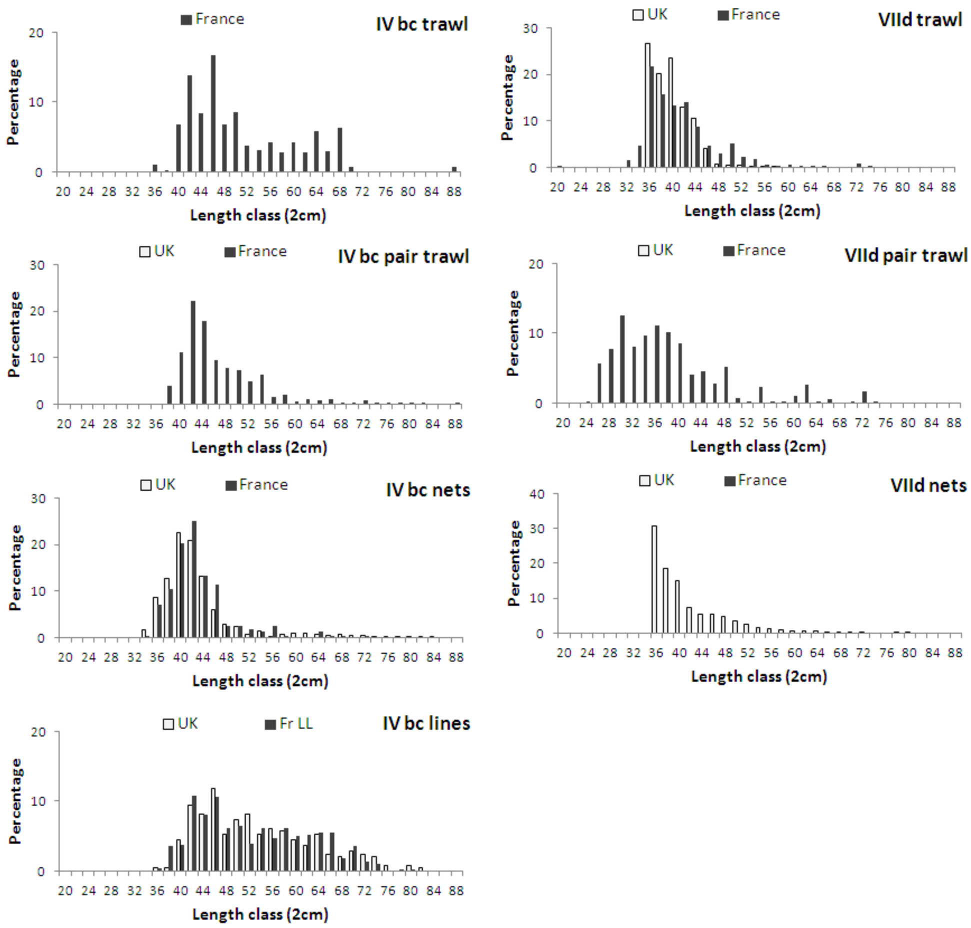


Figure 3.6.1.12. Sea bass in the Northeast Atlantic. Sea bass in Divisions IVb,c and VIId: Comparison between percentage length composition of annual landings of UK and French vessels using different gear types (Fr LL = French longlines).

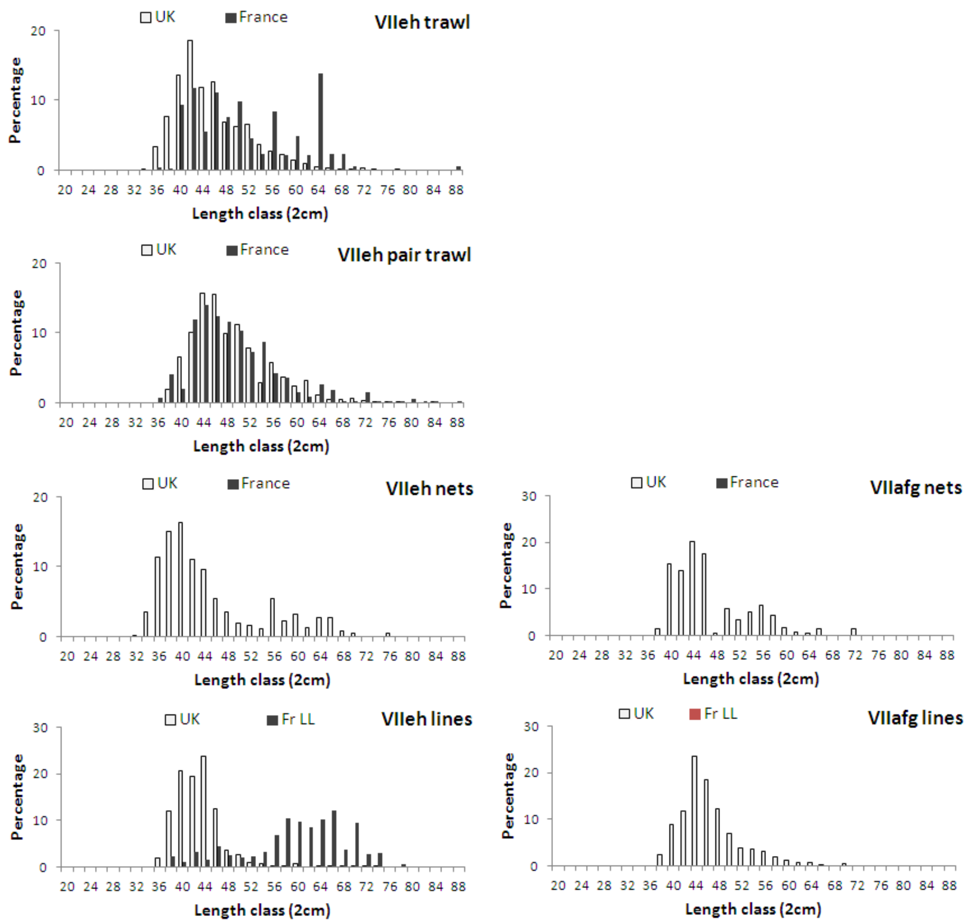


Figure 3.6.1.13. Sea bass in the Northeast Atlantic. Sea bass in Divisions VIIe,h and VIIa,f,g: Comparison between percentage length composition of annual landings of UK and French vessels using different gear types (Fr LL = French longlines).

Final age–length compositions for assessment model

The following fishery datasets are proposed for the assessment model, and can be viewed in the indicated report table numbers. Tables 3.6.1.44 and 3.6.1.45 are total international landings-at-age compiled for ASAP runs by raising the UK landings-at-age by gear to total international landings weights for those gears where no age compositions are available, then raising the combined age compositions to the total international all-gears landings.

				Report Tables		
Model	Data type			Numbers	wt.-at-age	Landings
Stock	Fleet landings					3.6.1.26
Synthesis 3	Age comp.	UK otter	IVbc, VIIadefgh	3.6.1.27	3.6.1.31	
		UK midwater	IVbc, VIIadefgh	3.6.1.28	3.6.1.32	
		UK nets	IVbc, VIIadefgh	3.6.1.29	3.6.1.33	
		UK lines	IVbc, VIIadefgh	3.6.1.30	3.6.1.34	
	Length comp.	UK midwater	IVbc, VIIadefgh	3.6.1.35		
		French (all)	IVbc, VIIadefgh	3.6.1.36		
		French (all)	VIIIab	3.6.1.37		
ASAP	Age comp.	All fleets	IVbc, VIIadefgh	3.6.1.44	3.6.1.45	3.6.1.26

3.6.2 Survey data

UK Solent and Thames prerecruit surveys

The UK has conducted prerecruit trawl surveys in the Solent and the Thames Estuary since 1981 and 1997 respectively. These surveys all ended in 2009 although the Solent survey was repeated as a one-off survey in autumn 2011 to help provide recruitment indices for the sea bass benchmark assessment. The location of the surveys, tow positions and methods are described in the Stock Annex. Both surveys use a high headline sea bass trawl, although in the Thames it is deployed as a twin rig and in the Solent as a single rig.

Abundance indices for ages 2–4 in the Solent and ages 0–3 in the Thames have large interannual variability (Tables 3.6.2.1 and 3.6.2.2; Figures 3.6.2.1 and 3.6.2.3). Strong year classes are apparent in 1989, 1995 and 1997, but in the last decade, year-class strength has been less variable, a pattern also seen in the commercial fishery. The survey indicates a general trend of increasing recruitment since the early 1990s. The most recent Solent survey in 2011 indicates very weak 2008 and 2009 year classes.

Some year-effects (where all or most age classes show a reduced or elevated index in a year) are evident in 2007 in the Solent September survey and in 1996 and 2003–2007 in the May–July survey (Figure 3.6.2.1). Year-class effects are not consistent across the survey and age range, and this is also shown by low correlation coefficients in the internal consistency plots (index for age *i*, year *y* plotted against age *i*-1, *y*-1; Figure 3.6.2.2)

The Thames survey shows fewer year effects and better internal consistency than the Solent survey (Figures 3.6.2.3 and 3.6.2.4). The overall trend is closer to the Solent September survey than to the Solent May–July survey, showing a trend of increasing recruitment in the 1990s although with a dip in the mid-1990s.

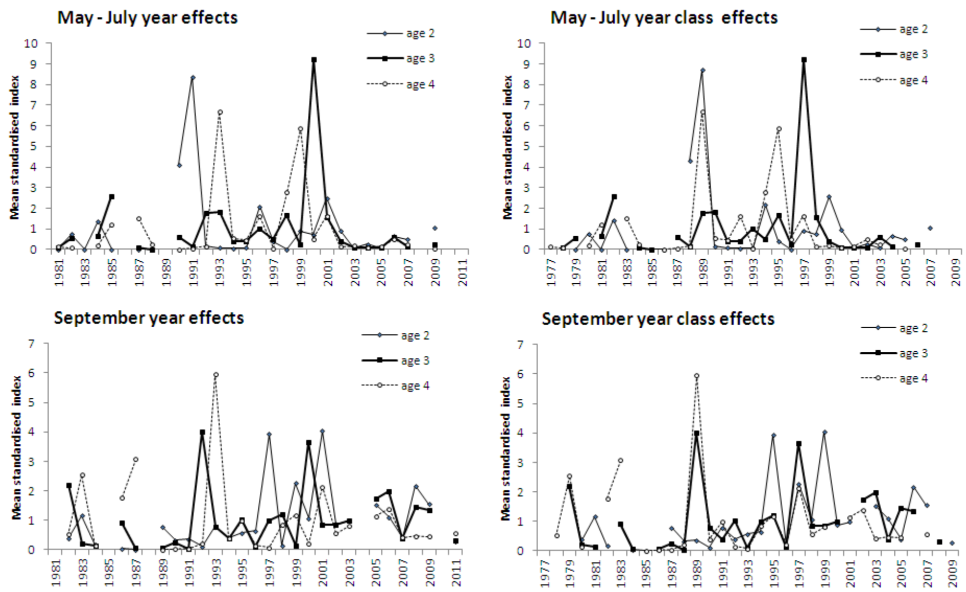


Figure 3.6.2.1. Sea bass in the Northeast Atlantic. UK(England) Solent sea bass survey: mean-standardized indices at ages 2, 3 and 4 plotted against year (left-hand plots) and year class (right-hand plots) for surveys in May–July (top) and September (bottom).

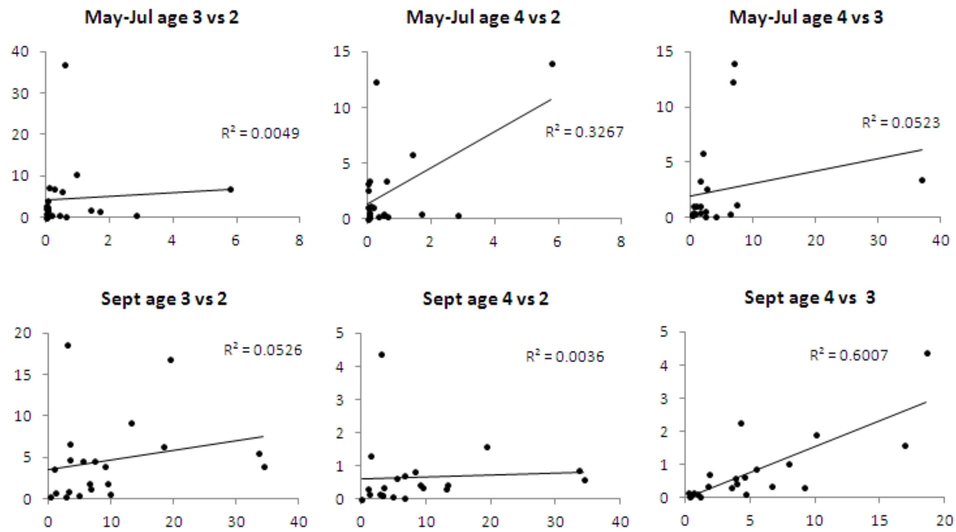


Figure 3.6.2.2. Sea bass in the Northeast Atlantic. UK(England) Solent sea bass survey: Internal consistency plots of abundance indices at successive ages in year classes: surveys in May–July (top) and September (bottom).

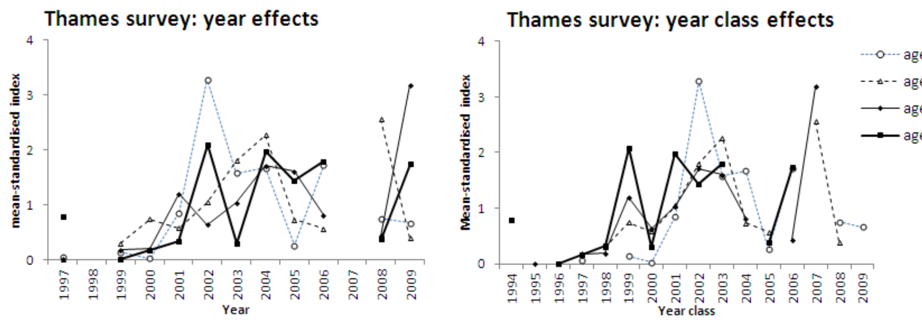


Figure 3.6.2.3. Sea bass in the Northeast Atlantic. UK(England) Thames sea bass survey in November: mean-standardized indices at ages 0–3 plotted against year (left-hand plots) and year class (right-hand plots).

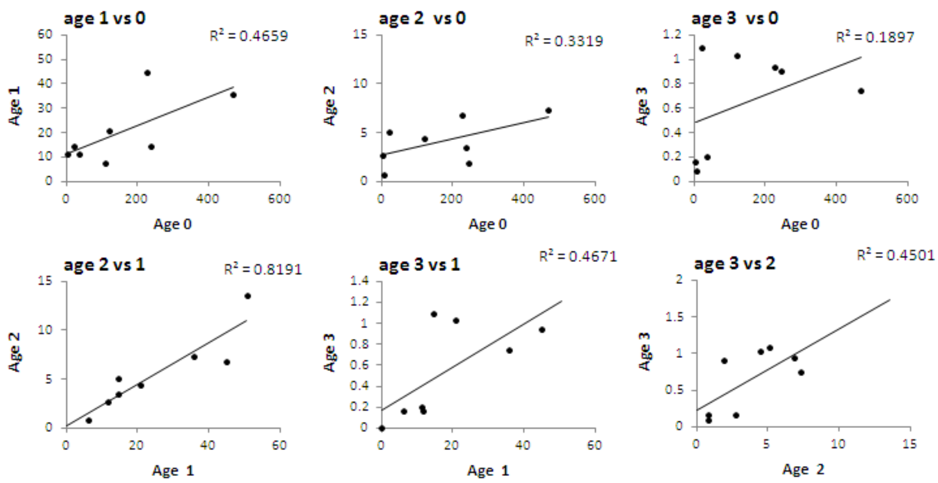


Figure 3.6.2.4. Sea bass in the Northeast Atlantic. UK(England) Thames sea bass survey in November: Internal consistency plots of abundance indices at successive ages in year classes.

Other 0-gp & 1-gp surveys

The UK has undertaken a seinenet survey in the Tamar Estuary, since 1985. Additional historical data are available from power stations in the Thames and Severn Estuary. Abundance indices for these surveys are given in the Stock Annex. Data are also available from 0-gp seinenet surveys in the Fal and Helford estuaries but recent data need to be analysed. An angling stakeholder at IBPNew 2012 presented data from a young bass survey in several estuaries in SE Ireland (ICES VIIg), indicating very low catch rates compared with similar surveys in estuaries in SW England, but a large increase in 2002 representing mainly fish of the 2002 year class which was also strongly represented in sea anglers catches in 2011.

Commercial catch-effort data

IBPNew2012 evaluated a range of commercial fishery lpue series for French and UK fleets operating in Areas IV and VII, including the lpue trends for participants in the Cefas voluntary logbook scheme. The series are described in the Stock Annex and the UK data are examined in detail in Armstrong and Maxwell (2012). UK vessels of 10 m and under were found to have a wide range of lpue trends depending on gear and area fished, often showing a very steep increase since the mid-2000s. This may be partly a consequence of more accurate reporting cause by the Registration of Buyers and Sellers regulations, but may also represent a bias caused by increased targeting of sea bass by vessels with insufficient quotas for other stocks.

French and UK (>10 m) trawlers in Areas IVb,c, VIId and VIIef show very similar lpue trends. With some exceptions (e.g. trawlers in VIId), UK >10 m vessels tend to show different lpue trends to 10 m and under vessels. Lpue for nets and lines are difficult to interpret for all vessel sizes, due to the problems of defining a suitable unit of effort.

Relative trends of sea bass lpue for 70–99 mm mesh UK otter trawls (1985–2011), French otter trawlers (2000–2010), and UK beam trawlers operating in IVbc,VIId, VIIeh and VIIafg show a general trend of increase in the 1980s and 1990s, followed by a levelling off and a decline after 2009 (Figure 3.6.2.5; Table 3.6.). There is unlikely to be any targeting of sea bass by beam trawlers, hence the lpues represent the incidence of sea bass as bycatch, assuming the same level of reporting accuracy over time.

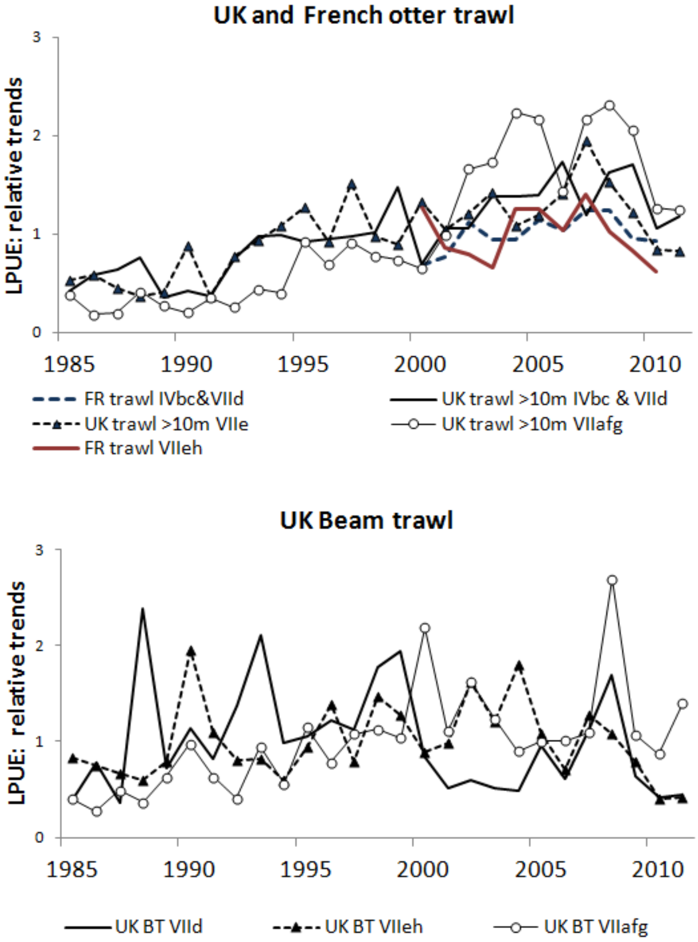


Figure 3.6.2.5. Mean-standardized trends in lpue of UK>10m and French otter trawlers, and UK beam trawlers, operating in IVbc, VIId, VIIeh and VIIafg.

Spain

Lpue data for Spanish fleets operating in ICES Areas VI–VIII and landing into Basque Country ports were provided to WGNEW in 2005, and the best indicator of sea bass abundance trends (lpue) in the period 1994–2004 was considered to be from vessels of the 'baka' otter trawl fleet working in Div. VIIIa,b,d and landing into the Basque port of Ondarroa. Data for later years were not available to WGNEW. Landings and effort data were provided to IBPNew by Spain, though not in the form of lpue indices.

3.6.3 Weights, maturities, growth

This section provides biological parameters of growth, maturity and natural mortality required for stock assessment of sea bass. Further information can be found in the Stock Annex and detailed methods and results are given in IBPNew 2012 working documents by Armstrong (2012) and Armstrong and Walmsley (2012b,c).

Growth parameters

Growth of sea bass in ICES Areas IV and VII were investigated using data from more than 90 000 sea bass sampled by Cefas since 1985. The samples are from fishery catches around England and Wales as well as from trawls surveys of young bass in the Solent and Thames estuary. The inshore surveys are mainly young sea bass up to 3–5 years of age, whereas the fishery samples include fish up to 28 years of age. Wide variations in year-class strength result in equally wide variations in numbers of fish sampled per year class, with similar year-class signals appearing all around the UK coast.

The sampled sea bass showed sexual dimorphism of growth from about seven years of age onwards (Figure 3.6.3.1). Samples of fish became increasingly dominated by females from around 12 years of age (i.e. in the plus-group in the assessment).

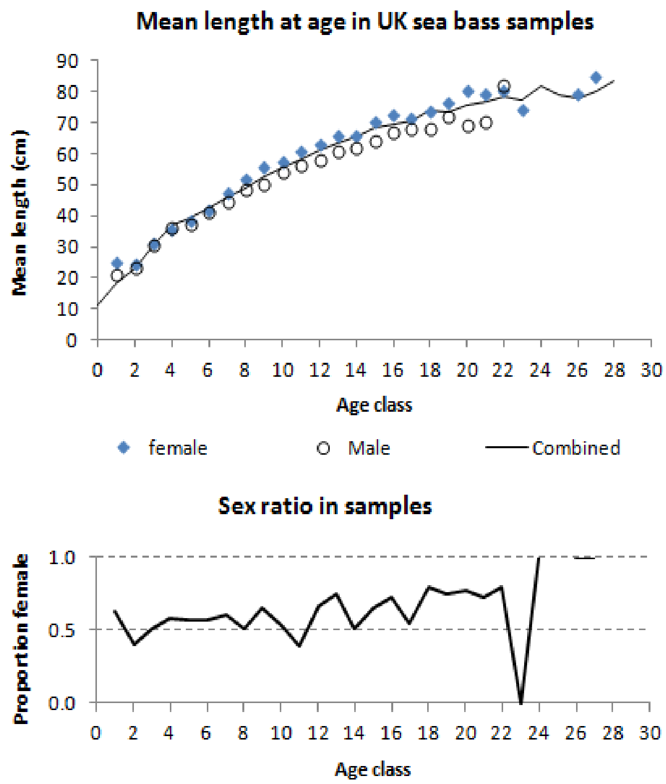


Figure 3.6.3.1. Top: mean length-at-age for male and female bass sampled since 1985 mainly from UK commercial catches plus some fish caught on surveys (other than Thames and Solent surveys where the fish are unsexed). Bottom: proportion female in samples.

Combined-sex mean lengths-at-age have not shown any trends over time (Figure 3.6.3.2). Length-at-age is also very similar in strong and weak year classes (Armstrong and Walmsley, 2012b). Hence data have been combined over the full series to estimate growth parameters. Growth curves fitted to data from each area are plotted in Figures 3.6.3.3–3.6.3.5. The fit to young bass is improved in IVbc and VIId due to inclusion of many fish of 0–5 years of age from inshore surveys. Ages are referred to 1 January, according to month of capture.

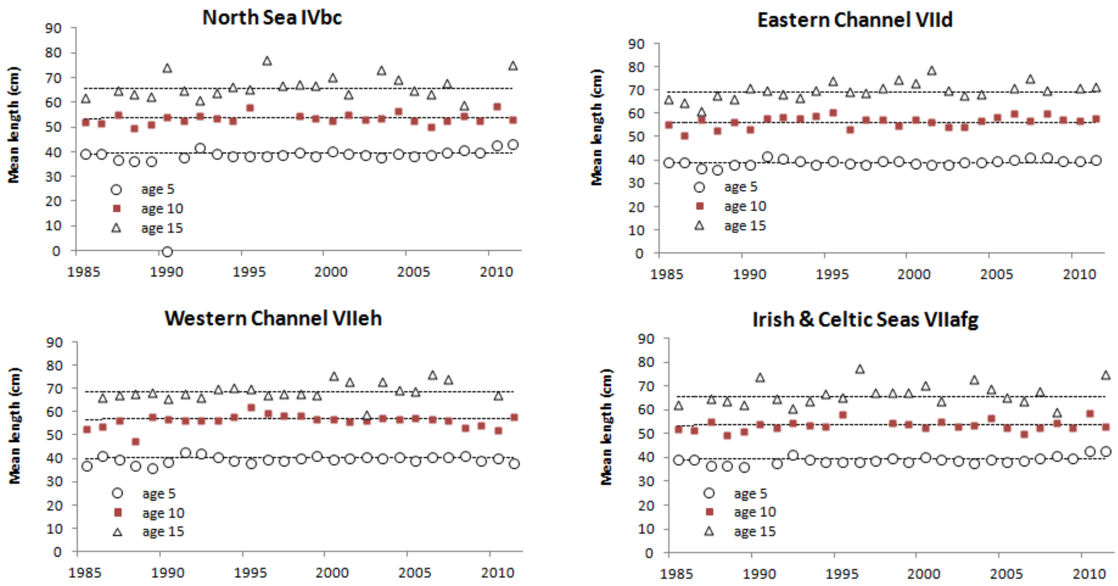


Figure 3.6.3.2. Mean length-at-age for combined-sex sea bass sampled mainly from UK commercial catches, by year, for fish aged 5, 10 and 15. Dotted lines are the series means.

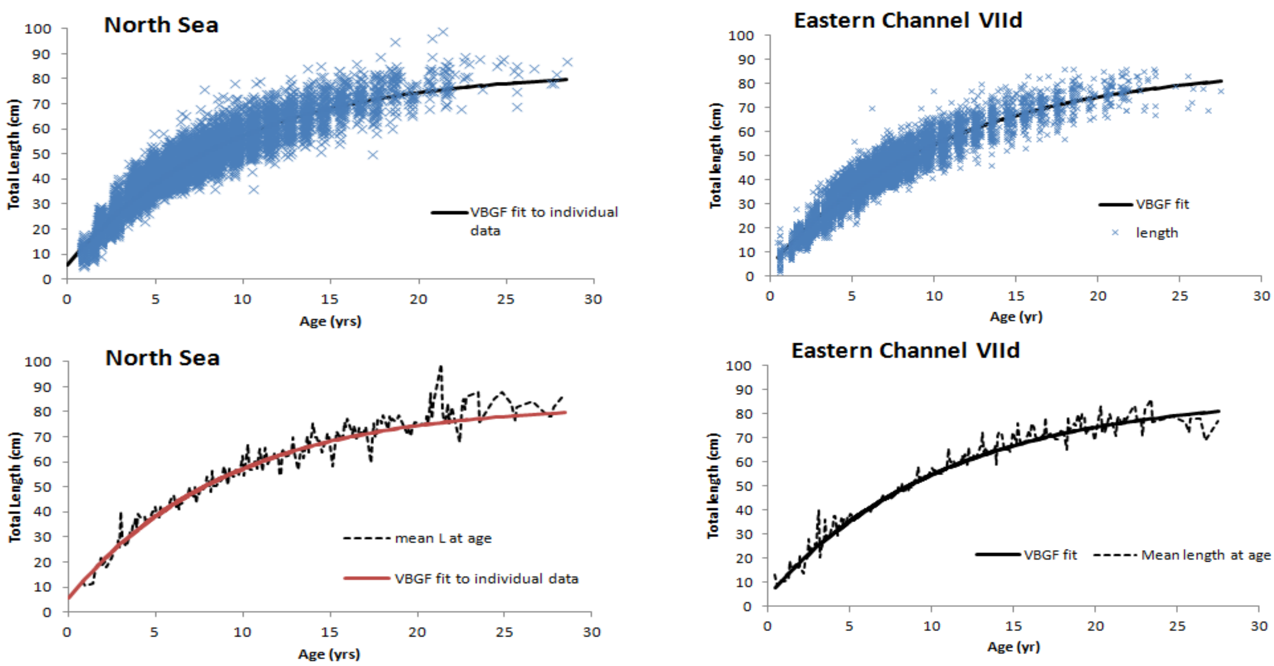


Figure 3.6.3.3. Top: Individual age–length observations for North Sea (IVbc) and eastern Channel (VIId) sea bass in UK samples, and fitted VBGF (combined sexes; VIId plot has data filtered to remove every second fish below 20 years of age, though all fish contribute to model fit). Bottom: Comparison of mean length-at-age in in 1-month age bins with the growth curve fitted to individual data.

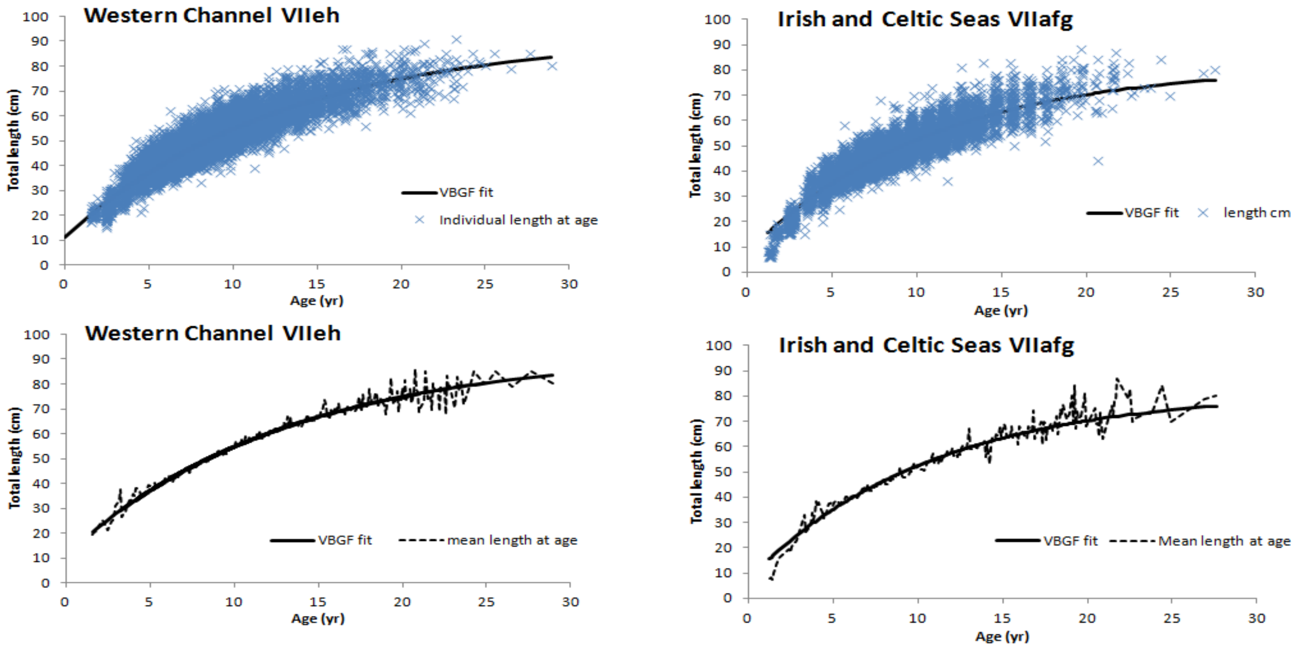


Figure 3.6.3.4. Top: Individual age–length observations for western Channel and approaches (VIIeh) and Irish Sea and Celtic Sea (VIIafg) sea bass in UK samples, and fitted VBGF (combined sexes). Bottom: Comparison of mean length-at-age in 1-month age bins with the growth curve fitted to individual data.

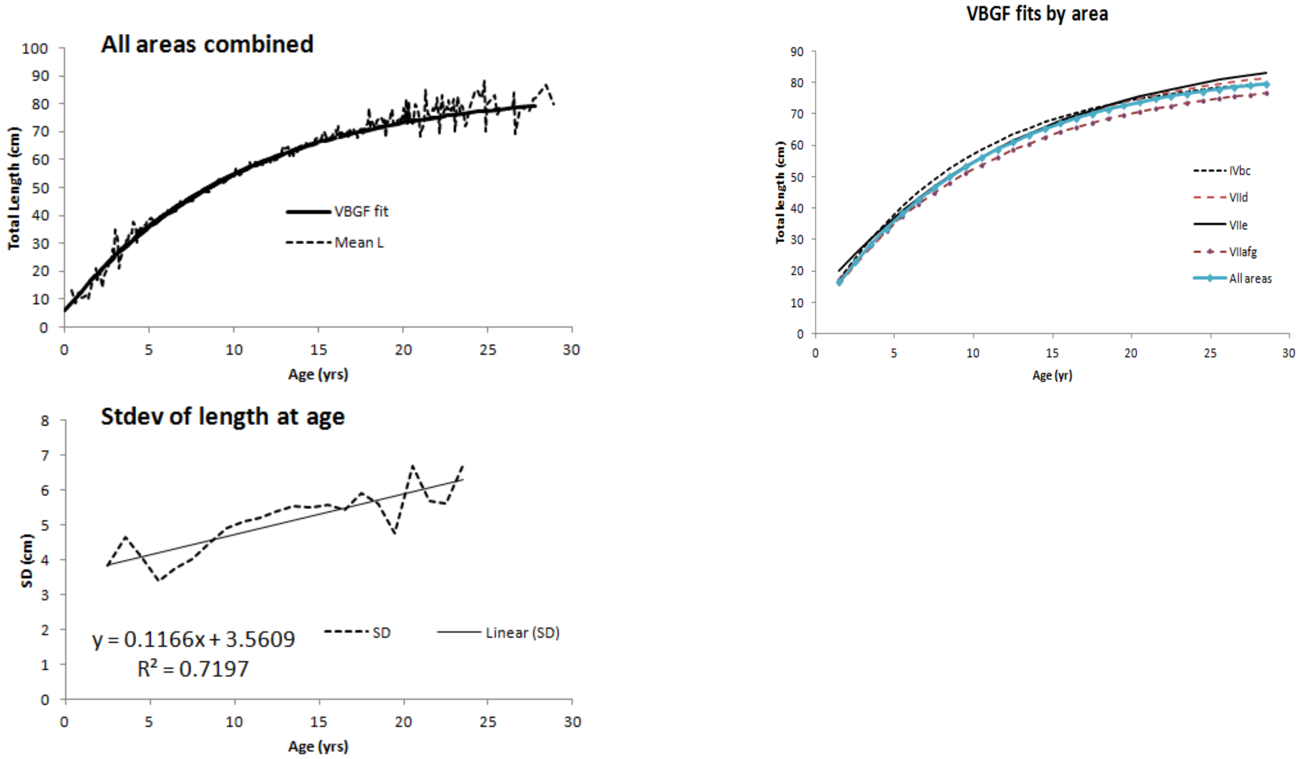


Figure 3.6.3.5. Top left: Von Bertalanffy growth curve fitted to all UK data for sea bass from 1985–2011. Dotted line shows mean lengths in 1-month age bins (curve is fitted to individual data). Bottom: standard deviation of length-at-age distributions in raw age data. Top right: fitted VBGF curves by area.

Von Bertalanffy model parameters were estimated by area using an absolute error model minimizing ∑(obs-exp)^2) in lengths-at-age:

AREA	IVBC	VIID	VIIE	VIIAFG	ALL AREAS
Linf (cm)	82.98	87.22	92.27	81.87	84.55
K	0.1104	0.09298	0.07697	0.09246	0.09699
t0 (years)	-0.608	-0.592	-1.693	-1.066	-0.730

As expected, the standard deviation of length-at-age increased with length, and the trend could be described by the linear model SD = 0.1166 * age + 3.5609 (Figure 3.6.3.5).

Maturity-at-length and age

Data sources

Relatively few samples of sea bass have been collected since the 1980s in Areas IV and VII to estimate the proportion mature in relation to length and age. Most bass are landed whole and are very expensive to purchase for dissection. A Working Document by Armstrong and Walmsley (2012c) to IBPNew 2012 provides revised maturity parameters using samples collected by Cefas since 1982. These included fish analysed by Pawson and Pickett (1996) to provide estimates of size-at-maturity that have been widely cited since then, and additional samples collected in more recent years.

Samples have come from all around the coast of England and Wales (Table 3.6.3.1), though few fish have been sampled in the Irish Sea (VIIa). Sampling rates have been sporadic over time, with increased collections in 1983–1985, 1990–1991 and 2009 (Tables 3.6.3.2 and 3.6.3.3). The 2009 collections, for which results are given in ICES WGNEW (2012), were derived from only a few fishing trips with relatively large numbers sampled per trip, and covering a narrow range of lengths. The data from these few samples were excluded from final model fits due to their leverage on a restricted part of the maturity ogive reducing the fit of the model for lengths at or below L50%.

The coverage of samples by length and age class has been severely compromised over time by focusing sampling on fishery landings. The current minimum landing size of 36 cm means that very few fish have been sampled over much of the ascending limb of the maturity ogive.

Choice of maturity marker

From consideration of the seasonal spawning cycle of sea bass and the dynamics of ovary maturation, estimation of maturity ogives was restricted to the months of December to April (inclusive), and all females with maturity stages III (early maturing) and over in those months were treated as being mature. The same approach was adopted for male sea bass. See Armstrong and Walmsley (2012c) for a detailed argument for choice of tome period and maturity stage as marker for maturity.

Maturity model

Maturity was modelled using a binomial error structure and logit link function, fitted in *R* to individual observations. The logistic model describing proportion mature by 1-cm length class *L* was formulated as:

$$\text{Pmat}(L) = 1/(1+e^{-(a+bL)})$$

defined by the parameters slope *b* and length intecept *a*. These parameters were estimated separately for females and males.

This can also be expressed as

$$\text{Pmat}(L) = 1/(1+e^{-b(L+c)}) \text{ where } c = a/b$$

For Stock Synthesis 3 model inputs, the parameters required are the slope (b: entered as a negative value) and the length inflection, which is the estimated length at 50% maturity ($L^{50\%}$).

The fitted ogives, excluding 2009 data, are given in Figure 3.6.3.6 and the parameters of the model are summarized below:

	(A) females	(b) males
Intercept (b)	-13.556	-16.851
Slope (a)	0.3335	0.4861
b/a	-40.6488	-34.6652
L25%	37.35	32.41
L50%	40.65	34.67
L75%	43.95	36.93

The logistic model for females and males is:

Pmat(L) = 1/(1+e-0.3335(L-40.649)) (females)
Pmat(L) = 1/(1+e-0.4861(L-34.665)) (males)

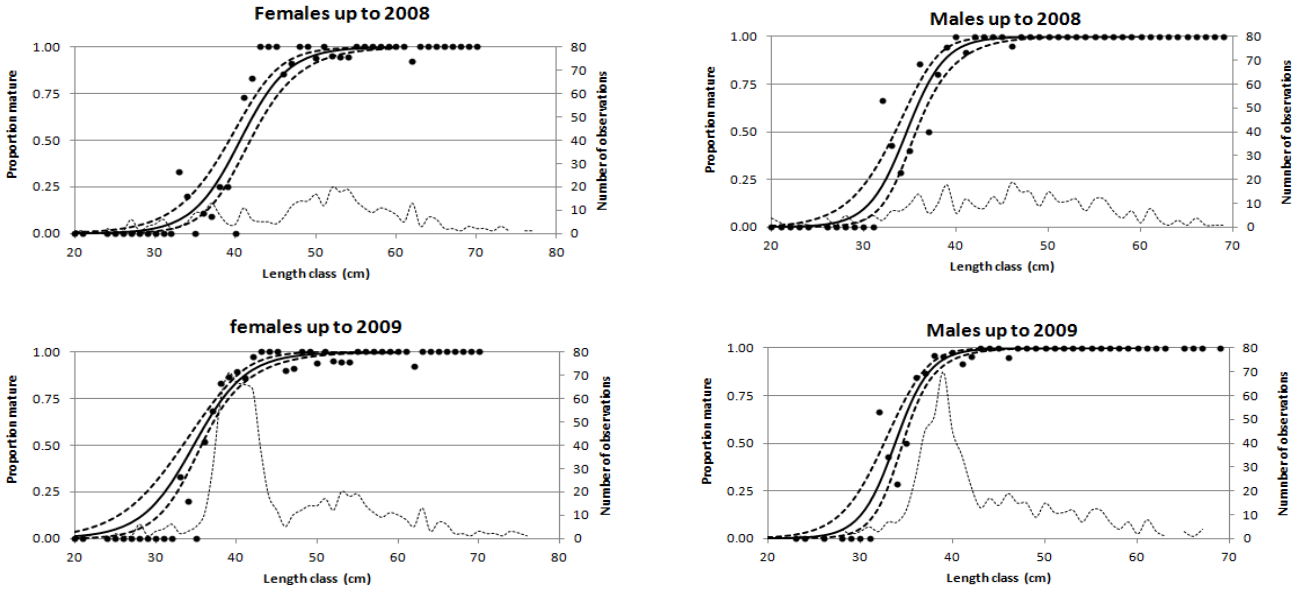


Figure 3.6.3.6. Logistic maturity ogives (with 95% confidence intervals) fitted to individual maturity records for sea bass during December–April 1982–2009. Top plot: excluding 2009 data (top); bottom plot: including 2009 data. Points are proportion mature in the raw data. Dotted line is the number of observations per length class.

Inclusion of 2009 data results in a better fit to data with larger proportions mature, and poor fit to data for length classes with small proportion mature (Figure 3.6.3.6, and suggests an L50% for females at 35 cm. The effect on males is less extreme, but could indicate earlier maturity in recent years than in the 1980s and 1990s. However IBPNew 2012 decided to retain the ogives excluding 2009 data due to the small number of fishing trips sampled in 2009, and the limited length range of those fish.

The maturation range for females during 1982–2003 occurs at ages 4 to 7, and for males at ages 3–6, as shown by the proportion mature at age in the same samples used for estimation of length-based maturity ogives (table below), and the growth data provided by Armstrong and Walmsley (2012b). The raw proportions mature from the 1982–2008 sample set are given in the text table below.

	FEMALES	MALES
age 2	0.00	0.00
age 3	0.00	0.27
age 4	0.17	0.54
age 5	0.21	0.61
age 6	0.55	0.91
age 7	0.95	0.98
age 8	1.00	1.00
age 9	0.95	0.98
age 10+	1.00	1.00

Samples collected in the southern North Sea from 2005 to 2011 by the Netherlands (Quirijns and Bierman, 2012) indicate 50% maturity in female sea bass at age 4. This is substantially lower than the age at 50% maturity of six years in the Cefas 1982–2003 samples, and closer to the ogive from Cefas data including the large 2009 sample (Figure 3.6.3.6), for which L50 was around 35cm (~4 years old). This may confirm that sea bass could now be maturing earlier than in the 1980s–early 2000s, at least for the North Sea. A clearer indication of maturity patterns will require a sampling programme and data collection method that ensures representative sampling of mature and immature bass across the geographic range of the population, using a robust, validated marker for maturity.

Natural mortality

A variety of methods are given in the literature relating natural mortality rate M to life-history parameters such as von Bertalanffy growth parameters k and Linf (asymptotic length), length or age at 50% maturity and apparent longevity particularly in an unexploited or very lightly exploited population. These methods were applied to the following sea bass life-history parameters by Armstrong (2012):

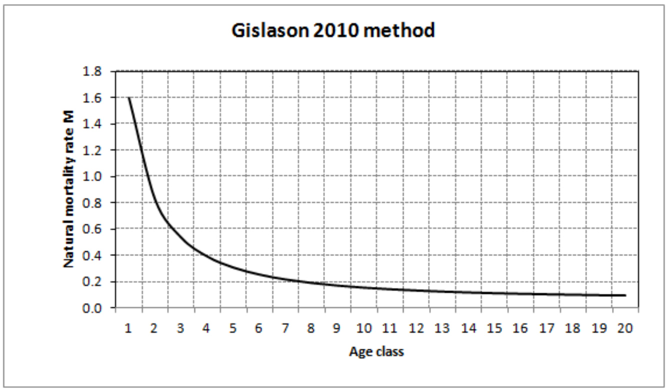
LIFE-HISTORY PARAMETERS	
VBGF K (combined sex)	0.097
VBGF Linf (combined sex)	84.55
VBGF to (combined sex	-0.73
Age at 50% maturity females (L50% converted to age)	6
Age at 50% maturity males (L50% converted to age)	4
Max age (combined sex)	28
Length at 50% mat females	40.65
Length at 50% mat males	34.67

The probability of encountering very old bass is partly a function of the interaction of year-class strength and sampling rates, as well as mortality, however the occurrence of sea bass to almost 30 years of age suggests low rates of mortality. The observed maximum age of 28 years in sea bass samples in the UK was recorded in the early 1980s, following a period of relatively low fishery landings. Age compositions of recreational fishery caught bass in southern Ireland, presented by stakeholders at

IBPNew 2012, also show ages up to 26 years. This stock has been subject to a commercial fishery ban for many years.

Inferences on natural mortality rates are given below:

Source	Formulation	Combined sex M		
Hoenig 1983	variety of taxa ln(M) = 1.44-0.982*ln(tmax);	0.160		
	teleosts ln(M) = 1.46-1.01*ln(tmax)	**0.149**		
Alverson and Carney 1975	M = 3k/(exp(0.38*tmax*k)-1)	**0.161**		
Pauly 1980	M=exp(-0.0152+0.6543*ln(k)-0.279*ln(Linf,cm)+0.4634*lnT(oC))	0.196	temperature C	12
		0.211		14
		0.224		16
Ralston 1987	M=0.0189+2.06*k	**0.219**		
Beverton 1992	M=3k/(exp(*am* *k)-1) am = age at 50% maturity	0.369	female *am* ; comb sex k	
		0.614	male *am* , comb sex k	
Jensen (1997)	M=1.5K	**0.146**		
Gislason 2010	M = exp(0.55-1.61*Ln(L) + 1.44* Ln (Linf)+ Ln(K))	**Age class**	Length	M
		1	13.1	1.599
		2	19.7	0.827
		3	25.7	0.539
		4	31.1	0.395
		5	36.1	0.312
		6	40.5	0.258
		7	44.6	0.221
		8	48.3	0.195
		9	51.6	0.175
		10	54.7	0.159
		11	57.5	0.147
		12	60.0	0.138
		13	62.2	0.130
		14	64.3	0.123
		15	66.2	0.117
		16	67.9	0.113
		17	69.4	0.109
		18	70.8	0.105
		19	72.1	0.102
		20	73.2	0.100



The inferred values of M, with the exception of the Beverton method, are in the range 0.15–0.22. The average of the Gislason estimates for ages 3–20 is 0.19.

Hooking mortality, and mortality of discarded bass from commercial vessels

The NMFS in the US has in the past used an average hooking mortality of 9% for striped bass, estimated by Diodati and Richards, 1996. Striped bass are very similar to European sea bass in terms of morphology, habitats and angling methods. A literature review of hooking mortality for a range of species compiled by the Massachusetts Division of Marine Fisheries included a total of 40 different experiments by 16 different authors where striped bass hooking mortality was estimated over two or more days (Gary A. Nelson, Massachusetts Division of Marine Fisheries, pers. comm.) The mean hooking mortality rate was 0.19 (standard deviation 0.19). Direct experiments are needed on European sea bass to estimate hooking mortality for conditions and angling methods typical of European fisheries.

A fraction of sea bass discarded from commercial line vessels and netters may survive depending on the extent of injury or stress. This will affect the calculation of fishing mortality reference points that are conditional on selectivity patterns. Trawl-caught undersized bass are less likely to survive. Unfortunately no estimates of survival rates of commercial bass discards are available.

3.6.4 Assessment model

This section is in five parts:

- A basic exploration of an international catch-at-age matrix (compiled by raising from combined fleets with annual age composition data in Areas IVbc and VIIa,d,e,f,g,h to all commercial landings in this area);
- An assessment carried out on the international landings-at-age data using the ASAP model from the NOAA toolbox);
- Development of a Stock Synthesis 3 model allowing use of length and age composition data for Areas IVb,c and VIIa,d,e,f,g,h;
- Exploration of assessment possibilities for Bay of Biscay and southern Irish stocks;
- Implications of missing data on recreational catches in assessment.

Basic exploration of landings-at-age matrix

A single catch-at-age matrix was generated which combined the catches-at-age from sampled fleets and raises to all fleets and regions (Tables 3.6.1.39 and 3.6.1.40). This matrix was used in the ASAP exploration described in the next section although it must be considered an approximation due to extrapolation of UK age compositions to a larger volume of catches of other countries for which no age compositions were available. Since there was no catch of age 1 sea bass in this matrix, it was not considered in this analysis. Since this analysis computed the survivorship of a cohort from one age to the next, the age 12+ catch was not considered in this analysis. Thus, ages 2–11 for years 1985–2010 remained for consideration. The total mortality rate for each cohort and age was computed by the usual $Z_{y,a} = -\log(C_{y+1,a+1}/C_{y,a})$. These estimates of total mortality at year and age were then plotted by age against year and by year against age to determine if there were any obvious shifts in mortality over age or time.

The plots did not indicate any major changes at age over time (Figure 3.6.4.1). While there is a fair amount of noise, as is expected when computing these year and age specific values, there are no indications of a strong increase or decrease in these total mortality estimates for each age over time. The plots did show a strong increase in estimated total mortality-at-age in almost every year (Figure 3.6.4.2). These trends at age can be interpreted as selectivity patterns, indicating that an asymptotic selectivity pattern is appropriate to this stock. Again, while there is a fair amount of noise in each plot, there are no overall systematic changes observed in the plots at age by year, indicating stability in the selectivity pattern over time.

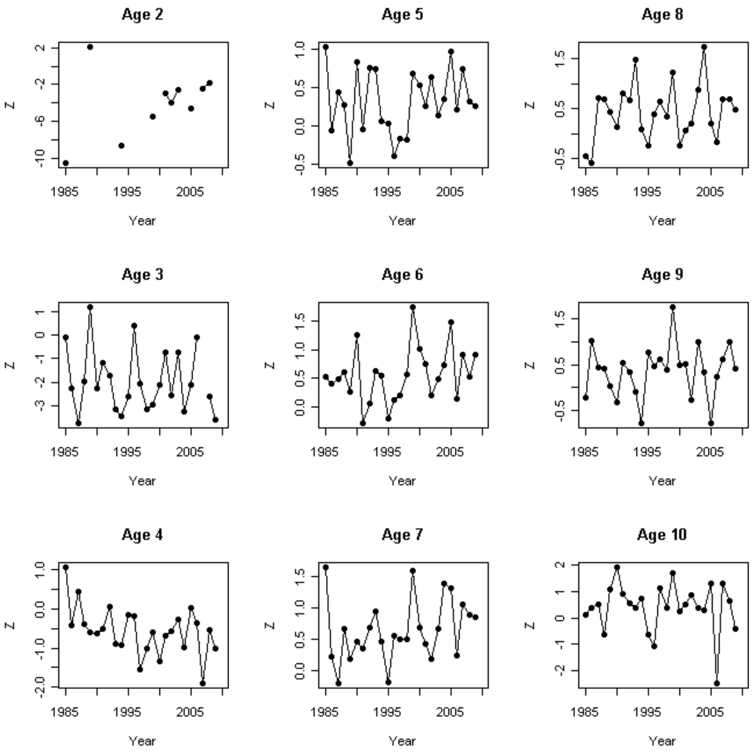


Figure 3.6.4.1. Estimated total mortality by age plotted against year. Note the y-axes differ among plots.

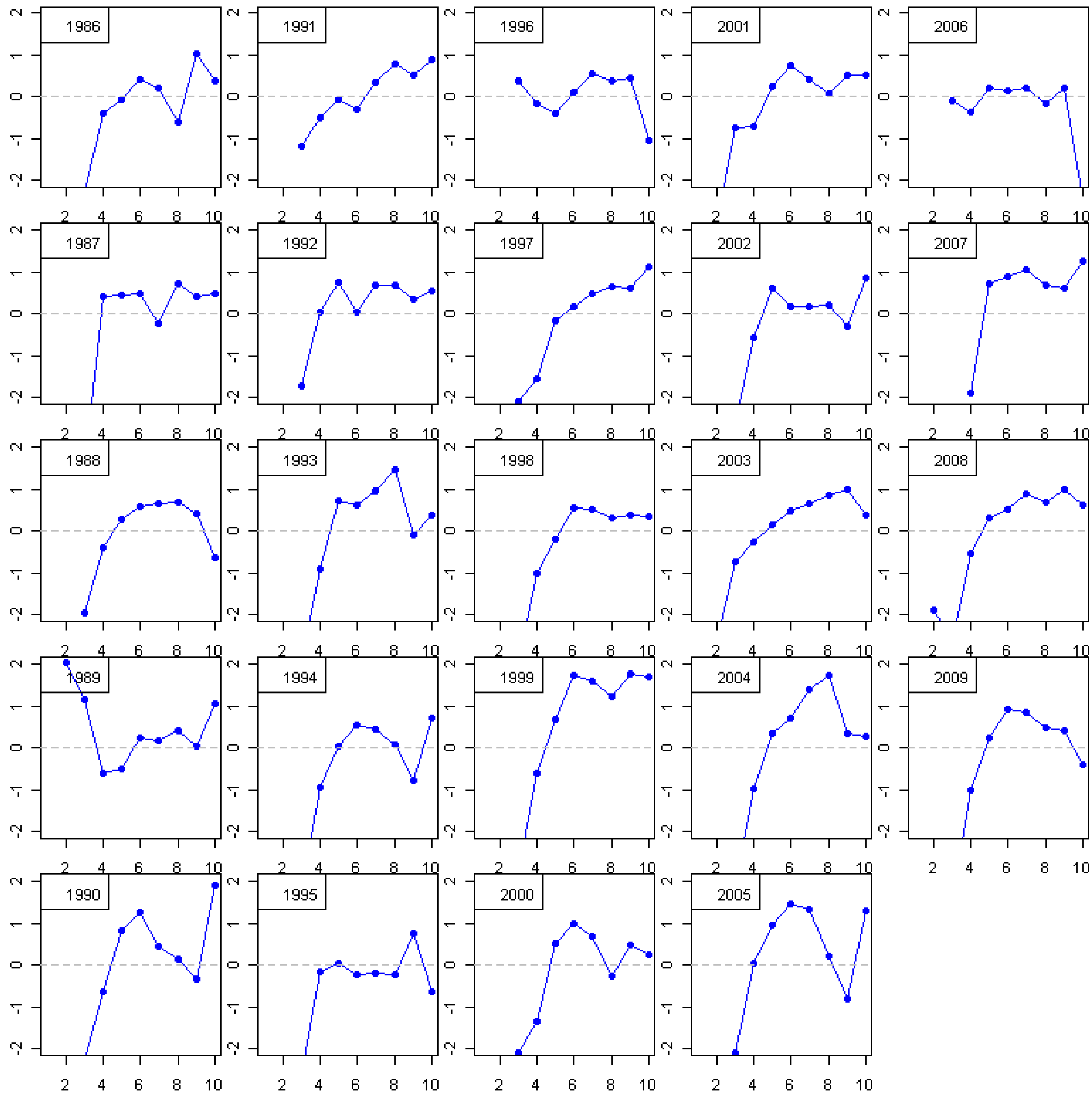


Figure 3.6.4.2. Estimated total mortality by year plotted against age. Note the y-axes are the same for all plots.

ASAP exploration of sea bass data

Data and model formulation

The dimensions for sea bass were years 1985–2010, ages 1–12+, and one fleet encompassing all catch information together. A single matrix of catch-at-age was used to generate the proportions of catch-at-age. One weight-at-age matrix was provided and used with catch and stock biomass estimates. The time-series of annual total catch in metric tons was also provided for all years. The combination of weights-at-age in kg and total catch in tons means that ASAP estimates the population abundance-at-age in thousands of fish. Three surveys were available for tuning the model (Tables 3.6.2.1 and 3.6.2.2): Solent spring survey, Solent autumn survey and Thames survey, which only had information for young ages (ages 2–4 for Solent spring and autumn, ages 0–3 for Thames). The Thames 0-gp index was dropped as the ASAP model did not include this age class. The Solent spring data ranged from 1985–2009, with missing years 1986, 1989, and 2008. The Solent autumn data ranged from 1986–2009, with missing years 1988 and 2004. The Thames data ranged from 1997–2009, with missing years 1998 and 2007. Each survey was entered as separate age-specific indices to avoid the complication of fitting survey selectivity parameters over so few age classes, giving a total of nine tuning indices spanning ages 1–4. There was no tuning information available for ages 5–12. The Solent spring indices were tuned to month 5, the Solent autumn indices were tuned to month 10, and the Thames indices were tuned to month 9, meaning that 5/12, 10/12, or 9/12 of the annual mortality had occurred when computing predicted indices. Natural mortality was set to 0.2 for all years and ages. Maturity-at-age was held constant over all years and followed the empirical means at age for females presented during the meeting.

The commercial fleet selectivity was assumed to be flat-topped, with selectivity at ages 7–12 all fixed at 1.0, but selectivity for all younger ages was estimated as free parameters. All nine indices used the logscale CV associated with the entire survey in each year, these values generally ranged from 0.2–0.8. The total catch in weight was fit assuming a logscale CV of 0.05, while the fleet catch-at-age assumed an effective sample size of 50 in each year when computing the multinomial error contribution to the likelihood. A stock recruitment relationship could not be fit. Instead a Beverton–Holt relationship was assumed with steepness fixed at 1.0. The unexploited recruitment was estimated as a free parameter and recruitment deviations with logscale CV of 0.6 allowed highly variable annual recruitment estimates. A penalty was applied to the estimated numbers-at-age in the first year, 1985, for deviating from an equilibrium population with total mortality-at-age computed from the natural and fishing mortality-at-age in 1985. This penalty was employed to prevent wide swings in estimated numbers-at-age in the first year where no tuning information for the strength of these cohorts was available.

Results

The total catch in weight was fit nearly perfectly, as expected, and there were no indications of problems in the catch-at-age residuals (Figure 3.6.4.3). The signals in the indices were fit reasonably well (Figure 3.6.4.4), although there were indications that the input CVs were too small (RMSE generally above 2). The estimated fleet selectivity pattern was to the left of the maturity-at-age, meaning that fish are being caught before they can spawn (Figure 3.6.4.5). The spawning–stock biomass (computed on January 1) showed a declining trend over time while the fishing mortality rate was relatively flat, with a slight increasing trend over time (Figure 3.6.4.6). There was a moderate to strong retrospective pattern apparent in this assessment (Figure 3.6.4.7).

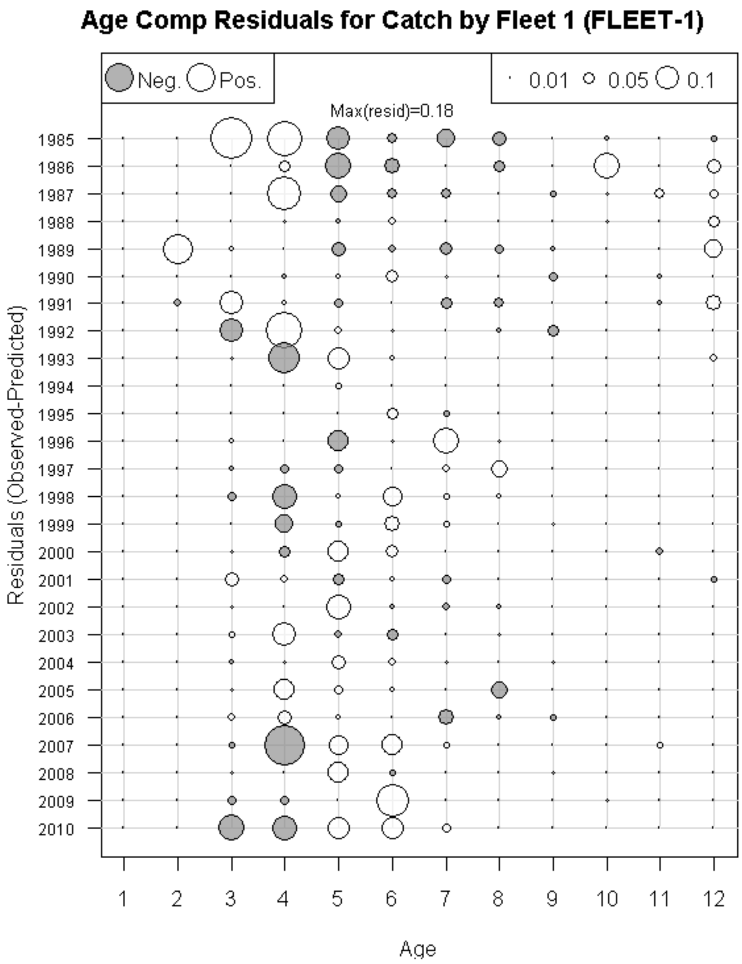


Figure 3.6.4.3. ASAP model residuals of international landings-at-age for sea bass.

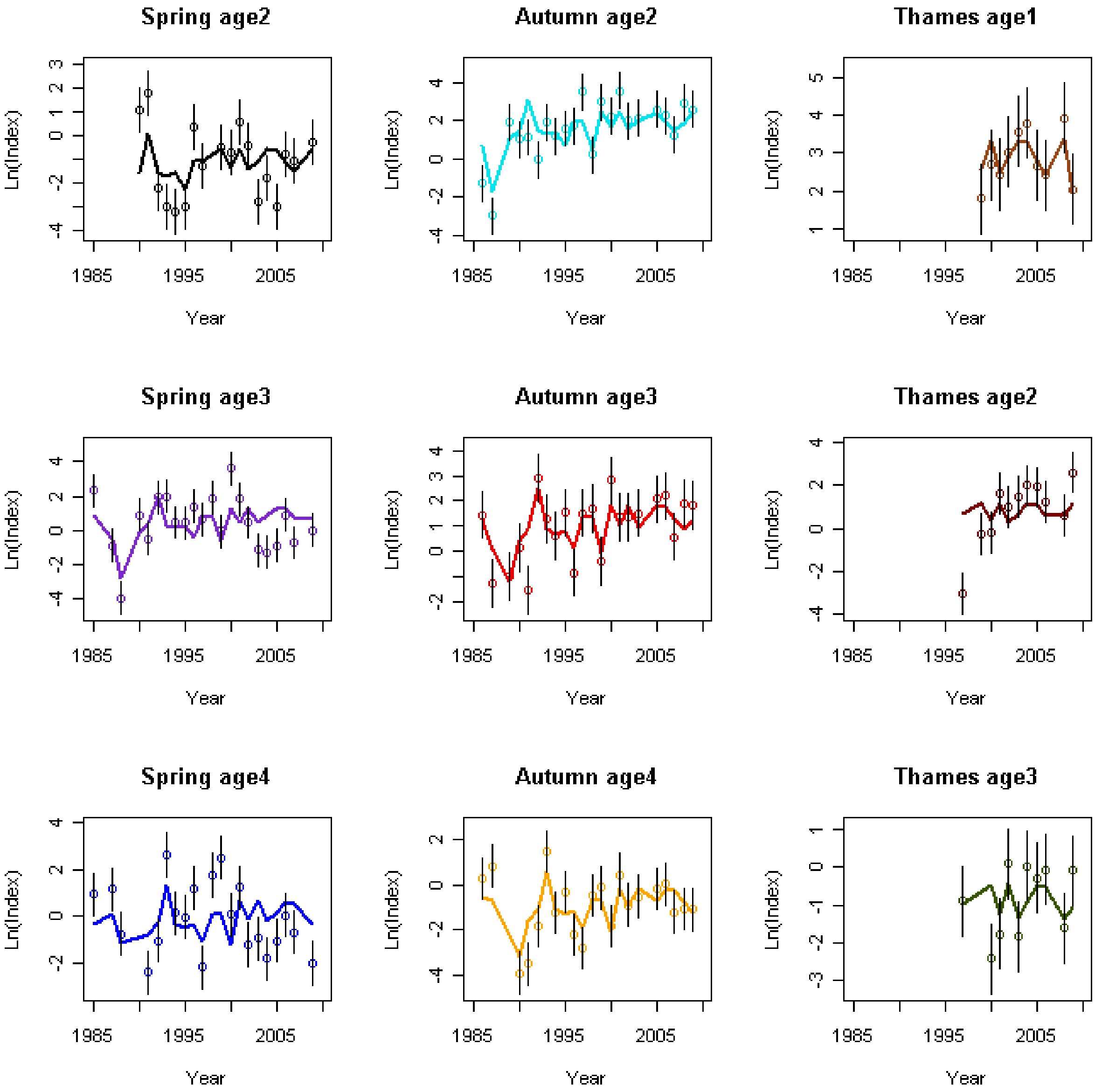


Figure 3.6.4.4. ASAP model fits to sea bass indices.

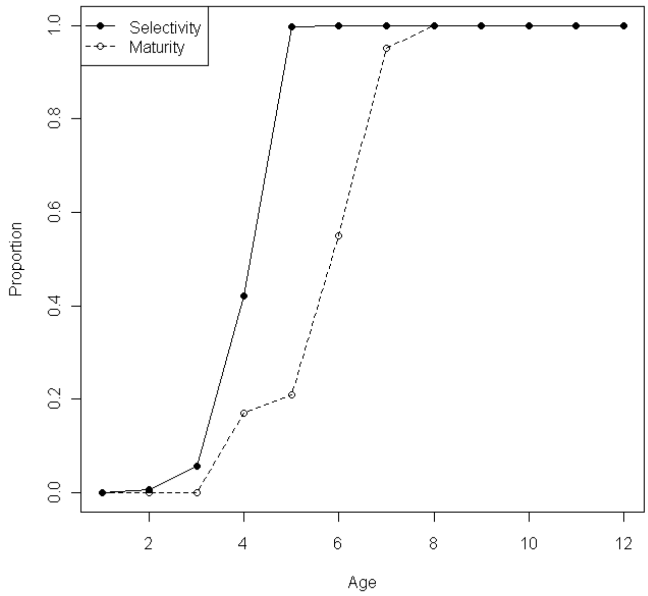


Figure 3.6.4.5. Sea bass fleet selectivity and maturity-at-age (females), both assumed constant over all years.

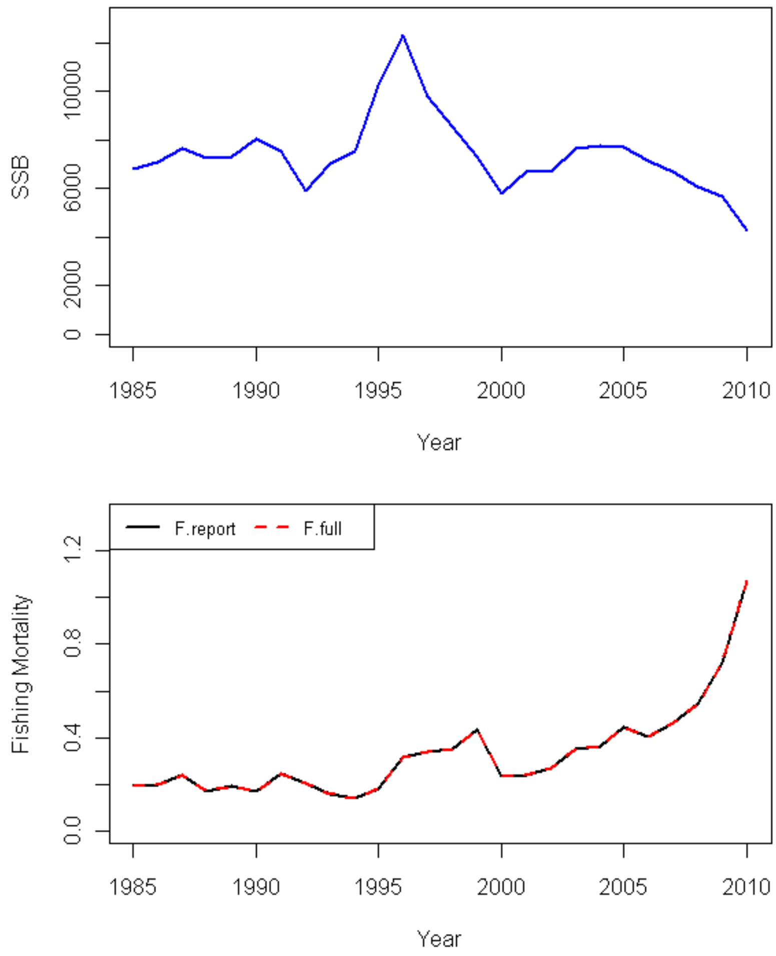


Figure 3.6.4.6. Spawning–stock biomass and fishing mortality rate for sea bass.

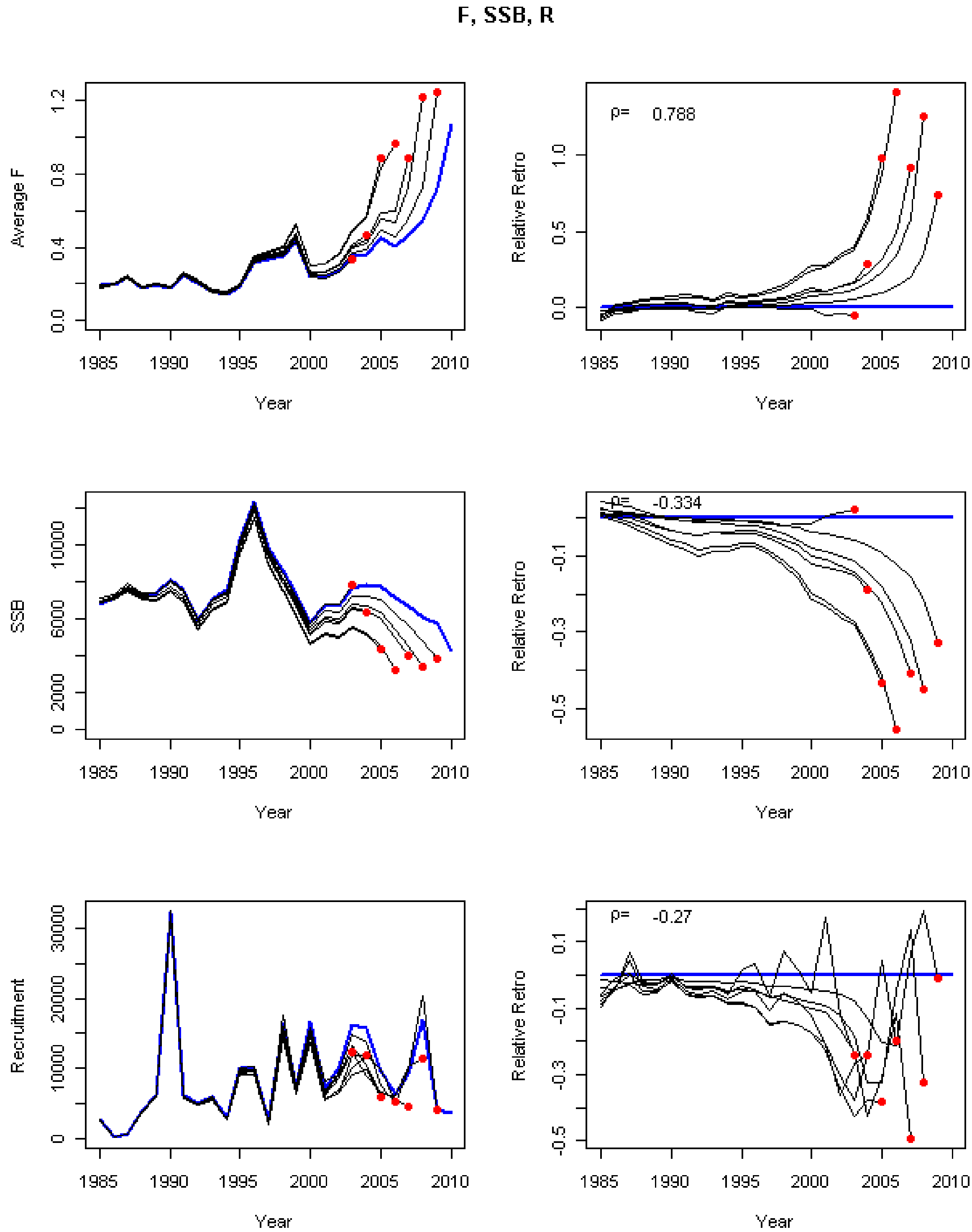


Figure 3.6.4.7. Retrospective patterns for sea bass fishing mortality rate (ages 6–9+), spawning–stock biomass, and recruitment. Left panels show regular scale, right panels show relative differences compared to the final estimates. Rho values denote the average of the endpoints from the seven peels.

Development of Stock Synthesis 3 model for sea bass in Areas IVbc and VIIa,d,e,f,g,h

Data and model formulation

The development of a sea bass assessment model by IBPNew 2012 built on experiences from application of the statistical, fleet-based separable model developed by

Pawson *et al*. (2007b) and updated by ICES WGNEW (ICES, 2008). The Pawson *et al*. model was fitted only using UK age compositions for trawls, midwater trawls, nets and lines, separately for Areas IVbc, VIId, VIIeh and VIIafg, and was intended mainly to estimate fleet selection patterns. Although it excluded any tuning data, the recruitment series for each sea area closely resembled the Solent survey indices and to an extent the shorter Thames series, and was able to provide coherent selection patterns by fleet.

The IBPNew 2012 assessment required a modelling framework capable of handling a mixture of age and length data for fisheries, including data for French fleets that had length composition data but no age composition data, and for which the length data were available only since the 2000s. The Stock Synthesis (SS) assessment model (Methot, 1990) was chosen for this purpose, primarily for its highly flexible statistical model framework allowing the building of simple to complex models using a mix of data compositions available. This model is written in ADMB (www.admb-project.org), is forward simulating and available at the NOAA toolbox: http://nft.nefsc.noaa.gov/SS3.html. For European sea bass a range of assessment models were built using Stock Synthesis 3 (SS3) version 3.29b to integrate the mix of fisheries and survey data available (fleet-based landings; landings age or length compositions and discards length compositions for variable combinations of fleets and years; three surveys providing recruitment indices) and biological information from recent research on growth rates, maturity and mortality.

Two basic model structures were explored, with the same specifications where possible:

1) Age and length model; including age compositions for the four UK fleets and combined length compositions for the French fleets.
2) Length only model; including only the length composition data for all fishery fleets.

Both models include the survey data as age-based indices. The input data and the model specifications used during the benchmark are outlined in Figures 3.6.4.8 and 3.6.4.9 and Table 3.6.4.2.

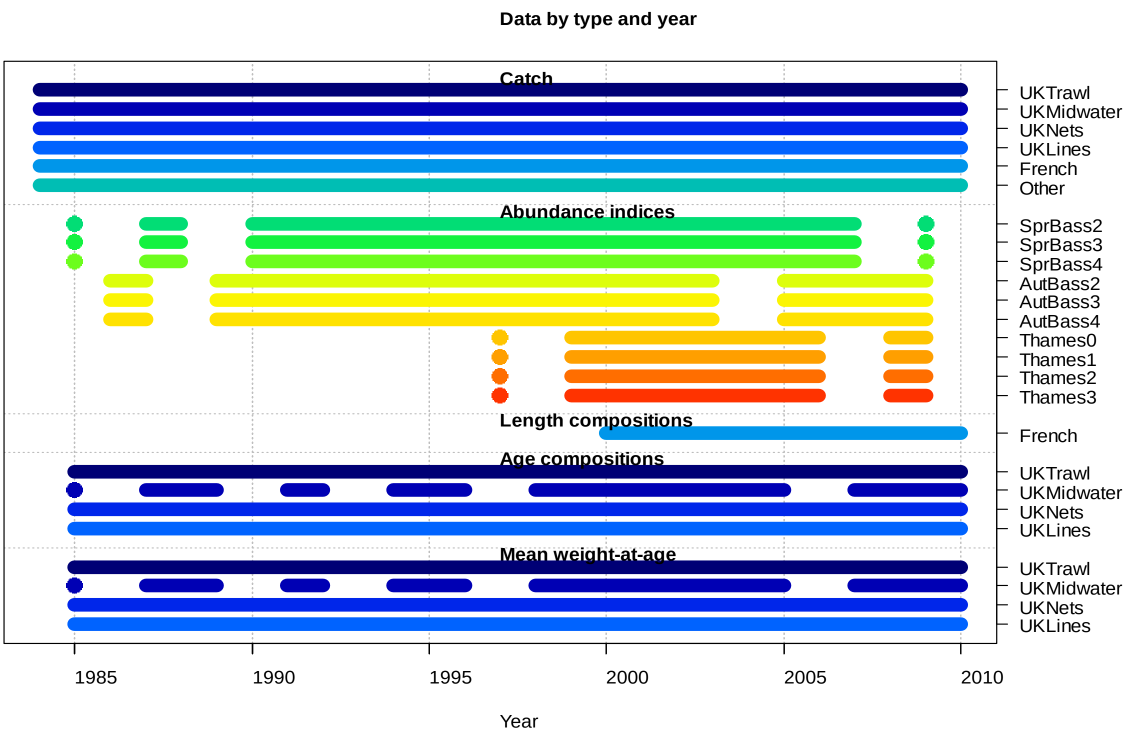


Figure 3.6.4.8. Input data for the baseline age and length based stock synthesis model.

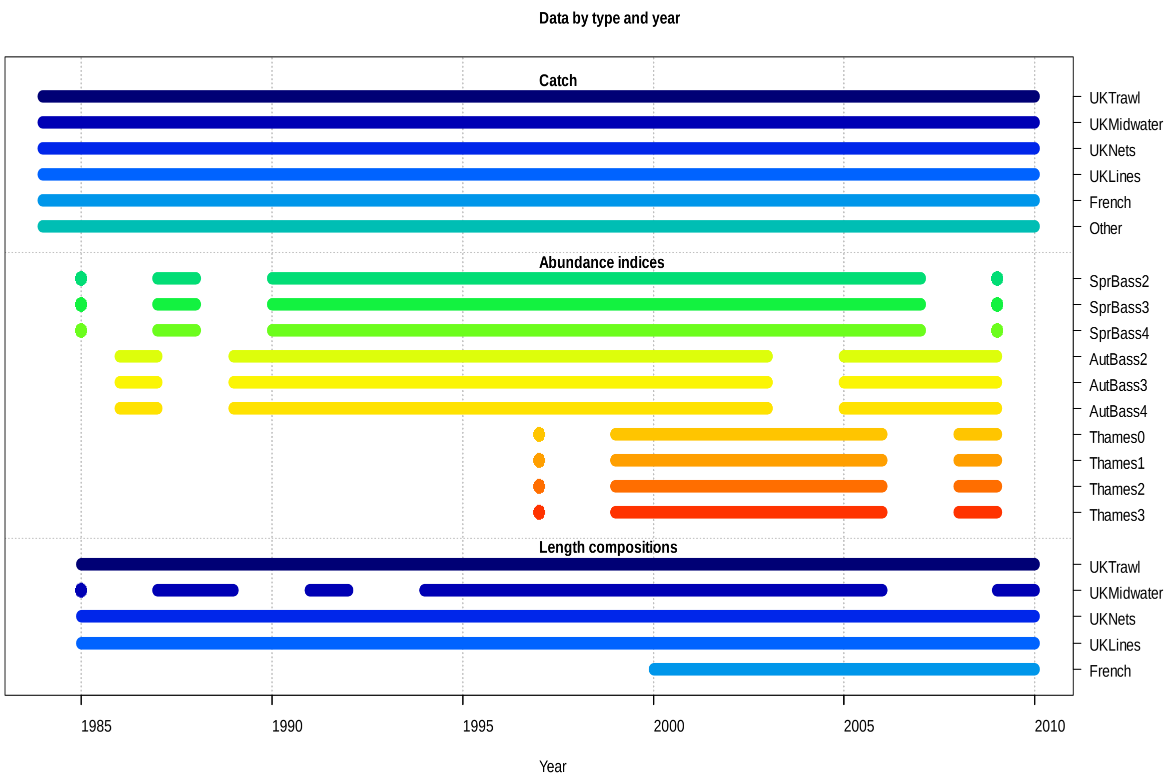


Figure 3.6.4.9. Input data for the baseline length based stock synthesis model.

Model building steps

The development of a final SS3 model configuration involved a series of model building steps.

In the first step, SS3 data input and control files were established for the age–length and length only models including initial assumptions for parameters such as length at minimum and maximum ages, and which ran successfully giving coherent diagnostics.

A number of adjustments were then made to the base models configuration (in consultation with the model developer, Rick Methot) in order for the models to process the input data and provide a better fit:

- The input effective sample sizes for the age and length compositions of the landings samples (based on sampled trips: Tables 3.6.1.16–3.6.1.25) were reduced to more closely match the values output from the model.
- The recruitment variability parameter σ_R was increased to 0.9 to allow the model to fit the highly variable recruitment patterns implied by the data.
- The minimum age for the age–length model was increased from age 0 to age 2 producing a better fit to the selectivity for the UK fleets, due in part to the very limited information at the younger ages. This adjustment was also tested in the length only model, for which the outcome was a slight change in the pattern of recruitment, and minimum age was left at zero for the length-only model.
- Selectivity was modelled as a function of length for all fleets, including fleets in the age–length model where the model is fit using observed and expected age compositions of landings.

Following these adjustments, two baseline models (age–length and length only) were identified, and the diagnostics compared. For the model considered to provide the best overall fit to the different datasets, a series of additional runs was then carried out to explore the sensitivity to input data, model settings and assumptions regarding selectivity and natural mortality. This included runs incorporating a limited available set of discards estimates, a range of fishery lpue series, and an additional mortality component to represent recreational fishing mortality.

The component likelihoods, number of parameters estimated and SSB estimate for 2010 were tabulated for the baseline models and sensitivity model runs examined (Table 3.6.4.3). Full diagnostic plots for all runs conducted during model development and sensitivity analysis are available in pdf format on the IBPNew 2012 SharePoint site.

UK age composition data supplied to IBPNew 2012 had the plus group fixed at 12+, as had been chosen for previous assessments applied by WGNEW to UK data only. For comparison purposes and for future use in the calculation of F_{MSY} and projections, an F_{BAR} range of $F_{(5–11)}$ was selected. Using the outputs from the length-only model, a number of age ranges for F_{BAR} showed very similar trends over time (Figure 3.6.4.10 shows two examples of F_{BAR}). When discards and the recreational fishery data are included, or there are known changes to selectivity patterns or the plus group changes this would need further analysis.

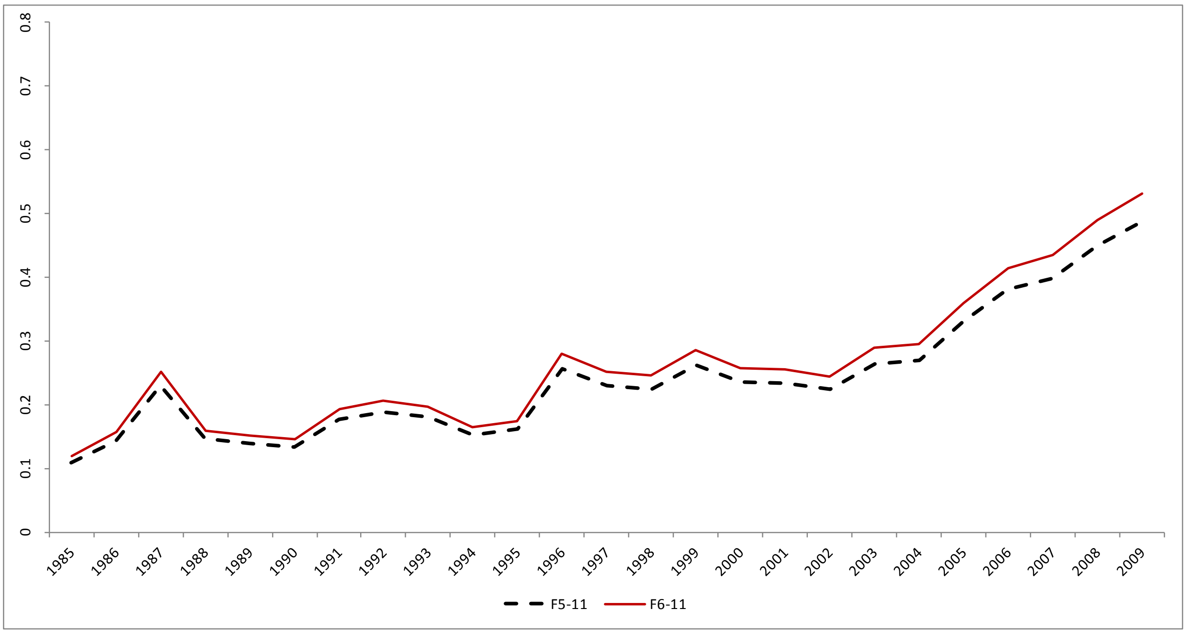


Figure 3.6.4.10. FBAR for ages 5–11 and 6–11 from baseline length-only model.

Comparison of baseline length-only (run 1A) and age-length (run 1B) models: stock trends

Stock trends for the two baseline models are compared in Figure 3.6.4.11.

The two baseline models give similar estimates of recruitment, but the length-only model estimates higher values of F throughout the series and correspondingly lower estimates of SSB.

The two models show similar patterns of recruitment until 2005 with strong year classes in 1989, 1997 and 1999. The recruitment patterns after 2005 differ, with the age–length model showing a smooth decline compared to a more variable pattern given by the length-only model which indicates relatively strong year classes in 2006 and 2007.

Both models show transient increases in SSB in the mid-1990s and 2000s due to strong recruitment, and declining SSB since 2005. However the age–length model shows a depletion of SSB in 2010 to around half the 1985 value whereas the length-only model shows similar SSB in 1985 and 2010. Inspection of the model estimates of numbers-at-age show that the age–length model predicts larger numbers for the 1983 and earlier year classes with little evidence of the pre-1983 year-class variability evident in the length-based model as well as in the raw age sample data for all UK fleets combined (see Figure 3.6.4.23). This may be a reflection of low sampling rates for age compositions in the 1980s.

Both models show a trend of increasing fishing mortality over time, accelerating after 2002, although F is higher for the whole time-series in the length-only model.

Comparison of baseline length-only (run 1A) and age-length (run 1B) models: diagnostics

A comparison of the likelihoods for the individual components of the baseline models (Table 3.6.4.3: model runs 1A and 1B), where the input data are the same, shows that the age–length model gives a marginally better fit to the survey data and the length-only model gives a better fit to the catch, equilibrium catch (for initial depletion in 1985) and recruitment. A negative likelihood value is given for size-at-age in the age–length model suggesting a fitting problem.

The two models show similar residual patterns for the surveys (Figures 3.6.4.12–3.6.4.14) with the Solent autumn survey being fitted more closely than the other two surveys. The Solent spring survey shows strong negative residuals for all years from 2002 onwards. The Thames survey fits poorly for all ages, particularly age 0.

The age–length model (run 1B) shows strong residual patterns for the UK fleet age compositions, underestimating the numbers-at-ages 4–6 in the trawl and net fleets in most years and in the lines fleet up to 2002, and underestimating the older ages in the midwater trawl fleet (Figures 3.6.4.18–3.6.4.21). There is a tendency to underestimate catches from the very strong 1989 year class. In general, the length-only model fits the fleet length compositions more closely than the age–length model fits the fleet age compositions, but tends to underestimate the most abundant length classes. For example, numbers at 36 cm (approximately five years old) are underestimated in four of the fleets for the majority of the time-series. Both models fit length compositions for the combined French fleets, but the length-only model shows a marginally better fit than the age–length model (Figures 3.6.4.22).

Comparison of baseline length-only (run 1A) and age-length (run 1B) models: retrospective analysis

Both baseline models show no evidence of the retrospective bias apparent in the ASAP model fits (Figure 3.6.4.24; same y-axis scale for both runs). The retrospective estimates for the age–length model (run 1B) were less variable than for the length-only model, apart from a large adjustment between runs ending in 2006 and 2007.

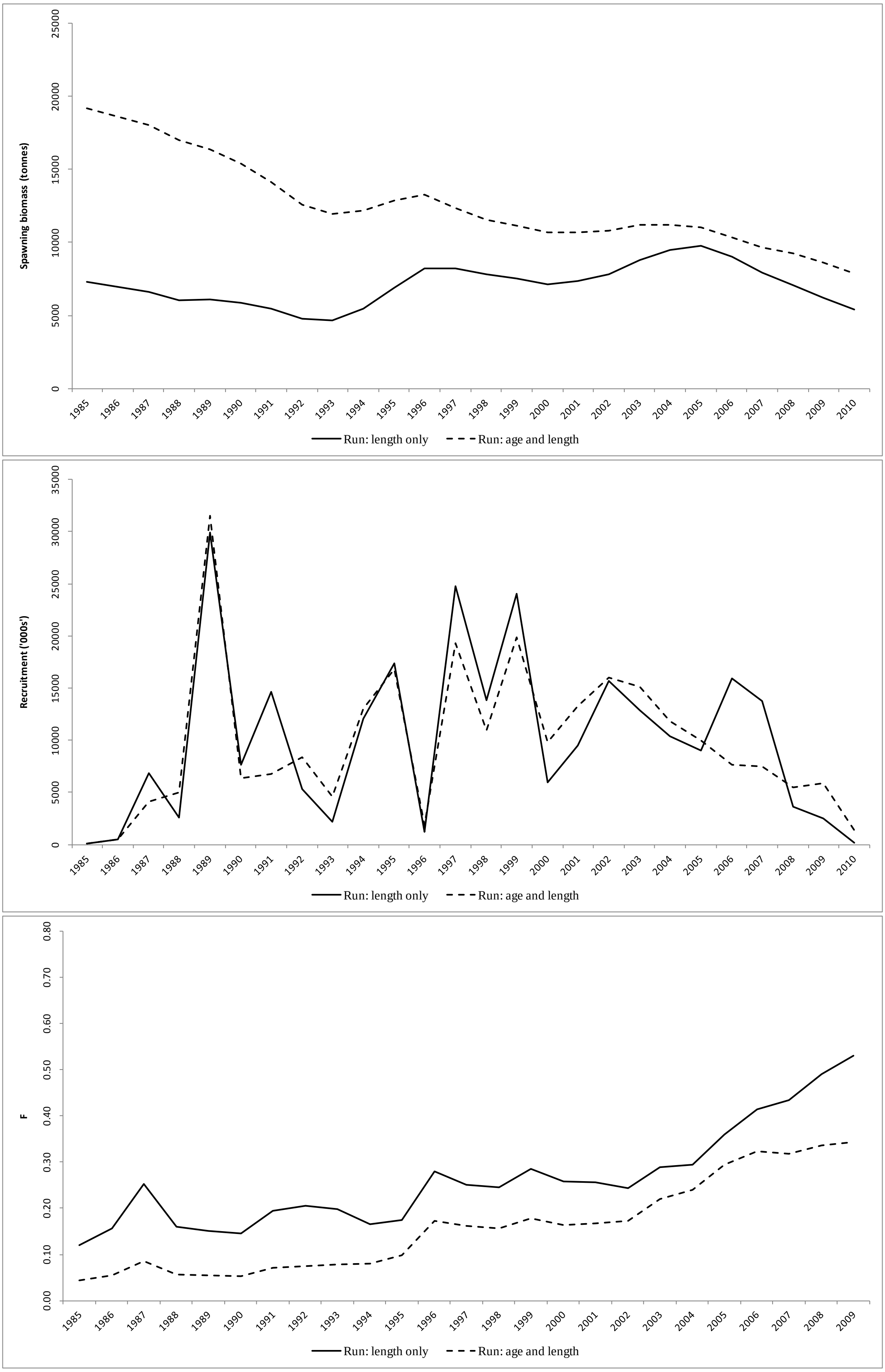


Figure 3.6.4.11. Comparison between the baseline length-only (run 1Aa) and age–length run 1B) models for SSB, recruitment and F_{5-11}.

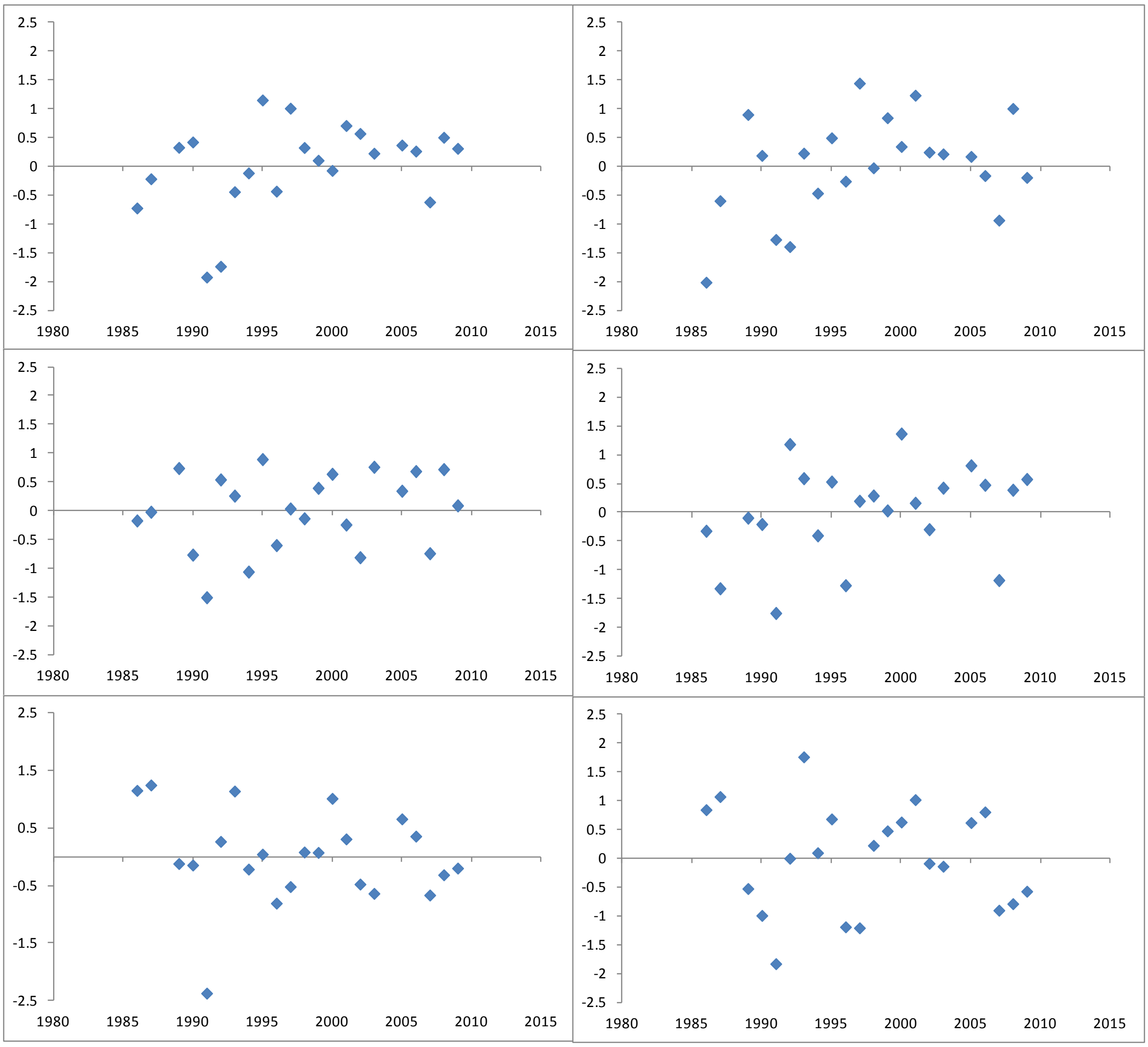


Figure 3.6.4.12. Log residuals for the Solent autumn bass survey for the baseline length-only run 1A (left) and age–length model run 1B (right) for ages 2 (top), 3 (middle) and 4 (bottom).

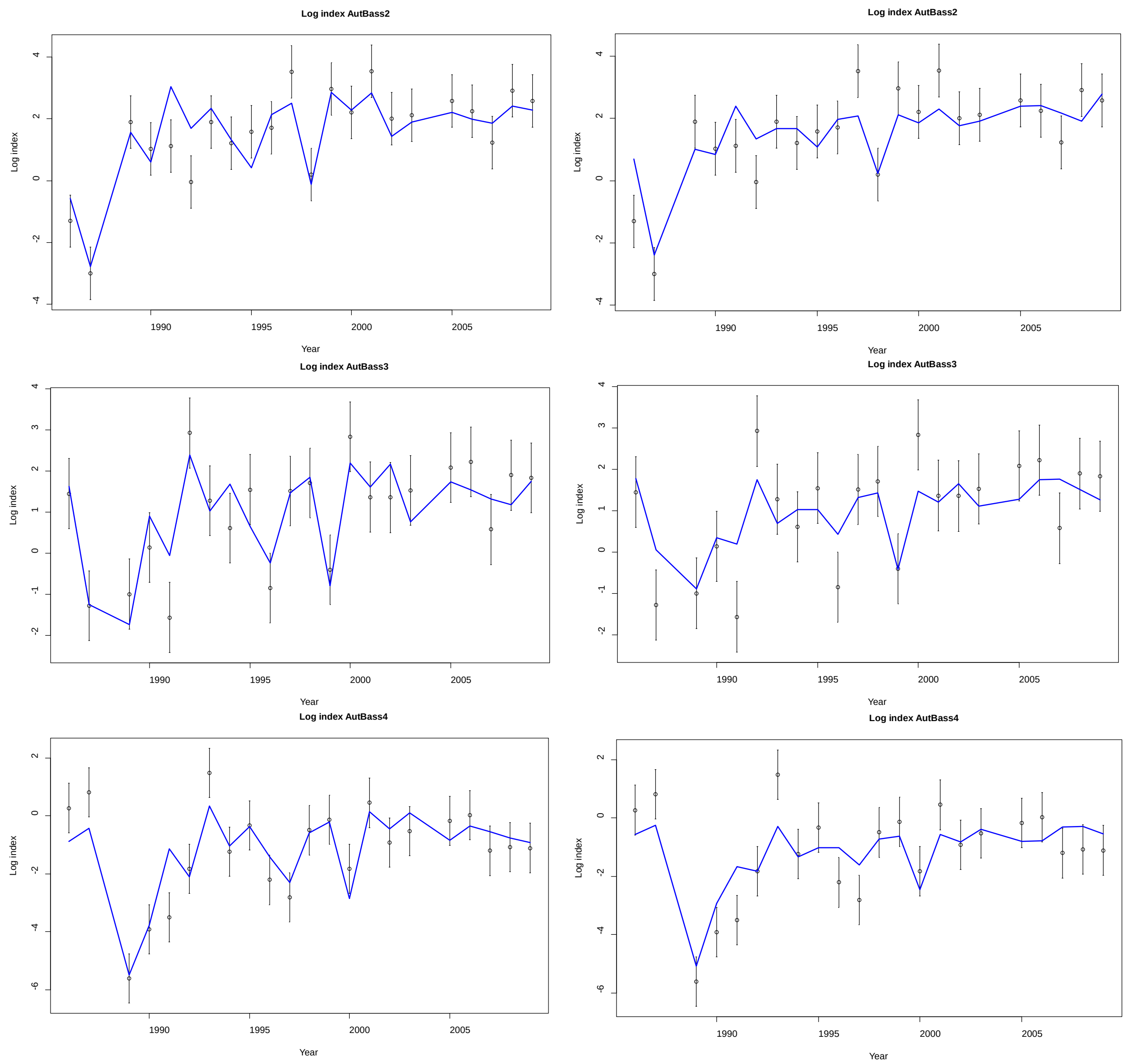


Figure 3.6.4.13: Solent autumn bass survey indices and modelled fit (blue line) for the baseline length-only model run 1A (left) and age–length model run 1B (right) model for ages 2 (top), 3 (middle) and 4 (bottom).

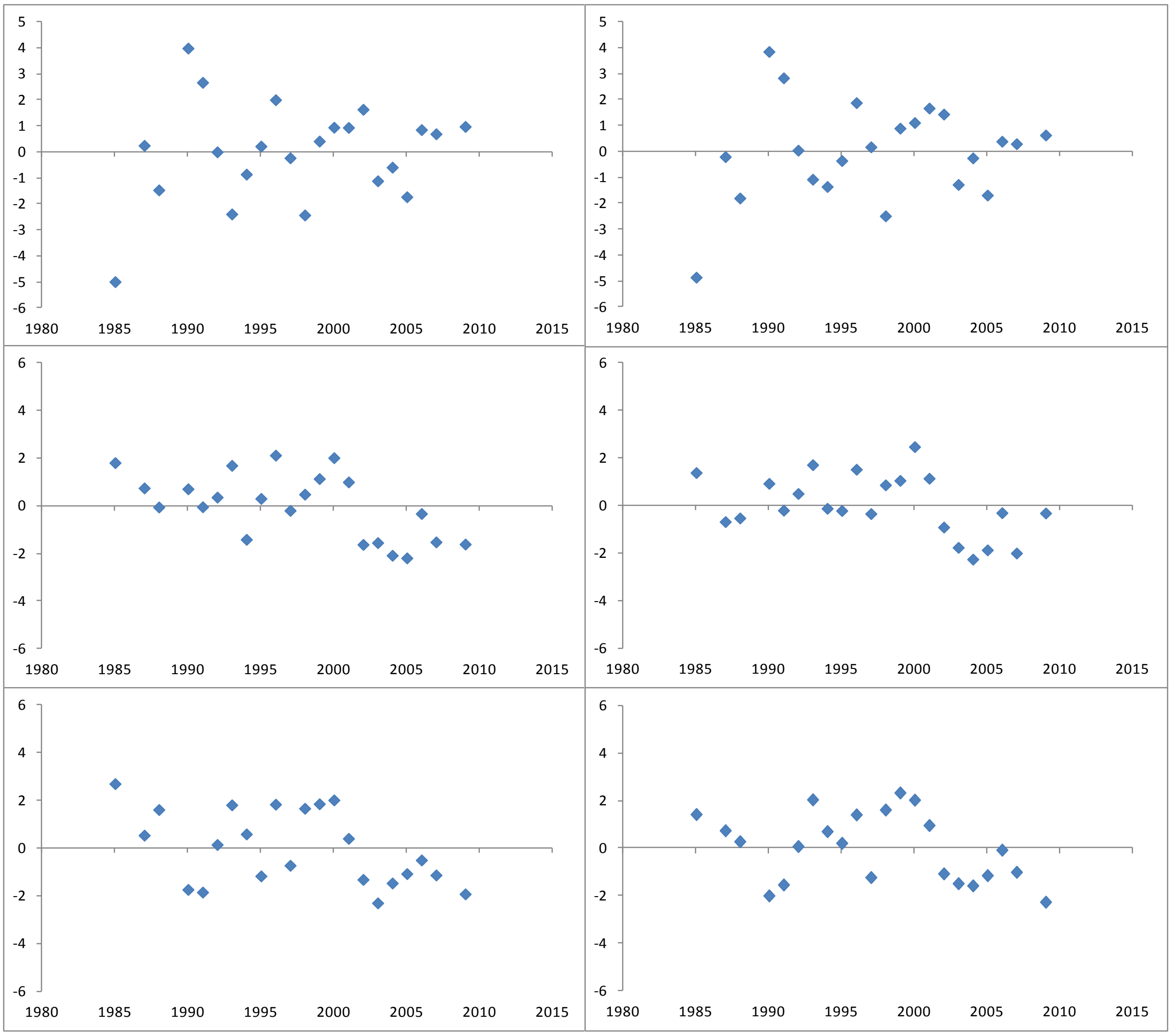


Figure 3.6.4.14. Log residuals for the Solent spring bass survey for the baseline length-only run 1A (left) and age–length model run 1B (right) for ages 2 (top), 3 (middle) and 4 (bottom).

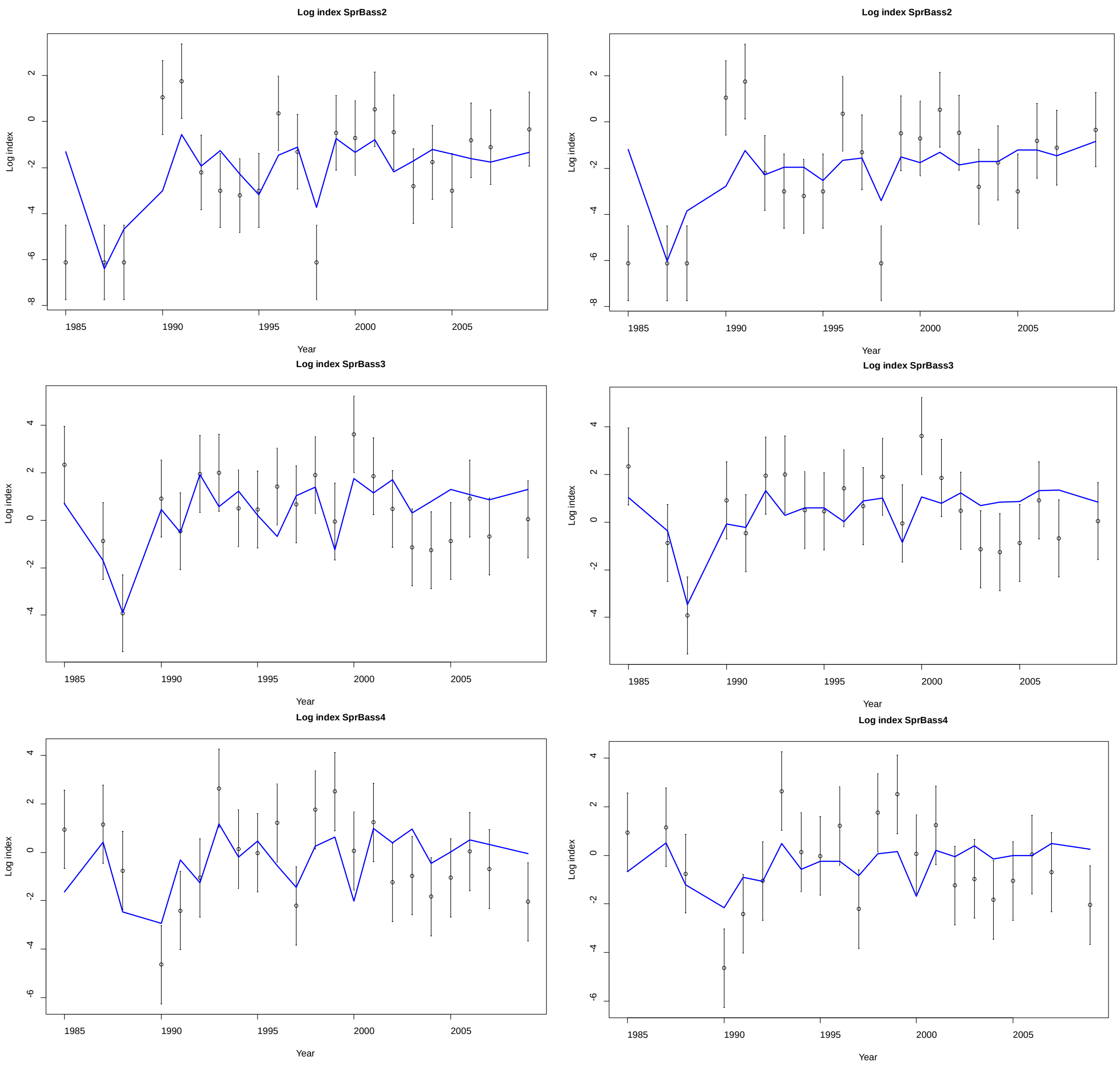


Figure 3.6.4.15. Solent spring bass survey indices and modelled fit (blue line) for the baseline length-only model run 1A (left) and age–length model run 1B (right) model for ages 2 (top), 3 (middle) and 4 (bottom).

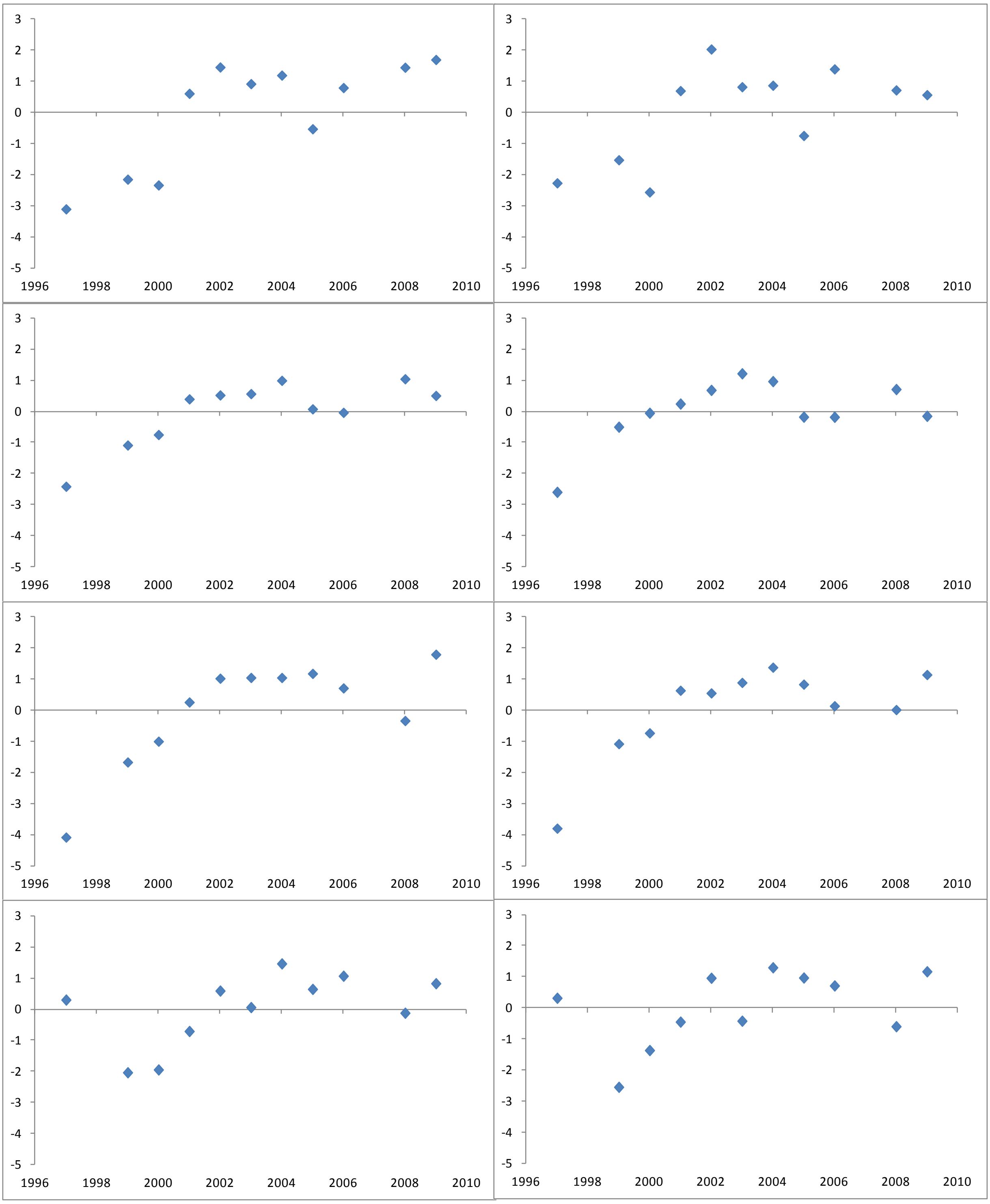


Figure 3.6.4.16. Log residuals for the Thames bass survey for the baseline length-only run 1A (left) and age–length model run 1B (right) for ages 0–3. Age 0 is at top and age 3 at bottom.

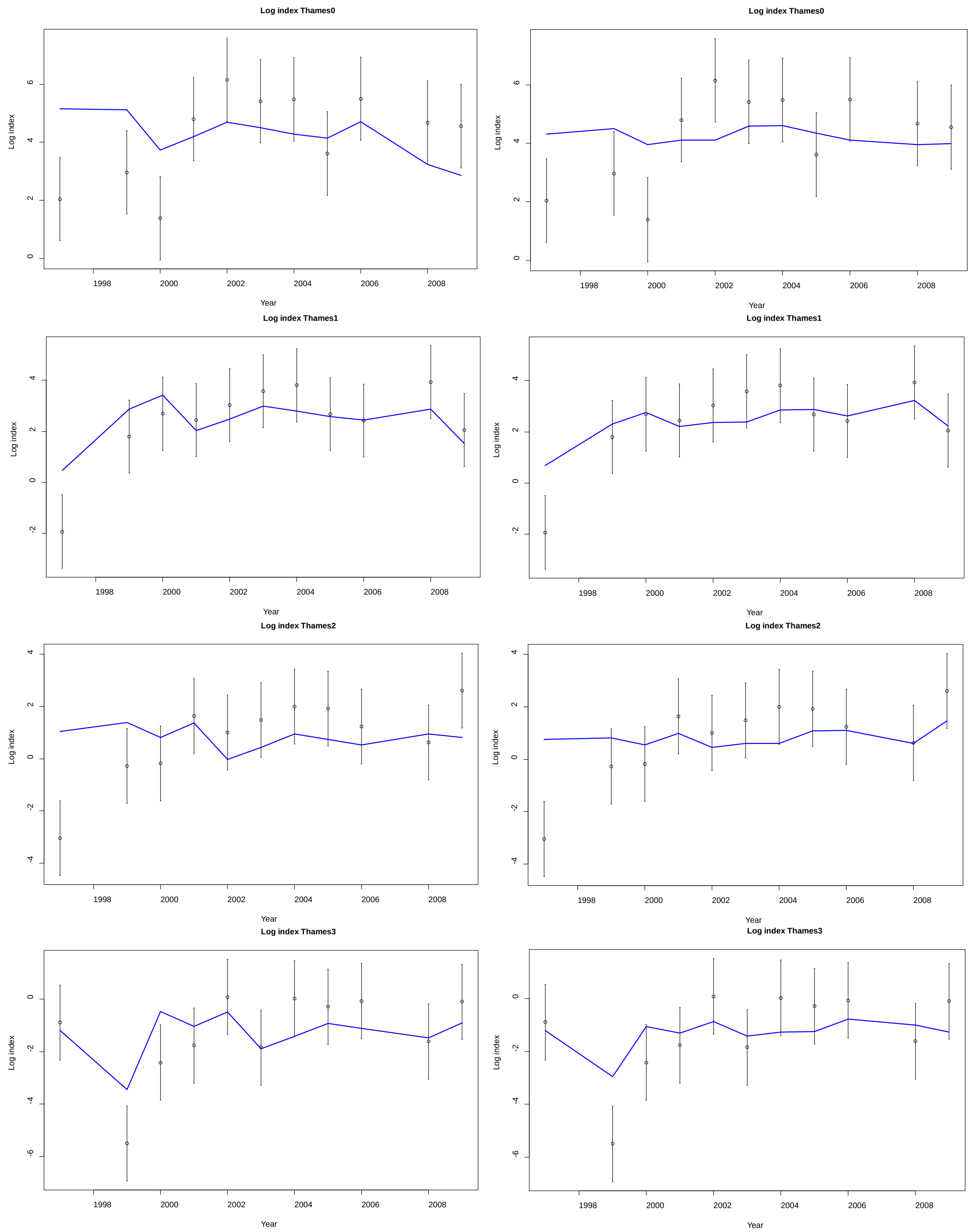


Figure 3.6.4.17. Thames bass survey indices and modelled fit (blue line) for the baseline length-only model run 1A (left) and age–length model run 1B (right) model for ages 0–3. Age 0 is at top and age 3 at bottom.

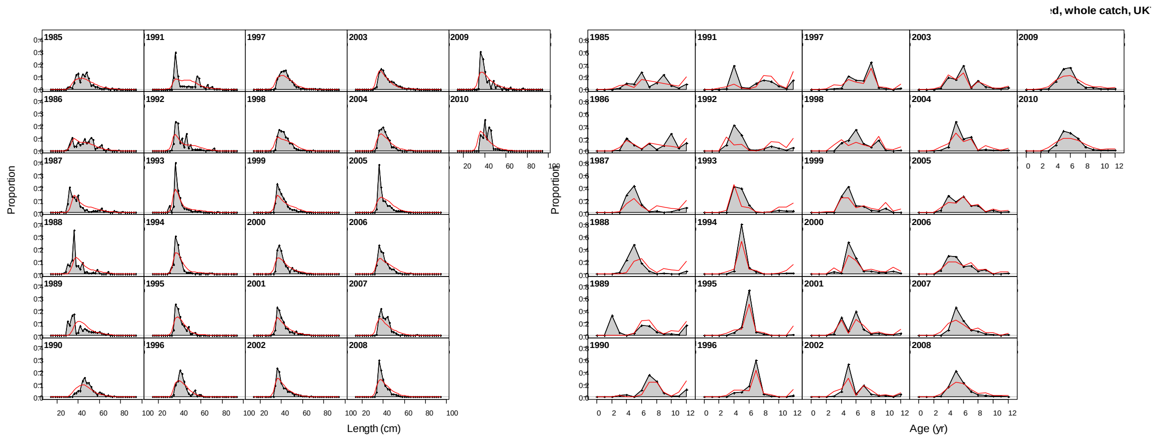


Figure 3.6.4.18. Length and age compositions with fits (red line) for the UK trawl fleet (baseline length-only run 1A: left; age–length run 1B: right).

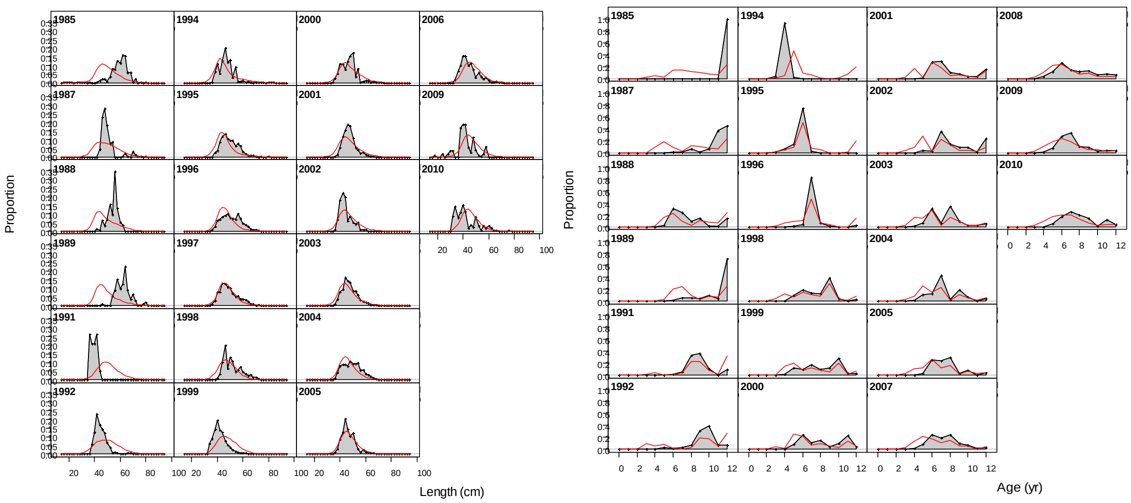


Figure 3.6.4.19. Length and age compositions with fits (red line) for the UK midwater trawl fleet (baseline length-only run 1A: left; age–length run 1B: right).

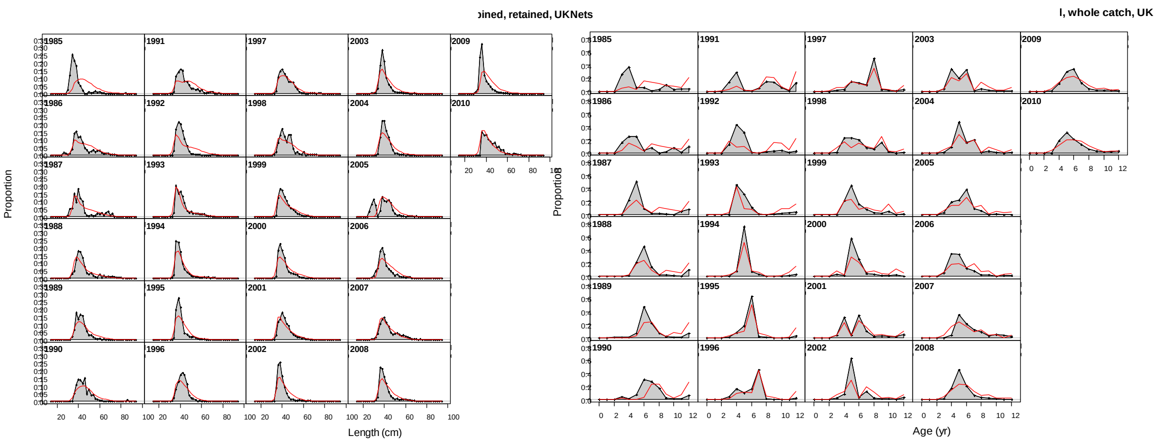


Figure 3.6.4.20. Length and age compositions with fits (red line) for the UK net fleet (baseline length-only run 1A: left; age–length run 1B: right).

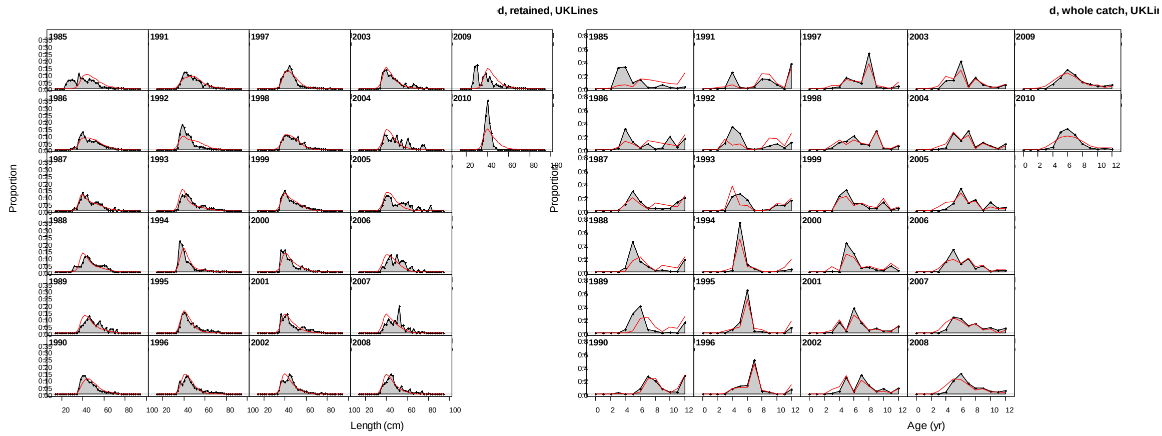


Figure 3.6.4.21. Length and age compositions with fits (red line) for the UK line fleet (baseline length-only run 1A: left; age–length run 1B: right).

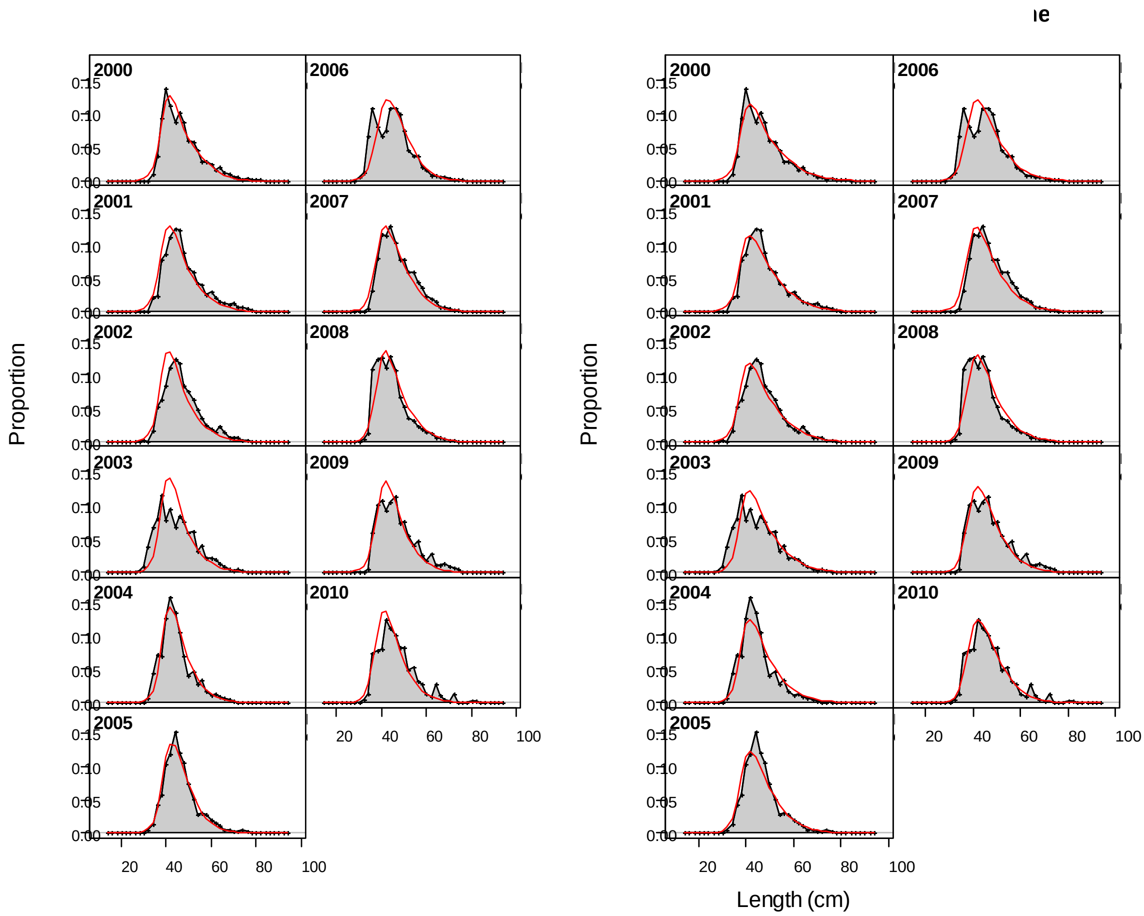
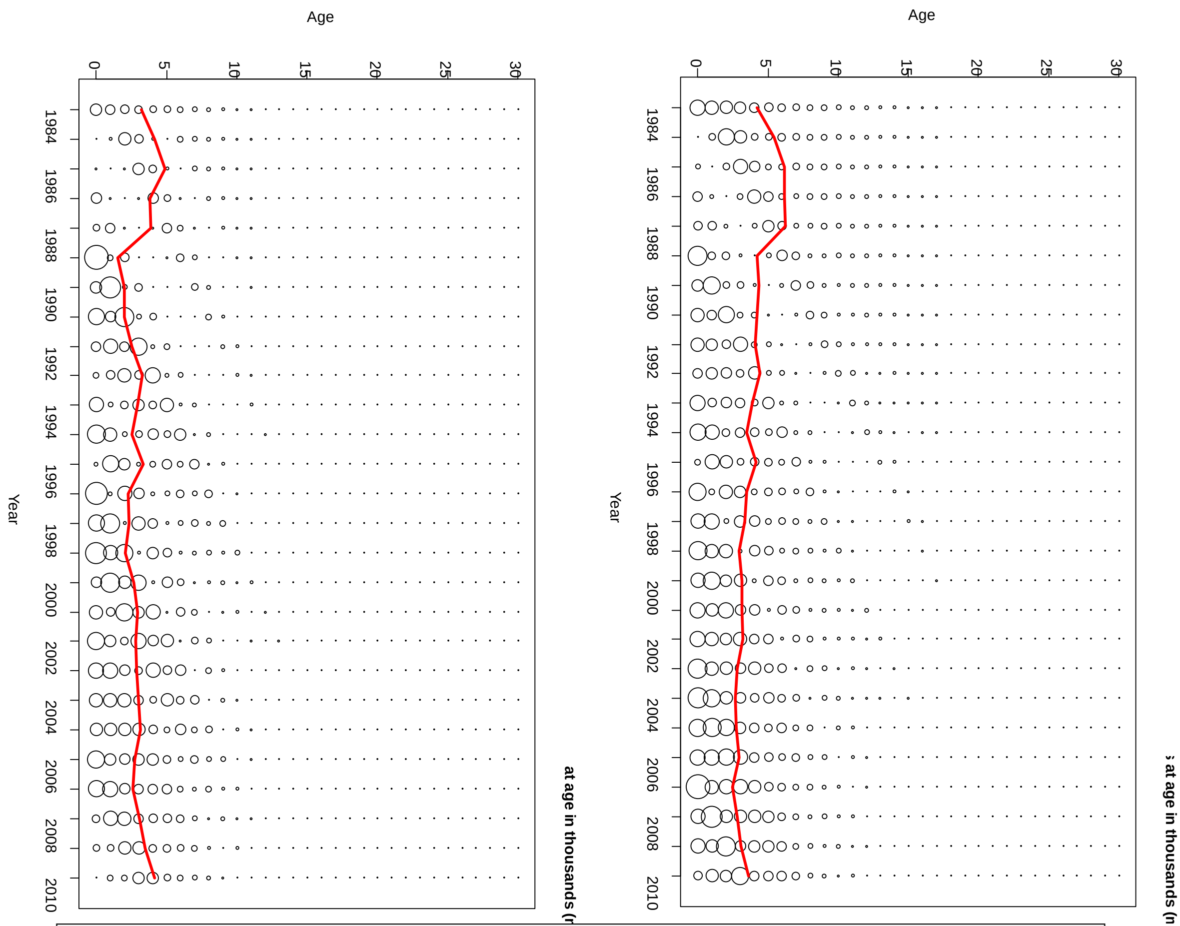


Figure 3.6.4.22. Length compositions and fits (red line) for the French fleet (baseline length-only run 1A: left; age–length run 1B: right).



	Age class																													
year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**No. fish**
1985			3.5	19.3	16.6	6.9	12.2	1.8	5.9	17.5	4.8	3.3	3.0	0.8	1.8	0.6	0.1	0.3	0.8	0.5	0.1	0.1	0.1				0.2			**1014**
1986			0.1	2.6	25.2	17.4	3.7	10.2	2.2	4.9	17.3	3.3	2.4	3.3	1.7	1.9	1.0	0.8	0.4	0.6	0.5	0.2		0.1		0.1				**1015**
1987		0.1		4.2	17.4	33.4	10.2	1.8	3.2	0.9	1.9	11.7	3.1	3.0	1.4	2.0	1.0	0.7	1.4	0.4	0.7	0.7	0.4		0.1		0.1	0.1	0.1	**1354**
1988				0.4	4.6	27.0	24.8	11.1	2.6	3.9	0.8	1.8	8.7	3.2	3.0	2.0	1.8	1.5	0.6	0.8	0.7	0.3				0.1	0.1	0.1		**1427**
1989	1.2	7.4	10.3	0.5	1.7	5.9	17.8	15.7	6.3	2.3	3.2	1.6	2.8	12.1	1.9	1.9	3.2	1.1	1.1	0.5	0.5	0.6	0.2	0.1		0.1		0.1		**1870**
1990		17.7	17.9	12.4	1.1	1.7	6.1	14.2	10.7	3.5	1.4	1.1	0.8	1.1	6.1	0.4	1.0	0.9	0.7	0.3	0.1	0.7		0.0						**2097**
1991		6.5	36.6	10.3	10.7	1.0	0.8	2.8	9.4	8.1	3.5	0.5	1.1	1.1	0.6	4.5	0.6	0.7	0.5	0.1	0.4	0.1	0.2							**3367**
1992	0.7	2.6	1.9	28.8	24.3	17.9	0.8	0.7	1.8	5.3	6.9	2.2	0.5	0.7	0.4	0.6	2.9	0.2	0.3	0.1	0.2	0.0	0.1	0.1						**3982**
1993	0.0	3.1	4.0	2.7	32.3	20.0	12.0	0.9	0.7	2.0	6.3	5.9	2.1	1.0	1.2	1.1	0.8	2.8	0.3	0.3	0.3	0.2	0.0	0.0						**4609**
1994	0.4	0.7	2.7	2.8	5.2	64.3	9.2	4.6	0.5	0.1	1.1	3.1	2.4	0.7	0.4	0.3	0.3	0.2	0.8	0.1	0.1	0.1								**6620**
1995		0.2	0.1	0.7	2.7	7.8	72.4	4.8	3.1	0.2	0.3	0.5	2.2	1.8	1.0	0.5	0.2	0.2	0.4	0.4	0.2	0.1	0.1	0.1	0.1	0.1	0.0			**3704**
1996		0.1	0.3	0.2	6.9	9.4	15.6	53.1	3.9	2.2	0.2	0.4	0.6	2.3	1.7	0.7	0.4	0.3	0.4	0.3	0.4	0.3	0.1	0.1	0.1	0.1		0.0		**3896**
1997			0.2	1.2	3.1	21.5	12.9	10.8	41.1	2.8	1.4	0.3	0.2	0.2	1.6	0.9	0.4	0.2	0.6	0.1	0.0	0.3	0.0	0.0						**4423**
1998		0.1	0.0	1.8	13.1	13.1	22.4	8.5	8.2	26.0	2.4	0.8	0.1	0.2	0.7	1.1	0.7	0.4	0.0	0.0		0.1	0.1		0.0					**3388**
1999			0.4	0.5	13.5	24.1	10.5	11.2	5.4	6.1	20.0	2.1	1.8	0.3	0.7	0.6	1.6	0.4	0.2	0.1	0.1	0.1	0.0	0.2	0.0					**3359**
2000		0.1	0.1	1.9	0.6	32.8	26.1	7.4	8.6	3.1	4.0	12.4	1.0	0.4	0.1	0.3	0.2	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0					**4759**
2001			0.2	2.8	18.9	3.7	37.1	13.5	3.8	5.9	2.8	3.2	6.2	0.6	0.4	0.1	0.2	0.0	0.2	0.1	0.0	0.0				0.0				**4985**
2002		0.3	0.3	5.5	10.4	42.1	3.4	16.1	6.6	2.3	3.7	1.2	1.9	5.1	0.4	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0			0.0				**4759**
2003			0.0	1.7	14.2	11.8	34.6	2.7	15.6	5.4	2.3	2.1	1.7	1.5	5.0	0.6	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0						**3438**
2004			0.0	1.0	5.2	29.2	15.3	28.6	2.1	8.4	3.7	1.0	1.4	0.9	0.4	2.5	0.2	0.0						0.0	0.0					**2383**
2005			0.1	3.1	12.1	15.8	29.9	12.6	14.4	1.4	5.2	1.4	1.6	0.5	0.2	0.5	1.2		0.1				0.1							**1824**
2006				1.7	14.2	21.7	14.3	17.6	7.5	12.2	1.5	4.0	1.8	0.6	0.4	0.7	0.1	1.6		0.1										**1339**
2007			0.1	0.4	5.6	27.8	23.4	12.0	12.6	5.9	5.8	2.1	2.5	0.8	0.4	0.3	0.2	0.4	0.1											**1944**
2008				0.6	6.5	28.7	31.6	13.8	5.6	5.9	2.6	2.1	0.8	0.8	0.4	0.2	0.2	0.0	0.1	0.2										**3056**
2009			0.1	0.4	6.8	26.5	38.1	17.8	4.5	2.2	1.4	1.0	0.9	0.1	0.2		0.0				0.1									**3385**
2010				0.1	9.8	24.3	24.6	20.5	9.7	5.0	1.4	2.6	0.7	0.4	0.3	0.2		0.1	0.0	0.0		0.0	0.0							**2165**
																														80162

Figure 3.6.4.23. Expected numbers-at-age in thousands for the baseline length-only model run 1A (top left) and age–length model run 1B (top right). Figure at bottom shows the annual percentage at age in the raw age samples collected by the UK for all Areas in IVbc and VIIa,d,e,f,g,h with darker shading indicating higher percentages.

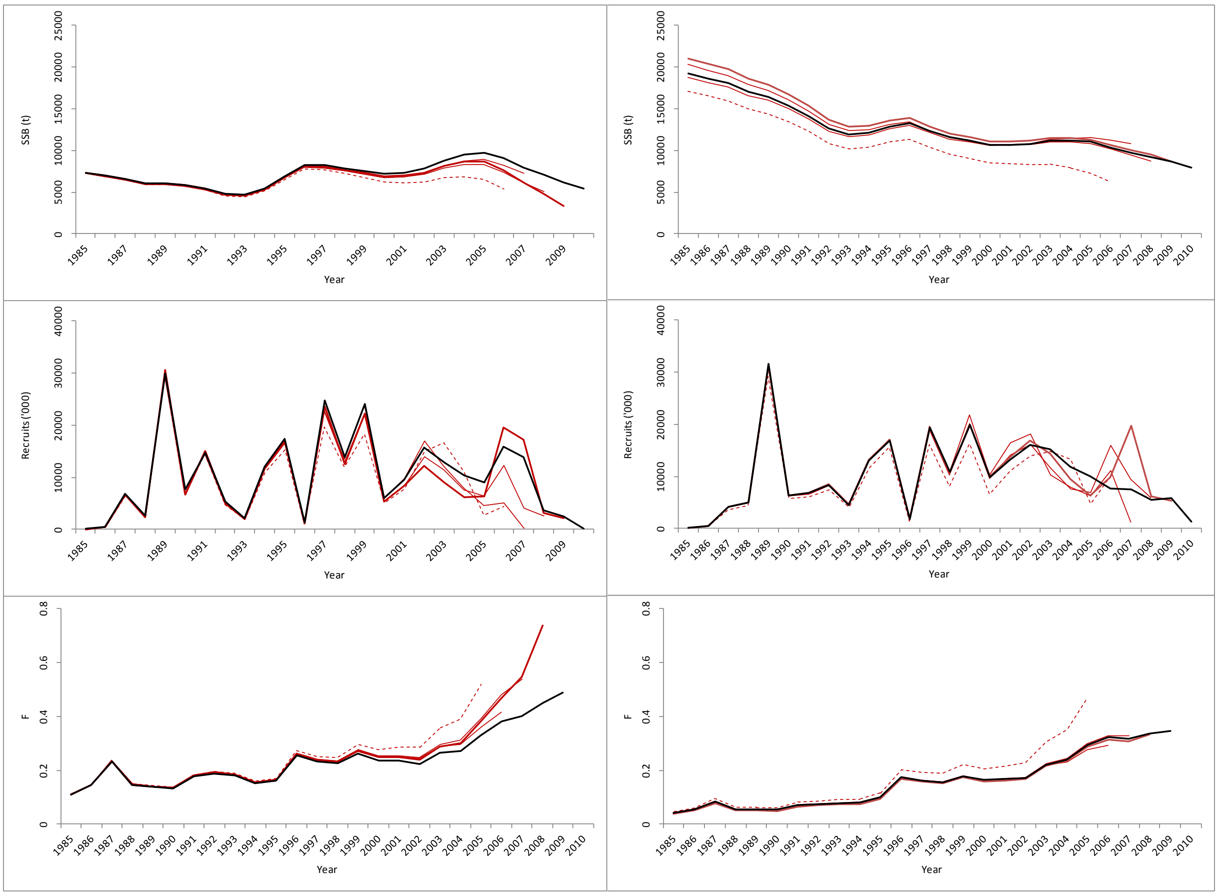


Figure 3.6.4.24. Retrospective analysis of SSB, recruits (age 0) and $F_{5\text{–}11}$ estimates for the baseline length-only model run 1A (left) and age–length model run 1B (right), with four year peel.

Sensitivity analyses for length-only model

A further 13 model runs were carried out on the length-only base case scenario to examine sensitivity to input data, model settings and assumptions. The runs are described below:

Sensitivity	Run No.	Change from base model
Numbers-at-age in initial year	2	CV on equilibrium catch (1980–1984) increased from 10% to 30%
	3A	Equilibrium catch = average landings 1975–1984
	3B	Starting year 1975 (landings only for 1975–1984).
Trawl survey tuning data	4	Exclusion of the Solent spring survey
	5	Exclusion of Thames survey
	6	Exclusion of Solent spring and Thames surveys
	7	Exclusion of all survey data
Inclusion of commercial lpue tuning data	8	Age-aggregated tuning-series for UK trawls and beam trawls, and French otter trawls, included in model.
Discards estimates	9	Inclusion of discards estimates and associated length composition data for UK trawls and nets in 2002–2010 (all areas combined) and combined discards from French fleets in 2009 and 2010 (all areas combined)
Selectivity model	10	Double normal (domed) selectivity for the UK net fleet estimated by the model

SENSITIVITY	RUN NO.	CHANGE FROM BASE MODEL
Natural mortality rate	11	Natural mortality values increased from 0.2 to 0.25 across all ages
Natural mortality rate	12	Natural mortality using the Gislason vector of M's for each age
Growth parameters	13	Length at maximum age estimated by the model

<u>Initial year populations (runs 2,3 & 4):</u>

- Run 2: Increasing the CV on initial equilibrium catch from 10% to 30% results in the model estimating lower initial population sizes, but also results in higher SSB in 2010 than the base case and an increase in the likelihood for the catch component (Figure 3.6.4.25; Table 3.6.4.3).
- Run 3A: Calculating the equilibrium catch as the mean of 1975–1984 landings rather than the larger 1980–1984 average value has a minor effect on trends (Figure 3.6.4.25).
- Run 3B: Extending the model back to 1975 (i.e. including landings only into the model prior to 1985, apportioned between fleets according to 1985 proportions) has little effect on 1985–2000 SSB but leads to higher SSB in 2010 and lower F in recent years (Figure 3.6.4.26), similar to run 2, and increasing the likelihoods. Inspection of the predicted numbers-at-age for 1975 to 1990 shows that the model fills an uninformative matrix of numbers-at-age for year classes prior to 1983, due to the lack of any length or age data.

<u>Trawl survey tuning data</u>

- Runs 4–6: Excluding the Solent spring survey, Thames survey or Solent spring and Thames surveys have a relatively minor effect on trends, reducing F slightly in the most recent years (Figure 3.6.4.27). The biggest reduction in F is from removal of the Solent spring survey which indicates a longer recent period of poor recruitment.
- Run 7. Removal of all surveys removes all the tuning data, and the model is unable to estimate recruitment values that match the year-class signals in the surveys or catch-at-age matrices (Figure 3.6.4.27). A flat trend in F is estimated, with SSB increasing over time. This shows that the surveys are important in helping to tune recruitment within the model as the catch-at-length information alone does not contain enough information for the model to estimate recruitment.

<u>Inclusion of commercial fishery lpue</u>

- Run 8: Adding eight lpue series (three beam trawl series and five otter trawl series shown in Figure 3.6.2.5) helps the model to tune the older ages. The recruitment series is almost unaffected, but initial SSB in the 1980s is reduced, and the final SSB in 2010 is increased with a corresponding reduction in F in the most recent years (Figure 3.6.4.28). There is no improvement to the fit of the model to the length compositions or surveys and the model produces poor fits to the three beam trawl fleet lpues. The SS3 generates biomass trends more in line with the UK otter trawl fleets

(10 m and over) which exhibit low lpue in the 1980s, increasing lpue through the 1990s and a reduction over the last few years (Figure 3.6.2.5), but the relative change between the 1980s and the 2000s is lower in the SS3 run than in the trawl lpues. Without further analysis of the reliability of commercial lpue as an index of sea bass biomass, IBPNew preferred to retain the lpues as supporting evidence rather than an input to the assessment model.

Inclusion of discards estimates

- Run 9: Inclusion of discards estimates and associated length composition data for UK trawls and nets in 2002–2010 (all areas combined) and French trawls (2009 and 2010) has negligible effect on SSB and F trends (Figure 3.6.4.28) but causes a large and unrealistic spike in recruitment in 2007. The likelihood component for discards is negative (Table 3.6.4.3).

Allowing domed selectivity for UK nets

- Run 10. Fixed and driftnets are expected to have domed selectivity, and changing the selectivity for the UK net fleet to a double normal (four additional parameters) improves the likelihood with the length compositions and recruitment for the individual components (Table 3.6.4.3). This change results in lower F and higher SSB throughout the series, without affecting the relative trends (Figure 3.6.4.28). This is proposed for the final SS3 run. As there is no *a priori* reason to expect other gears to have domed selectivity, these are retained as asymptotic, avoiding the need to estimate four additional parameters for each additional fleet allowed to have domed selectivity (the combined French fleet is predominantly trawls). An additional sensitivity run (not shown) fixed one parameter of the dome-shaped selectivity for UK nets. This rescaled the SSB, recruits and F compared to run 10. Although the outcomes differ they still remain within the boundaries of the sensitivity analysis.

Sensitivity to natural mortality rate

- Run 11. Increasing M-at-age from the baseline value of 0.2 (from maximum observed ages and life-history parameters) to 0.25 across all ages scales up estimates of recruitment and SSB and reduces the $F_{5\text{–}11}$ across the time-series (Figure 3.6.4.29). The likelihood estimates for the overall model and subcomponents are smaller than the likelihoods from the length only model.
- Run 12. Using the Gislason age-dependent M (values declining from 1.6 at age 1 to 0.16 at age 10 and to 0.1 at age 20), scales up recruitment substantially but has little impact on the absolute value of SSB (Figure 3.6.4.29). The SSB estimate for 2010 is close to the estimate from baseline run 1A but the estimate for 1985 is reduced. The trend in F is altered only slightly. The value of length composition component of the likelihood decrease.

Length at maximum age estimated by the model

- Run 13. Allowing the model to estimate length at maximum age, rather than fixing it based on von Bertalanffy growth model fits, produces stock trends very similar to the run with domed selectivity for UK nets (Figure 3.6.4.25). It improves all likelihood components apart from the length composition. The increased length composition likelihood increases the overall likelihood suggesting a poorer fit of the model to the data. Three additional sensitivity runs (not plotted) allowed SS3 to estimate i) the von Bertalanffy growth parameter K, ii) the age at the minimum length and iii) simultaneous estimation of K and length at maximum age. These runs resulted in larger F_{5-11} estimates compared to the base length-only model 1A.

Figure 3.6.4.25. Sensitivity analysis of SS3 assessment model (length-only base run 1A) estimates of SSB (top plot), recruitment (middle plot) and F_{5-11} (bottom plot). Comparison of base model run with sensitivity runs 2 and 3a (equilibrium catches for initial year populations), 10 (dome-shaped selectivity for UK nets) and 13 (L at AMAX estimated by model).

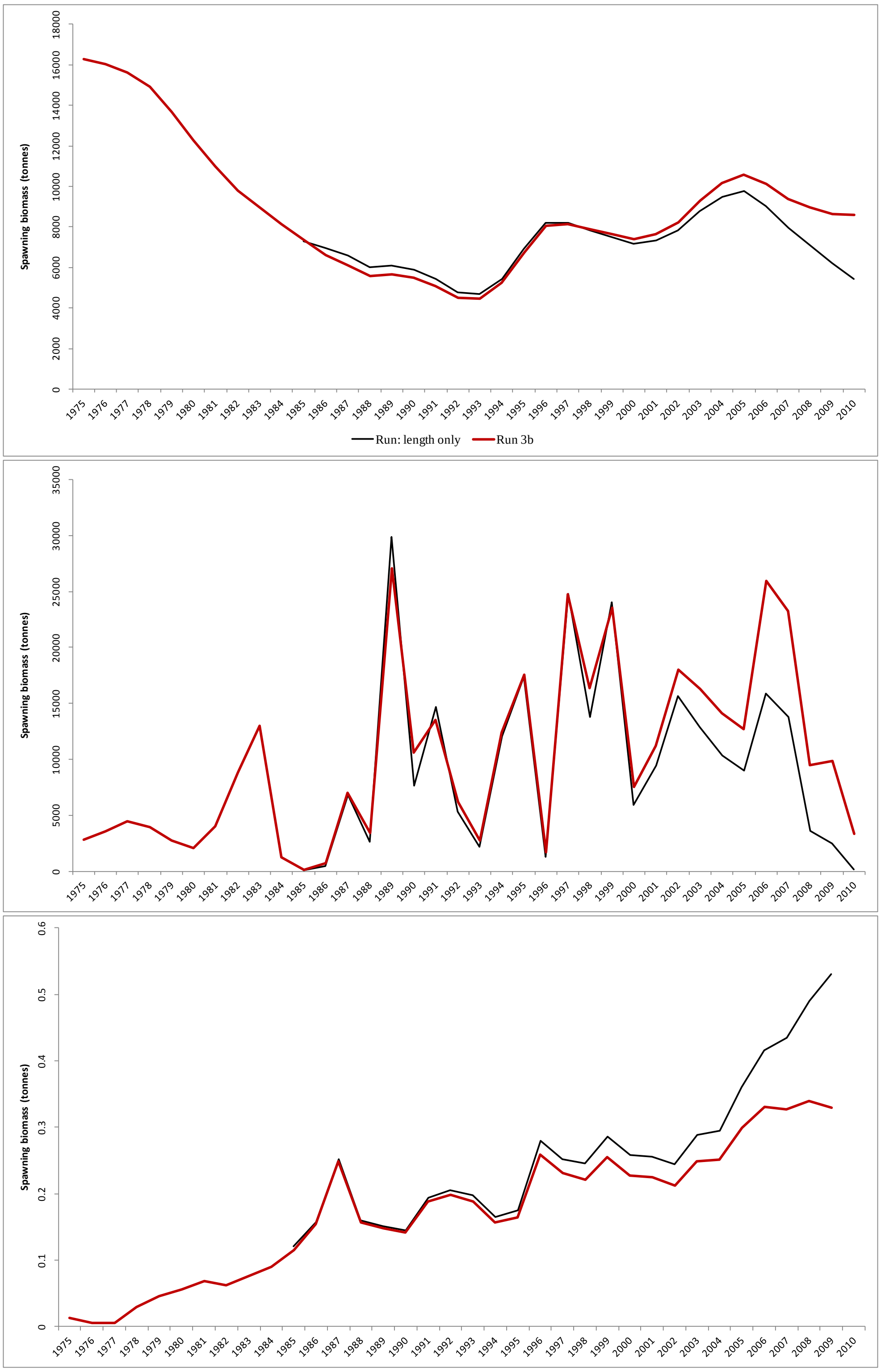


Figure 3.6.4.26. Sensitivity analysis of SS3 assessment model (length-only base run 1A) estimates of SSB (top plot), recruitment (middle plot) and F_{5-11} (bottom plot). Comparison of base model run with sensitivity run 3b (landings estimates extended back to 1975). Run 3b is the thicker line reaching higher SSB in 2010.

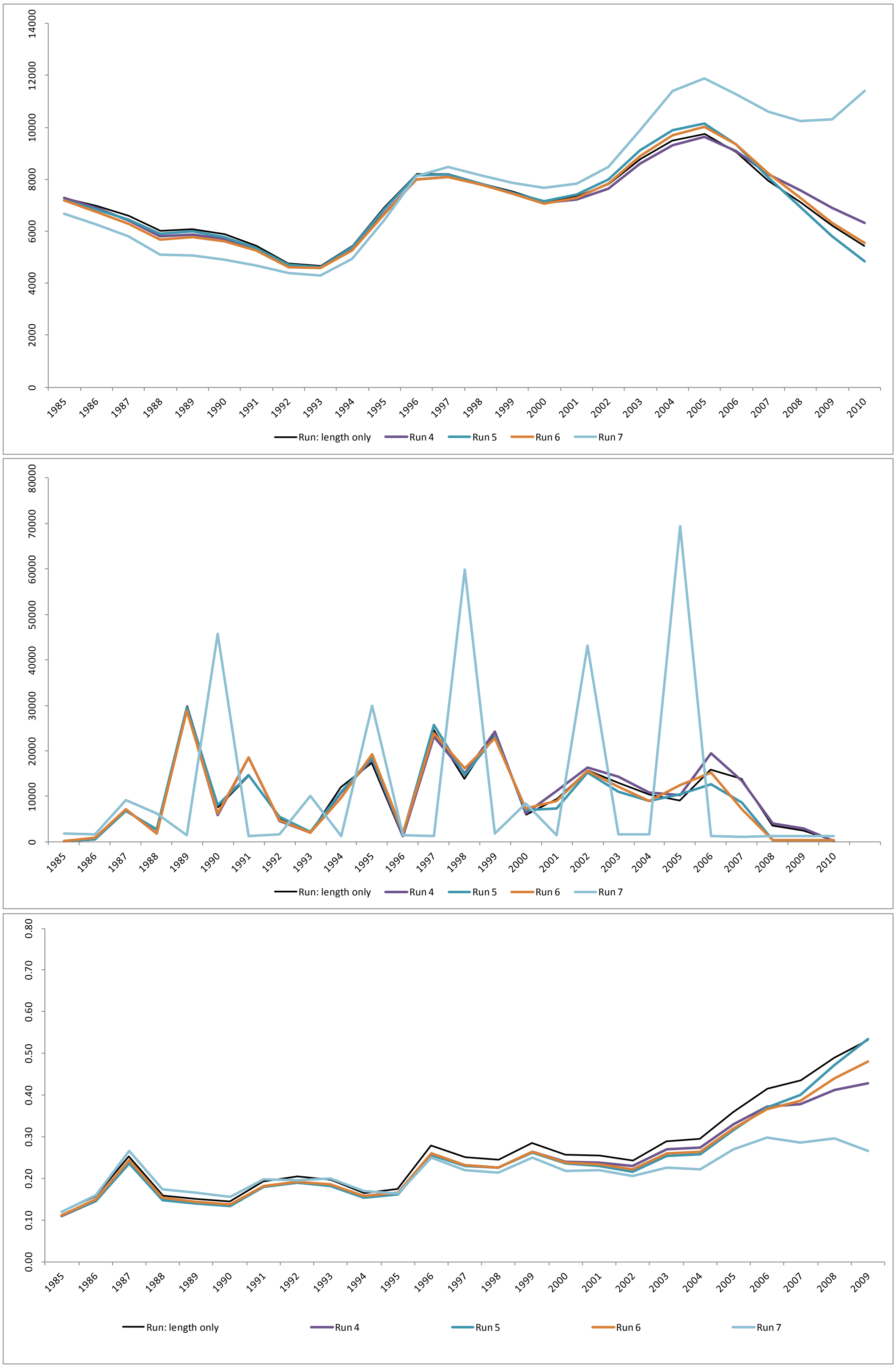


Figure 3.6.4.27. Sensitivity analysis of SS3 assessment model (length-only base run 1A) estimates of SSB (top plot), recruitment (middle plot) and $F_{5\text{–}11}$ (bottom plot). Comparison of base model run with sensitivity runs 4 (Solent spring survey removed), 5 (Thames survey removed), 6 (Solent spring and Thames surveys removed) and 7 (all surveys removed).

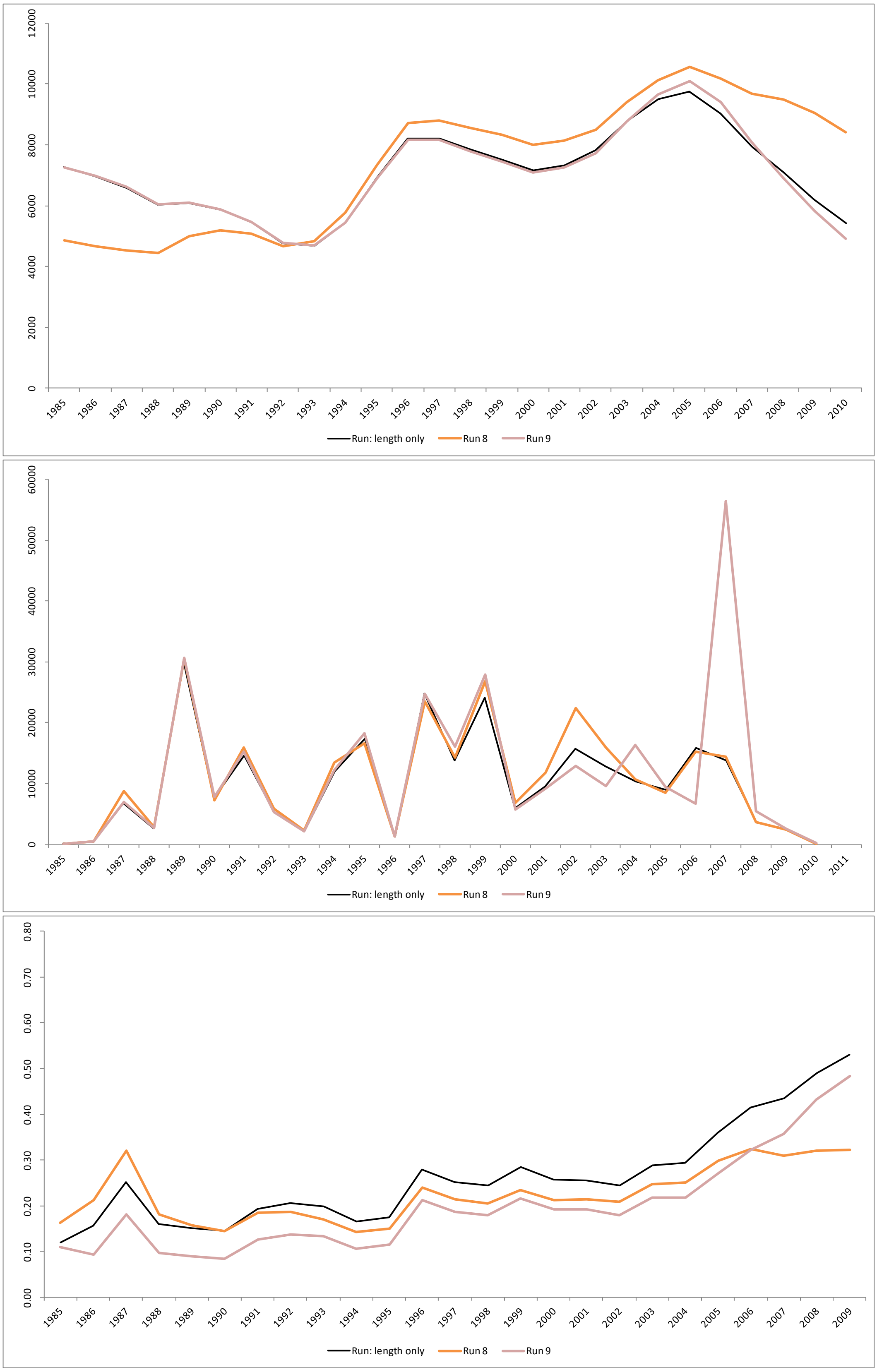


Figure 3.6.4.28. Sensitivity analysis of SS3 assessment model (length-only base run 1A) estimates of SSB (top plot), recruitment (middle plot) and F_{5-11} (bottom plot). Comparison of base model run with sensitivity runs 8 (commercial lpue series added), 9 (Discards data added).

Figure 3.6.4.29. Sensitivity analysis of SS3 assessment model (length-only base run 1A) estimates of SSB (top plot), recruitment (middle plot) and F_{5-11} (bottom plot). Comparison of base model run with sensitivity run 11 (M increased to 0.25 across all ages) and 12 (Gislason model estimates of M-at-age).

Conclusions regarding sensitivity analyses

With the exception of excluding all survey tuning data, all sensitivity runs based on the length-only model indicate increasing F and declining SSB since around 2000, and very poor recruitment since 2008. The different model configurations would not alter the conclusion that SSB would continue to decline due to the elevated F and as fish of the weak year classes since 2008 reach maturity around 2015 onwards.

IBPNew recommendations on final SS3 model choice for IVb,c and VIIa,d,e,f,g,h.

Criteria for choosing a superior model configuration should include:

1) the best overall fit to the data (in terms of negative loglikelihood, likelihood ratio test or AIC);
2) biologically reasonable patterns of estimated recruitment and selectivities;
3) a good visual fit to length and age compositions;
4) lower correlation and higher precision of parameter estimates;
5) retrospective performance.

The choice between the baseline age–length and length-only models is not straightforward. The length-only model fits the observed fishery length compositions quite well, but does not contain any explicit information on year-class variability. The age–length model contains explicit age composition data for UK fleets. It appears to fit the UK fishery age compositions poorly in the early part of the series, but has a better fit for later years, and shows better retrospective consistency. The length-only and age–length models show very similar fits to the recruitment-series. A major difference between the two models is that the age–length model estimates a much higher biomass at the start of the time-series, which is not suggested by ancillary data on fishery lpue. However the recent trends in SSB and F are quite similar. The age–length model produced the largest number correlating parameters; this model also had much stronger correlations between the parameters.

Plausible sensitivity runs carried out on the length-only model mostly returned the same relative patterns in SSB, F and recruitment. However, IBPNew 2012 considers that the variability between sensitivity runs is such that the model is not an appropriate basis at this stage for a full analytical assessment with forecasts, and should be considered as a trends-only assessment pending further work. The length-only model, based on the criteria above, is currently the most appropriate model for a trends-only assessment. However, IBPNew recommends that further exploration of the age–length model is undertaken prior to WGNEW 2013, to determine if better use can be made of available age composition data including:

- Obtaining age structure estimates for as much of the French landings as possible;
- Obtaining better estimates of discards and appropriate length compositions for as many fleets as possible;
- Evaluating the relative quality of length compositions compared with age compositions over the time-series, where available, to allow the best quality data to be included in the model.

On the basis of the runs presented here, the advice for the stock based on a "trends only" assessment is not likely to be affected by choice of model, but the estimation of biological reference points may be sensitive to choice of model. This needs to be explored further by WGNEW.

Assessment of sea bass in Irish waters (ICES Areas VIIb,c,j)

No fishery or survey data were available to IBPNew for this stock, and no assessment was possible.

Time-series of recreational fishery catch rates from an angling club in Cork, southern Ireland, was provided to IBPNew 2012 by a stakeholder at the meeting (Figure 3.6.15). This shows high values in the 1960s, thought to be influenced by a very strong 1959 year class, and a subsequent large decline to very low values. There are indications in anglers' data for an improved year class formed in 2002.

Assessment of sea bass in the Bay of Biscay (Area VIIIa,b)

Length cohort analysis

Little information on sea bass biology and data on exploitation are available for Areas VIIIab: there are no growth parameter estimates, ALKs are only available for 2008–2010 and no abundance indices (either survey or commercial fishery based) are readily available. It is thus not possible to carry out an assessment comparable to the one developed for Area IV and VII.

An exploratory analysis of the length–frequency data was carried out using a length cohort analysis (Jones, 1984) applied to the pooled-gears length–frequency distributions from French fleets fishing in the Bay of Biscay. The main difficulty in length-cohort analysis is that its application requires estimates or assumptions about the underlying growth rates (Linf and K), and the choice of input growth parameters can critically influence the results obtained (Jones, 1990). As no growth parameters estimates are readily available for Bay of Biscay sea bass, two sets of values were used for comparison : i) a set of estimates obtained from Area IV and VII and used in the stock assessment described above (Linf=85 cm and K=0.09) and ii) a set of parameters obtained during the IBPNew 2012 from fitting a VB growth model to length–age data collected in the Bay of Biscay in 2009 and 2010 (Linf=95 cm and K=0.10). The estimates of F at length and N at initial length were then used to calculate equilibrium yield under a series of fishing mortality levels using a length based Thompson and Bell model.

Results (Figure 3.6.4.30) clearly show the strong impact of assumptions on growth parameters on equilibrium yields which makes the use of this method very problematic with the limited biological knowledge available. Furthermore, this method relies on strong assumptions which may not be met in the case of sea bass, namely that length composition data are sampled from a stock at equilibrium, with no variation in exploitation over time and no variation in year-class strength. This underlines, for this area, the critical need for data (biological and fishery related) to be able to carry out an analytical assessment of the stock, either as a separate stock or in a joint assessment with the more northern areas.

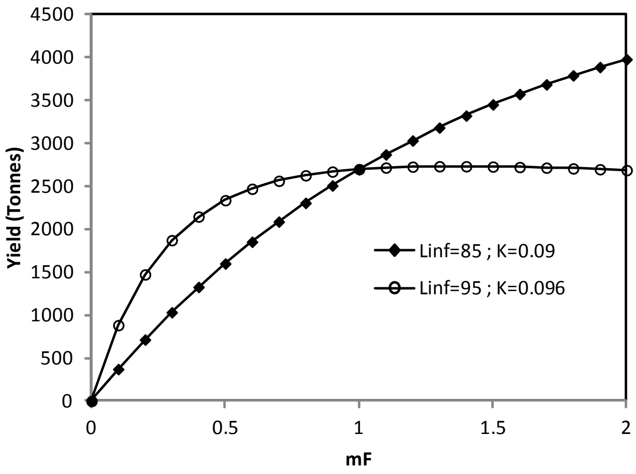


Figure 3.6.4.30. Equilibrium yields at various level of fishing mortality obtained under alternative hypothesis on von Bertalanffy growth parameters.

Inclusion of Bay of Biscay data in Stock Synthesis model

Runs 1A and 1B, the length-only and age–length models for IVb,c and VIIa,d,e,f,g,h, were re-run to include a seventh fleet representing the French fleet in the Bay of Biscay. Length compositions for this fleet are provided for the years 2000 onwards. Tuning data for the Bay of Biscay are not included.

Inclusion of Bay of Biscay data (Figure 3.6.4.31) scales up the SSB and recruitment compared with SS3 runs 1A and 1B. Although a trend of increasing F is shown, the rate of increase is lower than in IV and VII and terminal F is much lower.

A potential problem with this simple extension of the SS3 model is the possibility for different growth patterns in the warmer waters of the Bay of Biscay, affecting the fit of the length-based model. The absence of any age composition data precludes a direct evaluation of year-class variations, and it is therefore not possible to evaluate how well the Solent and Thames recruit surveys match recruitment patterns in the Bay of Biscay population.

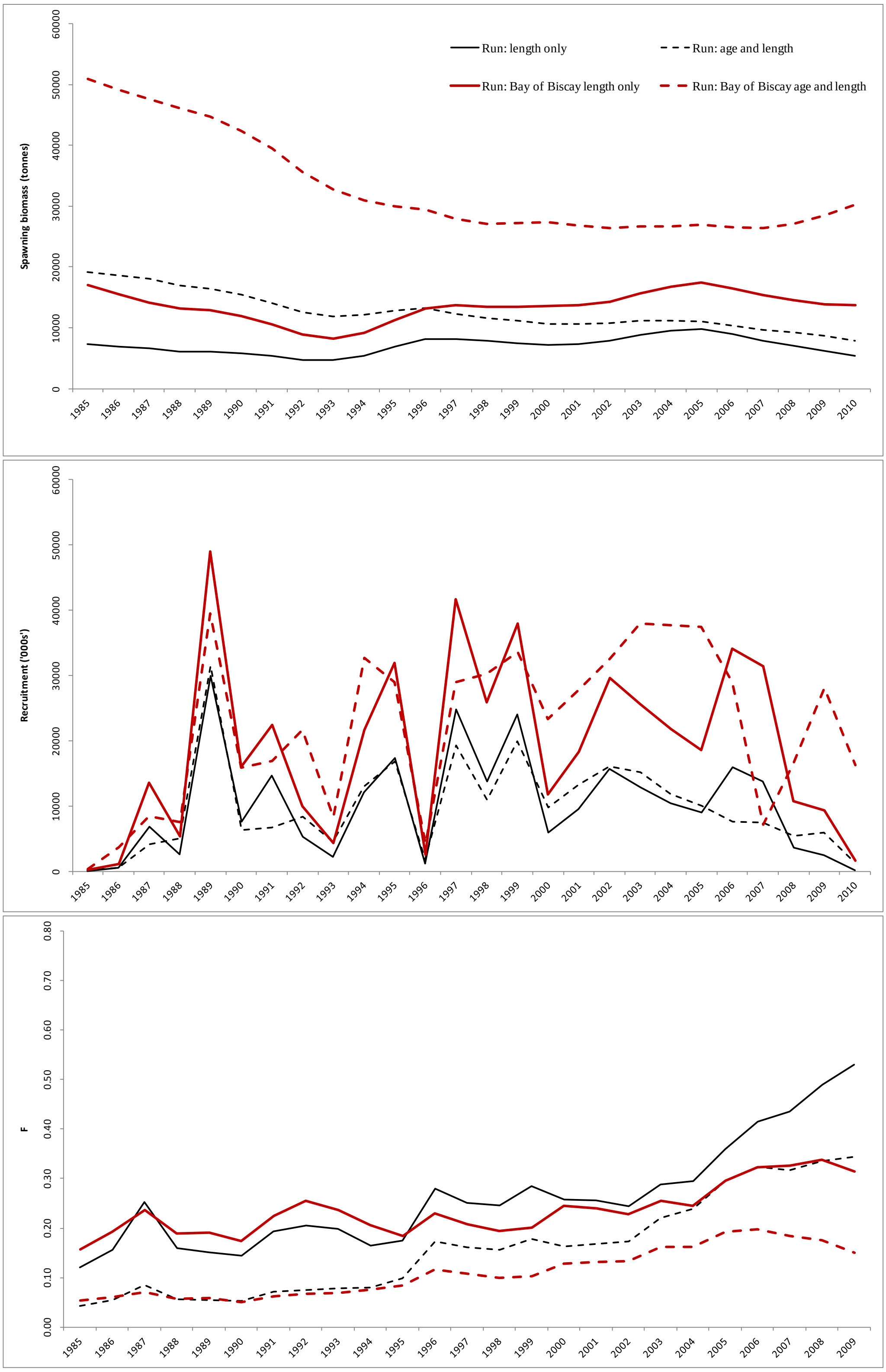


Figure 3.6.4.31. Comparison between the age–length and length based models with and without the Bay of Biscay for SSB, recruitment and F_{5-11}.

Conclusions regarding Bay of Biscay stock

Further analysis of growth rates are needed to allow any interpretation of length composition data for this area. Inclusion of Bay of Biscay data in the SS3 model assumes that there is a single biological stock, a hypothesis which can neither be confirmed nor disproved with current knowledge. Relative abundance indices for prerecruit and recruited sea bass are also needed for this area. IBPNew considers that no assessment can at present be performed for sea bass in the Bay of Biscay.

Implications of missing recreational catches in assessment model

Recreational catch estimates for sea bass are currently available for only 2010, and only for France and the Netherlands. Data for surveys in the UK in 2012 are not yet available. For France and Netherlands, the combined estimates of recreational fishery removals for 2010, including an assumed hooking mortality of 20% for released fish, is 1115 t.

	All Areas IV–VIII			Areas IV and VII only				
	kept	released	CV	Proportion in IV&VII	kept	released	hooking mortality for releases	total removed
France 2010	2350	830	0.51	0.4	940	332	20%	1006
Netherlands 2010	96	65	0.31	1	96	65	20%	109
Total								1115

These removals would represent 19% of a combined fishery removal of 5850 t in 2010 (1115 t recreational + 4736 t commercial), although this percentage will be imprecise due to the large CVs for the recreational catch estimates (for France, the CV for Areas IV and VII will be larger than 0.51 as only 40% of the catch estimate is for this area). The addition of recreational catches from the UK, Belgium and other countries would increase this percentage, but addition of commercial discards weights for all international fleets would reduce the percentage. Estimates of discards weights of sea bass in Areas IV and VII in 2010 for UK trawls and nets, and French fleets, are around 200 t (Tables 3.6.1.12–3.6.1.14). These figures exclude discards from other national fleets or UK fleets not sampled. Retained catches of sea bass by UK sea angers were estimated in the late 1980s and early 1990s to be around 400 t per year (Dunn *et al.*, 1989; Dunn and Potten, 1994), although these estimates are of unknown accuracy. It is possible, therefore, that recreational fisheries could potentially account for around 20% of the fishing mortality in recent years. It is not possible to evaluate how the recreational fishing mortality rate may have altered over time, and how this would affect the fit of the model, including initial depletion rate. Further work is needed at WGNEW 2013 to consider how to handle recreational data (recent estimates and missing historical data) in assessments and advice for sea bass.

3.6.5 Short-term projections

Short-term projections were not carried out, although the scenario of increasing F, declining SSB and very poor recruitment since 2008 would lead to an expectation of further SSB decline. Procedures for carrying out trends-only projections should be developed at WGNEW 2013.

3.6.6 Appropriate reference points (MSY)

IBPNew 2012 was not in a position to develop MSY reference points for sea bass based on the SS3 runs. Further work is needed at WGNEW 2013 to develop biological reference points.

3.7 Future research and data requirements

There are several important limitations to knowledge of sea bass populations, and deficiencies in data, that should be addressed in order to improve the assessments and advice for sea bass in the NE Atlantic. IBPNew 2012 makes the following recommendations:

- Robust relative abundance indices are needed for adult bass in all areas. Their absence is a major deficiency which will reduce the accuracy of the assessment and the ability to make meaningful forecasts. The establishment of dedicated surveys on spawning grounds could provide valuable information on trends in abundance and population structure of adult bass as well as providing material for investigating stock structure and linkages with recruitment grounds.
- Recruitment indices are needed for a wider geographic range including the Celtic/Irish Sea and Biscay areas.
- Further research is needed to better understand the spatial dynamics of sea bass (mixing between ICES areas; effects of site fidelity on fishery impacts; spawning site–recruitment ground linkages; environmental influences).
- Studies are needed to investigate the accuracy/bias in ageing, and errors due to age sampling schemes historically.
- Continued estimation of recreational catches is needed across the stock range, and information to evaluate historical trends in recreational effort and catches would be beneficial for interpreting changes in age–length compositions over time.

3.8 External reviewers comments

The modelling decisions made were reasonable and the sensitivity analyses conducted supports the final model selection. Section 4.6.4 describes a number of modifications to the Stock Synthesis analyses which were conducted after the meeting concluded. These modifications were made based on advice provided by Dr Richard Methot, the author of Stock Synthesis, and so are assumed to be correct. However, detailed comments on these changes cannot be made because they were not discussed during the meeting. This demonstrates the need to have external experts who are familiar with the software used in the benchmark assessment.

The determination that the modelling supports a "trends only" level of assessment was a pragmatic decision based on the limited amount of time available during the meeting to conduct model runs (due to the first part of the meeting being used for data issues). While this may not be desirable for management purposes, the trends still provide information which should be useful. This is an improvement over the previously conducted assessment because it incorporates more information. The "trends only" assessment is also appropriate due to the lack of understanding regarding some basic biology, such as fine-scale stock structure and movement, as well as a lack of survey tuning information for the older fish in the population. Thus, the stock assessment leads have crafted the best possible assessment model given the limited information and time available and this assessment should form the basis for management advice.

3.9 Stakeholders comments

Stakeholders from European Anglers Alliance and Irish Bass expressed their apprehensiveness about the management of sea bass by TAC and quota. Sea bass has, arguably, greater socio-economic value as a sport fish than as a commercial food-fish.

Some general concerns

If there is only one stock of bass in the Northeast Atlantic, its fidelity to summer feeding areas may effectively divide it into a number of management units. A single TAC area incorporating all of these will obscure local characteristics, such as a wider range of available sizes, of value to recreational fisheries.

The late maturity of the fish presents obstacles for its co-management with species which are fished using non-selective gears which harvest them at younger age.

TAC management can result in discarding and may encourage "black" landings.

The difficulties of maintaining coexisting recreational angling and commercial bass fisheries are emphasized.

A concern for recreational fisheries is that commercial non-selective gears reduce the average individual size of the landings.

The socio-economic argument of higher values generated by tourism associated with recreational angling, particularly where bass are at low density at the limits of their range, is emphasized.

As sea bass is a very important recreational species a socio-economic impact report ought to be prepared as happened for the Baltic Salmon Management Plan.[1]

Anecdotal information from local anglers and member organizations of the EAA is that sea bass abundance has declined in recent years and is still doing so. The EEA also maintains that the average size of bass caught by anglers has fallen. EAA may be able to provide more solid data (logbooks, competition results, etc.) but not in time for this benchmark report.

Points made with particular reference to the Republic of Ireland's sea bass fishery

The obstacles to maintaining a stock with the biological characteristics of bass are accentuated at the periphery of its northern range. The history of this fishery demonstrated its inability to sustain commercial fishing pressures.

The biological characteristics of the fish which accentuate its vulnerability include its relatively slow growth, late maturity and sensitivity to certain environmental variables, particularly temperature. Occasional strong year classes may contribute a large proportion of stock numbers. These may be particularly significant at the periphery of its range.

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[1] "Data analysis to support the development of a Baltic Sea salmon action plan (2009)", published 26/01/2009, Report, Annexes http://ec.europa.eu/fisheries/documentation/studies/study_baltic_sea_salmon_action_plan/index_en.htm

Angling stakeholders identified the practicalities of using angler cpue data to demonstrate trends in the abundance of bass. Such methods should include, where available, data on the incidence of larger fish ("trophy" or "specimen" individuals).

A number of measures were employed to restore bass numbers, among them, size limit, close season, bag limits for anglers, restriction of fishing methods to rod and line. In the course of implementing them the commercial fishery was also extinguished.

A lower level of appraisal which monitors trends in bass abundance, rather than "more intrusive" analytical assessment is more appropriate to bass fisheries which do not generate commercial catch data.

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Table 3.6.1.1. Nominal landings (t) of bass by stock area. Source: FishStat except landings for France in 1999–2010 supplied to WGNEW 2012 by Ifremer.

AREA	IVBC VIID	VIIEH	VIIAFG	IVA VIA VIIBCJ XII	VIIIABD	VIIIC	IXA	TOTAL ICES
1975	92	190	7	20	0	0	0	309
1976	67	44	3	0	0	0	0	114
1977	68	45	9	0	0	0	0	122
1978	172	372	11	0	1146	0	576	2277
1979	316	458	7	0	1132	0	550	2463
1980	210	616	30	0	1086	0	460	2402
1981	158	738	44	0	0	0	370	1310
1982	172	565	50	0	0	0	691	1478
1983	261	569	40	2	1363	0	522	2757
1984	400	508	27	1	2886	0	681	4503
1985	219	469	55	1	2477	0	475	3696
1986	387	579	14	0	2607	0	401	3988
1987	264	1049	53	1	2479	0	410	4256
1988	308	569	48	3	2292	14	208	3442
1989	366	478	74	5	2215	326	196	3660
1990	281	505	37	1	1679	396	236	3135
1991	390	494	97	0	1796	303	187	3267
1992	287	551	67	0	1776	254	147	3082
1993	429	518	47	0	1613	247	161	3015
1994	636	423	118	0	1728	308	189	3402
1995	815	594	169	8	1549	334	154	3623
1996	850	1357	123	3	1473	376	206	4388
1997	811	1131	123	0	1428	290	223	4006
1998	688	1042	249	50	1294	258	153	3734
1999	980	1176	32	1	1130	221	171	3711
2000	894	1406	106	4	2362	241	139	5152
2001	962	1402	137	5	2309	166	111	5092
2002	1214	1220	188	14	2398	83	89	5206
2003	1761	1582	116	2	2626	75	86	6248
2004	1934	1634	163	4	2386	221	141	6483
2005	2123	2143	161	2	2800	197	256	7683
2006	1852	2483	212	2	2877	155	576	8157
2007	2207	1754	241	6	2758	116	772	7853
2008	2176	1774	302	5	2746	142	513	7658
2009	2370	1437	211	5	2354	138	501	7016
2010	2352	2205	179	9	2258	200	577	7779

Table 3.6.1.2. Sea bass in Divisions IVb,c, and VIId. Official landings by country and ICES estimates of catches (t).

	Belgium	Denmark	France	France[1] (ICES)	Netherlands	UK(Sco)	UK(E,W&NI)	Total (ICES)
1984	0	0	324	324	0	0	76	400
1985	0	0	144	144	0	0	75	219
1986	0	0	295	295	0	0	92	387
1987	0	0	180	180	0	0	84	264
1988	0	0	199	199	8	0	101	308
1989	0	1	272	272	2	0	91	366
1990	0	<0.5	210	210	0	0	71	281
1991	0	<0.5	222	222	0	0	168	390
1992	0	<0.5	204	204	0	0	83	287
1993	0	1	282	282	0	0	146	429
1994	0	<0.5	279	279	0	0	357	636
1995	0	1	339	339	0	<0.5	475	815
1996	0	1	527	527	4	<0.5	318	850
1997	0	1	487	487	1	<0.5	322	811
1998	0	2	372	372	32	<0.5	282	688
1999	0	1	0	611	32	3	333	980
2000	0	5	701	612	60	<0.5	217	894
2001	0	2	701	681	74	0	205	962
2002	0	1	858	868	94	6	245	1214
2003	133	1	1206	1197	158	3	269	1761
2004	119	1	1159	1318	188	0	308	1934
2005	149	1	1126	1377	319	1	276	2123
2006	150	2	1086	1145	299	6	250	1852
2007	128	1	1340	1429	373	24	252	2207
2008	118	<0.5	1020	1290	375	41	352	2176
2009	125	<0.5	1623	1483	389	20	353	2370
2010	175	4	1452	1363	391	26	393	2352

Source: ICES Bulletin Statistique.

[1] Landings for 1999–2010 supplied to WGNEW by Ifremer.

Table 3.6.1.3. Sea bass in Divisions VIIe,h. Official landings by country and ICES estimates of catches (t).

	Belgium	Denmark	France[1]	Channel Is.	Netherlands	Spain	UK(Sco)	UK(E,W&NI)	Total (ICES)
1984	0	0	444	25	0	0	0	39	508
1985	0	0	432	18	0	0	0	19	469
1986	0	0	543	15	0	0	0	21	579
1987	0	0	1019	14	0	0	0	16	1049
1988	0	18	509	12	0	0	0	30	569
1989	0	1	390	48	0	0	0	39	478
1990	0	0	389	25	0	0	0	91	505
1991	0	0	434	16	0	0	0	44	494
1992	0	0	475	36	0	0	0	40	551
1993	0	0	422	45	0	0	0	51	518
1994	0	0	306	49	0	0	0	68	423
1995	0	0	424	69	0	0	0	101	594
1996	0	0	1135	56	4	0	0	162	1357
1997	0	0	907	74	0	0	0	150	1131
1998	0	0	784	79	16	0	0	163	1042
1999	0	0	752	108	0	0	4	312	1176
2000	0	0	1137	130	0	0	0	139	1406
2001	0	0	1149	80	3	0	0	170	1402
2002	0	0	902	73	2	0	0	243	1220
2003	2	0	1258	84	5	0	0	233	1582
2004	4	0	1237	159	3	0	0	231	1634
2005	3	0	1750	220	8	0	0	162	2143
2006	6	0	2075	193	9	0	1	199	2483
2007	6	0	1314	160	3	0	28	243	1754
2008	7	0	1402	143	5	<0.5	<0.5	217	1774
2009	2	0	1140	103	6	0	3	183	1437
2010	2	0	1825	144	8	0	35	191	2205

Source: ICES Bulletin Statistique.

[1] Landings for 1999–2010 supplied to WGNEW by Ifremer.

Table 3.6.1.4. Sea bass in Divisions VIIa,f&g. Official landings by country and ICES estimates of catches (t).

	Belgium	France[1]	Ireland	UK(Sco)	UK(E,W&NI)	Total	Total(ICES)
1984	0	0	0	0	27	27	27
1985	0	44	0	0	11	55	55
1986	0	3	0	0	11	14	14
1987	0	27	3	0	23	53	53
1988	0	6	0	0	42	48	48
1989	0	13	0	0	61	74	74
1990	0	10	0	0	27	37	37
1991	0	70	0	0	27	97	97
1992	0	42	0	0	25	67	67
1993	0	14	0	0	33	47	47
1994	0	8	0	0	110	118	118
1995	0	38	0	<0.5	131	169	169
1996	0	41	0	<0.5	82	123	123
1997	0	35	0	<0.5	88	123	123
1998	0	207	0	<0.5	42	249	249
1999	0	0	0	<0.5	32	32	32
2000	0	56	0	<0.5	50	228	106
2001	0	54	0	0	83	301	137
2002	0	55	0	0	133	261	188
2003	19	16	<0.5	0	81	162	116
2004	36	49	0	3	75	217	163
2005	54	34	0	1	72	260	161
2006	55	39	<0.5	0	118	257	212
2007	44	28	0	1	168	284	241
2008	63	58	0	1	180	334	302
2009	46	26	0	1	138	237	211
2010	38	49	0	1	91	228	179

Source: ICES Bulletin Statistique.

[1] Landings for 1999–2010 supplied to WGNEW by Ifremer.

Table 3.6.1.5 Sea bass in Divisions IVa, VIa, and VIIb,c,j&k, and Subarea XII. Official landings by country (t).

	Belgium	Denmark	France	Ireland	Netherlands	Norway	Spain	UK(Sco)	UK (E,W&NI)	Total
1984	0	0	1	0	0	0	0	0	0	1
1985	0	0	1	0	0	0	0	0	<0.5	1
1986	0	0	0	0	0	0	0	0	<0.5	0
1987	0	0	0	1	0	0	0	0	0	1
1988	0	0	0	0	3	0	0	0	0	3
1989	0	0	4	1	0	0	0	0	0	5
1990	0	0	0	1	0	0	0	0	0	1
1991	0	0	0	0	0	0	0	0	<0.5	0
1992	0	0	0	0	0	0	0	0	<0.5	0
1993	0	0	0	0	0	0	0	0	<0.5	0
1994	0	0	0	0	0	0	0	0	<0.5	0
1995	0	0	0	0	0	0	0	<0.5	8	8
1996	0	0	0	0	0	0	0	<0.5	3	3
1997	0	0	0	0	0	0	0	0	<0.5	0
1998	0	<0.5	0	0	0	0	40	<0.5	10	50
1999	0	0	0	0	0	0	0	<0.5	1	1
2000	0	0	1	0	0	0	3	<0.5	<0.5	4
2001	0	0	2	0	0	0	3	0	0	5
2002	0	0	2	0	0	0	<0.5	0	12	14
2003	0	0	1	0	1	<0.5	0	0	<0.5	2
2004	<0.5	0	3	0	0	<0.5	1	0	<0.5	4
2005	0	0	2	0	0	0	0	0	0	2
2006	0	0	2	0	0	<0.5	0	<0.5	<0.5	2
2007	0	<0.5	6	0	0	<0.5	0	<0.5	<0.5	6
2008	0	0	5	0	0	<0.5	<0.5	0	<0.5	5
2009	0	0	4	1	0	<0.5	0	0	0	5
2010	0	0	9	0	0	0	0	0	0	9

Source: ICES Bulletin Statistique.

Table 3.6.1.6. Sea bass in Division VIIIa,b&d. Official landings by country and ICES estimates (t).

	Belgium	France[1]	Netherlands	Spain	UK(Sco)	UK(E,W&NI)	Total (ICES)
1984	0	2886	0	0	0	0	2886
1985	0	2477	0	0	0	0	2477
1986	0	2607	0	0	0	0	2607
1987	0	2474	0	0	0	5	2479
1988	0	2277	0	0	0	15	2292
1989	0	2215	0	0	0	0	2215
1990	0	1679	0	0	0	0	1679
1991	0	1779	0	17	0	0	1796
1992	0	1762	0	14	0	0	1776
1993	0	1599	0	14	0	0	1613
1994	0	1711	0	17	0	0	1728
1995	0	1549	0	0	0	0	1549
1996	0	1459	0	0	0	14	1473
1997	0	1416	0	0	0	12	1428
1998	0	1263	0	27	0	4	1294
1999	0	1117	0	11	0	2	1130
2000	0	2295	0	67	0	<0.5	2362
2001	0	2238	3	68	0	0	2309
2002	0	2216	0	182	0	0	2398
2003	<0.5	2497	0	127	0	2	2626
2004	<0.5	2284	0	96	0	6	2386
2005	0	2722	0	74	0	4	2800
2006	0	2707	0	168	0	2	2877
2007	1	2677	0	79	0	1	2758
2008	0	2600	0	146	<0.5	<0.5	2746
2009	1	2152	0	201	0	0	2354
2010	0	2089	0	167	2	0	2258

Source: ICES Bulletin Statistique.

[1] Landings for 1999–2010 supplied to WGNEW by Ifremer.

Table 3.6.1.7. Sea bass in Division VIIIc. Official landings by country (t).

	France	Portugal[1]	Spain	Total
1984	0	0	0	0
1985	0	0	0	0
1986	0	0	0	0
1987	0	<0.5	0	0
1988	14	<0.5	0	14
1989	0	1	325	326
1990	1	<0.5	395	396
1991	2	1	300	303
1992	0	<0.5	254	254
1993	0	<0.5	247	247
1994	0	2	306	308
1995	0	<0.5	334	334
1996	0	<0.5	376	376
1997	0	<0.5	290	290
1998	0	<0.5	258	258
1999	0	<0.5	221	221
2000	2	<0.5	239	241
2001	<0.5	<0.5	166	166
2002	8	<0.5	75	83
2003	1	1	73	75
2004	39	1	181	221
2005	57	1	139	197
2006	2	2	151	155
2007	1	1	114	116
2008	0	1	141	142
2009	6	6	126	138
2010	2	2	196	200

Source: ICES Bulletin Statistique.

[1] Contains mixed landings of two sea bass species particularly before 2006.

Table 3.6.1.8. Sea bass in Division IXa. Official landings by country (t).

	Denmark	France	Portugal[1]	Spain[1]	Total
1984	0	0	431	250	681
1985	0	0	311	164	475
1986	0	0	219	182	401
1987	0	0	216	194	410
1988	0	0	115	93	208
1989	0	0	104	92	196
1990	0	0	90	146	236
1991	0	0	76	111	187
1992	0	0	53	94	147
1993	0	0	57	104	161
1994	0	0	55	134	189
1995	0	0	42	112	154
1996	0	0	48	158	206
1997	0	0	39	184	223
1998	0	0	38	115	153
1999	0	0	37	134	171
2000	0	0	49	90	139
2001	0	0	42	69	111
2002	0	0	43	46	89
2003	<0.5	0	46	40	86
2004	0	0	66	75	141
2005	0	0	176	80	256
2006	0	0	459	117	576
2007	0	0	544	228	772
2008	0	0	402	111	513
2009	0	2	413	86	501
2010	0	0	487	90	577

Source: ICES Bulletin Statistique.

[1] Contains mixed landings of two sea bass species. Particularly before 2006.

Table 3.6.1.9. Landings and effort for Spanish vessels, by gear type, in Areas VIIIa,b&d from 2007 to 2009.

LANDINGS IN KG (sales notes)

Area	*Gear*	2007	2008	2009	2010	2011
VIIIc, Ixa	Bottom otter trawl	2,053	832	4,209	4,009	7,713
	Bottom pair trawl	3		2,675	434	2,002
	Purse seine	76,538	8,849	16,371	17,425	7,206
	Gillnets	60,024	16,338	54,993	69,406	78,786
	Longlines	57,265	4,991	22,768	77,319	76,552
	Artisanal fisheries	131,372	109,067	98,874	132,066	145,785
VIIIabd	Bottom otter trawl	73,188		99,548	107,280	211,468
	Bottom pair trawl	5,937		2,635	21,843	63,223
	Purse seine			1,655	467	223
	Gillnets	9,516		21,347	9,514	1,357
	Longlines	1,761		857	1,371	2,231

EFFORT (days fished)

Area	*Gear*	2007	2008	2009	2010	2011
VIIIc, IXa	Bottom otter trawl	50209	43493	48239	85584	94455
	Bottom pair trawl	15372	13413	28280	36885	64141
	Purse seine	44561	47794	60105	63661	110461
	Gillnets	27308	31600	41337	31733	42180
	Longlines	9099	10732	11127	11500	13420
	Artisanal fisheries	76524	78442	83337	83712	119804
VIIIabde	Bottom otter trawl	6050	5984	5902	5218	8015
	Bottom pair trawl	3281	2393	3752	4833	5276
	Purse seine		38	1400	4027	12305
	Gillnets	2979	3836	5459	3859	3130
	Longlines	2353	3024	2587	5268	4819
	Artisanal fisheries	3265	1501	6680	9167	5139

Table 3.6.1.10. Absolute difference (tonnes) between Cefas logbook scheme estimates of sea bass landings and official data for the UK(E&W) fleet of nets and lines vessels (Armstrong and Walmsley, 2012a).

	Areas IV, VIId, VIIeh, VIIafg		
	nets	lines	total
1985	46	-28	18
1986	93	64	157
1987	254	74	328
1988	237	46	283
1989	73	44	117
1990	88	7	95
1991	30	0	30
1992	56	49	105
1993	265	-17	248
1994	564	454	1018
1995	163	122	285
1996	99	141	240
1997	309	845	1154
1998	125	146	271
1999	287	16	303
2000	366	240	606
2001	230	328	558
2002	153	281	434
2003	364	342	706
2004	484	605	1089
2005	216	552	768
2006	269	285	554
2007			
2008			
2009	84	369	453
2010	4	305	309

Table 3.6.1.11. Discards sampling rates for UK (England & Wales): nos. observed trips by year compared with total number of fleet trips. Trips with bass catch are given.

	Total number of fishing trips						Number of discard trips sampled						Number of sampled trips with bass					
	Trawl	Midwater	Nets	Lines	Other	Total	Trawl	Midwater	Nets	Lines	Other	Total	Trawl	Midwater	Nets	Lines	Other	Total
IVbc																		
2002	13580	176	1929	535	6599	22819	25	0	0	0	2	27	3	0	0	0	0	3
2003	13230	158	1099	534	7457	22478	37	0	0	1	0	38	5	0	0	0	0	5
2004	10961	267	1200	805	6835	20068	65	0	4	0	0	69	8	0	0	0	0	8
2005	11475	279	1730	905	6893	21282	32	1	2	0	0	35	4	0	0	0	0	4
2006	13559	188	4360	608	8910	27625	42	0	25	0	0	67	6	0	8	0	0	14
2007	14636	119	4422	1130	8956	29263	85	0	44	1	1	131	12	0	12	0	0	24
2008	12702	60	5340	1383	8783	28268	56	0	16	2	0	74	11	0	10	0	0	21
2009	14498	187	5224	1073	22917	43899	54	0	25	0	1	80	8	0	7	0	0	15
2010	12809	182	5838	1308	21306	41443	49	0	17	0	1	67	13	0	6	0	0	19
2011	13162	252	6821	685	24678	45598	47	0	15	0	0	62	4	0	5	0	0	9
VIId																		
2002	2601	19	746	341	3068	6775	1	0	0	0	0	1	1	0	0	0	0	1
2003	3160	37	744	496	2821	7258	3	0	0	0	3	6	2	0	0	0	0	2
2004	2641	33	725	366	2800	6565	9	0	2	0	2	13	6	0	0	0	0	6
2005	1947	25	531	387	3616	6506	5	1	0	0	0	6	5	1	0	0	0	6
2006	2969	20	6237	909	6326	16461	4	0	0	0	0	4	4	0	0	0	0	4
2007	3683	27	13778	1417	10169	29074	3	0	26	0	0	29	1	0	2	0	0	3
2008	3756	14	14772	1060	10106	29708	2	0	6	0	0	8	2	0	4	0	0	6
2009	3448	20	16935	1388	13049	34840	8	0	6	0	0	14	7	0	2	0	0	9
2010	3257	15	16189	1519	16301	37281	12	0	2	0	0	14	5	0	0	0	0	5
2011	3038	21	16929	1168	16085	37241	10	0	14	0	1	25	4	0	3	0	0	7
VIIeh																		
2002	10698	523	2582	1083	6225	21111	19	0	1	0	1	21	7	0	0	0	0	7
2003	10451	581	2150	783	5906	19871	42	1	6	0	15	64	19	1	1	0	0	21
2004	10640	474	2264	736	5989	20103	64	1	11	1	13	90	31	0	1	0	0	32
2005	9681	284	2516	936	6590	20007	48	1	2	0	4	55	21	1	0	0	0	22
2006	11789	314	4710	2093	9262	28168	74	2	5	0	0	81	30	1	2	0	0	33
2007	12950	572	6929	3082	10567	34100	129	1	21	0	0	151	59	1	2	0	0	62
2008	11902	564	7967	3325	10287	34045	107	0	14	0	0	121	45	0	3	0	0	48
2009	11012	512	8504	4950	15005	39983	73	0	17	0	0	90	30	0	0	0	0	30
2010	11240	472	7850	6234	16781	42577	59	0	31	0	0	90	17	0	3	0	0	20
2011	9953	476	9079	6403	18145	44057	63	0	21	0	1	85	13	0	0	0	0	13
VIIafg																		
2002	12816	1209	1230	825	2558	18638	13	0	6	0	3	22	1	0	1	0	0	2
2003	14242	1227	784	159	2658	19070	26	0	13	0	2	41	8	0	1	0	0	9
2004	13669	771	1051	1248	2808	19547	34	0	7	0	1	42	10	0	0	0	0	10
2005	13505	518	990	1408	2870	19291	14	0	3	0	0	17	2	0	1	0	0	3
2006	12825	477	2285	2298	6479	24364	19	0	7	0	1	27	5	0	0	0	0	5
2007	12799	237	2760	3778	7352	26926	52	0	14	0	0	66	11	0	0	0	0	11
2008	13293	338	3613	3903	8653	29800	58	0	17	0	0	75	15	0	2	0	0	17
2009	12498	265	4042	5043	13467	35315	31	0	16	0	0	47	16	0	1	0	0	17
2010	10854	239	3262	5169	14810	34334	26	0	11	0	0	37	9	0	1	0	0	10
2011	10533	123	3850	5916	16887	37309	26	0	26	0	0	52	7	0	2	0	0	9

Table 3.6.1.12. Estimated annual numbers and weight of sea bass discarded by UK otter trawl fleets in Areas IV, VIId, VIIeh and VIIafg, with numbers of sampled trips shown.

Length cm	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
8	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	4263
12	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	566	0
16	0	0	0	0	0	0	0	1126	0	0
18	0	0	0	0	0	0	0	3378	0	0
20	0	0	47	0	0	0	0	22 522	0	0
22	0	0	0	0	0	0	0	14 639	0	0
24	0	0	1458	0	0	8715	0	8170	2613	0
26	8808	488	896	0	3459	30 748	0	3909	21 429	0
28	0	1464	9635	539	8663	29 619	32 284	1069	33 462	1888
30	11 329	191	35 720	12 716	19 868	38 240	2597	4690	16 089	3219
32	30 192	18 820	65 321	1790	13 405	14 249	27 549	8474	37 627	4150
34	5665	13 693	29 528	3092	16 776	10 432	3034	8842	21 639	10 810
36	0	4453	1477	0	1520	242	50	20	675	0
38	0	0	0	0	0	0	0	0	0	1001
40	0	0	78	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	37	0	0	0
56	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0
Total Nos	55 994	39 110	144 160	18 137	63 691	132 245	65 550	76 839	134 101	25 330
Tonnes	21.4	17.9	58.5	6.8	25.0	41.7	23.2	17.2	47.4	9.5
% discarded	25	13	40	10	23	38	22	30	47	14
No. samples	58	108	172	99	139	269	223	166	146	146

Table 3.6.1.13. Estimated annual numbers and weight of sea bass discarded by UK gillnet fleets in Areas IV, VIId, VIIeh and VIIafg, with numbers of sampled trips shown.

Length cm	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
8	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	1859	0	0	0	0	0
22	0	0	0	0	1859	0	0	340	8150	0
24	0	0	0	0	0	254	0	0	0	0
26	0	0	0	0	0	0	0	340	0	0
28	0	0	0	0	7435	127	0	0	0	0
30	0	0	0	0	3718	286	0	0	0	0
32	0	0	0	0	7435	381	0	340	0	0
34	0	0	0	0	1859	1016	4444	0	0	32 632
36	0	0	0	0	1859	127	0	340	0	0
38	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	3722	0	0	0	0	0
50	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0
54	0	0	0	44 973	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0
58	0	0	0	0	1859	0	0	0	0	0
60	0	0	0	0	0	0	202	0	0	0
62	0	0	0	0	0	0	0	0	0	0
64	0	0	0	0	0	0	0	0	0	0
66	0	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0
Total Nos	0	0	0	44 973	31 604	2192	4646	1360	8150	32 632
Tonnes	0.00	0.00	0.00	85.6	18.4	0.9	2.7	0.5	1.2	16.2
% discarded	0	0	-	33	20	2	2	0	5	15
No. samples	7	19	24	7	37	105	53	64	61	76

Table 3.6.1.14. Number of fishing trips sampled for retained and discarded weight of sea bass on French vessels using different gear types in 2010 and 2009.

2010	ICES AREA	NUMBER OF SAMPLES	WEIGHT OF DISCARDS (T) ESTIMATED	TOTAL WEIGHT LANDINGS (T)	% DISCARDED
bottom trawl	IVbc	8	2	81	2
bottom trawl	VIId	29	140	507	28
bottom trawl	VIIeh	8	1	209	0
bottom trawl	VIIIab	42	<1	414	0
longline	VIIIab	2	<1	543	0
net	IVbc	6	<1	33	0
net	VIId	13	<1	68	0
net	VIIeh	6	<1	58	0
net	VIIIab	22	<1	419	0
pelagic trawl	VIId	14	11	505	2
pelagic trawl	VIIeh	6	1	1319	0
pelagic trawl	VIIIab	10	<1	365	0

2009	ICES AREA	NUMBER OF SAMPLES	WEIGHT OF DISCARDS (T) ESTIMATED	TOTAL WEIGHT LANDINGS (T)	% DISCARDED
bottom trawl	IVbc	16	34	155	22
bottom trawl	VIId	29	78	683	11
bottom trawl	VIIeh	9	9	189	5
bottom trawl	VIIIab	72	29	391	7
longline	VIIeh	17	1	71	1
longline	VIIIab	34	5	538	1
net	IVbc	3	<1	5	0
net	VIId	26	1	56	2
net	VIIeh	12	<1	33	0
net	VIIIab	159	5	523	1
pelagic trawl	IVbc	1	<1	1	0
pelagic trawl	VIId	15	12	404	3
pelagic trawl	VIIeh	7	4	693	1
pelagic trawl	VIIIab	89	6	401	1

Table 3.6.1.15. Numbers of hauls sampled by Spain for estimation of discards since 2003, by ICES areas. The métiers sampled are indicated. No discarded bass have been recorded.

	ICES area			
Year	VI	VII	VIII	IX
2003	3	562	140	72
2004	41	643	74	39
2005	2	592	236	119
2006	3	669	94	127
2007	2	757	232	151
2008	7	540	284	188
2009	6	444	315	185
2010	2	647	356	114
2011	3	194	432	102

Metiers sampled

GNS_DEF_>=100_0_0
GNS_DEF_60-99_0_0
OTB_DEF_>=55_0_0
OTB_DEF_>=70_0_0
OTB_DEF_>100_0_0
OTB_DEF_100-119_0_0
OTB_DEF_70-119_0_0
OTB_MCD_>=55_0_00
OTB_MCF_>=70_0_0
OTB_MDD_>100_0_0
OTB_MPD_>=55_0_0
OTB_SPF_>=70_0_0
PS_SPF_0_0_0
PTB_DEF_>=55_0_0
PTB_DEF_>=70_0_0

Table 3.6.1.16. Sea bass in the Northeast Atlantic. UK(E&W) sampling of bass landings for length composition in Divisions IVb, c.

	Otter trawls			Pair trawl			Drift and gill nets			Lines			Other gears		
Year	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured
1985	2.2	4	20	0.0	1	42	9.6	6	52	2.5	4	47	0.1	0	0
1986	2.8	2	7	0.0	0	0	16.6	3	13	6.8	3	31	0.2	0	0
1987	7.6	9	11	0.0	0	0	20.0	19	116	1.6	17	100	0.0	0	0
1988	8.8	3	4	0.0	0	0	21.5	14	347	4.1	20	118	0.0	0	0
1989	2.9	6	25	0.0	0	0	19.4	16	395	3.9	14	46	0.0	0	0
1990	2.7	3	13	0.0	0	0	13.3	3	98	6.0	13	27	0.1	0	0
1991	2.7	3	3	0.0	0	0	9.6	3	38	7.9	13	98	1.1	0	0
1992	4.5	2	2	0.0	0	0	12.1	8	140	4.8	34	171	0.0	6	23
1993	6.4	2	2	0.0	0	0	24.9	14	177	1.8	37	130	0.5	0	0
1994	26.7	18	154	0.0	0	0	87.1	26	1207	3.2	27	200	1.8	0	0
1995	29.7	6	11	0.0	0	0	103.2	19	501	2.2	35	124	0.9	0	0
1996	33.1	2	11	0.0	0	0	52.8	7	133	2.9	13	35	0.6	0	0
1997	18.1	6	37	0.0	0	0	47.6	12	44	2.7	72	140	0.0	0	0
1998	17.5	0	0	0.0	0	0	28.8	18	521	2.5	33	147	0.1	0	0
1999	16.2	6	90	0.0	0	0	48.1	18	725	12.9	51	266	0.4	0	0
2000	22.3	3	43	0.0	0	0	25.9	19	569	3.9	11	51	0.5	0	0
2001	15.2	4	25	0.0	0	0	19.6	18	808	9.5	17	285	0.5	0	0
2002	19.9	4	35	0.4	0	0	38.3	144	2847	18.0	33	137	1.0	0	0
2003	24.1	6	48	0.0	0	0	52.1	160	3052	8.2	0	0	0.5	1	22
2004	27.2	2	4	0.0	0	0	50.9	6	123	4.7	5	57	0.8	0	0
2005	23.0	5	146	0.0	0	0	42.9	12	318	3.4	1	12	0.7	0	0
2006	24.6	6	154	0.1	0	0	46.0	35	642	1.6	5	35	0.6	0	0
2007	18.1	7	168	0.0	0	0	39.6	7	438	3.8	6	124	0.6	0	0
2008	25.5	6	21	0.0	0	0	71.1	12	948	10.7	1	1	0.5	0	0
2009	40.5	0	0	0.0	0	0	62.1	8	1105	4.3	0	0	1.3	0	0
2010	43.8	1	3	0.0	0	0	95.9	8	492	9.4	22	291	1.2	0	0

Table 3.6.1.17. Sea bass in the Northeast Atlantic. UK(E&W) sampling of bass landings for length composition in Divisions VIId.

	Otter trawls			Pair trawl			Drift and gill nets			Lines			Other gears		
Year	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured
1985	0.0	0	0	0.0	0	0	13.0	1	68	3.3	3	164	0.0	0	0
1986	5.4	6	57	0.0	0	0	35.9	8	282	19.5	14	216	0.0	0	0
1987	23.1	6	199	0.0	0	0	24.6	5	101	9.1	7	29	0.1	1	7
1988	37.4	7	163	0.0	0	0	15.2	5	160	13.5	6	606	0.0	0	0
1989	36.1	3	14	4.9	0	0	20.9	6	242	2.6	1	8	0.0	1	42
1990	9.8	4	100	0.0	0	0	6.1	3	27	3.1	4	123	0.0	0	0
1991	22.9	9	59	0.0	0	0	74.1	17	129	49.6	18	378	0.0	0	0
1992	22.5	4	54	0.0	0	0	30.4	11	944	9.3	27	1273	0.2	2	9
1993	49.0	17	355	0.0	0	0	19.0	54	881	41.3	34	651	0.4	17	48
1994	72.0	46	2274	0.1	0	0	96.1	103	2711	68.0	54	1082	3.3	16	177
1995	66.3	37	545	0.0	0	0	78.6	76	3227	97.2	18	331	31.6	18	273
1996	47.2	23	396	0.1	0	0	76.8	52	1312	94.3	32	569	10.9	18	177
1997	56.6	37	1907	0.0	0	0	96.6	31	396	88.4	21	766	11.2	7	49
1998	75.6	20	868	0.0	0	0	52.6	19	450	92.6	20	1114	11.6	5	23
1999	91.6	18	333	1.9	4	114	64.0	31	1380	80.6	27	1247	19.2	8	24
2000	54.9	16	267	0.0	0	0	43.6	52	3533	31.4	16	665	27.5	1	2
2001	69.3	25	960	0.0	0	0	48.8	36	1120	27.8	12	435	0.0	0	0
2002	51.3	25	257	0.0	0	0	90.3	52	3016	36.1	23	512	6.2	1	3
2003	73.3	33	771	7.6	1	102	60.4	31	1284	36.6	15	668	0.0	0	0
2004	70.6	9	230	0.0	0	0	106.6	11	939	46.1	15	374	0.2	2	2
2005	30.9	3	251	0.0	0	0	101.7	4	214	37.1	7	192	0.0	0	0
2006	55.0	3	173	0.0	0	0	86.1	5	237	24.4	7	136	0.0	0	0
2007	44.3	4	46	3.9	0	0	93.4	8	188	49.7	6	157	2.4	0	0
2008	70.1	8	570	0.0	0	0	137.4	33	1378	34.8	11	382	4.9	0	0
2009	48.0	6	478	0.9	0	0	141.9	72	1182	42.1	5	125	10.3	1	4
2010	46.3	11	350	0.0	0	0	128.9	39	1228	47.0	0	0	17.5	0	0

Table 3.6.1.18. UK(E&W) sampling of bass landings for length composition in Divisions VIIe,h.

	Otter trawls			Pair trawl			Drift and gill nets			Lines			Other gears		
Year	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured
1985	7.0	9	175	0.6	1	1	3.4	4	35	8.0	6	23	0.5	0	0
1986	9.8	16	2465	2.2	0	0	4.3	2	749	4.4	7	551	1.0	4	119
1987	7.4	50	1064	0.0	1	589	5.7	18	1020	3.0	30	250	0.1	0	0
1988	11.4	17	310	7.7	0	0	6.0	7	1838	4.5	6	266	0.2	0	0
1989	22.8	5	356	4.2	1	832	9.5	3	566	2.6	10	254	0.4	0	0
1990	50.7	7	266	22.8	0	0	16.9	3	243	0.5	1	15	0.1	0	0
1991	16.5	6	289	14.5	0	0	13.1	6	1689	0.3	0	0	0.2	2	41
1992	18.6	7	336	7.9	0	0	7.1	6	343	6.2	29	133	0.1	0	0
1993	21.7	42	834	1.0	0	0	11.2	10	261	16.5	14	334	0.1	1	26
1994	28.5	52	1788	0.0	0	0	19.1	20	703	19.0	35	658	0.3	0	0
1995	43.3	25	916	1.1	1	19	28.9	21	584	26.9	30	619	0.6	0	0
1996	36.9	32	1210	87.2	1	214	19.1	14	618	13.4	25	466	5.6	0	0
1997	45.9	14	400	71.4	0	0	18.9	10	477	9.9	22	474	4.0	0	0
1998	40.3	14	375	84.7	0	0	19.1	19	373	17.9	28	672	0.4	0	0
1999	24.7	13	599	216.2	0	0	18.7	16	952	49.7	39	1161	0.4	0	0
2000	55.9	21	1455	52.1	0	0	14.2	19	2862	12.7	9	528	1.8	0	0
2001	46.4	23	1240	95.5	0	0	18.2	19	1475	6.6	27	783	0.7	0	0
2002	74.9	19	1016	108.6	0	0	40.9	22	1175	1.8	45	1269	8.3	0	0
2003	87.2	9	403	119.2	0	0	15.5	22	1411	10.7	45	1447	0.8	0	0
2004	58.7	8	334	130.8	0	0	38.1	8	568	3.6	12	293	0.2	0	0
2005	63.9	17	1284	78.3	2	299	12.4	5	387	7.4	13	475	0.1	0	0
2006	72.0	5	429	27.8	0	0	41.5	4	272	44.1	44	479	0.2	0	0
2007	82.1	7	507	60.0	4	489	41.8	13	606	67.8	7	232	0.6	0	0
2008	68.2	19	1158	19.7	9	1302	56.3	8	535	61.6	3	94	1.5	0	0
2009	46.2	7	329	10.2	6	625	52.5	12	663	67.9	10	560	1.6	0	0
2010	35.5	23	1118	41.9	3	376	50.9	17	612	90.3	9	408	1.8	1	3

Table 3.6.1.19. Sea bass in the Northeast Atlantic. UK(E&W) sampling of bass landings for length composition in Divisions VIIa,f,g.

	Otter trawls			Pair trawl			Drift and gill nets			Lines			Other gears		
Year	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured	Landings (t)	No. trips sampled	No. fish measured
1985	5.9	4	37	0.0	0	0	4.1	4	26	0.8	6	51	0.1	6	16
1986	3.4	6	91	0.0	0	0	3.9	5	88	2.8	7	96	1.1	0	0
1987	7.4	4	86	0.0	0	0	4.7	2	84	4.4	15	178	6.7	0	0
1988	12.1	6	883	0.0	0	0	21.5	16	736	8.1	21	375	0.4	0	0
1989	29.3	34	377	0.0	0	0	11.7	23	664	19.7	1	2	0.8	0	0
1990	11.6	38	588	0.0	0	0	10.9	2	88	4.8	4	95	0.0	0	0
1991	6.5	17	466	0.0	0	0	16.2	5	217	2.8	22	487	0.0	0	0
1992	5.2	6	68	0.0	0	0	14.8	5	41	3.4	21	500	0.7	0	0
1993	17.8	7	203	0.0	0	0	10.2	16	367	2.8	38	311	1.2	0	0
1994	12.8	20	505	0.3	0	0	26.6	10	643	64.8	39	1843	5.4	1	51
1995	39.3	16	843	0.2	0	0	51.5	35	2012	42.5	24	419	6.5	3	338
1996	26.4	2	240	0.0	0	0	37.6	42	1463	18.0	36	720	0.2	0	0
1997	37.9	13	435	0.0	0	0	31.8	52	1830	18.5	22	692	0.2	1	78
1998	23.8	13	349	0.0	0	0	7.8	30	924	8.2	30	887	2.3	0	0
1999	17.4	16	366	1.4	0	0	5.6	14	565	4.5	32	1119	3.3	1	70
2000	23.0	9	313	0.0	0	0	19.3	28	981	4.8	29	723	2.6	0	0
2001	30.1	17	293	0.0	0	0	34.6	24	597	14.2	58	1432	2.2	1	57
2002	41.3	14	1007	0.0	0	0	63.6	35	989	19.3	45	1113	7.3	0	0
2003	45.2	8	458	0.0	0	0	18.0	17	882	9.2	31	1051	0.5	1	7
2004	45.4	4	350	0.0	0	0	10.4	3	42	18.0	8	262	0.4	2	14
2005	46.2	12	904	0.0	0	0	14.9	13	260	11.0	4	242	0.3	0	0
2006	49.3	6	211	4.9	1	100	24.3	4	154	37.2	15	404	2.6	0	0
2007	57.3	7	242	0.0	0	0	63.9	15	655	45.7	12	575	0.2	0	0
2008	67.0	7	1284	0.0	0	0	57.0	11	597	54.5	18	1050	0.5	1	3
2009	50.4	0	0	0.0	0	0	55.7	8	297	31.5	4	272	1.1	0	0
2010	29.5	0	0	0.0	0	0	23.4	7	234	33.4	11	342	0.7	0	0

Table 3.6.1.20. UK(E&W) sampling of bass landings for length and age composition, by area, gears combined.

	North Sea IV				Eastern Channel VIId			
	No. length samples	No. lengths	No. age samples	No. ages	No. length samples	No. lengths	No. age samples	No. ages
1985	15	161	37	219	4	232	22	311
1986	8	51	11	108	28	555	43	546
1987	45	227	54	373	19	336	28	412
1988	37	649	30	203	18	929	25	466
1989	36	466	89	490	11	1293	49	534
1990	19	138	80	412	11	250	63	813
1991	19	139	114	635	44	566	113	1036
1992	50	336	107	480	44	2280	211	2286
1993	53	309	88	381	122	1935	188	2213
1994	71	1561	106	1092	219	6244	252	4146
1995	60	636	49	279	149	4376	133	1897
1996	22	179	44	101	125	2454	133	1783
1997	90	221	116	284	96	3118	110	2217
1998	51	668	94	634	64	2455	71	1198
1999	75	1081	134	529	88	3098	70	1071
2000	33	663	139	464	85	4467	89	1410
2001	39	1118	102	915	73	2515	85	1982
2002	181	3019	219	1917	101	3788	118	2528
2003	167	3122	133	762	80	2825	92	1190
2004	13	184	24	114	33	1545	38	517
2005	18	476	55	476	13	604	29	247
2006	44	624	35	298	14	485	27	208
2007	19	723	17	258	18	391	49	437
2008	18	916	14	640	48	2112	78	890
2009	8	1105	6	680	84	1789	97	1175
2010	30	740	28	501	50	1578	45	756

Table 3.6.1.21. UK(E&W) sampling of bass landings for length and age composition, by area, gears combined.

	Western Channel VIIe,h				Irish & Celtic Seas VIIafg			
	No. length samples	No. lengths	No. age samples	No. ages	No. length samples	No. lengths	No. age samples	No. ages
1985	20	234	17	159	16	120	63	330
1986	29	3884	15	94	18	275	30	269
1987	99	2923	58	336	21	348	38	240
1988	30	2374	24	329	43	1994	50	466
1989	19	2008	146	403	58	1043	85	451
1990	11	524	200	710	44	771	47	196
1991	14	2019	223	866	44	1770	130	935
1992	42	812	175	638	32	609	71	633
1993	67	1455	259	1189	61	881	125	901
1994	107	3149	175	961	70	3042	46	515
1995	77	2138	102	595	78	3612	55	969
1996	72	2508	68	1170	80	2423	94	952
1997	47	1351	55	1262	88	3035	55	993
1998	61	1784	71	905	73	2160	103	764
1999	68	2712	117	1305	63	2120	102	493
2000	49	4842	213	2228	66	2017	213	758
2001	69	3498	179	1396	100	2379	294	1353
2002	86	3460	80	722	94	3109	112	743
2003	76	3261	123	1109	57	2398	57	867
2004	28	1195	30	552	13	668	11	167
2005	37	2445	84	707	29	1406	39	361
2006	48	1174	59	549	25	859	13	317
2007	29	1666	129	862	32	1430	45	396
2008	36	2992	66	1128	31	1923	33	595
2009	138	5598	88	1513	11	527	21	217
2010	141	5032	48	822	17	551	11	161

Table 3.6.1.22. Sea bass in the Northeast Atlantic. Sampling of bass landings in France for length composition in Divisions IVb,c (from 2009, because of non- specific sea bass sampling at sea, high level of sampling can appear although fish samples is very low).

No. OF TRIPS SAMPLED FOR LENGTH

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	0	0	0	0	0	0	0	0	0	0	0
Longlines	0	0	0	0	0	0	0	0	0	0	0
Nets	0	0	0	0	0	0	0	0	0	3	15
Bottom trawl	0	0	0	0	0	0	0	0	0	19	10
Pelagic trawl	0	0	0	0	0	0	0	0	0	1	1
Purse seine	0	0	0	0	0	0	0	0	0	0	0
Danish seine											
Other gears											

LANDING (TONNES)

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	0	0	2	0	1	0	2	8	14	0	5
Longlines	2	4	2	6	4	5	4	0	0	0	5
Nets	10	12	14	10	16	15	18	15	14	5	33
Bottom trawl	39	64	136	121	120	128	74	80	92	155	81
Pelagic trawl	0	1	4	9	1	2	1	0	8	1	1
Purse seine	0	0	0	0	0	0	0	0	0	0	0
Danish seine	0	0	0	0	0	0	0	0	0	0	0
Other gears	0	0	0	0	0	0	0	0	0	0	1

Table 3.6.1.23. Sampling of bass landings in France for length composition in Division VIId (from 2009, because of non-specific sea bass sampling at sea, high level of sampling can appear although fish samples is very low).

No. OF TRIPS SAMPLED FOR LENGTH

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	0	0	0	0	0	0	0	0	0	0	0
Longlines	0	0	0	0	0	0	0	0	0	0	0
Nets	0	0	0	0	0	0	0	0	0	13	20
Bottom trawl	0	0	4	6	10	7	4	3	7	52	37
Pelagic trawl	0	0	0	1	1	7	4	2	3	43	16
Purse seine	0	0	0	0	0	0	0	0	0	0	0
Danish seine	0	0	0	0	0	0	0	0	0	0	0
Other gears	0	0	0	0	0	0	0	0	0	0	0

LANDING (TONNES)

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	9	70	70	108	79	89	105	142	82	89	93
Longlines	5	6	7	11	11	13	16	26	11	8	8
Nets	52	63	80	101	98	85	81	89	53	56	68
Bottom trawl	397	375	443	688	710	645	594	807	749	683	507
Pelagic trawl	89	76	104	131	272	391	242	246	254	404	505
Purse seine	0	0	0	0	0	0	0	0	0	0	0
Danish seine	0	0	0	0	0	0	0	0	0	23	27
Other gears	9	11	6	12	6	4	9	15	13	58	28

Table 3.6.1.24. Sea bass in the Northeast Atlantic. Sampling of sea bass landings in France for length composition in Division VIIe,h (from 2009, because of none specific sea bass sampling at sea, high level of sampling can appear although fish samples is very low).

No. OF TRIPS SAMPLED FOR LENGTH

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	39	99	76	72	71	23	63	35	23	11	5
Longlines	14	2	3	6	7	11	10	34	18	22	5
Nets	2	1	0	1	6	4	11	28	25	9	14
Bottom trawl	2	0	0	2	2	7	7	8	11	22	17
Pelagic trawl	2	0	3	3	5	4	12	6	5	11	11
Purse seine	0	0	0	0	0	0	0	0	0	0	2
Danish seine	0	0	0	0	0	0	0	0	0	0	0
Other gears	0	0	0	0	0	0	0	0	0	0	0

LANDING (TONNES)

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	192	141	133	169	128	149	189	173	168	83	84
Longlines	97	154	137	144	158	182	239	211	151	71	84
Nets	45	35	33	40	35	48	41	53	61	33	58
Bottom trawl	204	226	280	262	358	433	403	273	246	189	209
Pelagic trawl	588	577	303	632	548	925	1177	596	749	693	1319
Purse seine	1	8	6	3	4	5	21	4	22	20	13
Danish seine	0	0	0	0	0	0	0	0	0	3	11
Other gears	10	8	9	7	7	8	5	4	6	49	48

Table 3.6.1.25. Sea bass in the Northeast Atlantic. Sampling of sea bass landings in France for length composition in Division VIIIa,b (from 2009, because of non-specific sea bass sampling at sea, high level of sampling can appear although fish samples is very low).

No. OF TRIPS SAMPLED FOR LENGTH

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	0	0	31	14	19	16	23	20	14	0	0
Longlines	47	40	57	52	30	30	12	9	14	49	28
Nets	31	47	50	50	32	42	31	18	37	208	220
Bottom trawl	32	28	47	44	57	63	55	58	50	144	182
Pelagic trawl	0	0	2	3	3	3	0	1	1	135	53
Purse seine	0	0	0	0	0	0	0	0	0	1	4
Danish seine	0	0	0	0	0	0	0	0	0	0	0
Other gears	0	0	0	0	0	0	0	0	0	0	0

LANDING (TONNES)

Gear	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Handlines	104	101	103	127	132	88	111	139	105	175	168
Longlines	530	549	540	686	749	721	764	781	684	538	543
Nets	731	569	553	539	524	535	581	688	556	523	419
Bottom trawl	433	332	334	286	408	492	456	524	546	391	414
Pelagic trawl	464	635	612	814	410	803	752	507	658	401	365
Purse seine	10	35	57	21	36	55	16	19	42	5	14
Danish seine	0	0	0	0	0	0	0	0	0	1	37
Other gears	22	17	18	24	26	28	27	19	9	119	128

Table 3.6.1.26. Sea bass in the Northeast Atlantic. Landings by "fleet" summed over Division IVb,c, VIId, VIIe,h and VIIafg, for input to assessment model. Landings for Bay of Biscay (VIIIa,b) are given.

Year	UK otter trawl	UK Midwater trawl	UK nets	UK lines	France (all)	Other	Total IVbc, VIIa,d,e,f,g,h	Bay of Biscay VIIIa,b
1985	15	1	30	15	870	146	1076	2420
1986	21	2	61	34	1180	17	1315	2547
1987	45	0	55	18	1840	21	1979	2417
1988	70	8	64	30	1028	39	1238	2224
1989	91	9	61	29	917	53	1161	2164
1990	75	23	47	14	849	25	1033	1640
1991	49	14	113	61	971	17	1225	1738
1992	51	8	64	24	1001	37	1184	1721
1993	95	1	65	62	979	48	1251	1562
1994	140	0	229	155	786	60	1370	1671
1995	179	1	262	169	1057	110	1777	1513
1996	144	87	186	129	2395	82	3023	1425
1997	159	71	195	120	1984	91	2620	1383
1998	157	85	108	121	1773	143	2388	1234
1999	150	220	136	148	1843	168	2665	1117
2000	156	52	103	53	1806	227	2397	2295
2001	161	95	121	58	1883	162	2482	2238
2002	187	109	233	75	1824	199	2628	2216
2003	230	127	146	65	2471	407	3445	2497
2004	202	131	206	72	2604	515	3730	2284
2005	164	78	172	59	3161	757	4392	2722
2006	201	33	198	107	3259	724	4522	2707
2007	202	64	239	167	2770	772	4213	2677
2008	231	20	322	162	2750	760	4244	2600
2009	185	11	312	146	2649	709	4013	2152
2010	155	42	299	180	3236	845	4758	2089

Table 3.6.1.27. Sea bass in the Northeast Atlantic. Estimated numbers-at-age for bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: TRAWLS (nos. fish).

YEAR	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12+
1985	0	287	1293	1086	3706	511	1348	3229	777	327	1073
1986	0	148	3252	1518	564	1783	376	1357	4410	588	1954
1987	0	310	15549	24366	7432	755	1397	171	389	2385	4073
1988	0	2121	21091	45329	16656	4207	633	972	382	272	4082
1989	31571	4227	253	3149	16208	14914	5497	2380	2618	1296	15857
1990	0	1168	1710	490	5457	18337	12730	3409	957	671	6114
1991	0	395	19332	1603	1026	4673	7296	6319	2641	255	7304
1992	0	5069	23603	14242	890	784	1502	4121	2462	617	3181
1993	0	388	54411	51055	15243	619	479	1504	3609	2356	2978
1994	0	870	8544	162828	19532	6238	454	96	574	2084	3175
1995	0	1172	9460	27105	156779	12200	4157	363	148	174	3755
1996	0	1069	8540	9137	21032	73642	5257	2309	123	210	2859
1997	0	628	3868	33195	23358	21429	68762	4077	1507	193	3474
1998	0	294	19559	25218	49978	16707	9560	24530	1230	436	1215
1999	87	95	49306	78844	20591	18237	5558	3755	11342	746	1088
2000	0	5914	1774	89986	44508	8323	8476	3937	4496	7421	1427
2001	223	5076	56358	12240	75098	19158	5183	6093	2645	3693	7783
2002	0	4024	19643	115378	9264	42010	10107	4698	4631	1516	9587
2003	0	4340	46788	37874	92709	6457	33695	11045	3886	2590	7771
2004	0	1206	15540	117370	48769	57111	1397	6183	2870	1286	2129
2005	0	5502	52720	34696	51453	20353	21054	2501	5981	995	3104
2006	0	14221	76405	73547	30341	34725	12905	17101	1378	1711	2378
2007	0	356	22195	106103	57214	21355	16876	6170	4095	1180	2172
2008	0	3755	48903	128086	69038	26739	9710	8683	3038	3190	1209
2009	0	596	19294	51618	55676	18733	4898	4312	1221	837	2188
2010	0	125	14082	48534	43725	31336	9106	2444	1119	1155	1025

Table 3.6.1.28. Sea bass in the Northeast Atlantic. Estimated numbers-at-age for bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: MIDWATER TRAWL (nos. fish).

YEAR	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12+
1985	0	0	0	0	0	0	0	0	0	0	137
1986	-	-	-	-	-	-	-	-	-	-	-
1987	0	0	0	0	9	6	40	7	36	224	270
1988	0	0	0	93	986	757	295	443	42	52	480
1989	0	0	0	0	45	280	253	227	440	190	3432
1990	-	-	-	-	-	-	-	-	-	-	-
1991	0	0	218	218	604	1463	8618	9256	3027	0	2446
1992	0	0	0	230	114	190	513	2163	2759	521	474
1993	-	-	-	-	-	-	-	-	-	-	-
1994	0	5	118	3	0	0	0	0	0	0	0
1995	0	14	83	206	1052	39	6	0	0	0	0
1996	0	0	289	795	3890	71623	5580	1647	21	333	2017
1997	-	-	-	-	-	-	-	-	-	-	-
1998	0	0	249	6227	12333	8915	8478	26204	2624	360	1802
1999	0	0	3361	20817	17212	30942	15778	20554	48997	4964	6126
2000	0	15	60	2475	7585	3270	4496	1459	2829	7075	1363
2001	0	0	176	884	19449	19953	6925	5181	3072	2797	11351
2002	0	2	33	2126	1410	21521	8661	5626	5342	402	13768
2003	0	0	1782	6787	28353	6022	32115	8271	2768	2867	4833
2004	0	7	1254	12498	14367	48093	3198	20688	8007	353	4014
2005	0	0	121	2225	16210	15231	18417	2018	5483	0	2717
2006	-	-	-	-	-	-	-	-	-	-	-
2007	0	0	659	4305	12038	9214	11686	4780	3249	1079	1703
2008	0	53	517	1726	3699	2017	1626	1801	881	1120	870
2009	0	0	101	713	2441	2915	946	881	189	334	396
2010	0	8	34	1670	5318	7922	6403	4560	386	3631	1305

Table 3.6.1.29. Sea bass in the Northeast Atlantic. Estimated numbers-at-age for bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: GILL / DRIFTNETS (nos. fish).

Year	age 2	age 3	age 4	age 5	age 6	age 7	age 8	age 9	age 10	age 11	age 12+
1985	0	9811	14260	2238	2386	266	1239	3869	984	1419	1625
1986	0	11414	17736	17701	3055	5888	225	1720	5459	973	7180
1987	0	80	14010	31300	5771	1209	1180	464	307	3398	4867
1988	0	0	1014	13111	27458	8792	1359	1469	491	271	6345
1989	776	931	657	4500	30311	14080	4654	1181	916	644	4421
1990	0	1553	350	2550	11257	9958	6352	1025	669	513	2263
1991	0	13454	27470	1777	780	4610	14517	12946	5597	417	12567
1992	0	11880	39087	28086	557	293	1323	2322	3481	892	2553
1993	0	249	33556	23265	8571	785	235	521	1684	1911	3376
1994	2	536	23374	218682	21583	9588	649	186	1719	4110	8698
1995	0	4414	27219	56712	198292	6913	3121	330	280	761	10328
1996	0	10341	35627	22971	35303	94961	3581	1637	121	168	4207
1997	0	3413	4655	26323	22234	18279	89438	4590	2622	637	4294
1998	0	812	26100	25713	22604	9368	6255	17912	1613	440	945
1999	22	0	32221	68971	24360	11944	4617	2946	8479	513	1105
2000	0	4311	1056	74273	34286	5098	4421	1706	1096	2462	613
2001	119	5817	41752	5048	45307	13320	3280	4011	2701	3335	6748
2002	0	8232	26242	184854	9582	36220	8612	4206	5137	1711	10391
2003	0	6197	54798	31410	52011	2051	6685	2451	979	663	1860
2004	0	2638	21733	114580	40057	49459	2478	7541	2252	668	2261
2005	0	6544	38905	45783	79590	17947	12836	706	2230	630	438
2006	0	10936	76519	75401	27189	18909	4174	5644	543	1772	1995
2007	0	648	10515	78809	46185	26954	20987	7769	10923	10535	5064
2008	0	6471	70258	188626	82455	25664	12097	10168	5942	3371	2971
2009	0	1502	40302	100073	116153	43938	13247	6957	6744	5719	3375
2010	0	190	59197	95333	63985	39510	17872	8820	5622	4702	8224

Table 3.6.1.30. Sea bass in the Northeast Atlantic. Estimated numbers-at-age for sea bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: LINES (nos. fish).

YEAR	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12+
1985	0	9010	9328	2534	3970	628	374	1629	415	250	715
1986	0	578	8254	3211	862	2259	347	717	5215	956	4312
1987	0	114	1341	3945	1899	515	532	411	499	1670	2592
1988	0	23	1691	13184	4620	2264	554	1040	213	473	5369
1989	0	0	594	3259	4691	588	332	90	187	61	1788
1990	0	162	41	62	556	1892	1457	563	248	244	1975
1991	0	189	9627	513	303	1104	5934	5390	2191	69	14784
1992	0	1897	6707	4759	285	212	453	1158	1658	591	2160
1993	0	133	9857	11515	7486	674	336	940	3949	3375	7208
1994	0	78	4408	134792	20138	9624	740	188	1778	4772	8066
1995	0	218	8496	27340	107376	6146	4312	315	601	561	14097
1996	0	235	10225	14007	16001	59837	4704	4426	145	425	8142
1997	0	550	3458	18947	13622	9287	60554	3012	1447	676	3944
1998	0	2238	10256	11796	19658	8170	6474	26381	2834	993	5515
1999	17	274	29278	41760	13664	13780	5215	4917	16776	1728	5481
2000	0	457	315	21530	13759	2856	3327	1469	1173	4492	1218
2001	42	776	7822	1442	18150	7307	2043	3590	1598	1793	4719
2002	0	766	2806	15076	2882	17448	7789	2552	5003	1331	5648
2003	0	67	6087	6840	21909	1840	8945	2891	1274	842	3133
2004	0	302	1875	14520	8427	17393	2101	6511	3381	1061	5459
2005	0	186	1435	4590	14704	5224	7489	547	5636	1807	2247
2006	0	33	17749	39493	14001	22796	5742	10879	1267	2603	3043
2007	0	17	6544	31560	28333	14600	17959	8547	10950	5195	9134
2008	0	197	4980	27227	41880	21465	12180	12468	5414	4904	6960
2009	0	297	8189	20393	35010	25405	11338	8798	4558	4318	6460
2010	0	592	5097	33008	39661	28692	11487	3772	1741	2158	1437

Table 3.6.1.31. Sea bass in the Northeast Atlantic. Mean weights-at-age (kg) for bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: TRAWLS.

YEAR	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12+
1985	0.000	0.409	0.610	0.711	0.861	0.952	1.121	1.360	1.501	1.825	3.043
1986	0.000	0.367	0.509	0.790	0.927	1.065	1.324	1.304	1.752	2.031	2.875
1987	0.000	0.312	0.429	0.626	0.895	1.117	1.323	1.743	2.133	2.332	3.400
1988	0.000	0.358	0.449	0.584	0.885	1.148	1.487	1.666	1.846	2.056	2.842
1989	0.463	0.508	0.953	0.550	0.768	1.167	1.359	1.563	1.874	1.885	2.658
1990	0.000	0.580	0.731	0.995	1.063	1.264	1.588	1.849	2.015	2.447	3.208
1991	0.000	0.623	0.650	0.779	0.866	1.172	1.609	2.020	2.295	2.683	3.499
1992	0.000	0.601	0.646	0.881	1.121	1.422	1.387	1.558	1.977	2.330	3.896
1993	0.000	0.608	0.587	0.719	1.014	1.263	1.579	1.557	1.942	2.258	3.649
1994	0.000	0.424	0.592	0.650	0.966	1.325	1.686	1.649	2.077	2.521	3.534
1995	0.000	0.567	0.613	0.729	0.843	1.254	1.442	1.804	2.793	2.220	3.174
1996	0.000	0.575	0.652	0.729	0.857	1.146	1.759	2.067	2.234	2.721	3.492
1997	0.000	0.601	0.656	0.736	0.866	1.016	1.256	1.792	2.349	2.555	3.573
1998	0.000	0.623	0.658	0.764	0.890	1.056	1.231	1.493	1.904	2.868	3.695
1999	0.439	0.361	0.639	0.740	0.922	1.064	1.305	1.603	1.843	2.288	3.509
2000	0.000	0.647	0.660	0.718	0.925	1.242	1.492	1.684	1.943	2.115	3.819
2001	0.651	0.600	0.637	0.657	0.838	1.142	1.478	1.686	2.119	2.277	2.769
2002	0.000	0.610	0.625	0.673	0.882	1.125	1.520	1.739	1.909	2.190	2.862
2003	0.000	0.605	0.666	0.737	0.893	1.193	1.431	1.749	1.989	2.185	3.206
2004	0.000	0.691	0.722	0.741	0.911	1.055	1.432	1.585	2.681	1.992	3.383
2005	0.000	0.623	0.622	0.723	0.867	1.037	1.278	1.313	2.184	2.158	2.954
2006	0.000	0.567	0.646	0.738	0.913	1.027	1.270	1.427	1.673	2.091	3.088
2007	0.000	0.640	0.602	0.696	0.865	0.992	1.101	1.382	1.646	1.794	3.551
2008	0.000	0.523	0.574	0.625	0.804	1.030	1.207	1.410	1.622	1.652	3.133
2009	0.000	0.603	0.596	0.650	0.776	1.064	1.414	1.669	1.981	2.249	3.560
2010	0.000	0.697	0.586	0.656	0.785	0.933	1.144	1.492	1.891	1.946	2.503

Table 3.6.1.32. Sea bass in the Northeast Atlantic. Mean weights-at-age (kg) for bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: MIDWATER TRAWL.

YEAR	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12+
1985	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.538
1986											
1987	0.000	0.000	0.000	0.000	1.805	1.927	1.994	2.361	2.225	2.222	3.245
1988	0.000	0.000	0.000	0.661	1.007	1.067	1.475	1.556	1.363	1.554	3.233
1989	0.000	0.000	0.000	0.000	1.458	1.596	1.920	2.038	2.433	2.657	3.052
1990											
1991	0.000	0.000	1.211	1.211	1.271	1.251	1.348	1.544	1.510	0.000	4.046
1992	0.000	0.000	0.000	1.191	1.276	1.317	1.770	1.922	2.092	2.143	2.418
1993											
1994	0.000	0.611	0.685	0.847	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.584	0.617	0.663	0.793	0.890	0.814	0.000	0.000	0.000	0.000
1996	0.000	0.000	0.797	0.771	0.850	1.085	1.417	1.686	2.915	2.102	3.418
1997											
1998	0.000	0.000	0.664	0.937	0.937	1.067	1.309	1.559	1.571	2.593	4.575
1999	0.000	0.000	0.804	0.947	1.116	1.188	1.443	1.727	1.970	2.283	3.802
2000	0.000	0.697	1.157	0.847	1.153	1.360	1.585	2.025	2.192	2.418	3.486
2001	0.000	0.000	0.838	0.943	0.996	1.273	1.570	1.717	1.912	2.503	2.689
2002	0.000	0.693	0.753	1.078	1.133	1.230	1.623	1.826	2.195	2.336	2.803
2003	0.000	0.000	0.631	0.740	0.976	1.061	1.326	1.603	2.027	2.284	3.030
2004	0.000	0.547	0.699	0.867	0.957	1.203	1.431	1.684	2.112	2.536	3.228
2005	0.000	0.000	0.714	0.937	1.060	1.161	1.413	1.582	2.024	0.000	2.722
2006											
2007	0.000	0.000	0.846	0.769	0.920	1.123	1.266	1.483	1.812	2.081	2.770
2008	0.000	0.612	0.653	0.769	1.026	1.208	1.478	1.614	1.987	2.031	2.796
2009	0.000	0.000	0.825	0.791	0.890	1.097	1.285	1.432	1.629	2.407	2.153
2010	0.000	0.602	0.646	0.780	0.885	0.987	1.289	1.416	1.217	2.077	2.771

Table 3.6.1.33. Sea bass in the Northeast Atlantic. Mean weights-at-age (kg) for bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: GILL / DRIFTNETS.

YEAR	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12+
1985	0.000	0.349	0.521	0.758	0.884	0.999	1.187	1.643	1.736	2.260	2.930
1986	0.000	0.477	0.634	0.834	1.012	1.147	1.164	1.376	1.911	3.663	2.098
1987	0.000	0.428	0.482	0.650	0.974	1.328	1.544	2.093	2.254	2.296	3.328
1988	0.000	0.000	0.686	0.670	0.931	1.165	1.555	1.559	1.776	1.703	3.397
1989	0.574	0.613	0.637	0.644	0.796	1.124	1.263	1.371	1.615	1.962	2.721
1990	0.000	0.656	0.785	0.744	0.789	1.273	1.498	1.884	1.787	1.941	3.125
1991	0.000	0.675	0.652	0.990	0.950	1.289	1.626	2.078	2.257	2.092	3.779
1992	0.000	0.585	0.683	0.789	1.068	1.560	1.590	1.801	2.031	2.173	3.544
1993	0.000	0.588	0.641	0.765	1.033	1.406	1.959	1.679	2.279	2.638	3.701
1994	0.219	0.577	0.635	0.708	0.980	1.354	1.673	1.712	2.077	2.369	3.687
1995	0.000	0.523	0.668	0.816	0.854	1.189	1.504	2.114	2.848	2.537	3.323
1996	0.000	0.651	0.663	0.719	0.880	1.017	1.436	1.985	1.888	2.345	4.020
1997	0.000	0.679	0.739	0.765	0.900	1.061	1.348	1.743	2.687	2.196	3.680
1998	0.000	0.645	0.673	0.702	0.951	1.194	1.470	1.715	2.363	3.023	3.516
1999	0.439	0.000	0.722	0.817	0.885	1.089	1.440	1.839	1.964	2.320	3.905
2000	0.000	0.713	0.766	0.763	0.922	1.081	1.235	1.500	1.636	2.339	3.701
2001	0.625	0.643	0.652	0.723	0.885	1.135	1.443	1.730	2.163	2.396	2.839
2002	0.000	0.626	0.667	0.690	0.884	1.054	1.410	1.584	1.827	1.878	2.560
2003	0.000	0.686	0.731	0.767	0.847	1.087	1.418	1.888	2.227	2.240	2.859
2004	0.000	0.717	0.819	0.800	0.938	1.099	1.415	1.556	2.070	2.325	3.348
2005	0.000	0.690	0.662	0.843	0.992	1.194	1.260	1.480	1.795	2.229	2.452
2006	0.000	0.617	0.689	0.753	0.944	1.173	1.385	2.022	2.086	2.462	3.351
2007	0.000	0.557	0.620	0.712	0.895	1.242	1.296	1.454	1.991	2.453	2.916
2008	0.000	0.529	0.576	0.650	0.840	1.034	1.235	1.675	1.838	2.056	3.226
2009	0.000	0.635	0.634	0.732	0.870	1.113	1.417	1.688	1.743	2.026	2.492
2010	0.000	0.661	0.602	0.717	0.880	1.121	1.436	1.850	2.467	2.625	3.019

Table 3.6.1.34. Sea bass in the Northeast Atlantic. Mean weights-at-age (kg) for sea bass landed into the UK from Division IVb,c, VIId, VIIe,h and VIIafg: LINES.

YEAR	AGE 2	AGE 3	AGE 4	AGE 5	AGE 6	AGE 7	AGE 8	AGE 9	AGE 10	AGE 11	AGE 12+
1985	0.000	0.305	0.387	0.534	0.726	0.780	1.207	1.426	1.814	2.035	3.083
1986	0.000	0.402	0.497	0.792	0.988	1.191	1.367	1.458	1.681	1.756	2.998
1987	0.000	0.274	0.433	0.664	0.960	1.431	1.475	1.721	2.054	2.139	3.541
1988	0.000	0.409	0.426	0.539	0.937	1.241	1.476	1.718	1.663	1.868	3.050
1989	0.000	0.000	0.468	0.522	0.623	1.178	2.093	2.497	2.535	2.570	3.284
1990	0.000	0.674	0.738	0.846	1.005	1.205	1.565	1.876	2.115	2.202	3.538
1991	0.000	0.628	0.659	0.960	0.978	1.278	1.632	2.221	2.406	2.331	4.031
1992	0.000	0.553	0.678	0.900	1.210	1.614	1.671	1.904	2.193	2.599	4.120
1993	0.000	0.393	0.626	0.820	1.181	1.578	1.864	1.865	2.254	2.557	3.799
1994	0.000	0.648	0.537	0.669	0.975	1.313	1.734	1.701	2.102	2.400	3.467
1995	0.000	0.515	0.644	0.710	0.863	1.350	1.789	1.917	2.625	2.675	3.636
1996	0.000	0.572	0.593	0.665	0.864	1.107	1.614	2.223	1.851	3.091	3.883
1997	0.000	0.490	0.602	0.707	0.877	1.027	1.281	1.748	2.333	2.564	3.634
1998	0.000	0.314	0.670	0.839	1.005	1.205	1.430	1.810	2.348	3.331	4.024
1999	0.439	0.355	0.685	0.848	1.062	1.226	1.518	1.833	2.114	2.416	3.762
2000	0.000	0.646	0.647	0.776	1.001	1.246	1.482	1.861	2.155	2.488	3.473
2001	0.701	0.652	0.686	0.779	0.982	1.259	1.524	1.849	2.105	2.359	3.057
2002	0.000	0.632	0.649	0.786	1.107	1.188	1.647	1.774	2.160	2.302	3.321
2003	0.000	0.589	0.680	0.782	0.945	1.212	1.487	1.777	1.994	2.317	3.069
2004	0.000	0.646	0.719	0.787	1.031	1.217	1.585	1.824	2.149	2.473	3.101
2005	0.000	0.702	0.663	0.800	1.005	1.348	1.457	1.263	2.472	3.821	3.099
2006	0.000	0.582	0.812	0.821	0.957	1.015	1.285	1.624	2.227	2.776	3.523
2007	0.000	0.639	0.634	0.737	0.881	1.070	1.324	1.672	1.996	2.305	2.949
2008	0.000	0.584	0.633	0.724	0.920	1.154	1.344	1.548	1.859	1.918	2.905
2009	0.000	0.583	0.607	0.727	0.867	1.109	1.440	1.653	1.972	2.027	2.693
2010	0.000	0.789	0.743	0.845	0.933	1.047	1.286	1.740	2.029	2.261	2.846

Table 3.6.1.35. Sea bass in the Northeast Atlantic. Estimated numbers-at-length for sea bass landed into the UK from Divisions IVb,c, VIId, VIIe,h and VIIafg: MIDWATER TRAWLS (nos. fish).

Length	1985	1987	1988	1989	1991	1992	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2009	2010
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	234	0
20	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	467	0
26	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	511	0
30	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1022	0
32	7	0	0	0	0	0	0	0	0	0	0	25	0	0	0	32	0	0	0	1022	12620
34	1	0	0	0	0	0	15	0	21	6	0	6674	559	0	0	63	38	0	633	0	20126
36	4	0	0	0	418	16	147	193	223	649	59	10099	2933	197	49	670	155	90	2147	0	11164
38	0	0	0	0	334	4894	4364	3975	802	1879	82	15966	6482	897	344	2001	624	268	3259	4522	15387
40	0	0	0	0	334	11022	7745	5570	1925	5466	624	21768	12788	3609	884	4261	1145	774	5121	4995	21668
42	14	0	96	0	418	20153	3804	13127	2107	5641	2048	15526	12911	7921	1081	5131	1262	1144	5036	4952	16119
44	36	1219	32	0	84	14340	8728	17242	2554	9138	6767	14020	8843	10546	983	8942	1282	1812	3218	1489	2392
46	72	5919	446	19	0	12528	14011	19789	2805	8733	13119	8367	14530	12622	295	7982	1158	1304	3657	757	5461
48	72	7260	223	0	0	10412	8272	15316	3193	7364	4288	5628	18163	12021	442	7313	1520	927	2542	3086	3111
50	30	4718	478	0	0	5550	9187	14103	2431	7054	8350	4183	20224	7371	246	4481	1382	1084	962	1119	11466
52	109	2020	1116	0	0	3274	2066	14298	2262	4774	6873	2900	4185	3641	197	4568	1347	572	1850	290	4724
54	238	2298	670	116	0	417	6405	9264	2199	3737	3134	1603	9728	2790	246	3317	1390	255	1217	72	677
56	225	0	2423	193	0	980	464	11435	3199	3858	3562	1052	300	1561	49	1918	832	111	755	467	4278
58	386	0	925	329	0	596	721	9379	2323	2755	4863	701	1100	1762	49	1243	817	205	1023	1533	2303
60	334	0	351	213	0	98	966	4407	1452	2639	3079	614	1249	907	49	1178	515	93	384	0	4607
62	481	157	255	271	0	204	213	2987	1193	2416	2185	789	1249	565	0	762	418	107	180	0	2303
64	465	627	0	484	0	196	420	982	812	1617	1563	351	591	355	0	256	264	44	178	0	706
66	175	157	0	193	0	588	377	1096	443	588	1832	351	707	355	0	256	138	46	197	0	677
68	174	0	0	77	0	490	44	1314	279	761	1052	263	291	105	0	255	86	23	100	0	0
70	14	783	0	135	0	98	126	940	248	211	934	0	358	118	0	97	19	23	50	0	0
72	66	313	0	58	0	0	257	237	195	349	339	0	174	25	0	63	11	4	17	0	0
74	0	157	0	0	0	98	251	430	63	79	161	88	58	53	0	128	8	4	33	0	0
76	7	157	0	0	0	0	126	0	42	41	126	40	58	25	0	32	11	12	0	0	519
78	0	0	0	19	0	98	0	237	11	6	12	40	0	0	0	32	2	4	0	0	0
80	7	157	0	39	0	0	251	474	21	22	12	40	0	0	0	0	2	0	17	0	0
82	0	0	0	0	0	0	126	27	11	0	0	0	0	0	0	0	8	0	0	0	0
84	0	0	0	0	0	0	126	0	11	6	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.6.1.36. Sea bass in the Northeast Atlantic. Length–frequency of sea bass landed by French fleets from Divisions IVb,c, VIId, VIIe,h and VIIafg VIId: ALL GEARS COMBINED (numbers of fish).

length class	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
14	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	717
22	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	3455	0	0	0	0	0	292	0
30	0	0	1015	13054	14	0	15689	0	0	473	0
32	0	0	0	58717	13057	9903	32459	181	8250	2239	9811
34	9931	17962	12469	105655	78811	29872	179130	4715	28986	10714	28290
36	34932	19809	38249	125326	127801	97890	285704	39335	229758	124925	169311
38	85866	68920	46427	180475	124051	128022	217657	102714	263071	211881	177571
40	126730	76594	62503	119495	227214	231750	178250	146272	266408	225545	182105
42	102836	98008	82461	145456	282390	266905	196868	145122	237160	193030	283064
44	80478	109595	91064	104545	243107	344681	289998	164011	270810	222613	251956
46	93344	106857	86723	130023	188494	270532	285451	130859	228996	238849	230227
48	80934	77694	62163	115806	126685	239265	263272	100043	142650	155222	188149
50	55399	57055	55905	91915	72581	169478	200874	99210	112385	159658	186310
52	52948	51658	46180	93878	82331	115269	119836	75929	74336	114530	109212
54	42094	36737	35998	48742	50633	62106	99509	74405	66260	84649	120550
56	26460	35839	26001	60839	60284	67741	99674	55147	48853	96257	71590
58	27357	22762	19019	31614	31334	61132	54522	46087	39689	51578	62211
60	23581	25834	14210	33688	19126	43591	45908	28056	29840	36547	31544
62	14295	18773	11129	30691	23996	35774	23763	23057	28335	57472	19076
64	18044	13532	16771	18823	14799	25788	20607	18091	14420	24016	62005
66	10773	11068	11011	13230	10650	12456	14969	8715	12694	21415	26388
68	9903	9120	5447	7960	8569	13360	13976	8793	9039	27466	9340
70	5709	11771	4795	5374	4880	8908	9653	4835	6821	20198	8541
72	5721	5733	4559	5617	2974	8053	4521	2707	4714	12083	29128
74	2345	5345	1825	3275	2675	9811	3424	1962	1623	7551	1884
76	2595	2782	1260	1356	2567	5020	2883	1010	1257	979	2114
78	2102	1691	357	297	548	2378	731	399	534	1765	182
80	888	583	155	783	425	1365	201	158	261	264	5525
82	1021	296	109	112	149	107	261	37	8	1004	6097
84	548	204	0	148	295	0	30	59	0	0	863
86	123	0	0	0	0	0	0	0	0	0	0
88	0	61	0	0	149	0	0	0	0	0	1207
90	0	0	0	0	0	0	0	0	0	0	0
92	0	0	0	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	0

Table 3.6.1.37. Sea bass in the Northeast Atlantic. Estimated numbers-at-length for bass landed by French fleets in the Bay of Biscay (Area VIIIa,b): ALL GEARS (nos. fish).

length	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
14	0										
16	0										
18	0										
20	0	0	3701	0	0	0	0	0	0	32	0
22	0	0	0	0	0	0	0	0	0	65	0
24	2607	3938	0	0	15605	0	0	121	4059	211	86
26	1490	9845	0	0	41377	0	4451	121	9966	498	0
28	1117	26299	6573	489	14091	0	12463	5039	27564	997	0
30	1328	20100	4022	3152	0	0	10683	1947	21637	1635	122
32	1927	36855	2091	7704	12406	6334	9977	4584	52403	1509	11539
34	36971	66772	51937	56872	78666	68001	128647	88529	180878	6149	8670
36	132217	131357	156038	127570	191848	181936	222957	208585	493133	85095	30653
38	175715	153333	203862	173895	219241	163829	185502	229949	569012	164667	57576
40	192369	189157	217809	200680	259327	171689	324438	246079	626600	197775	83709
42	259189	202696	165991	204417	277671	214164	248829	274018	597047	188197	141522
44	260424	237227	171741	194807	244906	252334	294239	226908	683140	214175	141111
46	195124	216449	193506	172573	150048	196627	212649	259499	451508	168219	120002
48	120974	169613	258856	161586	176284	172175	170456	180890	519090	132709	91792
50	94864	98353	144094	103003	127766	142780	120985	135173	401111	104553	82183
52	62294	71624	73496	89977	104274	86624	84292	113677	242174	81118	79810
54	42697	31728	66301	62690	64641	75518	42957	78366	195469	62391	61306
56	30817	36551	48017	53854	84266	65610	31826	62947	157435	65351	40885
58	35946	26767	43332	34749	43996	54704	53876	54438	107477	39725	23310
60	30023	14262	17960	36106	52862	38860	47670	48771	107759	27637	16104
62	28458	21905	24871	28677	30310	28186	37826	47227	107734	32109	14735
64	33743	22165	18058	14954	18709	28889	41991	51000	79884	21707	25040
66	13730	9022	15943	15572	20833	19815	10891	13891	38552	18042	10655
68	12664	13246	14549	10858	9747	11730	7295	29818	29649	14300	6467
70	6351	9365	20291	5758	19221	18568	5429	21857	27232	12364	18534
72	11387	11318	18637	4829	10244	13065	5282	7740	31314	7848	14232
74	12544	8480	12729	6220	10358	9064	6152	6104	26920	5342	5477
76	9948	709	1089	1963	3908	2837	3678	2975	13437	2385	1847
78	1260	342	825	856	4247	2300	1824	1435	7776	2782	1663
80	11101	0	265	1746	1357	1965	747	650	12791	1692	6675
82	1405	536	0	547	0	0	303	217	250	477	385
84	610	0	155	447	0	185	84	243	189	162	557
86	219	0	0	0	0	1093	146	0	255	440	0
88	0	301	112	0	0	0	110	0	0	0	1264
90	0	0	0	0	0	0	0	0	0	164	0
92	0	0	0	0	0	0	0	0	0	0	0
94	0	0	0	0	0	0	0	0	0	0	0

Table 3.6.1.38. Sea bass in the Northeast Atlantic. Estimated numbers-at-length for sea bass landed by Spanish bottom-trawl (OTB & PTB) vessels from Areas VIIIabd, sampled by AZTI and IEO (nos. fish).

Length (cm)	2010	2011
34	1548	301
36	2064	8913
38	3887	24 976
40	12 274	21 266
42	16 809	25 287
44	12 673	16 231
46	12 663	28 452
48	4304	11 880
50	8633	13 736
52	3759	11 399
54	2199	13 718
56	4255	10 235
58	771	6456
60	3834	5360
62	1077	5306
64	1264	3236
66	1330	1302
68	1697	2430
70	2492	1141
72	0	1096
74	76	798
76	0	551
78	1246	265
80	39	291
82	0	152
84	35	56
Nos. trips sampled	11	26
No. fish measured	300	931

Table 3.6.1.39. Sea bass in the Northeast Atlantic. International fishery age compositions raised to all fleets in Areas IVbc, VIId, VIIeh, VIIafg (thousands of fish).

Year	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12+
1985	0	413	574	133	224	33	43	187	37	41	78
1986	0	75	446	199	48	132	6	67	237	33	169
1987	0	2	730	667	213	32	107	12	24	163	181
1988	0	3	68	474	428	132	39	52	8	14	149
1989	160	31	18	100	361	236	68	20	34	14	178
1990	0	21	10	33	162	279	199	44	19	12	81
1991	0	149	198	18	14	46	178	173	61	3	154
1992	0	122	474	327	19	19	33	80	101	25	74
1993	0	7	690	447	153	18	10	17	57	58	102
1994	0	6	154	1686	214	81	7	2	18	39	74
1995	0	30	185	393	1597	124	51	6	5	9	113
1996	0	106	398	214	382	1974	149	65	3	9	121
1997	0	47	73	470	316	342	1143	101	41	9	104
1998	0	23	378	343	556	259	210	599	55	13	60
1999	0	1	519	1045	410	316	157	151	412	38	66
2000	0	113	25	933	527	72	64	46	26	76	15
2001	6	199	912	93	548	192	37	82	29	20	59
2002	4	123	410	1822	73	257	126	34	49	17	65
2003	4	211	1584	718	970	60	214	103	46	21	59
2004	0	55	437	2046	628	601	31	90	38	31	68
2005	4	198	1398	1171	1449	302	150	5	64	28	22
2006	4	394	1605	1343	447	331	81	121	12	18	90
2007	4	0	430	2305	1079	391	264	95	97	142	44
2008	4	47	973	2869	1105	436	137	132	52	27	34
2009	0	27	647	1671	2082	653	182	68	49	28	33
2010	0	1	965	1759	1298	836	278	112	45	72	58

Table 3.6.1.40. Sea bass in the Northeast Atlantic. International fishery mean weights-at-age for age compositions raised to all fleets in Areas IVbc, VIId, VIIeh, VIIafg (kg).

Year	Age2	Age3	Age4	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12+
1985	0.106	0.329	0.475	0.652	0.813	0.884	1.160	1.498	1.667	2.160	2.979
1986		0.472	0.581	0.825	0.997	1.142	1.302	1.366	1.785	2.557	2.500
1987		0.322	0.453	0.641	0.933	1.282	1.415	1.877	2.069	2.206	3.324
1988		0.359	0.458	0.592	0.918	1.167	1.516	1.627	1.763	1.859	3.139
1989	0.466	0.527	0.623	0.580	0.772	1.151	1.353	1.554	1.906	1.994	2.766
1990		0.626	0.740	0.786	0.883	1.263	1.559	1.859	1.947	2.223	3.253
1991		0.673	0.655	0.916	0.993	1.237	1.558	1.944	2.121	2.321	3.842
1992		0.586	0.670	0.830	1.128	1.463	1.544	1.738	2.060	2.300	3.763
1993		0.564	0.610	0.745	1.059	1.419	1.755	1.676	2.137	2.485	3.742
1994	0.219	0.491	0.613	0.680	0.974	1.331	1.701	1.695	2.088	2.411	3.574
1995		0.532	0.652	0.769	0.852	1.259	1.587	1.941	2.710	2.552	3.460
1996		0.642	0.649	0.706	0.869	1.083	1.563	2.060	2.031	2.622	3.797
1997		0.646	0.673	0.739	0.881	1.035	1.301	1.761	2.504	2.407	3.633
1998		0.422	0.667	0.769	0.930	1.116	1.343	1.641	2.039	3.060	4.036
1999	0.439	0.357	0.679	0.807	0.979	1.149	1.431	1.739	1.981	2.315	3.771
2000		0.674	0.703	0.744	0.952	1.220	1.456	1.736	2.007	2.319	3.614
2001	0.648	0.625	0.647	0.696	0.888	1.199	1.513	1.735	2.065	2.378	2.799
2002		0.621	0.649	0.691	0.926	1.132	1.547	1.735	2.027	2.124	2.828
2003		0.652	0.699	0.752	0.899	1.133	1.395	1.717	2.028	2.247	3.097
2004		0.704	0.773	0.776	0.936	1.125	1.462	1.668	2.213	2.267	3.221
2005		0.660	0.640	0.795	0.960	1.145	1.338	1.423	2.178	3.047	2.892
2006		0.589	0.683	0.761	0.933	1.060	1.295	1.591	1.963	2.492	3.337
2007		0.587	0.616	0.709	0.882	1.118	1.250	1.511	1.925	2.345	2.995
2008		0.528	0.578	0.647	0.848	1.071	1.276	1.554	1.811	1.898	3.000
2009		0.621	0.620	0.707	0.845	1.101	1.421	1.659	1.846	2.054	2.774
2010		0.748	0.608	0.725	0.867	1.037	1.317	1.683	2.254	2.319	2.927

Table 3.6.2.1. Sea bass in the Northeast Atlantic. Abundance indices from the UK(England) trawl surveys of juvenile bass in the Solent (VIId) in May–July and September (nos. per ten minute tow).

	May–July			September		
Year	age 2	age 3	age 4	age 2	age 3	age 4
1981	0.00	0.30	0.25			
1982	0.51	2.17	0.16	3.25	10.10	0.38
1983				9.87	0.91	1.88
1984	0.95	2.66	0.43	1.38	0.65	0.09
1985	0.00	10.33	2.56			
1986				0.27	4.26	1.31
1987	0.00	0.42	3.18	0.05	0.28	2.27
1988	0.00	0.02	0.47			
1989				6.68	0.37	0.00
1990	2.84	2.48	0.00	2.81	1.15	0.02
1991	5.78	0.62	0.09	3.08	0.21	0.03
1992	0.11	7.04	0.35	0.95	18.59	0.16
1993	0.05	7.33	14.02	6.65	3.59	4.39
1994	0.04	1.63	1.14	3.33	1.84	0.29
1995	0.05	1.57	0.97	4.83	4.69	0.72
1996	1.43	4.09	3.36	5.52	0.43	0.11
1997	0.27	1.94	0.11	33.62	4.52	0.06
1998	0.00	6.75	5.79	1.22	5.50	0.61
1999	0.61	0.95	12.30	19.37	0.67	0.87
2000	0.49	37.03	1.06	9.06	16.94	0.16
2001	1.71	6.33	3.43	34.42	3.92	1.57
2002	0.63	1.62	0.29	7.42	3.87	0.40
2003	0.06	0.32	0.38	8.37	4.60	0.59
2004	0.17	0.28	0.16			
2005	0.05	0.42	0.35	13.12	7.98	0.84
2006	0.44	2.47	1.03	9.51	9.21	1.02
2007	0.33	0.50	0.50	3.42	1.78	0.30
2008				18.52	6.66	0.34
2009	0.72	1.03	0.13	13.25	6.25	0.33
2010						
2011				2.25	1.39	0.42

Table 3.6.2.2. Sea bass in the Northeast Atlantic. Abundance indices from the UK(England) trawl surveys of juvenile sea bass in the Thames Estuary (IVc) in November (nos. per ten minute tow).

YEAR	AGE 0	AGE 1	AGE 2	AGE 3
1997	7.737	0	0.048	0.41
1998				
1999	19.54	6.033	0.764	0
2000	4.015	14.74	0.832	0.089
2001	121.5	11.47	5.108	0.171
2002	469	20.71	2.716	1.093
2003	225.6	35.76	4.429	0.159
2004	238.92	44.99	7.32	1.03
2005	37.04	14.49	6.86	0.75
2006	245.54	11.26	3.46	0.94
2007				
2008	107.55	50.69	1.86	0.2
2009	95.43	7.79	13.59	0.91

Table 3.6.2.3. Sea bass in the Northeast Atlantic. Time-series of lpue for UK otter trawl and beam trawl gears (10 m+ LOA vessels) and French otter trawlers. Units: kg per day. UK data are for ICES rectangles where >95% of the sea bass landings have been recorded since 1985.

Year	FR OTB IVbc&VIId	UK OTB >10 m IVbc & VIId	UKOTB >10 m VIIe	UK OTB >10 m VIIafg	FR trawl VIIeh	UK BT VIId	UK BT VIIeh	UK BT VIIafg
1985		11.67	4.80	8.26		1.30	2.46	1.34
1986		16.32	5.26	3.99		2.59	2.25	0.92
1987		17.76	4.05	4.25		1.19	1.96	1.63
1988		21.23	3.30	9.01		7.92	1.79	1.22
1989		9.65	3.71	5.92		2.39	2.35	2.09
1990		11.58	7.98	4.38		3.79	5.81	3.25
1991		10.37	3.32	7.70		2.74	3.26	2.10
1992		20.79	6.91	5.61		4.59	2.41	1.35
1993		26.95	8.37	9.64		7.02	2.42	3.15
1994		27.52	9.79	8.67		3.28	1.79	1.86
1995		25.73	11.47	20.38		3.50	2.81	3.82
1996		26.23	8.34	15.10		4.07	4.10	2.60
1997		27.29	13.70	20.01		3.76	2.34	3.59
1998		28.18	8.73	17.10		5.90	4.35	3.76
1999		40.95	8.06	16.15		6.46	3.77	3.46
2000	49.07	19.31	11.94	14.16	14.28	2.84	2.62	7.30
2001	55.17	29.21	9.33	21.87	9.78	1.73	2.93	3.69
2002	79.99	29.23	10.86	36.51	8.93	1.99	4.81	5.40
2003	67.77	38.53	12.73	37.94	7.50	1.70	3.57	4.11
2004	67.36	38.56	9.74	49.18	14.21	1.63	5.37	3.00
2005	81.36	38.61	10.68	47.74	14.23	3.19	3.20	3.35
2006	74.05	48.21	12.71	31.50	11.81	2.02	2.10	3.37
2007	88.97	33.15	17.57	47.62	15.94	3.72	3.77	3.65
2008	88.39	45.19	13.78	50.97	11.58	5.61	3.23	8.99
2009	68.37	47.33	10.93	45.07	9.36	2.13	2.34	3.57
2010	66.70	29.31	7.60	27.69	7.00	1.40	1.21	2.90
2011	N/A	32.68	7.47	27.37	N/A	1.48	1.25	4.66

Table 3.6.3.1. Number of sea bass sampled by Cefas for maturity by ICES Division from 1985 onwards.

	ICES Division					
	IVb	IVc	VIIa	VIId	VIIe	VIIf
Males	102	20	1	135	374	67
Females	181	73	28	443	760	227

Table 3.6.3.2. Number of male sea bass sampled by Cefas for maturity by year and month.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1982						9			13				22
1983	20				16	32	22	14	13	17	8	1	143
1984	20	1	26	18	12	7	24		35	7	1	4	155
1985	37	3	15		37	23	12	10	3	22	9	13	184
1986		3	3	19		5	14		13			3	60
1987									8		4		12
1988					9	1	2	1	20	9	2		44
1989		1											1
1990	2	3	5	4		10	6	1	15	2	3	72	123
1991			1	1	56	17	4	2	1		5		87
1992			9		5	6		2	2		1		25
1993						2	2	2				11	17
1994			10										10
1998					1	2	2	3			3		11
1999	14	8	21										43
2003			1	4	2								7
2009				234				143					377
Total	93	19	91	280	138	114	88	178	123	57	36	104	1321

Table 3.6.3.3. Number of female sea bass sampled for maturity by year and month.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1982						5			19				24
1983	27				35	28	39	31	16	17	13	1	207
1984	19	5	22	16	29	8	24		36	13	11	17	200
1985	18	1	1	4	15	31	10	15	7	26	14	8	150
1986	2	12		8	7	6	20	3	26	2		7	93
1987									8		7		15
1988					12	1	2	1	8	8	3		35
1989		5											5
1990	3	5		2	1	20	12	4	26	2	11	75	161
1991					40	14	14	9	14		9	1	101
1992			6		11	11	5	3		3	1		40
1993				5	2	2	1	3	2	4		7	26
1994			4		2								6
1996				1									1
1998					2	5	5	4			3		19
1999	29	13	23			2		1		1	1		70
2003			11	7	10								28
2009				364				414					778
Total	98	41	67	407	166	133	132	488	162	76	73	116	1959

Table 3.6.4.2. Stock synthesis 3 model settings for baseline model runs 1a and 1b.

Characteristic	Settings
Starting year	1985
Ending year	2010
Equilibrium catch for starting year	Mean landings by fleet: 1980–1984
Number of areas	1
Number of seasons	1
Number of fishing fleets	6
Number of surveys (recruit surveys)	3 surveys, modelled as 10 single-age fleets at ages 0–4
Individual growth	Von Bertalanffy, parameters fixed, combined sex
Number of estimated parameters	48
Population characteristics	
Maximum age	30
Genders	1
Population length bins	4–100, 2 cm bins
Ages for summary total biomass	0–12+
Data characteristics	
Data length bins (for length structured fleets)	14–94, 2 cm bins
Data age bins (for age structured fleets)	0–12+
Minimum age for growth model	0 [age 2 for age–length model]
Maximum age for growth model	30
Maturity	Logistic 2-parameter – females; L50 = 40.65 cm
Fishery characteristics	
Fishery timing	-1
Fishing mortality method	Hybrid
Maximum F	2.9
Fleet 1: UK Trawl selectivity	Asymptotic
Fleet 2: UK Midwater trawl selectivity	Asymptotic
Fleet 3: UK Nets selectivity	Asymptotic (dome shaped forsensitivity run)
Fleet 4: UK Lines selectivity	Asymptotic
Fleet 5: Combined French fleet selectivity	Asymptotic
Survey characteristics	
Solent spring survey timing	0.42
Solent autumn survey timing	0.83
Thames survey timing	0.75
Catchabilities (all surveys)	Analytical solution
Survey selectivities	[all survey data entered as single ages; sel = 1]
Fixed biological characteristics	
Natural mortality	0.2
Beverton–Holt steepness	0.999
Recruitment variability (σR)	0.9
Weight–length coefficient	0.00001296
Weight–length exponent	2.969
Maturity inflection (L50%)	40.649

Characteristic	Settings
Maturity slope	-0.33349
Length-at-age Amin	5.78 cm
Length at Amax	80.26 cm
Von Bertalanffy k	0.09699
Von Bertalanffy Linf	84.55
Von Bertalanffy t0	-0.730
Std. Deviation length-at-age	SD = 0.1166 * age + 3.5609

Table 3.6.4.3. Sensitivity analysis likelihoods.

Likelihood	Run 1A	Run 1B	Run 2	Run 3a	Run 3b	Run 4	Run 5	Run 6
	Base run with length only compositions	Base run with age and length compositions	StErr increase to 0.3 for initital equilibrium log catch	Intitial equilibrium catch as the average of 1975-84	Increase landings time-series to 1975	excl sprSolent all ages	excl Thames all ages	excl sprSolent all ages and Thames all ages
TOTAL	***1385***	***379***	***1350***	***1409***	***1336***	***1276***	***1307***	***1202***
Catch	1.26E-07	1.25E-07	1.39E-08	1.28E-07	1.49E-07	1.25E-07	1.27E-07	1.26E-07
Equil_catch	1.83E+01	1.82E-01	7.4	19.9	0.2	15.2	9.4	8.1
Survey	203.2	207.4	197.6	208.1	196.3	99.6	137.9	39.5
Discards								
Length_comp	1121.8	61.9	1118.0	1130.6	1111.3	1116.3	1117.5	1111.2
Age_comp		384.1						
Size_at_age		-296.1						
Recruitment	41.4	21.4	27.3	50.3	27.8	45.0	42.5	43.2
Forecast_Recruitment	0	0.0	0	0	0	0	0	0
Parm_priors	0.0356543	0.00531676	0.0356498	0.0357699	0.0354691	0.0355724	0.0355624	0.0354639
Parm_softbounds	0.00500012	0.00515291	0.00499747	0.00501699	0.00497034	0.00498597	0.00499158	0.00497537
Number of parameters	48	48	48	48	58	48	48	48
SSB	5420	7888	7792	4837	8577	6332	4839	5540

Likelihood	Run 7	Run 8	Run 9	Run 10	Run 11	Run 12	Run 13
	Excl all surveys	Inclusion of Commercial LPUE	Inclusion of discards	Dome shape selectivity on UK net fleet predicted by model	Natural mortality increase to 0.25	Gislason natural mortality by age	Length @ max age predicted by model
TOTAL	***1087.18***	***1754.3***	***1994.96***	***1249.91***	***1354.36***	***1364***	***1373***
Catch	1.25E-07	1.25E-07	1.26E-07	1.26E-07	1.25E-07	1.26E-07	1.25E-07
Equil_catch	1.38639	33.9983	21.9899	9.92718	3.20186	32.6	4.5
Survey		539.918	221.803	199.485	200.236	204.8	197.3
Discards			-0.316503				
Length_comp	1054.44	1135.17	1706.05	1002.05	1115.62	1086.0	1132.0
Age_comp							
Size_at_age							
Recruitment	31.3203	45.1747	45.4017	38.3124	35.2582	40.2	38.9
Forecast_Recruitment	0	0	0	0	0	0	0
Parm_priors	0.0351926	0.0356539	0.0262242	0.127733	0.0356958	0.0360829	0.0358317
Parm_softbounds	0.00492382	0.00500652	0.00762757	0.00583724	0.00499307	0.0050084	0.00502877
Number of parameters	48	48	52	52	48	48	49
SSB	11409.1	8415.26	4918.24	6502	6948	5402	6451

Annex 1: Stock annexes

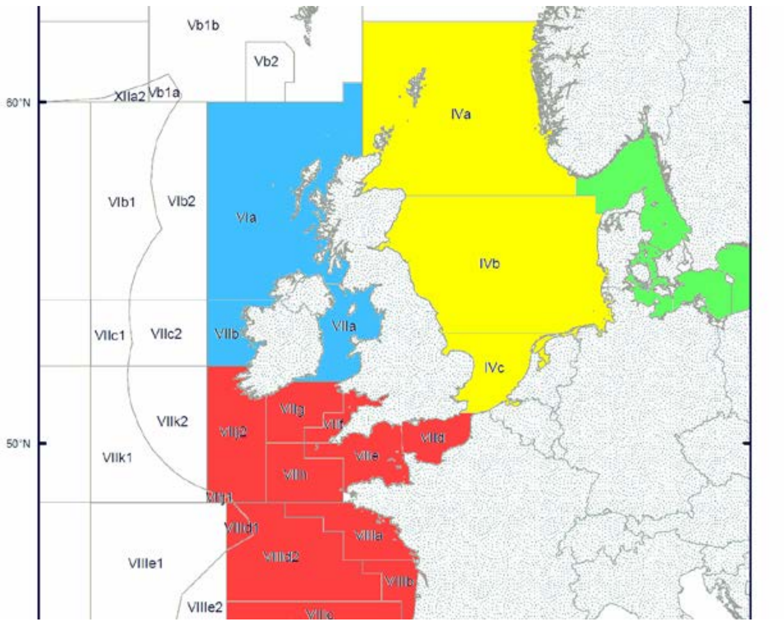
Turbot in ICES Subarea IV (North Sea)

Stock	Turbot in ICES Subarea IV (North Sea)
Working Group	WGNSSK
Date	November 2012
Revised by	IBPNew/Jan Jaap Poos.

A. General

A.1. Stock definition

Genetic studies within restricted geographical areas had illustrated the presence of distinct turbot populations in the Baltic and Irish Seas using neutral markers (e.g. Delbare and Declerck, 1999; Nielsen, 2004). Over the period 2009–2012, a genetic study of turbot population structure all over the species' distribution area has been conducted using both neutral and gene-associated genetic markers by Vandamme *et al.* (in prep). The neutral marker panel confirmed the break-up between the Baltic and Northeast Atlantic clusters. Within the latter, a more detailed pattern of genetic differentiation could be observed when gene-associated markers were also included in the analysis; results soon to be consulted on https://fishreg.jrc.ec.europa.eu/web/**fisheries-genetics**). This full analysis suggests a break between the southern and central parts of the North Sea, making turbot from the southern North Sea genetically more similar to those from the Western Waters. However, because it is unknown whether there are also differences in life history within the North Sea, and information on the number and location of spawning aggregations is missing, the break between IVc and VIId is insufficiently supported to be recommended for management purposes. Additionally, it is logistically difficult to split the North Sea into several management and assessment units. The proposed stock structure is represented in the figure below.



Stock structure of turbot in the Northeast Atlantic as proposed by IBP New 2012.

A.2. Fishery

In the 1950s the UK was the biggest contributor to the landings, with almost 50% of the landings coming from this country. In that early period, the landings fluctuated around 6000 tons per year. Currently, the landings are around 2700 tons per year. Most of the landings stem from the Netherlands that contributes between 50 and 60%. Within the Netherlands most of the landings come from the 80 mm beam trawl fleet fishing for flatfish species sole and plaice. Also in most other countries turbot is caught in mixed fisheries trawls. The second largest contributor to the landings in the last decade is Denmark. In Denmark there is a directed fishery for turbot using gill-nets.

Within the Netherlands, most of the landings come from the Southern Bight and the German Bight. In Belgium, turbot is mainly caught in mid-class (301–900 Hp) and large (>900 Hp) beam trawlers. These vessels are mostly flatfish directed (particularly towards plaice and sole, together with the associated bycatch species such as turbot, brill, dab, lemon sole, anglerfish and some roundfish. In Denmark turbot is taken only as bycatch in Danish fisheries. In the North Sea, where most of the Danish landings of turbot are taken, the gillnet fishery accounts for almost half of the landings.

Little information is known about discarding in the different fisheries catching turbot. The only available information comes from the Dutch beam trawl fleet in the period 2002–2007. It indicates very low estimates of discarding. No information is available for the period 1975–2002. In at least part of that period an EU-wide minimum landings size (MLS) of 30 cm was enforced. However, this minimum landings size was abandoned and member states have their own MLS rules and regulations. For example, Belgium now has a MLS of 30 cm, while in the Netherlands a minimum size of 25 cm exists, set by the producer organizations. Hence, despite the indications of low discarding in the Dutch fleets in the last decade, more MLS discarding may occur in other fleets, or have occurred in other periods.

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001; EC Council Regulation No 51/2006; e.g. N°40/2008, annex II_a). For example, for 2007, Council Regulation (EC) No 41/2007 allocated different days at sea depending on gear, mesh size, and catch composition: Beam Trawls could fish between 123 and 143 days per year. Trawls or Danish seines could fish between 103 and 280 days per year. Gillnets could allowed to fish between 140 and 162 days per year. Trammelnets could fish between 140 and 205 days per year.

Several technical measures are applicable to the flatfish fishery in the North Sea: mesh size regulations, minimum landing size, gear restrictions and a closed area (the plaice box).

Mesh size regulations for towed trawl gears require that vessels fishing North of 55 N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the plaice fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100 mm is required. In addition to this, since 2002 a small part of North Sea plaice fishery is affected by the additional cod recovery plan (EU regulation 2056/2001) that prohibits trawl fisheries with a mesh size <120 mm in the area to the north of 56°N.

The maximum aggregated beam length of beam trawlers is 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9 m. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation.

B. Data

B.1. Commercial catch

The landings of turbot are available through the EuroStat database. This database holds the officially recorded landings for all countries landing turbot in the North Sea. There are no records for the Dutch landings in the EuroStat database between 1984 and 1987. However, for the North Sea these missing landings have been estimated in a Dutch/Belgian research project, and have been used to fill in the gaps (Boon and Delbare, 2000). In the 1950s the UK was the biggest contributor to the landings, with almost 50% of the landings coming from this country. In that early period, the landings fluctuated around 6000 tons per year. Currently, the landings are around 2700 tons per year. Most of the landings stem from the Netherlands that contributes between 50 and 60%. Within the Netherlands most of the landings come from the 80 mm beam trawl fleet fishing for flatfish species sole and plaice. Also in most other countries turbot is caught in mixed fisheries trawls. The second largest contributor to the landings in the last decade is Denmark. In Denmark there is a directed fishery for turbot using gillnets.

There is no long-term continuous programme for age sampling of landings in any of the countries. Therefore, the age structure of the landings is estimated using data from different sources in different time periods. Starting in 1975, there is a four year time period for which the age structure of the landings have been estimated by Weber (1979). The age structure is estimated from market samples taken in Cuxhaven and Hamburg and research vessel surveys. Most of the samples represent landings in the Eastern part of IVb. The structure is based on a total of 9360 length and 6389 weight measurements combined with 6788 age samples. Samples are combined with the quarterly landings for England, the Netherlands and Germany and subsequently with the overall landings on an annual basis. The second dataset spans the period 1981–1990, is derived from landings in the Netherlands and available in the "Databras" project report (Boon and Delbare, 2000). A stratified sampling scheme was used to collect the samples, using quarters, auctions, and market categories as stratification levels. Between 398 and 862 age samples were taken annually for age-determination of fish. Most of the samples represent Area IVb and IVc. The Dutch data are subsequently raised to the total international landings. The third dataset spans the period 2000–2002. It was supplied by Cefas and based on the UK landings of turbot. These were raised on an annual basis to the total landings. The fourth and final dataset stems again from the Netherlands. It spans the years 1998 and 2004–2011. The age structure is estimated from stratified sampling accounting for auctions, quarters and market categories. These are raised to total Dutch landings by quarter. Between 494 and 1921 age samples were taken per year. The total Dutch landings are subsequently raised to the total international landings per year.

Little information is known about discarding in the different fisheries catching turbot. The only available information comes from the Dutch beam trawl fleet in the period 2002–2007. It indicates very low estimates of discarding. No information is available for the period 1975–2002. In at least part of that period an EU-wide minimum landings size (MLS) of 30 cm was enforced. However, this minimum landings size was abandoned and member states have their own MLS rules and regulations. For example, Belgium now has a MLS of 30 cm, while in the Netherlands a minimum size of 25 cm exists, set by the producer organizations. Hence, despite the indications of low discarding in the Dutch fleets in the last decade, more MLS discarding may occur in other fleets, or have occurred in other periods. Because of the indications of low discarding, the landings-at-age are assumed fully representative of the catch-at-age. The resulting catch-at-age matrix has two important characteristics. First, there appear to be some strong cohorts in the data and second, there is an apparent increase in the relative amount of two-year old fish being caught in the last decade. This shift is likely the result of the change in MLS regulations described above, while the recent data come from the Dutch landings only. This fleet has seen a decrease in MLS in the early 2000s. An alternative explanation for the apparent increase in two-year old being caught could be an error in the age-reading. However, no upward shift in the weight of fish at ages 2 and 3 was observed that would result from such an age-reading error.

B.2. Biological

Weight-at-age

Weight-at-age data in the catch for this stock are available for most but not all of the years during which there is age sampling of the landings (Figure 1.6.15). Data are available for the period 1981–1990 from the DATUBRAS database (Boon and Delbare, 2000), and then again for the years 1998, and 2004 to present from Dutch market sampling. Stock weights are estimated as the catch weights in Q2, coinciding with peak spawning of the stock. Hence stock weights estimates are available for the same time period, but excluding the years 2005 and 2006 where no samples were available in the second quarter. In addition to this average weights-at-age for the stock during the period 1976–1979 are available from Weber (1979). For both the catch and stock weights, estimated values for ages 6 and greater tend to show large interannual fluctuations, due to the limited number of fish sampled at these ages. The vast majority of landings are for ages 4 and younger and this is reflected in the number of samples for these ages.

With no data except a single year available in the 1990s (1998) to infer the trend in weight-at-age over the period 1991 to 2003, the group decided to use a constant annual weight-at-age vector over the entire period as input to the stock assessment models. This was determined as the mean weight-at-age using all data available over the whole period.

Future work on the use of catch and stock weight is recommended. First, the trends of individual weights in time can be described using a statistical model. Such a model could either describe the trends in time as a function of age only, or describe the growth in a cohort, estimating smooth trends in the parameters describing the growth of each cohort. Second, the variability of weight-at-age that is now removed from the assessment (by taking means of weights by age over the entire study period) could be added to the assessment results, by using the residual variance of the estimates of the means. This information about the variance could be used in combination with the MCMC estimates from the assessment to describe the combined effect of uncertainty in estimated numbers and the uncertainty in estimated weights.

B.3. Surveys

Two survey-series catching turbot are available. The Beam Trawl Survey (BTS ISIS), and the Sole Net Survey (SNS). The BTS index uses a beam trawl to catch demersal species. The index is based on the catch in one of the two nets. The BTS-ISIS index is based on catches between 52 and 239 individuals per year. The number of individuals used to generate an age–length key can be larger than the number of individuals used for the index, because the index is based on only the catch in one of the two nets, while age samples can be taken from both nets.

The procedure to create an age structured index series from the BTS-ISIS was updated prior to the working group. Previously, the each individual fish caught was linked to an age–length key based on its length. The age–length key was based on all age samples in the BTS survey since 1991. The updated procedure first links the individual fish from which otoliths are taken to the length sample. This allows direct ageing of the fish in the cpue. Those fish for which no direct age sample is available are then assigned to ages using the age–length key based on all fish in the period 1991–2011.

B.4. Commercial cpue

In addition to the survey based indices, there is also an index based on the Dutch 80 mm beam trawl fleet lpue. The potential bias in this lpue series as an indicator for stock abundances because of spatial targeting of the fleet has been addressed in Hammen *et al.*, 2011. There, a procedure was developed to obtain an age-structured index from the lpue, while trying to remove the spatial aspects of targeting. The resulting index series shows an increase of older ages over time, and a fairly good cohort structure.

C. Assessment: data and method

Model used: An age-structured assessment model in ADMB using spline smoothers. The .tpl file for the assessment is

Software used:

```
// ADMB code for simple catch-at-age model with CAA matrix and three indices
// Turbot assessment

DATA_SECTION
 init_int   nyrs
 init_int   nages
 init_int   minFbar
 init_int   maxFbar
 init_int   F_time_knots
 init_matrix obs_catch_at_age(1,nyrs,1,nages)
 init_matrix catch_weights(1,nyrs,1,nages)
 init_matrix stock_weights(1,nyrs,1,nages)
 init_int   nyrs_surv1
 init_int   nages_surv1
 init_number time_surv1
 init_matrix obs_surv1(1,nyrs_surv1,1,nages_surv1)
 init_int   nyrs_surv2
 init_int   nages_surv2
 init_number time_surv2
 init_matrix obs_surv2(1,nyrs_surv2,1,nages_surv2)
 init_int   nyrs_surv3
 init_int   nages_surv3
 init_number time_surv3
 init_matrix obs_surv3(1,nyrs_surv3,1,nages_surv3)
 init_number M
```

```
  init_vector maturity(1,nages)
  init_matrix bs1(1,4,1,7)
  init_matrix bs2(1,F_time_knots,1,nyrs)
  vector Fvec(1,11806)

PARAMETER_SECTION
  init_number logsigmaC(1)
  init_number logsigmaU1(1)
  init_number logsigmaU2(1)
  init_number logsigmaU3(1)
  init_vector sigma_offset(2,nages,1)
  init_vector log_sel_coff1(1,4,1)
  init_vector log_sel_coff2(1,4,1)
  init_vector log_sel_cofU1(1,4,1)
  init_vector log_sel_cofU2(1,4,1)
  init_vector log_sel_cofU3(1,4,1)
  init_vector log_temp_coff(1,F_time_knots,2)
  init_vector log_initpop(1,nyrs+nages-1,1)
  vector sigmaC(1,nages)
  vector sigmaU1(1,nages_surv1)
  vector sigmaU2(1,nages_surv2)
  vector sigmaU3(1,nages_surv3)
  vector effort_devs(1,nyrs)
  vector log_self1(1,nages)
  vector log_self2(1,nages)
  vector log_selU1(1,nages_surv1)
  vector log_selU2(1,nages_surv2)
  vector log_selU3(1,nages_surv3)
  vector TSB(1,nyrs)
  sdreport_vector SSB(1,nyrs)
  vector VB(1,nyrs)
  matrix F(1,nyrs,1,nages)
  matrix S(1,nyrs,1,nages)
  matrix N(1,nyrs,1,nages)
  matrix U1(1,nyrs_surv1,1,nages_surv1)
  matrix U2(1,nyrs_surv2,1,nages_surv2)
  matrix U3(1,nyrs_surv3,1,nages_surv3)
  matrix C(1,nyrs,1,nages)
  number f_c
  number f_s1
  number f_s2
  number f_s3
  sdreport_vector Fbar(1,nyrs)
  number Fmax
  number YPRmax
  number TAC
  objective_function_value f

PRELIMINARY_CALCS_SECTION
  // Add small constants (half of minimum) to observations, so log(0) doesn't explode
  obs_catch_at_age = obs_catch_at_age + 0.35;
  obs_surv1 = obs_surv1 + 0.0005;
  obs_surv3 = obs_surv3 + 0.015;
  // Create a sequence of Fbar values to evaluate YPR, in order to calculate Fmax:
  // Fvec <- c(0,10^-(9:5),seq(0.0001,1,0.0001),seq(1.001,2,0.001),seq(2.01,10,0.01))
  Fvec(1) = 0;
  Fvec(2) = 1e-9;
  for (int i=3; i<=7; i++)        Fvec(i) = Fvec(i-1) * 10;
  for (int i=8; i<=10006; i++)    Fvec(i) = Fvec(i-1) + 0.0001;
  for (int i=10007; i<=11006; i++) Fvec(i) = Fvec(i-1) + 0.001;
  for (int i=11007; i<=11806; i++) Fvec(i) = Fvec(i-1) + 0.01;

PROCEDURE_SECTION
  get_sigmas();
```

```
  get_mortality_and_survival_rates();
  get_numbers_at_age();
  get_catch_at_age();
  get_surv1_at_age();
  get_surv2_at_age();
  get_surv3_at_age();
  calculate_biomass();
  evaluate_the_objective_function();
  if (mceval_phase())
  {
    get_fmax();
    write_mcmc();
  }

REPORT_SECTION
  report << "Likelihoods" << endl;
  report << "f, f_c, f_s1, f_s2, f_s3" << endl;
  report << f << endl;
  report << f_c << endl;
  report << f_s1 << endl;
  report << f_s2 << endl;
  report << f_s3 << endl << endl;
  report << "Sigma parameters" << endl;
  report << "logsigmaC, logsigmaU1, logsigmaU2, logsigmaU3, sigma_offset" << endl;
  report << logsigmaC << " " << logsigmaU1 << " " << logsigmaU2 << " " << logsigmaU3 << endl;
  report << sigma_offset << endl << endl;
  report << "Selectivity spline coefficients" << endl;
  report << "log_sel_coff1, log_sel_coff2, log_sel_cofU1, log_sel_cofU2, log_sel_cofU3" << endl;
  report << log_sel_coff1 << endl;
  report << log_sel_coff2 << endl;
  report << log_sel_cofU1 << endl;
  report << log_sel_cofU2 << endl;
  report << log_sel_cofU3 << endl << endl;
  report << "Annual F spline coefficients" << endl;
  report << "log_temp_coff" << endl;
  report << log_temp_coff << endl << endl;
  report << "Sigmas" << endl;
  report << "sigmaC, sigmaU1, sigmaU2, sigmaU3" << endl;
  report << sigmaC << endl;
  report << sigmaU1 << endl;
  report << sigmaU2 << endl;
  report << sigmaU3 << endl << endl;
  report << "CAA Selectivities" << endl;
  report << "log_self1, log_self2" << endl;
  report << log_self1 << endl;
  report << log_self2 << endl << endl;
  report << "U Selectivities" << endl;
  report << "log_selU1, log_selU2, log_selU3" << endl;
  report << log_selU1 << endl;
  report << log_selU2 << endl;
  report << log_selU3 << endl << endl;
  report << "Annual F multiplier" << endl;
  report << "effort_devs" << endl;
  report << effort_devs << endl << endl;
  report << "Initial population" << endl;
  report << "recruitment, firstyear" << endl;
  report << exp(log_initpop(1,nyrs)) << endl;
  report << exp(log_initpop(nyrs+1,nyrs+nages-1)) << endl;
  report << endl;
  report << "Observed numbers in catch" << endl;
  report << "obs_catch_at_age" << endl;
  report << obs_catch_at_age << endl;
  report << "Estimated numbers in catch" << endl;
  report << "C" << endl;
```

```
 report << C << endl << endl;
 report << "Observed survey1" << endl;
 report << "obs_surv1" << endl;
 report << obs_surv1 << endl;
 report << "Estimated survey1" << endl;
 report << "U1" << endl;
 report << U1 << endl << endl;
 report << "Observed survey2" << endl;
 report << "obs_surv2" << endl;
 report << obs_surv2 << endl;
 report << "Estimated survey2" << endl;
 report << "U2" << endl;
 report << U2 << endl << endl;
 report << "Observed survey3" << endl;
 report << "obs_surv3" << endl;
 report << obs_surv3 << endl;
 report << "Estimated survey3" << endl;
 report << "U3" << endl;
 report << U3 << endl << endl;
 report << "Estimated numbers of fish" << endl;
 report << "N" << endl;
 report << N << endl << endl;
 report << "Estimated fishing mortality" << endl;
 report << "F" << endl;
 report << F << endl << endl;
 report << "Estimated Fbar" << endl;
 report << "Fbar(" << minFbar << "-" << maxFbar << ")" << endl;
 report << Fbar << endl << endl;
 report << "Estimated SSB" << endl;
 report << "SSB" << endl;
 report << SSB << endl << endl;
 report << "Estimated TSB" << endl;
 report << "TSB" << endl;
 report << TSB << endl << endl;
 report << "Maturity" << endl;
 report << "maturity" << endl;
 report << maturity << endl << endl;
 report << "Catch weights" << endl;
 report << "catch_weights" << endl;
 report << catch_weights << endl << endl;
 report << "Stock weights" << endl;
 report << "stock_weights" << endl;
 report << stock_weights << endl << endl;
 report << "Natural mortality" << endl;
 report << "M" << endl;
 report << M << endl;

FUNCTION dvariable dnorm(const dvariable& x, const dvariable& mu, const dvariable& sd)
 return 0.5 * (log(2*M_PI*sd*sd) + square(x-mu)/(sd*sd));

FUNCTION get_sigmas
 sigmaC(1) = mfexp(logsigmaC);
 for (int a=2; a<=nages; a++)
  sigmaC(a) = mfexp(logsigmaC + sigma_offset(a));
 sigmaU1(1) = mfexp(logsigmaU1);
 for (int a=2; a<=nages_surv1; a++)
  sigmaU1(a) = mfexp(logsigmaU1 + sigma_offset(a));
 sigmaU2(1) = mfexp(logsigmaU2);
 for (int a=2; a<=nages_surv2; a++)
  sigmaU2(a) = mfexp(logsigmaU2 + sigma_offset(a));
 sigmaU3(1) = mfexp(logsigmaU3);
 for (int a=2; a<=nages_surv3; a++)
  sigmaU3(a) = mfexp(logsigmaU3 + sigma_offset(a));
```

```
FUNCTION get_mortality_and_survival_rates
  // Calculate selectivity from sel_coffs, where selectivity is same for last two ages
  log_self1(1,7) = elem_div(exp(log_sel_coff1*bs1), 1+exp(log_sel_coff1*bs1));
  log_self1(8) = log_self1(7);
  log_self1(9) = log_self1(7);
  log_self2(1,7) = elem_div(exp(log_sel_coff2*bs1), 1+exp(log_sel_coff2*bs1));
  log_self2(8) = log_self2(7);
  log_self2(9) = log_self2(7);
  effort_devs = exp(log_temp_coff * bs2);

  // F = outer_prod(effort_devs,log_self);
  for (int t=1; t<=28; t++)
    for (int a=1; a<=nages; a++)
      F(t,a) = effort_devs(t) * log_self1(a);
  for (int t=29; t<=nyrs; t++)
    for (int a=1; a<=nages; a++)
      F(t,a) = effort_devs(t) * log_self2(a);
  for (int t=1; t<=nyrs; t++)
    Fbar(t) = mean(row(F,t)(minFbar,maxFbar));
  S = mfexp(-(F+M));

FUNCTION get_numbers_at_age
  for (int t=1; t<=nyrs; t++)
    N(t,1) = mfexp(log_initpop(t));
  for (int a=2; a<=nages; a++)
    N(1,a) = mfexp(log_initpop(nyrs+a-1));
  for (int t=1; t<nyrs; t++)
    for (int a=1; a<nages; a++)
      N(t+1,a+1) = N(t,a) * S(t,a);

FUNCTION get_catch_at_age
  C = elem_prod(elem_div(F,(F+M)), elem_prod(1-S,N));

FUNCTION get_surv1_at_age
  log_selU1 =  elem_div(exp(log_sel_cofU1*bs1), 1+exp(log_sel_cofU1*bs1));
  int offset = nyrs - nyrs_surv1;
  for (int t=1; t<=nyrs_surv1; t++)
    for (int a=1; a<=nages_surv1; a++)
      U1(t,a) = log_selU1(a) * N(offset+t,a) * mfexp(-time_surv1*(F(offset+t,a)+M));

FUNCTION get_surv2_at_age
  log_selU2 =  elem_div(exp(log_sel_cofU2*bs1), 1+exp(log_sel_cofU2*bs1));
  int offset = nyrs - nyrs_surv2;
  for (int t=1; t<=nyrs_surv2; t++)
    for (int a=1; a<=nages_surv2; a++)
      U2(t,a) = log_selU2(a) * N(offset+t,a) * mfexp(-time_surv2*(F(offset+t,a)+M));

FUNCTION get_surv3_at_age
  log_selU3(1,7) = elem_div(exp(log_sel_cofU3*bs1), 1+exp(log_sel_cofU3*bs1));
  log_selU3(8) = log_selU3(7);
  log_selU3(9) = log_selU3(7);
  int offset = nyrs - nyrs_surv3;
  for (int t=1; t<=nyrs_surv3; t++)
    for (int a=1; a<=nages_surv3; a++)
      U3(t,a) = log_selU3(a) * N(offset+t,a) * mfexp(-time_surv3*(F(offset+t,a)+M));

FUNCTION  calculate_biomass
  SSB = maturity * trans(elem_prod(N, stock_weights));
  TSB = rowsum(elem_prod(N, stock_weights));
  for (int t=1; t<=28; t++)
    VB(t) = log_self1 * elem_prod(N(t), catch_weights(t));  // biomass vulnerable to fleet1
  for (int t=29; t<=nyrs; t++)
    VB(t) = log_self2 * elem_prod(N(t), catch_weights(t));  // biomass vulnerable to fleet2
```

```
FUNCTION evaluate_the_objective_function
 f_c = 0.0;
 f_s1 = 0.0;
 f_s2 = 0.0;
 f_s3 = 0.0;
 // Commercial catch-at-age
 for (int t=1; t<=4; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=7; t<=16; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=24; t<=24; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=26; t<=28; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=30; t<=nyrs; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 // Survey 1
 for (int t=1; t<=nyrs_surv1; t++)
  for (int a=1; a<=nages_surv1; a++)
   f_s1 += dnorm(log(U1(t,a)), log(obs_surv1(t,a)), sigmaU1(a));
 // Survey 2
 for (int t=1; t<=28; t++)
  for (int a=1; a<=nages_surv2; a++)
   f_s2 += dnorm(log(U2(t,a)), log(obs_surv2(t,a)), sigmaU2(a));
 for (int t=30; t<=nyrs_surv2; t++)
  for (int a=1; a<=nages_surv2; a++)
   f_s2 += dnorm(log(U2(t,a)), log(obs_surv2(t,a)), sigmaU2(a));
 // Survey 3
 for (int t=1; t<=nyrs_surv3; t++)
  for (int a=1; a<=nages_surv3; a++)
   f_s3 += dnorm(log(U3(t,a)), log(obs_surv3(t,a)), sigmaU3(a));
 // Add all components
 f = f_c + f_s1 + f_s2 + f_s3;

FUNCTION get_fmax
 int i = 0;                    // element in Fvec being evaluated
 bool found = false;           // whether Fmax is found
 dvector sel = value(log_self2);     // selectivity to use, not necessarily between 0 and 1
 dvector f(1,nages);           // F at age when Fvec(i) is applied
 dvector z(1,nages);           // Z = F+M
 dvector n(1,nages);           // equilibrium population
 dvector c(1,nages);           // equilibrium catches
 dvector w = row(catch_weights,nyrs);  // catch weights to use
 double ypr = -1;              // highest YPR found so far
 double proposal;              // YPR being evaluated
 n(1) = 1;
 while (!found)
 {
  i++;
  f = Fvec(i) / mean(sel(minFbar,maxFbar)) * sel;
  z = f + M;
  for (int a=2; a<=nages; a++)
   n(a) = n(a-1) * exp(-(f(a-1)+M));
  for (int a=1; a<=nages; a++)
   c(a) = f(a)/z(a) * n(a) * (1-exp(-z(a)));
  proposal = sum(elem_prod(c, w));
  if (proposal > ypr)
  {
   ypr = proposal;
```

```
  }
  else
  {
   i--;  // move i back to optimum
   found = true;
  }
 }
 Fmax = Fvec(i);
 YPRmax = ypr;

FUNCTION write_mcmc
 // Likelihoods
 if (mcmc_lines == 0)
 {
  mcmc_like << "f f_c f_s1 f_s2 f_s3" << endl;
 }
 mcmc_like << f << " " << f_c << " " << f_s1 << " " << f_s2 << " " << f_s3 << endl;
 // Parameters
 if (mcmc_lines == 0)
 {
  mcmc_par << "logsigmaC logsigmaU1 logsigmaU2 logsigmaU3 ";
  for (int a=2; a<=nages; a++)       mcmc_par << "sigma_offset." << a << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_coff1." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_coff2." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_cof1." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_cof2." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_cof3." << i << " ";
  for (int i=1; i<=5; i++)           mcmc_par << "log_temp_coff." << i << " ";
  for (int i=1; i<=nyrs+nages-1; i++) mcmc_par << "log_initpop." << i << " ";
  mcmc_par << endl;
 }
 mcmc_par << logsigmaC << " " << logsigmaU1 << " " << logsigmaU2 << " " << logsigmaU3;
 mcmc_par << sigma_offset;
 mcmc_par << log_sel_coff1;
 mcmc_par << log_sel_coff2;
 mcmc_par << log_sel_cofU1;
 mcmc_par << log_sel_cofU2;
 mcmc_par << log_sel_cofU3;
 mcmc_par << log_temp_coff;
 mcmc_par << log_initpop << endl;
 // Fbar
 mcmc_f << Fbar << endl;
 // Selectivities
 if (mcmc_lines == 0)
 {
  for (int a=1; a<=nages; a++)       mcmc_sel << "log_self1." << a << " ";
  for (int a=1; a<=nages; a++)       mcmc_sel << "log_self2." << a << " ";
  for (int a=1; a<=nages_surv1; a++) mcmc_sel << "log_selU1." << a << " ";
  for (int a=1; a<=nages_surv2; a++) mcmc_sel << "log_selU2." << a << " ";
  for (int a=1; a<=nages_surv3; a++) mcmc_sel << "log_selU3." << a << " ";
  mcmc_sel << endl;
 }
 mcmc_sel << log_self1;
 mcmc_sel << log_self2;
 mcmc_sel << log_selU1;
 mcmc_sel << log_selU2;
 mcmc_sel << log_selU3 << endl;
 // Recruitment
 mcmc_rec << column(N,1) << endl;
 // Biomass
 mcmc_ssb << SSB << endl;
 // Sigma
 if (mcmc_lines == 0)
 {
```

```
  for (int a=1; a<=nages; a++) mcmc_sigma << "sigmaC." << a << " ";
  for (int a=1; a<=nages_surv1; a++) mcmc_sigma << "sigmaU1." << a << " ";
  for (int a=1; a<=nages_surv2; a++) mcmc_sigma << "sigmaU2." << a << " ";
  for (int a=1; a<=nages_surv3; a++) mcmc_sigma << "sigmaU3." << a << " ";
  mcmc_sigma << endl;
 }
 mcmc_sigma << sigmaC << " " << sigmaU1 << " " << sigmaU2 << " " << sigmaU3 << endl;
 // Reference points
 if (mcmc_lines == 0)
 {
  mcmc_ref << "Fmax " << endl;
 }
 mcmc_ref << Fmax << endl;
 // Counter
 mcmc_lines++;

GLOBALS_SECTION
 #include "admodel.h"
 int mcmc_lines = 0;
 ofstream mcmc_like("like.mcmc");
 ofstream mcmc_par("par.mcmc");
 ofstream mcmc_f("f.mcmc");
 ofstream mcmc_sel("sel.mcmc");
 ofstream mcmc_rec("rec.mcmc");
 ofstream mcmc_ssb("ssb.mcmc");
 ofstream mcmc_sigma("sigma.mcmc");
 ofstream mcmc_ref("ref.mcmc");
```

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Canum	Catch-at-age in numbers	1975–1978, 1981–1990, 1998, 2000–2002, 2004–now	1–9	Yes
Weca	Weight-at-age in the commercial catch	1981–1990, 1998, 2000–2002, 2004–now	1–9	Averaged
West	Weight-at-age of the spawning stock at spawning time.	1981–1990, 1998, 2000–2002, 2004–now	1–9	Averaged
Mprop	Proportion of natural mortality before spawning	1975–now	1–9	No, assumed 0
Fprop	Proportion of fishing mortality before spawning	1975–now	1–9	No, assumed 0
Matprop	Proportion mature at age	1975–now	1–9	No, assumed constant over years
Natmor	Natural mortality	1975–now	1–9	No, assumed constant over ages and years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	BTS ISIS	1985–now	1–7
Tuning fleet 2	SNS	1975–now	1–7
Tuning fleet 3	NL Beam trawl fleet	2002–now	1–9

D. Short-term projection

To be determined.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	0.29–0.37 year-1	95% confidence bounds F_{MAX} as proxy for F_{MSY}
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	Xxx	Explain

H. Other Issues

The final assessment we propose uses an lpue series for tuning. For species with strong targeting, this may lead to biased estimates of stock abundance. However, given the low catches of older fish in the survey time-series, the lpue series is probably the best indicator for stock abundance of older fish. The effects of targeting were removed as much as possible by using a method described in van der Hammen *et al*. (2011). Future research should confirm if the age-structured lpue time-series used in the assessment is a reliable indicator for age structured stock abundance.

The BTS ISIS age-structured survey time-series used in the assessment has been revised prior to the benchmark working group. Previously, the length structured catch per unit of effort was age structured using an age–length key that was composed of all sampled individuals in the time-series. The update linked the age estimates to length estimates for individual fish, where possible. The SNS survey is not updated and still uses an age–length key that is composed of all individuals in the time-series. Future research should study if using age–length keys collated by year do not give better results in the assessments. Using age–length keys by year has the advantage that the information of age structure within a year is better preserved. Such a procedure would also be more like the assessment procedure used for the other flatfish species sole and plaice.

Currently, the average weights-at-age are used in the assessment as an estimate of the weights-at-age within a given year. Hence, the interannual variability of weights is not accounted for in the assessment or the derived reference points. One method of including the variability of weights is to add the weight-at-age estimation as a likelihood component to the assessment model. In that way, the MCMC procedure that is used to estimate confidence bounds in F, SSB, and reference points can be used to show the uncertainties in these properties including the uncertainty in the weight-at-age estimates that are now not accounted for.

There is little knowledge of the natural mortality of this stock. For other flatfish species we have natural mortality estimates that are empirically derived from the cease in fishing during WWII. Using the statistical relationship as estimated by Gislason *et al*. (2010), we derived estimates for natural mortality that are higher than those for sole and plaice. The reason for these high estimates are the high K and L_∞. The benchmark group then decided to use M=0.2 per year, as is used for many other fish in the ICES areas. A simple exploration of the assessment model indicated that the model itself is not very informative about M, but that higher M values lead to a slightly lower log-likelihood. Further exploration of M for turbot would improve the appropriateness of the ICES advice that will result from using the assessment.

The data collected prior to 2003 clearly shows a lower selectivity for the younger ages in the landings-at-age table compared to the more recent period. By interpreting the landings-at-age data as catch-at-age information, the change in landings of young fish was interpreted by the benchmark working group as an increase in the catchability for those ages. This can be justified, with the knowledge of the abandoning of the 30 cm MLS by the EC. The alternative explanation for the change in catch-at-age table is that those age were discarded previously and hence an unobserved part of the catch-at-age prior to 2000. Having more catch-at-age information available from different countries would provide more insight in the landings-at-age and discards-at age, and possibly give more insight in what caused the changes in the landings-at-age information that is now available from single countries only.

I. References

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Turbot in IIIa

Stock	Turbot in IIIa
Working Group	WGNEW
Date	02 October 2012
Authors	M. Cardinale, H. Svedäng, A-B. Florin

A. General

A.1. Stock definition

Turbot (*Psetta maxima* L.) is distributed in ICES Area IIIa (Skagerrak and Kattegat). The stock has historically been composed by two major spawning components, one in the Eastern Skagerrak and the other in the southern part of the Kattegat (Cardinale *et al*., 2009). Nielsen *et al*. (2004) show a sharp cline in genetic differentiation when going from the low saline Baltic Sea to the high saline North Sea, where samples from Skagerrak and Kattegat are in the transition zone. This suggests that the Skagerrak and Kattegat populations are inherently different from the turbot in the North Sea. Over the period 2009–2012, a genetic study of turbot population structure all over the species' distribution area has been conducted using both neutral and gene-associated genetic markers by Vandamme *et al*. (in prep). The neutral marker panel confirmed a break-up between the Baltic and Northeast Atlantic clusters. Within the latter, a more detailed pattern of genetic differentiation could be observed, when gene-associated markers were also included in the analysis (results soon to be consulted on https://fishreg.jrc.ec.europa.eu/web/fisheries-genetics). Nevertheless, in the presence of strong natal homing, high residency and limited migration (see Section H1 for references and details) as is the case for turbot, the question whether populations (i.e. aggregation of adult fish during spawning) are genetically distinguishable is not crucial to the existence of self-sustaining population units and for management (Waples *et al*., 2008). Accordingly, the existence of separated spawning aggregations is a key factor regulating the dynamic of the populations (Svedäng *et al*., 2010) and thus they should be managed accordingly (Cardinale *et al*., 2011a).

A.2. Fishery

In the North Sea, turbot has been considered a highly prized fish ("prime") since the middle of the 1800s. Historically, it has been exploited within a multispecies fishery targeting turbot together with brill (*Scophthalmus rhombus*) and sole (*Sole solea*) (Mackinson, 2002). In IIIa, a target fisheries for turbot probably only occurred when the stock was large (i.e. before 1960s; Cardinale *et al*., 2009), while today turbot is only caught as bycatch in the trawl, trammelnet and gillnet fisheries, although due to its high economic value, targeting might occur in specific areas and seasons.

International landing series from IIIa between 1950 and 2010 are presented in Figure A.1. Over the period 1950–1989, these landings ranged around 300 t per year. The landings declined from over 300 t per year in 1989 to less than 100 t per year in 2011. Denmark landed on average 83% of the IIIa turbot. Other countries contributing to the total landings were - in descending order of importance - the Netherlands (mainly because of a peak in the second half of the seventies), Sweden, Norway, Belgium, Germany and the UK.

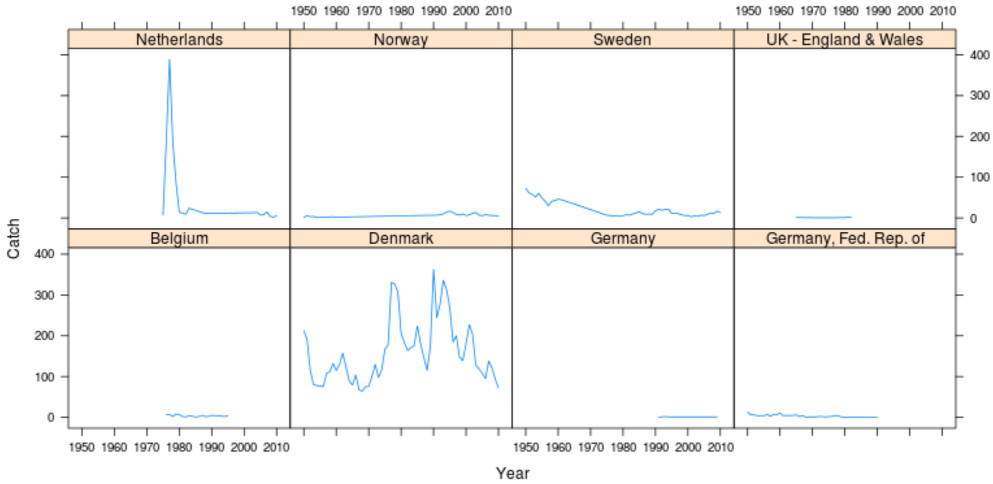

Figure A.1. Landings of turbot by country from 1950 to 2011 in IIIa. UK- Eng+Wales includes N. Ireland in 1991 (0.5 t), while Sweden reported aggregated catches for IIIa and IVa+b in 1973 (9.0) and 1974 (7.0).

A.3. Ecosystem aspects

Discards: Discarding of turbot in IIIa is considered negligible due to the high value of the species. Also, survival rates of discarded turbot are likely to be high. A Minimum Landing Size of 30 cm (as independently installed by various authorities) leads to the landing of many immature individuals and in particular females, while increasing the MLS to higher lengths leads to higher discarding percentages.

B. Data

B.1. Commercial catch

Commercial catch data are obtained from national laboratories of nations exploiting turbot in IIIa. Landings data are available by countries since 1901 from official ICES sources. Information on the size structure of the catches might be available at the national laboratories level for the most recent part of the time-series but they have never been compiled.

Sampling of commercial catch: Sampling of commercial catch is conducted by the national institutes according to the EU Data Collection Framework (DCF). However, due to the small amount of annual landings, sampling of commercial catches is sparse and also several countries might be exempted to sample turbot in IIIa. Sweden has not sampled turbot in IIIa in the last decades. In the past, biological samples of turbot from the Danish fisheries in IIIa have been taken both from landed catches and through the national at-sea-sampling programme.

The DCF exemptions to the general DCF sampling rules are:

1) Concerning lengths: the national programme of a Member State can exclude the estimation of the length distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

    1.1) the relevant quotas must correspond to less than 5% of the Community share of the TAC or to less than 100 tonnes on average during the previous three years;

1.2) the sum of all quotas of Member States whose allocation is less than 5% must account for less than 15% of the Community share of the TAC.

If the condition set out in point (1.1) is fulfilled, but not the condition set out in point (1.2), the relevant Member States may set up a coordinated programme to achieve the implementation of the sampling scheme described above for their overall landings, or another sampling scheme, leading to the same precision.

2) Concerning ages: the national programme of a Member State can exclude the estimation of the age distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

2.1) the relevant quotas correspond to less than 10% of the Community share of the TAC or to less than 200 tonnes on average during the previous three years;

2.2) the sum of all quotas of Member States whose allocation is less than 10%, accounts for less than 25% of the Community share of the TAC.

If the condition set out in point (2.1) is fulfilled, but not the condition set out in point (2.2), the relevant Member States may set up a coordinated programme as mentioned for length sampling.

If appropriate, the national programme may be adjusted until the 31st of January of every year to take into account the exchange of quotas between Member States.

Due to the relatively small numbers of turbot in commercial catches (per trip) and the high commercial value of this species, it is very difficult to collect data on biological variables in sufficient numbers for a meaningful analysis. Fishermen very often do not allow observers to take turbot otoliths on board of commercial vessels (even when informing them that it is possible to sample the otoliths through the operculum in this species, making it unnecessary to cut open the heads and thus not influencing the appearance of individual fish and their value to buyers in this way) or set aside sampling gonads for maturity staging (although the fish are gutted on board anyhow). Neither has buying turbot as part of the market sampling been considered an option for most countries either, because of the high prices. However, including the biological sampling in MS national proposals as a part of the DCF should solve this problem. On surveys, catches of turbot are generally even lower than on commercial vessels. Furthermore, turbot is a coastal, shallow water species meaning that offshore surveys such as the regular International Bottom-trawl Survey misses important habitat for turbot.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers. However, it remains to be investigated how many samples have been collected in the past and are available at the national laboratories level, which can be compiled for stock assessment purposes. It is also important that ages have been read using the same preparation techniques (section and stained, WKART, Workshop of age reading in turbot 2008 (ICES 2008)).

Mean weights-at-age in the stock and proportions of mature individuals (maturity ogive) are derived from the IBTS and Havfisken survey (see Section B.3.2). Also, a workshop has taken place in IJmuiden in 2012 (WKMSTB, Workshop on Maturity

Staging of turbot and brill (ICES 2012)). The workshop agreed on a common six point maturity scale for turbot across laboratories, and proposed optimal sampling strategy to estimate accurate maturity ogives.

Natural mortality

Natural mortality (M) at age will be estimated using biological information on growth, length–weight relationship and maximum size using the PRODBIOM software (Abella *et al*., 1997; Cardinale *et al*., 2011b). Alternatively, the same M as used in the North Sea assessment might be used, that was estimated from literature data using the equation of Gislason *et al.* (2010).

B.3. Surveys

B.3.1 International Bottom-trawl Survey

The International Bottom-trawl Survey (IBTS) started out as the International Young Herring Survey (IYHS) in 1966 (Heessen *et al*., 1997). The survey was standardized gradually from 1977, and is considered to be fully standardized from 1983 onwards, where it became known as the International Bottom-trawl Survey (IBTS). The surveys are carried out in 1st quarter (February) and in 3rd quarter (August–September) using standardized procedures among all participants. The standard gear is a GOV trawl, and at least two hauls are made in each statistical rectangle. Size information of the turbot catches is available and they can be used to construct an ALK or to estimate the proportion of the different age classes in the population for each year and season.

B.3.2 KASU Bottom-trawl Survey

The KASU survey is a standard BITS (Baltic International Trawl Survey), another group of standardized surveys. The trawl is a standard TV3-520 with rubber discs of 10 cm diameter on the groundrope and with a trawl speed at 3 knots. This trawl targets flatfish better than IBTS and is designed to provide annual abundance indices for cod, plaice and sole. This survey takes place in the Kattegat and Belt Sea twice a year in February and November, and is conducted by a Danish vessel, Havfisken from DTU Aqua. KASU time-series start in 1996 for the first quarter and 1994 for the fourth quarter data.

KASU data have been revised in 2006, due to changes in the database combined with a change of extraction programs in 2005. The revision of last year indices highlighted data treatment errors and the new time-series is considered improved compared to the old one.

Size information of the turbot catches is available from KASU and they can be used to construct an ALK or to estimate the proportion of the different age classes in the population for each year and season.

Data storage: The data are initially tabulated in an excel sheet where the data are scrutinised for consistency and quality, and the different correction factors that standardize the data among nations is applied. In the case of IIIa, only Sweden has conducted the IBTS survey so the standardization does not apply.

Index Calculation: An aggregated and standardized survey catch per unit of effort has been calculated up to 2009 by Cardinale *et al*., (2009) using IBTS survey data and historical data from Swedish trawl surveys since 1926. In the absence of age information for the surveys, statistical age slicing procedures (Scott *et al*., 2011) might be used to derive the number of fish per age class using length–frequency information from the survey.

B.4. Commercial cpue

Not used in this stock. However, data on catches and size of turbot should be available from the Danish sole fisherman survey, and also possibly from the Kattegat cod fisherman surveys (2009–2011).

B.5. Other relevant data

None.

C. Historical stock development

C.1. Choice of stock assessment model

The turbot in IIIa has never been assessed before.

C.2. Model used as basis for advice

The choice of the assessment model will be contingent on the amount and quality of the available data.

C.3. Assessment model configuration

The choice of the assessment model configuration will be contingent on the amount and quality of the available data.

D. Short-term projection

Short-term projections are not carried out for this stock.

E. Medium-term projections

Medium-term projections are not carried out for this stock.

F. Long-term projections

Long-term projections are not carried out for this stock.

G. Biological reference points

MSY framework for North Sea herring

There is no ICES MSY framework biomass trigger point and fishing mortality for this stock.

Precautionary reference points

There are no ICES precautionary reference points for biomass and fishing mortality for this stock.

H. Other issues

H.1 Biology of the species in IIIa

Turbot lives on sandy, rocky or mixed bottoms and is one of the few marine fish species that also inhabits brackish waters. Turbot is a batch spawner and in marine waters eggs are pelagic Spawning only occurs in marine waters (pelagic eggs), where it is a batch spawner (Murua and Saborido-Rey, 2003). The spawning season generally ranges from April to August. Turbot is one of the fastest growing flatfish. During the juvenile phase growth rates are high, turbot can reach 30 cm in three years. Growth curves of males and females diverge markedly from about age three and onwards, females growing larger than males (Molander, 1964; Jones, 1974). During the first years of life females grow from 8 to 10 cm a year. Females older than ten years still grow 1 or 2 cm a year. Turbot is a typical visual feeder and adults feeds mainly on highly mobile prey like other bottom-living fishes small pelagic fish and also, to a lesser extent, on larger crustaceans and bivalves. Due to their large mouthsize compared to other flatfishes they eat macrofauna (>1 mm) from the beginning of their benthic lives. The diet of the juveniles has been shown to consist of copepods, shrimps, barnacle larvae and gastropod mollusc larvae (Jones, 1973).

Turbot is a rather sedentary species, although more long distance migratory patterns have been observed. In the North Sea, migrations from the nursery grounds in the southeastern part to the more northern areas have been recorded (ICES 2012). Nevertheless, tagging studies from three different parts of the Baltic Sea all showed that adult turbot are very stationary, have high spawning site fidelity and that 95% of the fish moved less than 30 km from tagging site, although a few individual specimens showed displacements of 100s of km (Johansen, 1916; Aneer and Westin, 1990; Florin and Franzen, 2010). Thus, turbot generally occur in spatially separated stock units as it spawns at specific localities in shallow areas during summer (Molander, 1964; Curry-Lindahl, 1985; Voigt, 2002; Iglesias *et al*., 2003; Florin and Franzén, 2010) and with restricted movements as adults (Aneer and Westin, 1990; Støttrup *et al*., 2002; Florin and Franzén, 2010), and exhibit strong spawning site fidelity (Florin and Franzén, 2010). Inspection of historical data from the Skagerrak–Kattegat area also indicates spatially separate stock structure, at least in terms of spawning components, which is persistent over time (Cardinale *et al*., 2009).

H.2 Stock dynamics, regulation and catches through 20th century

According to time-series of standardized survey cpue (Cardinale *et al*., 2009), the reduction of turbot in IIIa occurred at the beginning of the industrialized fishery, which is usually considered to be the main cause of the decline of several stocks of many demersal species stocks in IIIa (Cardinale *et al*., 2012), showing instead that the pre-industrial fishery had already had a significant impact on the stock. Historical survey data shows that biomass of turbot in IIIa has declined at about 86% since 1925 with regard to initial values; the maximum individual body size has decreased around 20 cm from the beginning of the time-series (Cardinale *et al*., 2009). Moreover, the northern stock component within Area IIIa has been eradicated. These trends are likely to be underestimated due to the conservative approach used by assuming a low level of "technical creeping" for such a long period of time, suggesting that the actual reduction in biomass might have been between 92% and 95% (Cardinale *et al*., 2009). These results indicated a depleted status of the stock in IIIa and also different stock dynamics within the area (i.e. in comparison between the Skagerrak and the Kattegat) and also when compared to the estimated trends for the North Sea (ICES 2012).

An alternative interpretation to the overexploitation hypothesis is that the quantity and quality of the turbot nursery grounds has deteriorated due to pollution (in particular due to eutrophication) and increased frequency of hypoxia events occurring in the shallow sandy coastal waters of Denmark and Sweden (Pihl *et al.*, 2005), affecting the productivity of the stock. However, the decline of biomass was also accompanied by a large decrease in average maximum length, with large individuals, more abundant at the onset of the last century, being the first to be fished out with the beginning of the industrialized fishery. Thus, the above considerations corroborate the hypothesis that observed trends in length and stock size over the first part of the last century are a result of overexploitation.

H.3 Current fisheries

There is no direct or target fisheries of turbot in IIIa. The species is caught as bycatch in the trawl, trammelnet and gillnet fisheries, although due to its high economic value, targeting might occur for short period during the year in specific areas and seasons.

H.4 Management and ICES advice

Management plan

Hitherto, no management plan has been considered for turbot in IIIa.

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European sea bass in Subarea IVb,c and VIIa, d–h

Stock	European sea bass (*Dicentrarchus labrax*) in Subarea IVb,c and VIIa, d–h
Working Group	WGNEW
Date:	October 2012
Revised by	IBPNew 2012

A. General

A.1. Stock definition

Bass *Dicentrarchus labrax* is a widely distributed species in Northeast Atlantic shelf waters with a range from southern Norway, through the North Sea, the Irish Sea, the Bay of Biscay, the Mediterranean and the Black Sea to Northwest Africa. The species is at the northern limits of its range around the British Isles and southern Scandinavia.

Stock structure of sea bass in the Northeast Atlantic has been reviewed by WGNEW 2012 and IBPNew 2012 based on evidence from genetics studies, tagging studies, distribution of commercial catches and similarities in stock trends between areas, drawing also on extensive information contained in previous WGNEW and ICES SGBASS reports.

IBPNew considers that stock structure remains uncertain, and recommends further studies on sea bass stock identity, using conventional and electronic tagging, genetics and other individual and population markers (e.g. otolith microchemistry and shape), together with data on spawning distribution, larval transport and VMS data for vessels tracking migrating bass shoals, to confirm and quantify the exchange rate of sea bass between sea areas that could form management units for this stock. Such information is critical to support development of models to describe the spatial dynamic of the species under environmental drivers (e.g. temperature and food). Such modelling work is being carried out in France in the framework of a PhD study (R. Lopez).

The pragmatic view of IBPNew 2012 is to structure the baseline stock assessments into four units:

- Assessment area 1. Sea bass in ICES Areas IVbc, VIId, VIIe,h and VIIa,f&g (lack of clear genetic evidence; concentration of Area IV bass fisheries in the southern North Sea; seasonal movements of bass across ICES divisions). Relatively data-rich area with data on fishery landings and length–age composition; discards estimates and lengths; growth and maturity parameters; juvenile surveys, fishery lpue trends.
- Assessment area 2. Sea bass in Biscay (ICES Subarea VIIIa,b). Available data are fishery landings, with length compositions from 2000; discards from 2009; some fishery lpue.
- Assessment area 3. Sea bass in VIIIc and IXa (landings, effort).
- Assessment area 4. Sea bass in Irish coastal waters (VIa, VIIb, VIIj). Available data: Recreational fishery catch rates; no commercial fishery operating.

Fishery landings of sea bass are extremely small in Irish coastal waters of VIIa and VIIg and the stock assessment for assessment area 1will not reflect the sea bass populations around the Irish coast, which may be more strongly affiliated to the population in area 4 off southern, western and northern Ireland.

A.2. Fishery

General description

The commercial sea bass fisheries in Areas IV and VII have two distinct components: an offshore fishery on prespawning and spawning bass during November to April, predominantly by pelagic trawlers from France and the UK, and small-scale fisheries catching mature fish returning to coastal areas following spawning and in some cases immature sea bass. The inshore fisheries include many small (10 m and under) vessels using a variety of fishing methods (e.g. trawl, handline, longline, nets, rod and line). The fishery may be either targeting sea bass or taking sea bass as a bycatch with other species. Historical landings data for the small-scale fisheries have often been poorly recorded. Although sea bass can occur as target or bycatch of many vessels, the bulk of the catch can be taken by relatively few vessels. For example in the UK in 2010, sea bass landings were reported by 1480 vessels (including 1207 of 10 m and under), 10% of which were responsible for over 70% of the total landings of 719 t (Walmsley and Armstrong, 2012). For France, in 2009 sea bass landings were reported by 2226 vessels including 976 of 10 m and under. Three main métiers were responsible for over 83% of the total landings. Pelagic trawlers (31.5% of total landings, for 58 vessels and 276 seamen) and "liners+handliners" (21.7% of total landings for 416 vessels and 634 seamen) are very economically dependent of this species (Drogou *et al.*, 2011). French bottom trawlers often do not target sea bass, but this gear does represent 30.1% of the total landings (for 832 vessels and 2769 seamen). (Drogou *et al.*, 2011).

The fisheries in Area VIII are prosecuted mainly by France and Spain and in Division IXa by Spain and Portugal. The Portuguese fleet is predominantly polyvalent with small catches also recorded for purse-seines, trawls and gillnets.

According to the CHARM 3 Atlas of the Channel Fisheries, sea bass production in value represented €31 937 in 2008. It's the third most valuable species caught in the Channel (source: Agrimer) in 2008 behind sole and monkfish (tuna is not included in statistics). The market value sea bass depends greatly on how its caught, giving added value to certain métiers: according to CHARM3 Atlas of the Channel Fisheries, mean price of sea bass sold in the Channel (7EH+7D) by liners was €17.14 per kg in 2007 compared with €6.52 per kg for pelagic trawl, reflecting differences in volume and fish condition.

Sea bass are a popular target for recreational fishing in Europe, particularly for angling in the UK, Ireland and France, and increasingly in parts of southern Norway, the Netherlands and Belgium. Relatively little historical data are available on recreational fisheries although several European countries are now carrying out surveys to meet the requirements of the EU Data Collection Framework and for other purposes (ICES WKSMRF 2009; PGRFS 2010 & 2011; WGRFS 2012; Herfault *et al.*, 2010; Rocklin *et al.*, 2012 in prep; Van der Hammen and De Graaf, 2012).

More detailed descriptions of national fisheries can be found in ICES SGBASS (ICES 2004a).

Fishery management regulations

Sea bass are not subject to EU TACs and quotas. Commercial vessels catching bass within cod recovery zones are subject to days-at-sea limits according to gear, mesh and species composition. Under EU regulation, the MLS of bass in the Northeast Atlantic is 36 cm total length, and there is effectively a banned range for enmeshing nets of 70–89 mm stretched mesh in Regions 1 and 2 of Community waters[2]. A variety of national restrictions on commercial bass fishing are also in place. These include:

- a landings limit of 5 t/boat/week for all French and UK trawlers landing bass;
- closure of 37 bass nursery areas in England and Wales to specified fishing methods;
- UK regional byelaws in Cornwall and South Wales stipulating a 37.5 cm MLS;
- a minimum gillnet mesh size of 100 mm in South Wales;
- a variety of control measures in Ireland that effectively ban commercial fishing for bass in Irish waters; plus MLS of 40 cm;
- a licensing system from 2012 in France for commercial gears targeting sea bass;
- voluntary closed season from February to mid-March for longline and handline bass fisheries in Brittany.

Depending on country, measures affecting recreational fisheries include minimum landing sizes, restrictions on sale of catch, bag limits (Ireland), and gear restrictions (France; Netherlands).

A.3. Ecosystem aspects

Temperature appears to be a major driver for bass production and distribution (Pawson, 1992). Reynolds *et al*. (2003) observed a positive relationship between annual seawater temperature during the development phases of eggs and larvae of sea bass and the timing and (possibly) abundance of post-larval recruitment to nursery areas. In addition, early growth is related to summer temperature and survival of 0-groups through the first winter is affected by body size (and fat reserves) and water temperature (Lancaster, 1991; Pawson, 1992). Prolonged periods of temperatures below 5–6°C may lead to high levels of mortality in 0-groups in estuaries during cold winters. As a result, any SSB–recruit relationships may be obscured by temperature effects (Pawson *et al*., 2007a).

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[2] Region 1: All waters which lie to the north and west of a line running from a point at latitude 48°N, longitude 18°W; thence due north to latitude 60°N; thence due east to longitude 5°W; thence due north to latitude 60°30'N; thence due east to longitude 4°W; thence due north to latitude 64°N; thence due east to the coast of Norway.

Region 2: All waters situated north of latitude 48°N, but excluding the waters in Region 1 and ICES Divisions IIIb, IIIc and IIId.

B. Data

B.1. Commercial catch

B1.1. Landings data

Data available

Landings series for use in the assessment are available from three sources:

i) Official statistics recorded in the FishStat database since around the mid-1970s.

ii) French landings for 1999–2010 from a separate analysis by Ifremer of logbook and auction data.

iii) Survey estimates of landings from the UK fleet of 10 m and under vessels (which are not obliged to provide EU logbooks), carried out by Cefas.

Total international landings from sources (i) and (ii) combined increased from around 2000 t in the late 1970s to over 8000 t by 2006, the bulk coming from Areas IVb,c, VIIe and XIII. An important driver of the increase in landings since the 1990s was the increased landings in Divisions IVb,c, VIId and VIIe,h, coinciding with the large 1989 year class and a northward expansion of the sea bass population in the North Sea during a period of increasing sea temperatures.

WGNEW has previously given separate (unofficial) estimates of 29–65 t for Spanish Basque countries for Area VIII, but only for 1995–2005. These have not been updated but can be viewed in the WGNEW 2010 report and 2011 advice sheet.

Quality of official landings data

From 1999 onwards, French landings data from FishStat are replaced by more accurate figures from a separate analysis of logbook and auction data carried out by Ifremer, in which landings have been correctly allocated to fishing ground. The time-series for each component fishing ground therefore has a step change around 2000. To create input landings data from the 1980s for the two baseline stock units (North Sea + Channel + Celtic & Irish Seas) and Biscay southwards, it has been necessary to assume that the ratio of FishStat to Ifremer landings figures for 2000 onwards can be applied to FishStat figures for earlier years. The sensitivity of the assessment to this adjustment should be evaluated. Factors for adjustments have been calculated for each area and applied to the French landings data from FishStat: for IVbc+VIId area 1.04 has been used; for VIIeh area 1.6 has been used, and for VIIafg 0.62 has been used and 0.98 for the Bay of Biscay.

The accuracy of total landings statistics for Subareas IV, VII and Div. VIIIa are expected to have improved further since 2006 since the introduction of the registration of Buyers and Sellers in the UK, particularly for small vessels that do not have to supply EU logbooks. The accuracy of Dutch landings data from Area IV and VII has improved since the recreational line fishers were registered as commercial fishers when they want to sell their landings. Landings data for Division IXa are more accurate since 2006 when sea bass *Dicentrarchus labrax* landed into Portugal started to be recorded as the correct species rather than mainly as part of a mixed sea bass category with the spotted sea bass *Dicentrarchus punctatus*. This resulted in a sharp increase in reported landings of *D. Labrax* in 2006 (Figure B1.1).

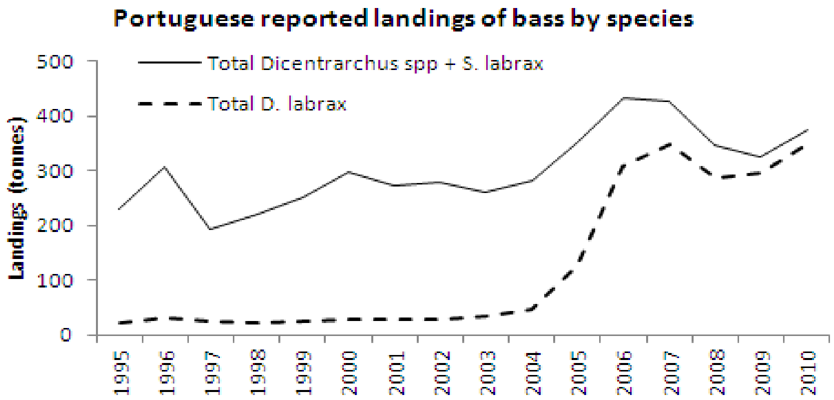


Figure B1.1. European sea bass in the Northeast Atlantic: Landings by area and gear type for Portuguese commercial fishing fleets.

Cefas bass logbook estimates of landings

The UK has previously attempted to estimate the sea bass landings of inshore commercial and recreational fishing boats between 1984 and 2006 using a voluntary logbook scheme in conjunction with a biennial census of vessels catching sea bass that covers different segments of coast in different years (Pickett, 1990). Estimates of annual catch and effort are obtained from a stratified selection of vessels issued with a bass logbook, and raised to the census counts of vessels in the same survey strata. The landings tables in previous WGNEW and ACOM advice (up to 2011) included "unallocated" landings which were the difference between the voluntary logbook estimates and the official UK statistics in each ICES area. The coverage of the logbook scheme has declined substantially. A review of the scheme in 2012 (Armstrong and Walmsley, 2012a) showed that the previous estimates provided to WGNEW included recreational charter boats, which have now been removed from the estimates for the years when they occur. Coverage of trawls has been extremely low. The Cefas logbook estimates for nets and lines still show substantial differences with official estimates, even for recent years since 2006 when the Registration of Buyers and Sellers has vastly improved recording of landings by 10 m-and under vessels. The utility of the logbook data are reviewed in the IBPNew 2012 benchmark assessment report.

Further information on availability and quality of landings data by country is provided by SGBASS (ICES, 2004).

B1.2. Discards estimates

UK data

Survey design and analysis

The UK sampling scheme involves a vessel-list sampling frame and random selection of vessels within strata defined by quarter, area and fleet métier. The vessel list for each quarter is stratified by area and predominant métier. A random, ranked draw list is generated each quarter for each vessel stratum, and observers work down the list to board the next available vessel on completion of a previous trip, according to targets for numbers of trips per stratum. Numbers and length compositions of discards and retained fish for each sampled trip are estimated by random sampling of the catch from a minimum of 60% of hauls during a trip. Estimation of annual bass discards and length compositions of landed and discarded fish at the fleet level are obtained by raising from sampled trips within each stratum then combining over strata. Discards estimates for IBPNew 2012 were obtained by use of a ratio estimator (auxiliary variable = landings), as there was evidence of a linear relationship between landings and discards of sea bass at the trip level.

Data coverage and quality

UK discards data are available for métiers associated with trawls and fixed/driftnets only. Discards from commercial line boats are expected to be relatively low and have high survival, so this fleet sector is excluded from the scheme for sea bass. As sampling is targeted at all species, annual coverage of the bass fisheries is relatively limited. Sample numbers by gear type and area are highest for otter trawls and nets (see benchmark assessment report), but of these, a variable and often small number of trips have bass catches. Only length–frequency data are available for discarded sea bass.

French data

Survey design and analysis

The French sampling schemes also utilize vessel-list sampling frames and random selection of vessels within strata defined by area and fleet sector. From the activity calendars of French vessels for year n-1, vessels are grouped by the métiers practised. Thus, a vessel may belong to multiple groups if practicing several métiers in the period. If the métier has to be sampled in priority No. 1, the vessel to be boarded is chosen randomly within this group of vessels. The observer then chooses to go onboard for a trip. During the trip, the fishing operations corresponding to métier No. 1 are sampled. Optionally, if the vessel practises several métiers during the trip, fishing operation of the métier No. 2 will also be sampled if the métier No. 2 is included in the annual sampling plan. If the métier is not part of the plan, it is requested to sample at least one fishing operation of this métier in the trip. (complete document on sampling protocol in French :http://sih.ifremer.fr/content/download/5587/40495/file/Manuel_OBSMER_V2_2_2012.pdf).

Data coverage and quality

Discards data are only available for French fleets from 2009 onwards, and only as length frequencies.

Spain

No bass discards were observed for any métier in the 2003–2011 period. Number of sampled hauls per métier and area were presented to IBPNew 2012 (see assessment report).

Discards data from other European countries

Discards data for Dutch beam trawlers were presented to ICES IBPNew 2012, as annual mean numbers discarded per hour in 2004–2010. No commercial fisheries for sea bass exist in Ireland.

B1.3. Recreational catches

Recreational marine fishery surveys in Europe are still at an early stage in development (ICES WKSMRF, 2009; PGRFS, 2010 & 2011; WGRFS, 2012). The following information was available to WGNEW 2012.

Data from France

The first national survey of recreational fishing in France (2006 to 2008) revealed that sea bass was the main target species for recreational fishermen, and that 378 500 people had fished recreationally for bass.

Survey method and analysis

A new study targeting sea bass was conducted between 2009 and 2011. In 2009, 15 000 households were phoned in the targeted districts using random digit dialling (RDD). The main goal was to estimate the population of sea bass recreational fishers and their socio-demographic profiles in the Bay of Biscay and in the Channel. In 2010–2011 a panel of 258 recreational fishermen was recruited during the RDD screening survey and kept diaries of their catches for one year for a total of 1170 trips. The main goal was to obtain a detailed description of fishing trips (travel, area of fishing, gears…) and the description of their catches (species, weight, length…) to be used for assessment.

Sea bass catches were estimated by raising the mean annual estimates from the diaries to the total population of recreational fishers from the RDD survey, by survey stratum. The estimated recreational catch of bass in the Bay of Biscay and in the Channel was 3170 t of which 2350 t was kept and 830 t released. The main gears used, in order of total catch, were fishing rod with artificial lure, fishing rod with bait, handline, longline, net and spear fishing. Approximately 80% of the recreational catch was taken by sea angling (rod and line or handline); 2610 t total catch and 1840 t kept (29% release rate). Around 60% of the recreational catch estimate was from Bay of Biscay.

Data quality

The precision of the estimate is relatively low (CV =-51%). Increasing the panel from 121 to 500 fishermen would be expected to improve precision to 25% and increasing this panel to 1000 would improve precision to 18%.

UK (E&W)

Several attempts have been made in the past to estimate recreational sea angling catches of sea bass in England and Wales or more restricted areas of the UK (Dunn *et al.*, 1989; Dunn and Potten, 1994). A new survey programme based on a statistically sound survey design commenced in 2012 to estimate fishing effort, catches (kept and released) and fish sizes for shore based and boat angling in England. The survey does not cover other forms of recreational fishing. Estimates will not be available until late 2013.

Netherlands

Sea bass are taken by recreational sea anglers in the Netherlands. A recent survey investigated the amount of sea bass caught (Van der Hammen and De Graaf, 2012; ICES WGRFS, 2012).

Survey method and analysis

Research was conducted from 2009 onwards. First a screening survey was carried out to identify fishing households, profile fishing households and select participants for a follow-up. In the screening survey, 109 293 people were approached by phone in order to estimate the number of inland and marine recreational fishers. Questions were asked to assess the age, gender and avidity of the fishers. The screening survey was followed by a diary survey, in which 1043 marine recreational fishers returned their diary at least once. Fishing (and economic) activity through regular contact (monthly) by survey interviewers was monitored. In addition, a small-scale 'on-site' sampling programme was implemented to provide additional independent data on catch, size and species composition of recreational fishers along the coast and charter boats.

Preliminary results of these surveys show that in total about 360 thousand individual sea bass were caught in 2010. Of these, 218 ± 130 (95% CI) thousands were retained, which is about 61%. In weight, 161 tonnes of sea bass were caught in total. Of this, 96 ± 60 (95% CI) tonnes were retained, which is 60%. These results are mainly applicable to Subarea IV.

Spain

A recreational boat fishing survey was performed in the Basque Country to estimate the total catch of the target species of this fishery. Fishermen were asked about their catches in 2009, and 555 surveys were collected. Sea bass catch data were modelled with a two-step GLM, using type of boat and total boat length as covariables. The results were extrapolated to the total number of boats using an updated census. The estimated catch for sea bass was in 2009 was 8.2 tons, with an associated standard error of 0.149 tons.

It is important to note that this estimation refers only to the fishing performed from boats. In order to estimate total recreational catches of sea bass, anglers fishing from coast and spear fishers need to be included in the survey. In 2012 a pilot study financed by the Data Collection Framework (DCF) is taking place in order to estimate total sea bass catches (taking into account all types of recreational fishing), and it is expected that the results if this study will increase significantly the estimated sea bass catch."

Other countries

Sea bass are a popular angling species in Ireland and are also caught in Belgium. Time-series of sea angling catch rates of sea bass in southern Ireland were presented at IBPNew 2012 by a stakeholder representative.

B.2. Biological sampling

B2.1. Length and age compositions of landed and discarded fish in commercial fisheries

Length and age compositions of sea bass landings were available to WGNEW & IBPNew 2012 from sampling in the UK and France.

UK

Sampling methods and analysis

The UK(E&W) sampling programme for length compositions of sea bass covers sampling at sea and on shore. The sampling design for at-sea sampling is described above. The onshore sampling programme uses an area list frame comprising port days, currently stratified by quarter, ICES division and an index of "port size". "Large" ports are sampled more intensively than "small ports". Separate list frames of ports are established for pelagic trawlers, beam trawlers and demersal trawl, nets and lines. Sampling targets are set to achieve a specified number of port visits by stratum, taking account the need for fleet based as well as stock based data specified by the EU Data Collection Framework, although other diagnostics are monitored such as numbers of fish measures and otoliths/scales collected by species. This scheme has only been in development and operation since around 2010 when Cefas took over the sampling from the Marine and Fisheries Agency. Prior to then, the sampling targets were mainly set as numbers of fish of each species to measure or age by quarter, district, and gear groupings, with minimum numbers of sampling trips also specified to spread the sampling out.

Length compositions are first vessel-raised using ratios of landed live weight to predicted live weight of the length–frequency calculated from a length–weight relationship:

$$W\ (kg) = 0.00001296\ (L+0.5)^{2.969}$$

Raised LFDs are then summed over vessels within a sampling stratum and raised to give total raised fleet LFDs per stratum, which are then combined. This procedure ensures sums-of-products ratios of 1.0 but will lead to some bias in numbers-at-length due to discrepancies between true fish weights and calculated fish weights from the length–weight relationship.

Data coverage and quality

Length and age compositions are supplied by the UK since 1985 for IVb&c, VIId, VIIe,h and VIIa,f&g, disaggregated by five gear types: otter trawl, pelagic pair trawl, drift and gillnets, lines, and other gears. Although separate ALKs are derived for the five areas, the same ALK is applied to all gear groups meaning that the age composition estimates for the different gears are not independent.UK sampling rates for length compositions have been very variable between area, gear and year strata. Most strata have some sampling coverage with the exception of pair trawls which have had zero or very low coverage in many years despite large catches, although sampling has improved recently (see assessment report). The sampling rate (trips sampled per tonne landed) has declined for all gears since the mid-2000s.

France

Sampling methods and analysis

The French sampling programme for length compositions of sea bass covers sampling at sea and on shore. Since 2009, both sampling types are first based on métiers composition and their relative importance per fishing harbours and month. Both are also designed to sample the whole catch following a concurrent sampling of species, potentially leading to low sea bass sample size. In order to complement this effort, specific sampling for sea bass at the market is added at times and harbours when higher landings are occurring, especially from métiers targeting sea bass. The sampling frame is based on the main harbours, gear types (or grouping of métiers) and month and is available to all samplers on a dedicated website. Real-time follow-up of the plan, refusal rates and their reasons, time taken to sample, all this information is also available from the website, together with sampling protocol (in French): http://sih.ifremer.fr/content/download/5587/40495/file/Manuel_OBSMER_V2_2_2012.pdf). Before 2009, only market specific sampling was in place, and the sampling plan was designed and followed by the stock coordinator. The French sampling programme for age compositions of sea bass is based on age–length keys with fixed allocation. For the VIIeh area, quarterly French landings at auctions are sampled in order to collect five scales (from 2000 to 2008) or three scales (from 2009) by length class (cm). For the VIIIab area the information is available only from 2010. For other areas the information is not available. All length samples are populated in a central database (Harmonie) and regular extracts are available in the COST format. Raising the data to the population is done using COST tools and a special forum for discussing the outcomes of the analysis is held every year in March, in order to gather all stock coordinators and prepare the datasets for the assessment working groups.

Data coverage and quality

Sampling has been very variable between areas and gears, with greatest consistency between years in VIIIa,b. There has been a general increase in numbers of trips sampled for length since 2009 (see assessment report).

Quarterly landings length and age compositions are available for all métiers in VIIeh area from 2000.

For all other areas, only length compositions are available. For VIId, quarterly length distributions are available from 2003 for bottom trawl and pelagic trawl. For IVbc length distributions are available from 2009 for various gears. For VIIIab length distributions per métier are available from 2000.

The statistical design of fishery sampling schemes has undergone change in recent years in the UK and France, following recommendations from ICES workshops on sampling survey design, with a move towards more representative sampling across trips within fleet segments. This can result in sampling more trips that have small catches of bass, and is one reason for the increase in numbers of sampled trips with bass since 2009 in France which does not imply an increase of the proportion in numbers of fish measured per trip.

Spain

Landings of *Dicentrarchus labrax*, which is not a target species for any Spanish fleet, were not sampled for length structure before the implementation of concurrent sampling in 2009. Length information is scarce for most part of the Spanish métiers. For this reason length structure is presented only for bottom-trawl activity in the Bay of Biscay in 2010 and 2011 where enough individuals have been sampled to allow an adequate extrapolation.

Other countries

Fishery landings length or age compositions from other countries catching bass were not available to WGNEW or IBPNew 2012. The Netherlands did collect age samples of sea bass every year from 2005 to 2008. From 2010 onwards, age samples are collected only once every three year. Otoliths and scales that are retrieved from the fish are sent to Cefas in the UK for age reading. Length samples are collected every year. All samples are collected in the auctions where most sea bass is landed, in the south of the Netherlands. The quality of the data is good enough to use them in assessments. However, both the length and age data need processing before they can be inserted in an assessment.

Effective sample sizes for length and age compositions

The effective sample size for annual estimates of length or age composition lie between the number of trips sampled and the number of fish measured or aged, due to cluster sampling effects. Effective sample sizes have not been computed yet for UK and French sampling data for sea bass. In the meantime, numbers of fishing trips sampled for length or age could be used as an annual measure of relative precision of datasets.

Accuracy and validation of age estimates

Age-reading consistency

Consistency in age reading of sea bass between four operators in Cefas and Ifremer was examined during a limited exchange of otolith and scale images between laboratories in 2011, organized by the ICES Planning Group on Commercial Catches, Discards and Biological Sampling (Mahé *et al*., 2012). A total of 155 fish of 17–74 cm was sampled on board French research vessels during two international surveys. The precision of ageing was similar for scales and otoliths. The coefficient of variation of age readings for individual fish was around 12% implying a standard deviation of +/- one year for a 10-year-old fish, with relatively few fish having identical readings by all four operators. However it was noted by the operators that photographic images were more difficult to evaluate than original age material, which was likely to have a negative effect on the consistency of ageing. These results provide no indication of the validity of ages, only the consistency between operators, and cannot indicate data quality in earlier years when different operators provided the age data. A more extensive age exchange is to be carried out in 2012.

Age validation

WGNEW was not aware of specific studies to validate absolute ages of sea bass derived from otolith or scale readings. Strong and weak year classes can be followed clearly to over 20 years of age in UK sample data although it is not known to what extent the elevated numbers of sampled fish in immediately adjacent year classes is a true reflection of year-class strength or a consequence of age errors discussed in the previous section. Year-class tracking is less clear in the younger ages 3–5 although this will be affected by gear selectivity and changes in fish behaviour.

Sea bass show relatively broad length-at-age distributions, and it has been noted in French data (Laurec *et al*., 2012, WD to IBPNew) that the length-at-age distributions can have unusual patterns including some multiple modes that could indicate age errors. This will result in some smoothing of age data across neighbouring year classes. In the UK data, unusual patterns in length-at-age distributions for some younger ages appear related more to effects of minimum landing size on data from the fishery.

Inclusion of age error parameters in Stock Synthesis model

CV's for ageing error by age class can be input to Stock Synthesis. Based on the ICES sea bass scale exchange in 2002, the CVs of ~12% can be specified as increasing values per age class to give a standard error of ~1 year per age class.

B2.2. Growth parameters

Pickett and Pawson (1994) provide plots of growth curves for female and male bass based on samples collected in the 1980s in Areas IV and VII. The samples used by Pickett and Pawson (1994) for growth and maturity analysis were obtained from a range of fishery and other sources.

A re-analysis of UK historical age–length data including more recent samples was conducted in 2012, using data for the full UK sampling series from 1985 to 2010 (Armstrong and Walmsley, 2012b). The data are derived from sampling of UK fishery catches around England and Wales as well as from trawls surveys of young bass in the Solent and Thames estuary. More than 90 000 sea bass have been aged since 1985. The inshore surveys are mainly young sea bass up to 3–5 years of age, whereas the fishery samples include fish up to 28 years of age.

All ageing is done from scales, excluding scales considered to be re-grown. On surveys, scales are collected in a length-stratified manner from individual hauls with a view to building age–length keys. A similar approach has historically been adopted for catch sampling. This may lead to non-random sampling of individual age groups when the catch numbers are well in excess of numbers sampled from an individual catch. It will also lead to some overestimation of the standard deviation of lengths-at-age.

All ages for fitting growth curves are referred to a nominal January 1 birthdate, according to month of capture. Parameters of the von Bertalanffy growth curve were fitted in Excel Solver using nonlinear minimization of ∑(obs-exp)^2 for lengths-at-age of individual fish, by area and for all data combined.

Von Bertalanffy model parameters were as follows:

AREA	IVBC	VIID	VIIE	VIIAFG	ALL AREAS
Linf (cm)	82.98	87.22	92.27	81.87	84.55
K	0.1104	0.09298	0.07697	0.09246	0.09699
t0 (years)	-0.608	-0.592	-1.693	-1.066	-0.730

Standard deviation of length-at-age distributions increases linearly with age according to:

SD (age) = 0.1166*age + 3.5609

B2.3. Maturity

Spawning grounds and season

Ripe adult bass have been caught by pelagic trawling in the south of Division VIIIa and in the north of Division VIIIb in the Bay of Biscay during January–March (Morizur, unpublished data), and planktonic egg surveys (Thompson and Harrop, 1987; Jennings and Pawson, 1992) have shown that bass spawn offshore in the English Channel and eastern Celtic Sea from February to May. Spawning started in the Mid-western Channel when the temperature range associated with bass egg distributions was 8.5–11°C, and appeared to spread east through the Channel as the surface water temperature exceeded 9°C. Seasonal patterns of occurrence of advanced maturity stages in UK samples also indicate spawning mainly January to May in ICES Areas IV and VII (Armstrong and Walmsley, 2012c). Spawning and ripe bass are also found in the southern North Sea (information from commercial fisheries and angler reports in Netherlands supplied to IBPNew 2012 by F. Quirijns).

Previous estimates of maturity-at-length/age, and data available for re-analysis

SGBASS (ICES 2004) reported that around Britain and Ireland, male bass mature at a length of 31–35 cm, aged 4–7 years, and females at 40–45 cm, aged 5–8 years, (Kennedy and Fitzmaurice, 1972; Pawson and Pickett, 1996), and data from the southern part of the Bay of Biscay (Lam Hoai, 1970; Stequert, 1972) indicate that male matures at a length of 35 cm (age 4) and females at 42 cm (age 6). Data provided by Masski (1998) from samples taken from VIIe bottom trawlers (41 females) indicate that 40% and 82% of females were mature at age 6 and 7 respectively, with a very small percentage mature at age 5.

Collection of maturity data are difficult as few adult bass are caught in surveys and bass are typically landed whole and are extremely expensive to purchase. Samples collected by the UK (Cefas) during 1982–2003 and 2009 in ICES Areas IV and VII were re-analysed for ICES IBPNew 2012 (Armstrong and Walmsley, 2012c). Samples have come from all around the coast of England and Wales, though few fish have been sampled in the Irish Sea (VIIa).

Defining a maturity marker for sea bass

Sea bass are multiple batch spawners, as indicated by size distributions of oocytes (eggs) in ovaries (Mayer *et al.*, 1990). This means that the ovary will start to mature oocytes through to vitellogenic stages during the months immediately prior to the spawning season. Historical maturity staging of sea bass by the UK has used the maturity key given in Pawson and Pickett (1996; Table B2.1). In their analyses, they treated stage 2 as mature, and stage 3 as immature. Their reasoning was that stage 3 ovaries (early maturing) were found in smaller bass than later stages (4+) indicating that many of these fish may not proceed to spawning. Sea bass migrate offshore to spawning grounds, and it is likely that early maturing fish could be over-represented, and advanced maturing fish underrepresented in inshore catches sampled during the period of spawning migrations. An additional spent stage (VIII) has been occasionally recorded.

The identification of a suitable marker to identify maturity has to take into account the probability of finding a fish at any maturity stage in different months, the duration of a stage, and the availability/catchability of fish at that stage of maturity. When the majority of mature sea bass have entered the batch spawning cycle in spring, all stages represented in batch spawning (III to VII) will be evident and should be distinct from immature fish. Hence, the best markers for maturity are the maturity stages representing different stages in the batch spawning cycle, sampled at a time when spawning is taking place (or immediately before), provided fish in all stages are equally catchable. This is the conclusion of recent ICES workshops on maturity staging of gadoids and flatfish, which recommends sampling within a month or so of the beginning and end of the spawning season. Experience with other roundfish and flatfish stocks is that it can be very difficult to distinguish between virgin females and fish that have spawned previously, when sampled in the non-spawning period. The

UK data were therefore re-analysed using samples from December to April, treating all fish of maturity stages 3 to 7 as mature.

Re-estimation of maturity ogives from UK data

Maturity was modelled using a binomial error structure and logit link function, fitted in *R* to individual observations. The logistic model describing proportion mature by 1 cm length class *L* was formulated as:

$$\text{Pmat}(L) = 1/(1+e^{-(a+bL)})$$

defined by the parameters slope b and length intecept a. Parameters were estimated separately for females and males. This can also be expressed as Pmat(*L*) = 1/(1+e-b(L+c)) where c = a/b. For Stock Synthesis 3 model inputs, the parameters required are the slope (b: entered as a negative value) and the length inflection, which is the estimated length at 50% maturity ($L^{50\%}$).

The 2009 data come from a large sample of sea bass taken in spring from a few trips specifically to revisit bass maturity, but this sample dominates the time-series of sampling which is spread over very many more trips and months than in 2009 and therefore has better coverage. Maturity ogives were therefore fitted including and excluding 2009 data. The inclusion of 2009 data, which was for a relatively restricted length range of fish around 40 cm, has the effect of improving the fit of the model near the top of the ascending limb of the maturity ogive for females (Figure B2.1). However the very high weighting for these lengths compared to the data for lengths <35 cm results in the model fitting very poorly to the smaller length classes. Excluding the 2009 data allows the length classes <35 cm to carry more weight, and the ogive appears to fit the data for 30–40 cm sea bass more closely, although the fit for lengths >40 cm is poorer. Addition of the 2009 data effectively shifts the L50% from around 41 cm to 35 cm. In contrast, inclusion or exclusion of the 2009 data has less effect on the model fit for males (Figure B2.1). On balance, it was considered undesirable for a few large hauls in a recent year to have excessive leverage in the model fit, and the model excluding 2009 was considered preferable as a long-term maturity ogive for use in assessments.

Table B2.1. Macroscopic characteristics of the maturity stages of the gonads of bass. (Pawson and Pickett, 1996).

Maturity stage		Ovary	Testis
I	Immature	Small thread-like ovary, reddish-pink	Small, colourless, thread-like; testis not practical to differentiate macroscopically <TL 20 cm
II	Recovering spent	Ovaries one-third length of ventral cavity, opaque, pink with thickened walls and may have atretic eggs	Testis one-third length of ventral cavity, often bloodshot with parts dark grey
III	Developing (early)	Ovaries up to one-half length of ventral cavity, orange-red, slight granular appearance, thin, translucent walls	Testes thickness 10–20% of length, dirty white, tinged grey or pink
IV	Developing (late)	Ovaries greater than one-third length of ventral cavity, orange-red; eggs clearly visible, but none hyaline	Testes flat-oval in cross section and thickness >20% of length, half to two-thirds of ventral cavity. White colour and milt expressed from vent if pressure applied to abdomen
V	Gravid (ripe)	Swollen ovaries two-thirds length of ventral cavity, pale yellow-orange; opaque eggs clearly visible with some hyaline	Testes bright white and more rounded-oval in cross section. Only light pressure required to cause milt to flow from vent
VI	Running	Ovaries very swollen; both opaque and larger hyaline eggs clearly visible beneath thin almost transparent ovary wall, and expressed freely with light pressure	Testes becoming grey-white and less turgid. Milt extruded spontaneously
VII	Spent	Ovary flaccid but not empty, deep red; very thick ovary wall; dense yellow atretic eggs may be visible	Testes flattened and grey, flushed with red or pink, larger than those at stage II or III

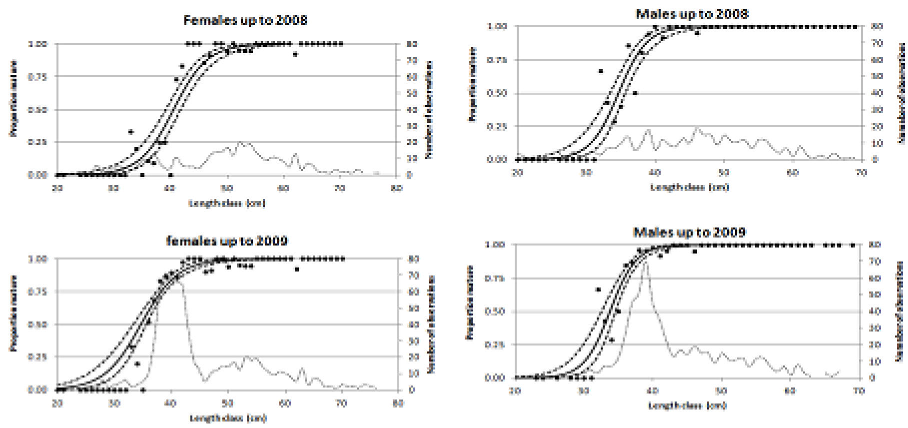


Figure B2.1. Logistic maturity ogives (with 95% confidence intervals) fitted to individual maturity records for sea bass during December–April. Top plot: excluding 2009 data (top); bottom plot: including 2009 data. Points are proportion mature in the raw data. Dotted line is the number of observations per length class.

The parameters of the model Pmat(*L*) = 1/(1+e-b(L+c)) are given below:

	A) Females	B) males
Intercept (a)	-13.556	-16.851
Slope (b)	0.3335	0.4861
c = b/a	-40.6488	-34.6652
L25%	37.35	32.41
L50%	40.65	34.67
L75%	43.95	36.93

The logistic model for females and males is:

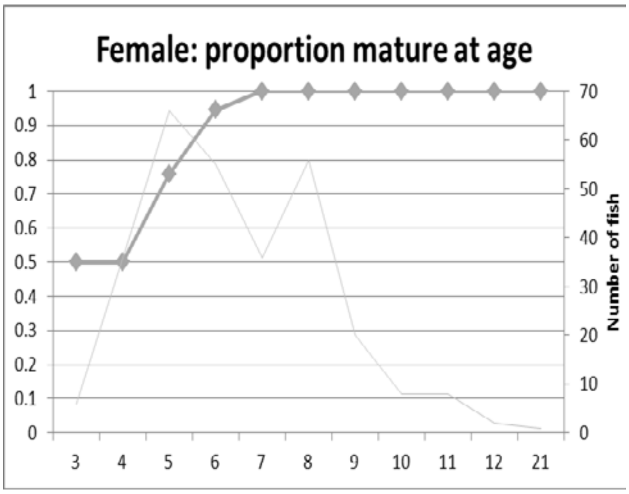
$$\mathrm{Pmat}(L) = 1/(1+e^{-0.3335(L-40.6488)}) \quad \text{(females)}$$
$$\mathrm{Pmat}(L) = 1/(1+e^{-0.4861(L-34.6652)}) \quad \text{(males)}$$

The maturation range for females occurs at ages 4 to 7, and for males at ages 3–6, as shown by the proportion mature at age in the same samples used for estimation of length-based maturity ogives (Table B2.2).

Table B2.2. Raw proportion mature at age in 1982–2003 UK samples from all areas.

	Females	Males
age 2	0.00	0.00
age 3	0.00	0.27
age 4	0.17	0.54
age 5	0.21	0.61
age 6	0.55	0.91
age 7	0.95	0.98
age 8	1.00	1.00
age 9	0.95	0.98
age 10+	1.00	1.00

Data on sea bass maturity have also been collected in the Netherlands since 2005. Methods and data are described by Quirijns and Bierman (2012). For male fish, too few specimens were measured to estimate maturity. Maturity-at-age and length is plotted in Figure B2.2. Note that only few fish were measured in the lowest age and length groups. At age 4, 50% of the females are mature. This is substantially lower than the age at 50% maturity in the Cefas 1982–2003 samples (Table B2.2), and closer to the ogive from Cefas data including the large 2009 sample (Figure B2.1), for which L50 was around 35 cm (~4 years old). This may confirm that sea bass could now be maturing earlier than in the 1980s–early 2000s, at least for the North Sea. The plot showing maturity-at-length for Netherlands samples is not based on enough measurements to show a reliable maturity ogive.



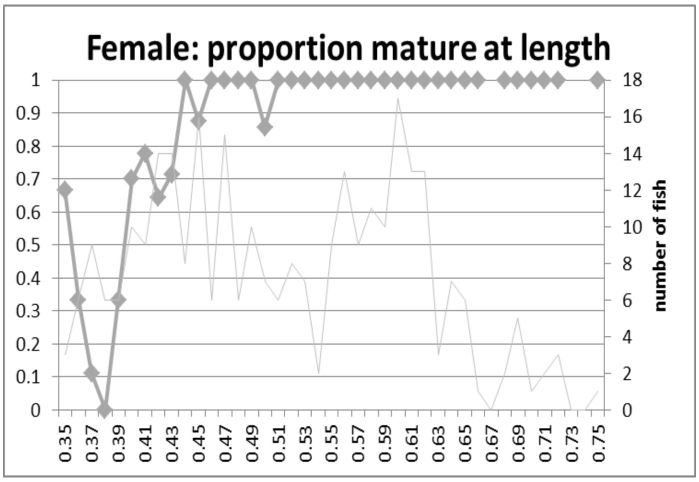


Figure B2.2. Proportion of mature at age and length (length in m) for female sea bass sampled in the southern North Sea by the Netherlands during 2005 (thick line). The thin line shows the number of fish measured on which the proportion of maturity is based.

B2.4 Larval dispersal, nursery grounds and recruitment

Bass larvae resulting from offshore spawning move steadily inshore towards the coast as they grow and, when they reach a specific developmental stage at around 11–15 mm in length (at 30–50 days old), it is thought that they respond to an environmental cue and actively swim into estuarine nursery habitats (Jennings and Pawson, 1992). From June onwards, 0-group bass in excess of 15 mm long are found almost exclusively in creeks, estuaries, backwaters, and shallow bays all along the southeast, south, and west coasts of England and Wales, where they remain through their first and second years, after which they migrate to overwintering areas in deeper water, returning to the larger estuaries in summer. Several studies indicate the existence of similar bass nursery areas in bays and estuaries on the French coasts of the Channel and Bay of Biscay and southern Ireland.

During winter, juvenile bass move into deeper channels or into open water, and return in spring to the larger estuaries and shallow bays on the open coast, where they remain for the next 2–3 years.

On the south and west coasts of the UK, juvenile bass emigrate from these nursery areas at around 36 cm TL (age 3–6 years, depending on growth rate), often dispersing well outside the 'home' range, and not necessarily recruiting to their specific parent spawning stock (Pawson *et al.*, 1987; Pickett and Pawson, 2004). It appears that there is substantial mixing of bass at this stage throughout large parts of the populations' distribution range. When they reach four or five years of age their movements become more wide-ranging and they eventually adopt the adult feeding/spawning migration patterns (Pawson *et al.*, 1994).

B2.5 Natural mortality M

There are no direct estimates of natural mortality available for Northeast Atlantic sea bass. Predation up to around age 4 will be in and near estuaries and bays. As with other fish species it is expected that M will be relatively high at the youngest ages, particularly given the slow growth rate in bass. A variety of methods are given in the literature relating natural mortality rate M to life-history parameters such as von Bertalanffy growth parameters k and Linf (asymptotic length), length or age at 50% maturity and apparent longevity particularly in an unexploited or very lightly exploited population. The probability of encountering very old bass is partly a function of the interaction of year-class strength and sampling rates, as well as mortality, however the occurrence of sea bass to almost 30 years of age suggests low rates of mortality. The observed maximum age of 28 years in sea bass samples in the UK was recorded in the early 1980s, following a period of relatively low fishery landings. Age compositions of recreational fishery caught bass in southern Ireland, presented by stakeholders at IBPNew 2012, also show ages up to 26 years (Figure. B2.3). This stock has been subject to a commercial fishery ban for many years.

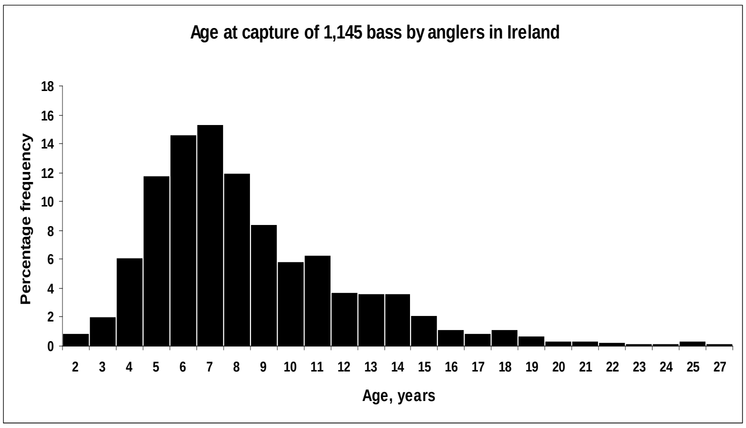


Figure B2.3. Age composition of bass from samples collected from recreational catches in southern Ireland (data courtesy Ed Fahy, IBPNew 2012 meeting).

Inferences on sea bass natural mortality based on some life-history models in the literature are given in IBPNew 2012 benchmark assessment section. The inferred values of M, with the exception of the Beverton method, are in the range 0.15–0.22 (Armstrong, 2012).

Hooking mortality of discarded/returned bass

The NMFS in the US has in the past used an average hooking mortality of 9% for striped bass, estimated by Diodati and Richards, 1996. Striped bass are very similar to European sea bass in terms of morphology, habitats and angling methods. A literature review of hooking mortality for a range of species compiled by the Massachusetts Division of Marine Fisheries included a total of 40 different experiments by 16 different authors where striped bass hooking mortality was estimated over two or more days (Gary A. Nelson, Massachusetts Division of Marine Fisheries, pers. comm.) The mean hooking mortality rate was 0.19 (standard deviation 0.19). Direct experiments are needed on European sea bass to estimate hooking mortality for conditions and angling methods typical of European fisheries.

B.3 Surveys

B3.1 UK Solent and Thames prerecruit surveys

The UK has conducted prerecruit trawl surveys in the Solent and the Thames Estuary since 1981 and 1997 respectively. These surveys all ended in 2009 although the Solent survey was repeated as a one-off survey in autumn 2011 to help provide recruitment indices for the bass benchmark assessment. The location of the surveys and the tow positions are shown in Figure B3.1. Both surveys use a high headline bass trawl, although in the Thames it is deployed as a twin rig and in the Solent as a single rig.

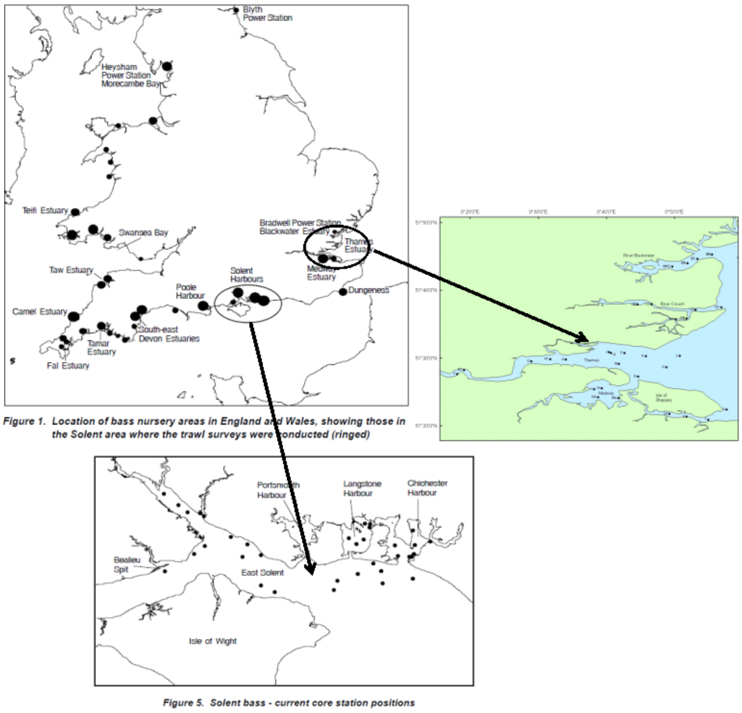


Figure B3.1. Location and tow positions for UK(England) Solent and Thames sea bass surveys.

The Solent survey has previously been presented to WGNEW as a combined index across ages in each year class. The index was derived by firstly rescaling the annual mean catch rate per age class to the mean for that age in the survey series, then taking the average of the rescaled values for ages 2–4 in each year class from surveys in May–July and September (i.e. up to six values represented in the annual combined index). The Thames survey data were worked up in the same way, although using a different age range for the combined index (ages 0–3). WGNEW 2012 provided the survey data in the more conventional tuning-file format, giving the standardized catch rates (arithmetic mean nos. per 10 minute tow) by year and age, separately for the two surveys (data in assessment report). These surveys have now been discontinued and will not be updated by future working groups unless new resources are allocated.

B3.2 Other 0-gp & 1-gp surveys

The UK has undertaken a seinenet survey in the Tamar Estuary, since 1985. Additional data are available from the Camel estuary and power stations in the Thames and Severn Estuary. These surveys are used as supporting information and not included in the assessment. Abundance indices for these surveys are given in Table B3.1. The Tamar survey abundance indices need to be updated to include more recent surveys. Seinenet surveys in the UK estuaries Fal and Helford also have data on 0-gp and 1-gp bass.

Table B3.1. Abundance indices for 0-gp and 1-gp bass. († discontinued).

	Estuary seine surveys			Power station screen	
	Tamar (0-group)	Tamar (1-group)	Camel	Severn	Thames
	VIIe	VIIe	VIIf	VIIf	IVc
1972				3	
1973				4	
1974				1	
1975				15	78
1976				127	100
1977				-	6
1978				-	5
1979				-	5
1980				9	37
1981			2	216	21
1982			123	83	56
1983			30	226	83
1984			134	8	62
1985	0.663	0.385	22	11	76
1986	0.005	0.014	1	3	14
1987	0.032	0.062	31	96	116
1988	1.484	1.284	48	98	54
1989	2.348	2.389	112	446	610
1990	1.038	1.516	89	25	433
1991	0.076	0.058	50	300	64
1992	2.216	2.431	25	280	104
1993	1.013	0.913	22	202	131
1994	1.126	0.346	134	-	26
1995	2.356	1.294	-	-	27
1996	0.102	0.047	119	242	†
1997	1.119	1.299	102	†	
1998	2.082	3.170	264		
1999	1.215	0.937	56		
2000	0.340	1.185	133		
2001	0.351	0.129	†		
2002	2.098	3.179			
2003	0.965	1.067			
2004	1.453	0.261			
2005	0.522	0.169			
2006	0.186	0.203			
2007	0.475	1.308			
2008	1.275	1.229			
2009	0.460				

B3.3 Evhoe survey: France

Sea bass are caught in small numbers in the French Evhoe trawl survey, which extends to the shelf edge in Subareas VII and VIII but also extends into coastal areas of the Bay of Biscay and the Celtic Sea where bass may be caught (cf the station map). Less than 10% of the stations have bass catches in most years. A mean of 0.5 sea bass per trawl has been recorded from 1987. Abundance indices are calculated as stratified means.

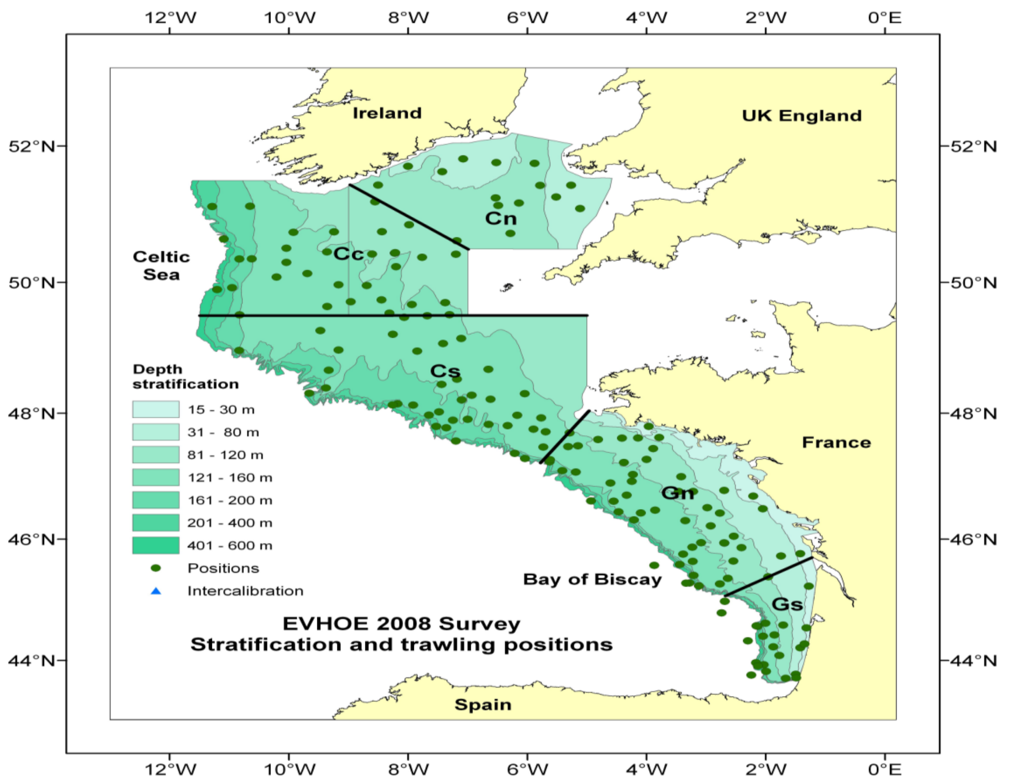


Figure B3.2. Station positions for French Evhoe bottom-trawl survey.

B.4 Commercial lpue

B4.1 UK bass logbook scheme

The UK bass logbook scheme is described in Section B1.1. Although the survey has severe limitations for estimation of total bass landings for UK vessels, individual logbooks provide time-series of varying duration on catch-rates of individual vessels using specific gears. The logbooks with sufficient data cover eight gear types within trawls, nets and lines, covering mainly 10 m and under vessels, excluding recreational vessels. The total numbers of logbooks have declined from 50–60 in earlier years to below 20 in recent years. No logbooks were issued in 2008:

Region	Year 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	7	9	11	19	9	8	15	16	15	22	16	14	18	16	16
2	0	10	10	15	17	14	13	23	10	25	24	20	24	19	17
3	2	4	6	5	7	7	4	6	7	6	9	3	8	5	3
4	5	5	7	9	7	8	7	11	11	4	6	4	4	4	4
5	7	6	10	13	9	9	10	18	8	10	9	7	11	12	11

Region	Year 2000	2001	2002	2003	2004	2005	2006	2007	2009	2010
1	16	19	14	12	13	8	6	0	3	3
2	15	15	13	14	7	10	5	0	3	2

3	2	5	3	5	5	5	7	0	3	3
4	4	5	6	7	1	3	4	0	3	1
5	9	10	9	4	2	5	6	2	1	1

(Region 1: North Sea IVbc, 2: eastern Channel VIId; 3: western Channel VIIeh; 4: Celtic Sea (VIIfg); Irish Sea (VIIa). The trend in number of records per year shows roughly the same pattern across gears:

An exploratory GAM method was developed (Armstrong and Maxwell, 2012) to extract a common temporal trend in lpue from the individual series for ICES Areas IVbc&VIId, VIIeh and VIIafg (referred in the models as areas 1&2, 3 and 4&5). This is analogous to combining series of tree ring counts from timbers of various ages to give a single series describing climate changes. The general method involves estimating logbook factors and year factors (and interactions) to minimize residual model error. Following initial model development and evaluation, a negative binomial error distribution with log link was selected. This can accommodate zero values and allows for the variance to increase with the mean. Working with a log link implies that the estimated trend with year is multiplicative not additive. The R command showing the exact options used for areas 1&2 combined (North Sea and VIId) is:

bass.gam3.12 = gam(lpue ~ factor(BookGear) + s(Year, k=10, bs="ts"), family=negbin(c(1,10)), optimizer="perf", data=bass.dat, subset=ARegion=="1and2")

Fitted trends and confidence intervals suggest an increasing lpue trend in regions 1&2 (North Sea & VIId), and 3 (VIIeh) (Figure B4.1). A relatively flat trend and possible recent decline is indicated in regions 4&5 (VIIafg) although the recent trend is highly imprecise. Residual checks indicate the model assumptions are reasonable. Model diagnostics and sensitivity to smoothing and other parameters are given in Armstrong and Maxwell (2012).

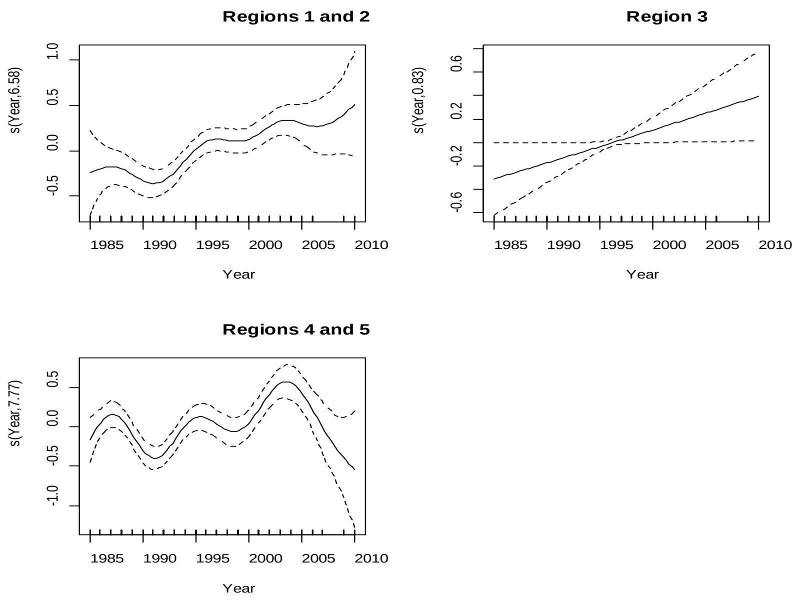


Figure B4.1. Cefas bass logbook lpue: Selected model for combined regions, plots showing year effects from a fitted model with separate mean value for each book number-gear combination and negative binomial error distribution, dashed lines are a 95% confidence interval.

B4.2 UK fleet lpue based on official catch dataseries

Armstrong and Maxwell (2012) review trends in UK commercial fishery lpue for sea bass in the North Sea (IV), eastern Channel (VIId), western Channel (VIIe) and Irish/Celtic Seas (VIIafg) from 1985–2011, and evaluate the possibility of using the time-series as relative abundance estimates for tuning stock assessment models.

Gears which catch bass are targeted at a variety of species, and the fishing effort is distributed across many areas where sea bass have zero or very low probability of capture. A number of approaches are possible to subset fishing trips to include only those that have a probability of catching the species for which lpue is to be estimated. One approach (Stephens and MacCall, 2004) is to cluster fishing trips according to species that occur in association, and use only the cluster with the species on interest for estimating lpue. This method has not yet been applied to UK data. An alternative method to subset trips was applied. This involved (a) selecting gear types that account for ~95% of the total bass landings in each area since 2005; (b) for the selected gears and areas, identify ICES rectangles accounting for ~95% of the total bass landings since 1985. Annual lpue was then estimated for each area and gear, separately for vessels of 10 m (LOA) and under and >10 m vessels. The LOA split is important because reporting of landings and effort of 10 m and under vessels has been very uncertain historically, particularly prior to the introduction of Buyers and Sellers regulations in 2005. Lpue of 10 m and under vessels may be very inaccurate prior to 1995.

It was not possible to evaluate the effect of any increase in targeting of bass by individual vessels using the selected gear types in the selected rectangles, or effects of technology creep. Increased targeting is likely to have happened for vessels with increasingly limited quotas for other species such as cod and which have switched to non-TAC species such as sea bass. For some gears, such as beam trawls, sea bass are not targeted and are purely a bycatch.

Too many lpue series have been examined to reproduce in the Stock Annex, but can be viewed in Armstrong and Maxwell, 2012.

B4.2 French lpue sets

Lpue of French trawlers in IVb,c, VIId and VIIeh is available from 2000 when Ifremer has estimated landings by ICES Divisions. A recent study has developed indices as kg/per day based on data from auction's sales. This study was carried out on French bottom trawlers (less than 18 m), having a fishing strategy with the least distant random sampling; this fleet usually doesn't target sea bass. Large Bias can be caused where: 1. an auction sale corresponds to several days of fishing, 2. technological advances are not taken into account, and 3 changes in fishermen's strategies are not taken into account. Never the less, for information, those from the Channel and North Sea have been compared to the UK Otter trawls lpue, and similarities shown on Figure B4.2 are observed. French lpue sets of the Bay of Biscay are available but require validation.

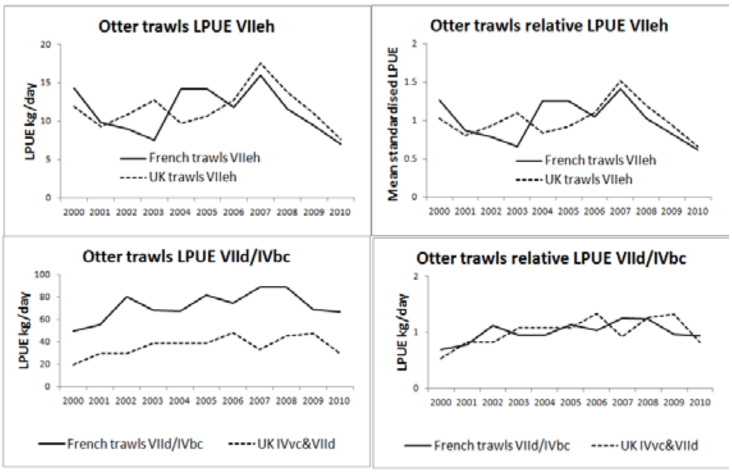


Figure B4.2. UK fleet lpue based on official catch dataseries, compared to the French lpue sets based on auction hall sales.

B4.3 Spain-Portugal: Biscay/VIII/IX

Landings and effort data were provided to IBPNew.

B.5. Other relevant data

None.

C. Assessment: data and method

Model used: Stock Synthesis 3 (SS3) (Methot, 2010)

Software used: Stock synthesis v3.23b (Methot, 2011)

The development of a sea bass assessment model by IBPNew 2012 was built on experiences from application of the statistical, fleet-based separable model developed by Pawson *et al*. (2007a) and updated by ICES WGNEW (Kupschus *et al*., 2008). The Pawson *et al*. model was fitted only using UK age compositions for trawls, midwater trawls, nets and lines, separately for Areas IVbc, VIId, VIIeh and VIIafg, and was intended mainly to estimate fleet selection patterns. Although it excluded any tuning data, the recruitment-series for each sea area closely resembled the Solent survey indices and to an extent the shorter Thames series, and was able to provide coherent selection patterns by fleet.

The IBPNew 2012 assessment required a modelling framework capable of handling a mixture of age and length data for fisheries, including data for French fleets that had length composition data but no age composition data, and for which the length data were available only since the 2000s. The Stock Synthesis (SS) assessment model was chosen, primarily for its highly flexible statistical model framework allowing the building of simple to complex models using a mix of data compositions available. This model is written in ADMB (www.admb-project.org), is forward simulating and available at the NOAA toolbox: http://nft.nefsc.noaa.gov/SS3.html. For European sea bass a range of assessment models were built using Stock Synthesis 3 (SS3) version 3.29b to integrate the mix of fisheries and survey data available (fleet-based landings; landings age or length compositions and discards length compositions for variable combinations of fleets and years; three surveys providing recruitment indices) and biological information from recent research on growth rates, maturity and mortality.

Two basic model structures were explored, with the same specifications where possible:

1) Age and length model; including age compositions for the four UK fleets and combined length compositions for the French fleets;
2) Length only model; including only the length composition data for all fishery fleets.

Input data

Years: 1985–2010

Model structure

- Temporal unit: annual based data (landings, lpue, age–frequency and length–frequency);
- Spatial structure: One area;
- Sex: Both sexes combined.

Fleet definition

Six fleets were defined as the gear for UK vessels, France and Other:

- UK trawl;
- UK midwater trawl;
- UK nets;
- UK lines;
- French fleets (combined);
- Other (Other countries and Other UK fleets combined).

Landed catches

Annual landings in tonnes from 1985 to 2010 for the six fleets from ICES Subdivisions IVb and c, VIIa, d–h were used in the assessment.

Abundance indices

Ten abundance indices were defined for each age up to four years for different areas and time period.

- Spring Solent survey in ICES Subdivision VIId covering ages 2 to 4 for years 1985 to 2009;
- Autumn Solent survey in ICES Subdivision VIId covering ages 2 to 4 for years 1986 to 2009;
- Autumn/Winter Thames survey ICES Subdivision IVc covering ages 0 to 3 for years 1997 to 2009.

Age composition of data for age–length model

The age bins were set at 0 to 11 with a plus group for ages 12 and over. Age compositions for four fishing fleets were used. The available age data and their disaggregated level differ among fleets:

- UK trawl; Annual total numbers and mean weight in kilograms for 1985 to 2010 were used in the age–length model;

- UK midwater trawl; Annual total number and mean weight in kilograms for 1985 to 2010 were used in the age–length model. Gaps in the time-series were present, for years 1986, 1990, 1993, 1997 and 2006;
- UK nets; Annual total numbers and mean weight in kilograms for 1985 to 2010 were used in the age–length model;
- UK lines; Annual total numbers and mean weight in kilograms for 1985 to 2010 were used in the age–length model.

Length composition of data

The length bin was set from 4 to 100 cm by 2 cm intervals. Length compositions for five fishing fleets were used. The available length data and their disaggregated level differ among fleets:

- UK trawl; Annual total numbers for 1985 to 2010 were used in the length only model;
- UK midwater trawl; Annual total numbers for 1985 to 2010 were used in the length only model;
- UK nets; Annual total numbers for 1985 to 2010 were used in the length only model;
- UK lines; Annual total numbers for 1985 to 2010 were used in the length only model;
- French all fleets combined; Annual total numbers for 2000 to 2010 were used in both the age–length and length only model.

Model assumptions and parameters

CHARACTERISTIC	SETTINGS
Starting year	1985
Ending year	2010
Equilibrium catch for starting year	Mean landings by fleet: 1980–1984
Number of areas	1
Number of seasons	1
Number of fishing fleets	6
Number of surveys (recruit surveys)	3 surveys, modelled as 10 single-age fleets at ages 0–4
Individual growth	von Bertalanffy, parameters fixed, combined sex
Number of estimated parameters	48
POPULATION CHARACTERISTICS	
Maximum age	30
Genders	1
Population length bins	4–100, 2 cm bins
Ages for summary total biomass	0–12+
DATA CHARACTERISTICS	
Data length bins (for length structured fleets)	14–94, 2 cm bins
Data age bins (for age structured fleets)	0–12+
Minimum age for growth model	0 [age 2 for age–length model]
Maximum age for growth model	30
Maturity	Logistic 2-parameter – females; L50 = 40.65cm

Characteristic	Settings
Fishery characteristics	
Fishery timing	-1 (whole year)
Fishing mortality method	Hybrid
Maximum F	2.9
Fleet 1: UK Trawl selectivity	Asymptotic
Fleet 2: UK Midwater trawl selectivity	Asymptotic
Fleet 3: UK Nets selectivity	Asymptotic (dome shaped forsensitivity run)
Fleet 4: UK Lines selectivity	Asymptotic
Fleet 5: Combined French fleet selectivity	Asymptotic
Survey characteristics	
Solent spring survey timing (yr)	0.42
Solent autumn survey timing (yr)	0.83
Thames survey timing (yr)	0.75
Catchabilities (all surveys)	Analytical solution
Survey selectivities	[all survey data entered as single ages; sel = 1]
Fixed biological characteristics	
Natural mortality	0.2
Beverton–Holt steepness	0.999
Recruitment variability (σR)	0.9
Weight–length coefficient	0.00001296
Weight–length exponent	2.969
Maturity inflection (L50%)	40.649 cm
Maturity slope	-0.33349
Length-at-age Amin	5.78 cm
Length-at-Amax	80.26 cm
von Bertalanffy k	0.09699
von Bertalanffy Linf	84.55 cm
von Bertalanffy t0	-0.730 yr
Std. Deviation length-at-age (cm)	SD = 0.1166 * age + 3.5609

D. Short-term projections

To be determined.

E. Biological reference points

To be determined.

F. Other issues

F.1 Historical overview of previous assessment methods

No previous methods for international data.

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