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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 Executive Summary

WKFLAT 2011 met from 1st to 8th February 2011 at ICES headquarters in Copenhagen. The meeting was chaired by Rob Scott (JRC) and the ICES co-ordinator was Jean-Claude Mahé (France). Chris Legault (USA) and Chris Francis (New Zealand) participated in the meeting as invited external experts. A total of 16 participants from seven countries were in attendance. Stakeholder representatives were in attendance for part of the meeting.

The main goals and objectives of the meeting were to evaluate the appropriateness of stock assessment data and methods for five flatfish stocks. These included sole in VIIa, sole in VIIIab, plaice in VIIa, plaice in VIIfg and megrim in IV and VI. For each stock the preferred stock assessment method was determined and the stock annexes updated with the agreed procedures for generating and collating the input data to the stock assessment and the methods for estimating stock status. Much of the work during the meeting focused on data quality issues. Issues relating to assessment methodology were considered only later in the meeting. Alternative assessment approaches were investigated for all stocks although in some cases time constraints allowed only for preliminary investigations to be conducted. The main results of the meeting were:

Sole in VIIIab (Bay of Biscay): Two new cpue series were calculated for French commercial vessels and were investigated for inclusion in the stock assessment. The existing assessment method (XSA) was retained with virtually no modifications to parameter settings, but including the two new tuning-series.

Sole in VIIa (Irish Sea): Alternative methods for raising the international catch-at-age matrix were investigated in order to reduce the impact of recent changes in sampling levels that have occurred at the national level. The existing assessment method (XSA) was retained with only minor modifications to the parameter settings.

Plaice in VIIa (Irish Sea) and **Plaice in VIIfg** (Celtic Sea): Several alternative methods were investigated to explore options for incorporating a short time-series of discard observations into the assessment. None of the approaches examined proved to be entirely satisfactory. The group concluded that the Aarts and Poos (2009) method, developed initially for North Sea plaice, could be used as a trends only assessment for the provision of management advice but could not be used as a basis for predicting future catch options.

Megrim in VI and IV: Only very limited data were available to WKFLAT. The group considered the basis for the stock definition and concluded that there was little evidence that megrim in Subdivisions VI and IV comprise separate stocks. WKFLAT applied several assessment methods to the data but was unable to recommend a preferred assessment for this stock.

2 Introduction

This benchmark workshop was convened in accordance with the advisory structure established by ACOM in 2007. Draft terms of reference were outlined in the document 2010/2/ACOM40. The main goals and objectives of the meeting were to evaluate the appropriateness of stock assessment data and methods for flatfish stocks of plaice in the Irish Sea and Celtic Sea, sole in the Irish Sea and Bay of Biscay and megrim in Subareas VI and IV. The key aspects of the terms of reference were:

- To compile and evaluate data sources for stock assessment.
- To solicit relevant information from industry and other stakeholders.
- To update the relevant stock annexes to provide a comprehensive description of the agreed procedure for generating assessment input data and for conducting the assessment according to the agreed method.

The initial work of the benchmark workshop was devoted to exploratory analyses of the available data with subsequent work focusing on addressing a number of assessment issues, to the extent possible.

The workshop was chaired by Rob Scott (JRC) with ICES co-ordinator, Jean-Claude Mahé (FR). Chris Legault (USA) and Chris Francis (NZ) attended as invited experts. Other participants included members of the ICES stock assessment working groups (WGCSE and WGHMM), industry representatives and members of the ICES secretariat. A full list of participants is provided in Annex 2.

Many of the issues that had been highlighted for consideration by WKFLAT related to data quality concerns, either in landings-at-age information, survey data or in discards sampling information. For this reason a longer period was allocated to the initial data workshop to allow these issues to be sufficiently addressed.

The main goals and objectives of the meeting were to evaluate the appropriateness of stock assessment data and methods for five flatfish stocks. These stocks included sole in VIIa, sole in VIIIab, plaice in VIIa, plaice in VIIfg and megrim in IV and VI. For each stock the preferred stock assessment method was determined and the stock annexes updated with the agreed procedures for generating and collating the input data to the stock assessment and the methods for estimating stock status. The group was unable to allocate sufficient time to a thorough examination of methods for short-term forecasting or to the re-examination of reference points. However, these issues were only relevant to two of the stocks considered and no problems with the approaches taken for these stocks had previously been identified.

3 Plaice in the Irish Sea (VIIa)

3.1 Current assessment and issues with data and assessment

In 2010, ICES considered that the state of the stock of plaice the Irish Sea was not known precisely. However, trends in the survey-series indicated an increasing stock and declining total mortality; ICES advised that the stock was above B_{pa} and below F_{pa}.

Historically plaice were targeted seasonally in the mixed demersal otter trawl fishery, but the fleet has declined markedly in the last decade (Figures 3.1 and 3.2). Plaice are taken as a bycatch in beam trawl fisheries targeting sole and in *Nephrops* trawlers. WGCSE (ICES 2010) noted that total effort (hours fished) for the mixed demersal otter trawl and beam trawl fleets had declined to the lowest level since 1979. The introduction of effort regulation in the early 2000s, in order to protect cod, effectively encouraged vessel operators to reduce mesh size and shift to other fisheries, particularly *Nephrops* trawling (Figures 3.1 and 3.2). Between 2005 and 2006, there was a significant increase in effort by the UK *Nephrops* fleets using mesh 89–99 mm (Figure 3.2). There is a high rate of discarding in all fleets. In 2009, observer data indicated 90% discarding by number in the UK fleet and 99% by the Irish fleet.

The assessment of plaice in the Irish Sea (VIIa) has been conducted using an ICA model since 2005. WGCSE (2010) estimated that fishing mortality rose to very high levels in the mid 1970s (F_{bar} >0.8) but declined from these levels over the subsequent 40 years. Since the early 1990s fishing mortality displayed a marked and almost continuous decline and in 2009 was estimated to be at the lowest level in the time-series (0.046). High SSB levels occurred at the beginning of the time-series, and although SSB was estimated to have been rising steadily since 2000 WGCSE still considered SSB short of the earlier highs. Estimated recruitment levels have been variable over the time-series but declined markedly in the early 1990s. Recruitment displayed only minor variations until 2008, which was estimated to be the highest value since 1988. However, this was followed by a recruitment estimate in 2009 of the lowest in the time-series.

The assessment method (ICA) employed by WGCSE in 2010 did not include discards in the catch and this was considered by the review group as a potential cause of the retrospective patterns, namely a consistently biased pattern for SSB (overestimated) and F_{bar} (underestimated). Discard rates in the plaice fishery can be very high and the lack of discards information in the stock assessment is considered a major deficiency in the methods employed to estimate stock status.

Regarding tuning information, a single survey with age information, UK-BTS, has been provided in recent years but this survey index had been based on limited spatial coverage (northeastern VIIa, east of the deep trench). An alternative survey, the NI-GFS, conducted in spring and autumn with greater spatial coverage suggests differing trends between sectors of the Irish Sea. However, due to a lack of age sampling the NI-GFS survey provides spawning biomass indices only. The NI-GFS indices are created using a time-invariant maturity ogive and a time-invariant unsexed length–weight relationship; both of which were determined from UK-BTS data for the entire Irish Sea combined and for the aggregated period 1993–2002. Changes in the maturity ogive and the length–weight relationship over time may thus lead to bias in the NI-GFS indices.

3.2 Compilation of available data

3.2.1 Catch and landings data

The summer fishery for plaice typically occurred in the northeastern Irish Sea, while the main sole fishery, which catches plaice as a bycatch, is situated in Liverpool and Morecambe bays. The *Nephrops* grounds are located in the western Irish Sea where many small plaice are found. Landings of plaice in 2009 were split between three major nations: Belgium 41%, UK (E&W) 38% and Ireland (21%). The landings were split evenly between beam trawlers (primarily Belgian vessels) targeting sole and otter trawlers fishing for whitefish or *Nephrops*.

Landed numbers-at-age for the younger ages (ages 2 to 4) have declined more rapidly over the last two decades than landings of older fish, despite the fact that large numbers of younger fish are caught by the beam trawl survey. This may indicate that the selection pattern and/or discarding behaviour of the fleets has changed over time but may also be a consequence of an increase in numbers of fish at older ages due to reduced fishing mortality in recent years. It is quite likely that both of these factors have contributed to this observation.

The procedures used to determine the total international landings figures are documented in the annex.

Although a sex-separated assessment of Irish Sea plaice could be taken into account, WKFLAT was not able to address this issue because the work required to raise the historical landing-series was too great.

Routine discard sampling has been conducted by the UK (E&W) since 2000 and by Ireland since 1993. Northern Ireland has collected data from 1996 but not between 2003 and 2005, and by Belgium since 2003. Length distributions of landed and discarded fish estimates have been presented by WGCSE (ICES, 2010) for UK (E&W), Irish and Belgian fleets.

WKFLAT used UK (E&W) discard sampling data from 2002 for otter trawlers and *Nephrops* trawlers, beam trawlers (some years) and also for gillnets and seines. A custom-designed raising procedure was developed for these data following the approach taken by Cefas previously for raising the discard data for the North Sea for input into STECF (see WD 3). Quarterly length frequencies were raised by landings and ALKs by sex were constructed using data from discard sampling, scientific surveys and market sampling.

WKFLAT investigated the Belgian discard data for the period since 2004. Few vessels were sampled by the Belgian programme and all were beam trawlers as indeed are the Belgian vessels fishing in VIIa. Quarterly length frequencies were raised by landings using COST in R (see WD 4). Quarterly ALKs constructed from discard sampling and market sampling.

WKFLAT also raised the discard data from the Republic of Ireland sampling programme by fishing effort (number of days) for 1996–1998, 2003–2005 and 2007–2009 (see WD 5). These data were not included in the total international discard numbers-at-age matrix due to concerns over data quality (see WD 6).

International discard tonnages and numbers-at-age were raised from UK (E&W) and Belgian data; Figure 3.3. The UK (E&W) national estimates were raised to incorporate additional discards from Ireland, N. Ireland, Scotland, and Isle of Man then collated with the Belgian data to give international numbers-at-age and tonnages discarded.

There is no accurate information on the level of misreporting, but given the partial uptake of the agreed TAC in recent years, it is not considered to be a significant problem for this stock.

Derivation of catch weight and stock weight-at-age

Historically, catch weights-at-age were constructed by fitting a quadratic smoother through the aggregated catch weights for each year. WKFLAT decided not to continue with this approach, but to make use of the mean weight-at-age from the landings data SOP corrected but unsmoothed (see WD 6). The quadratic smoothing was removed from data from 1995 onwards and WKFLAT recommend that this removal be continued as far back into the historical data as possible.

Stock weights-at-age have been constructed by back-calculating to the 1st of January from the aggregated catch weights for each year. A quadratic smoother (the same as above for catch weights-at-age) has been used by WGCSE for this purpose. WKFLAT decided not to continue with this approach, but to make use of the mean weight-at-age from the landings data as above for the catch weights.

Discard weights-at-age were also calculated by WKFLAT (see WD 6) for the years 2004–2009. However, these are based on data from Belgium and UK (E&W) only. Also the Belgian discard data were converted from length to weight using quarterly condition factors determined from UK(E&W) data (see WD 4). So, while the discard weights-at-age were indeed used in the assessment model, the stock weights-at-age were not altered to incorporate the discard weight-at-age information. This is an outstanding issue not fully addressed by WKFLAT and requires further work.

3.2.2 Biological data

Annual natural mortality (M) is assumed to be constant over ages and years, at 0.12 yr^{-1}. The value was estimated directly from tagging studies and has remained unchanged since 1983.

The maturity ogive used is based on survey information for this stock:

Age	1	2	3	4	5	6 and older
Mat.	0.00	0.24	0.57	0.74	0.93	1.00

Proportions of M and F before spawning are set to zero.

Plaice exhibit a high degree of sexual dimorphism in growth. Males reveal much reduced rates of growth after reaching maturity, whereas females continue to grow. The minimum landing size for plaice is 27 cm. Consequently the majority of landings represent mature females.

3.2.3 Survey tuning data

A single survey, UK-BTS, has been provided in recent years with age information and this survey index had been based on limited spatial coverage (northeastern VIIa). An alternative survey, the NI-GFS, conducted in spring and autumn has greater spatial coverage and suggests differing trends between sectors of the Irish Sea. However, due to a lack of age sampling the NI-GFS survey provides biomass indices only.

As was noted by WGCSE (ICES 2010), there is a conflict between the age-structured UK-BTS and the NI-GFS biomass indices. For use at WKFLAT, the UK-BTS index was extended to include stations across the entire Irish Sea (see WD 7). However, the conflict between the age-structured UK-BTS and the NI-GFS biomass indices was not fully resolved. There is some similarity between the two surveys when investigated by sector within VIIa, for example in the eastern Irish Sea both indicate sustained rises in biomass since 2001, while in the western Irish Sea both indicate a period of high biomass between 1990-2004 followed by a decline afterwards (Figure 3.4).

The SSB of plaice in the Irish Sea is also independently estimated using the Annual Egg Production Method (AEPM, Armstrong *et al.*, 2010). The results demonstrate substantial differences to ICES assessment values (from ICA), but they do confirm that SSB of plaice in the Irish Sea is lightly exploited. Splitting the SSB estimates from the AEPM into eastern and western Irish Sea areas also indicates that the perceived increase in plaice biomass is due to increased production in the eastern Irish Sea only in agreement with the trends noted above in UK-BTS and NI-GFS data (Figure 3.4 and ICES, 2010).

Details are provided in the stock annex.

WKFLAT noted that length-at-age of plaice has been declining throughout the Irish Sea, as indicated from the analysis of the extended UK-BTS (see WD 7). Further analysis is required to determine if fish have been maturing at an earlier age. The implications for the NI-GFS indices of the decline in mean length-at-age of plaice, must be evaluated given that the indices relies on a constant maturity ogive over length for unsexed fish to separate spawning plaice from immature plaice.

3.2.4 Commercial tuning data

Commercial lpue data has not been used in the assessment since 2004. Nevertheless, age based tuning data are available from three commercial fleets; the UK (E&W) otter trawl fleet for demersal fish only (UK (E&W) OTB, 1987–2008), the UK (E&W) beam trawl fleet (UK (E&W) BT, 1989–2008) and the Irish otter trawl fleet (IR-OTB, 1995–2008). WKFLAT chose not to reinstate the commercial lpue data because it is likely biased by the high rates of discarding. The recent low level of effort and very few fish recorded by these fleets is also problematic.

3.2.5 Industry/stakeholder data inputs

There was no industry/stakeholder data available at this benchmark meeting.

3.2.6 Environmental data

There was no further environmental data available at this benchmark meeting.

3.3 Stock identity, distribution and migration issues

Plaice occur throughout the Irish Sea, but are more abundant in areas of sandy substratum and in shallow waters with depths less than 50 m. No information other than the historical tagging studies of Dunn and Pawson (2002) was available at this benchmark meeting (see ICES 2010 and the annex). Very little mixing is considered to occur between the Irish Sea and Channel stocks or between the Irish Sea and North Sea (Pawson, 1995). However, very little mixing is evident between eastern and western Irish Sea areas indicating potential substocks within the Irish Sea. The survey data also indicate differing trends in biomass between the sectors and differing mean lengths-at-age (see Section 3.2.3, Figure 3.4 and WD 7). Similarly discard rates have an inherent spatial pattern (see WD 5), while the *Nephrops* fleet discard plaice on the western Irish Sea, the beam trawl fleet impacts the eastern area. WKFLAT did not pursue further analyses of substock structure in the catches because the international landings and discard data were not readily available on the scale required.

The management unit is considered to correspond to the stock unit for Irish Sea plaice.

3.4 Influence of the fishery on the stock dynamic

No information on the influence of the fishery on the stock dynamic was available at this benchmark meeting.

3.5 Influence of environmental drivers on the stock dynamic

No further information on the influence of the environmental drivers on the stock dynamic was available at this benchmark meeting. Time-series of recruitment estimates for all stocks in waters around the UK (Irish Sea, Celtic Sea, western and eastern Channel, North Sea) demonstrate a significant level of synchrony (Fox *et al.*, 2000). This could indicate that the stocks are subject to similar large-scale environmental forces and respond similarly to them.

3.6 Role of multispecies interactions

3.6.1 Trophic interactions

Lynam *et al.* (2011) have also demonstrated a planktonic regime shift in the 1980s in the Irish Sea with a decline in copepod biomass and an increase in phytoplankton. The extent to which changes in the ecosystem might impact on plaice is unknown.

No further analysis on trophic interactions was carried out at this benchmark meeting.

3.6.2 Fishery interactions

It is notable that the effort by the Belgian fishery in the Irish Sea depends on the fishing opportunities for flatfish in the Channel.

3.7 Impacts of the fishery on the ecosystem

No further information on the impact of the fishery on the ecosystem was available at this benchmark meeting. Discarding rates of other species in VIIa, including non-commercial species such as should be investigated further.

3.8 Stock assessment methods

3.8.1 Models

A number of alternative modelling approaches were applied to the Irish Sea plaice stock. These included the Aarts and Poos (Aarts and Poos, 2009) model that had previously been developed to address a very similar problem for the stock of North Sea plaice, the ASAP model (NOAA fisheries toolbox, see Section 5.8.1.1) and CASAL (Bull *et al.*, 2008).

The preferred model used by WKFLAT for the assessment of plaice in the Irish Sea is a version of the Aarts and Poos model for North Sea plaice adapted to include relative SSB indices and a plus group, hereafter the AP model. The assessment settings are shown in the following text table, with changes to the previous year's settings highlighted in bold. Historical settings are given in the stock annex.

Comparative analyses were conducted using the statistical catch-at-age model ASAP. The feature of ASAP which allows catch in weight to be estimated with error was utilized to explore whether the plaice VIIa data contained sufficient information to allow estimation of discards for years prior to 2004. Discard observations were available for years 2004–2009 and a range of assumptions were used for prior years with large coefficients of variation in the model fitting. The hope was that the estimated discards for years prior to 2004 would be robust to different series of input values due to the information in the other data sources, specifically the catch-at-age and survey data. Discards were treated as a fleet separate from the landings fleet.

CASAL is a statistical fisheries stock assessment programme that is designed to allow the user a great deal of flexibility in terms of model structure and fitting options (a detailed description is provided in the User Manual, Bull *et al.*, 2008). It is used in most assessments in New Zealand, and some in CCAMLR.

The model was age structured (initially ages 0–15; later 0–9), without sex (the available data were unsexed). All landings and discards (where used) were assumed known exactly (in tonnes). The following observations were fitted to:

Absolute abundance	AEPS
Relative abundance	NIGFSMar, NIGFSOct, UKBTSbio
Proportions-at-age	trawlpropns (from the fishery, all fleets/methods combined) discpropns (from discards), UKBTSpropns

and the following parameters were estimated: B_0 and $B_{initial}$ (1964); year-class strengths; catchabilities for the relative abundance indices; and selectivities for UKBTS, discards, trawl (1964–1970, 1971–1984, 1985–1996, 1997–2009). The estimated selectivities were initially double normal, but later 'allvalues' (i.e. one parameter per age, with a small smoothing constraint to encourage selectivities to be similar in adjacent age classes) to provide more flexibility. Lognormal likelihoods were used for the abundance data, and the Fournier likelihood for the at-age data. Because there appeared to be a conflict between the abundance and at-age data, a range of weightings were used for the latter data (from N = 5 (very lightly weighted), to N = 200 (strongly weighted)).

Assessment year		2010 WGCSE	2011 WKFLAT
Assessment model		ICA	AP
Tuning fleets	UK-BTS Sept	1989–2009, ages 2–7	Series omitted
	Extended UK-BTS Sept	n/a	1993–2009, ages 1–6
	UK(E&W) BTS Mar	Survey omitted	Survey omitted
	UK(E&W) OTB	Series omitted	Series omitted
	UK(E&W) BT	Series omitted	Series omitted
	IR-OTB	Series omitted	Series omitted
	UK(NI) GFS Mar	1992–2009	1993–2009
	UK(NI) GFS Oct	1992–2009	1993–2009
Time-series weights		Full time-series - unweighted	n/a
Num yrs for separable		9	n/a
Reference age		5	n/a
Terminal S		1	n/a
Catchability model fitted		linear	n/a
SRR fitted		No	n/a
Selectivity model		n/a	Linear Time Varying Spline at age (TVS)
Discard fraction		n/a	Polynomial Time Varying Spline at age (PTVS)
Landings number-at-age, range:		2–9+	1–9+
Discards N at age, yrs ages r		n/a	2004–2009, ages 1–5

3.8.2 Sensitivity analysis

Aarts and Poos

The full suite of AP model settings for the fishery selectivity model and the discard fraction-at-age was trialled for the assessment. The various combinations gave very different estimates of SSB and F. Only the most complex model generated a good fit to the available data and this model was also considered the best in terms of AIC. Given that the dominant gear in the Irish Sea has changed over time it is perhaps unsurprising that the model with constant time-invariant selectivity performed badly. Mesh changes in the otter trawl fleet since 2004 (i.e. the switch from otter trawlers targeting demersal fish to those targeting *Nephrops*) are expected to alter the discarding fraction in the recent period and therefore it is also unsurprising that models with time-invariant or linear trend in discarding fraction also performed poorly. An investigation of the selectivity pattern of the fishery from an untuned ('user-defined' - Terminal F values set to 0.1) VPA based on landings only data confirms that the landings-selectivity has changed over time (Figure 3.5).

The final AP model output and diagnostics are given in Table 3.1 and plots of the fitted selectivity function and discard fraction are given in Figures 3.6 and 3.7 respectively. Residual plots, and the catchability of the UK-BTS, are presented in Figures

3.8–3.11. Comparison plots between the NI-GFS indices and the model estimate SSB are given in Figure 3.12. The final AP model fit is shown in Figure 3.13 and data output given in the following tables: estimated annual SSB, F_{bar}, discard tonnage and recruitment with estimates of variability in Table 3.2; stock numbers-at-age in Table 3.3; fishing mortalities-at-age in Table 3.4; modelled landed numbers-at-age in Table 3.5 and modelled discarded numbers-at-age in Table 3.6.

ASAP

Two sets of analyses were explored. The first set of analyses used years 1964 through 2009. The discards for years prior to 2004 were set at either 600 tons or 1800 tons with coefficients of variation of 0.3 or 0.6. The results were encouraging for one model formulations where the estimated discards appeared to converge to similar estimates despite widely different input values (Figure 3.15), but not for another (Figure 3.16). The model formulations differed only by a slight change in how the stock–recruitment relationship was estimated and demonstrated that the discard estimates were not robust to different input series of discards.

This first analysis was especially challenging for the model because the survey information does not begin until 1993. So a second set of analyses were conducted which used a starting year of 1993, so that all estimates of discards would be informed by both catch and survey data. Because there was more information available for all estimates of discards, the CV of the input series was increased to 0.9 to allow greater flexibility to match other signals in the data. A wide range of possible discard series were input for years 1993 through 2003, but the model estimates did not converge to a similar time-series; instead they roughly followed the input values (Figure 3.17). It should be noted that a number of these runs exhibited strong retrospective patterns in the estimates of F and SSB.

These explorations demonstrate that the ASAP model is not able to estimate the discards for the years prior to 2004. However, the model results can be compared to other models under different assumptions of input discards (see Section 3.8.4).

These results demonstrate the need for additional information about early discards in the Irish Sea plaice fishery. This information could be simply a range of plausible discard fraction trends, such as calculated in the CASAL example. A better approach, but more difficult and time consuming, would be to determine the cause of discards back in time, by fleet if possible, and use this information to generate estimates of discards.

CASAL

Three initial runs were conducted. These runs were intended to evaluate the effect of discards on the assessments. The first run included no discards; the other two runs included the known discards (for 2004–2009) and two alternative discard histories constructed by assuming that the discard fraction [discards/(landings + catches), in t] followed an exponential curve passing through the known value in 2004, and taking half that value either 10 y earlier (Low discards) or 30 y earlier (High discards). The selectivity curve for all discards was that estimated from the 2004–2009 data. The at-age data were lightly weighted (N=5).

Results from these runs (Figure 3.18a) demonstrated some strong similarities and differences from the last assessment. The greatest similarity was in the estimated recruitments, which appeared similar to previous estimates and were very robust (i.e. the estimates did not vary much across all CASAL runs). This demonstrates that the year-class strength information in the at-age data is very strong (particularly when it is noted that these data received very light weighting). The pattern of F_{bar} estimates was also similar to that in the last assessment, except that the contrast was greater (the peak was higher, and the initial value lower). The greatest difference was in the SSBs which were much higher in the earlier years. However, both the CASAL runs and the previous assessment agree that SSB has been increasing since the late 1990s.

Fits to the abundance indices were reasonable, with model biomass estimates falling between the increasing trend suggested by the UKBTS data, and the fairly flat trend of the other datasets (Figure 3.18b). Fits to the at-age data (not shown) were very poor, but this was to be expected because these data were very lightly weighted.

The remaining runs (all without discards) were aimed at trying to understand why all CASAL runs produced very high initial biomass, with $B_{initial}$ always higher than B_0. Increasing the weight on the at-age data produced good fits to the at-age data, but SSBs were even higher.

An obvious reason that estimated SSBs were higher in recent years than those from the previous assessment is that the earlier assessment did not use the AEPS data, which were here treated as estimates of absolute biomass.

The primary reason for a high <u>initial</u> SSB appeared to be the fact that all selectivities estimated in the CASAL runs were strongly domed (e.g. Figure 3.19). Such domed selectivities require high initial biomass in order to produce enough fish to allow the recorded landings to have been caught in the early years of the fishery. To demonstrate this, a simple model was constructed with

- a single fishery, using the trawl1 selectivity as estimated in the broken line in Figure 3;
- a constant catch of 4000 t from 1964–1990 (this is the period before which landings started to drop, and the mean annual catch in this period was 4128 t);
- year-class strengths as estimated for Figure 3;
- $B_{initial} = B_0$.

No parameters were estimated for this model. Instead B_0 was varied to find what the minimum value was that would allow all the catches to be taken. This was 88 000 t. When the selectivity was modified to be 1 for all ages older than 3 y this minimum value of B_0 reduced to 50 000 t.

3.8.3 Retrospective patterns

A tentative retrospective run was attempted at WKFLAT. However, given that the discard data are limited to 2004–2009 removing a single year takes a substantial proportion of the data out of the model. The retrospective of the final AP run are presented in Figure 3.14.

3.8.4 Evaluation of the models

Given the lack of data for discards before 2004 for the model to fit to and a lack of knowledge as to the likely levels of discarding (no stakeholder input) WKFLAT were unable to conclude that the AP model was generating a realistic reconstruction of discards.

In order to explore the range of feasible historical discards, WKFLAT reconstructed discards for 1993–2003 assuming a constant and linearly declining (backward in time) discard proportion for each age and scaling the landings-at-age appropriately to generate discards-at-age. The ratios of the discarded numbers-at-age in 2004, 2009 and the average ratio for the period 2004–2009 were considered discarding was lowest in 2004 and highest in 2009 (see Figure 3.13, bottom right). Reasonable discard numbers-at-age were generated, when using the discard proportion-at-age in 2004 as a constant proportion backward in time (Figure 3.15). However, when reconstructing discards using the 2009 discard proportion-at-age, the estimated numbers discarded were considered unreasonably high even when a linear trend to zero discards in 1964 was included (Figure 3.16). The ICA assessment model used previously (ICES 2010) was re-run including these reconstructions of historical discards in the catch-at-age matrix. The results from the reconstruction considered the most reasonable were to

- increase the SSB by ~2 times the previous ICA estimate and reduce the scale of the increase in SSB since 2000, so that recent SSB does not rise to the level of the historical high;
- increase recruitment by ~5 times the previous ICA estimate;
- increase fishing mortality by ~0.1 and stabilize F_{bar} from 2002 rather than the decline in previous assessments.

The retrospective patterns were improved but not eliminated (Figure 3.17).

The alternative models created using the ASAP (NOAA Fisheries Toolbox 2008) and CASAL frameworks generated very different population levels, particularly for the historical period Figure 3.18.

Given the sensitivity of the assessment of plaice VIIa to the assumptions made about historical discarding WKFLAT could not agree on one assessment model over the others. Nevertheless when the estimates of SSB and F from the suite of models was standardized (to the mean and standard deviation of the outputs) and compared in terms of trend a consensus was evident between the models for the recent period Figure 3.19.

Each model revealed that average SSB in was greater during the 2000s than during the 1990s.

Each of the models displayed a decline in F between 1993 and 2004 with a period of relative stability in F between 2005 and 2009. Best estimates of F for 2009 for each of the models were low and ranged between 0.1 and 0.2.

The full range of the age composition of the landings is presented in Table 3.7. Weight-at-age in the landings of the full series and in the discards are given in Tables 3.8 and 3.9 respectively. Weight-at-age values used for the stock are given in Table 3.10. The tuning indices of the extended UK (E&W) September survey (UK-BTS-ext)) is presented in Table 3.11 and the NI-GFS is presented in Table 3.12.

3.8.5 Conclusion

For plaice in VIIa discard tonnages are estimated to have outstripped the landings since 2007; Figure 3.3. Discarding of plaice in VIIa is partly due to the minimum landings size in force and partly market driven because the landings have been lower than the TAC since 2003.

Due to the limited time-series of discard data available (since 2004) considerable uncertainty exists regarding the historical levels of discarding. This uncertainty translates into uncertain stock size and unknown exploitation status, particularly for plaice VIIa.

Given the consensus between the trends in F between the AP, ASAP and CASAL models (Figure 3.19), WKFLAT recommend that advice could be based on the relative trends in F and SSB from the AP model.

WKFLAT recognized the level of disagreement between the UK-BTS, AEPM and NI-GFS indices and suggested that there was no definite reason to base advice on any single survey index.

The mean annual catch weights should be used without the application of the quadratic smoother. Catch weights can be used as the stock weights.

3.9 Short-term and medium-term forecasts

3.9.1 Input data

Not recommended for this stock. Previous approaches are given in the stock annex.

3.9.2 Model and software

Not recommended for this stock. Previous approaches are given in the stock annex.

3.9.3 Conclusion

No work was done by WKFLAT 2011 in relation to medium-term forecasts for Irish Sea plaice. Details on the methodology used in previous years can be found in the stock annex.

3.10 Biological reference points

Previous BRPs are not consistent with new assessment methodology.

3.11 Recommendations on the procedure for assessment updates and further work

1) WKFLAT recommends that future assessments are carried out following the methodology proposed during this meeting and described in the Stock Annex.
2) WKFLAT recommended that the AP model should be tested against a stock for which there was a time-series of discarding available.
3) Biological reference points will need to be reinvestigated once an assessment has been agreed for this stock from which terminal estimates of population abundance and exploitation rate are considered sufficiently well estimated. This cannot be achieved at present.
4) Estimates of variability in the UK (E&W) discard estimates should be determined through a bootstrapping approach. Estimates of variability in the Belgian discard estimates are provided by the COST package but require further analysis. The discard estimates from N. Ireland require evaluation and alternative raising procedures for the Republic of Ireland data should be investigated.
5) Discard weights-at-age should be reinvestigated in order to incorporate data more representative of all fleets active in the fishery.

6) Procedures for including limited discard information into stock weights-at-age should be evaluated.

7) Temporal and spatial patterns in the maturity ogive and length–weight relationships should be fully addressed and any differences identified should be incorporated into the raising of the length frequencies from the NI-GFS, which currently assumed time and spatial invariance in these components.

8) The procedure for updating the UK-BTS to include the extended area should be further evaluated and the proportions of available habitat in the various sectors should be determined to more accurately combine data from the sectors.

9) The spatial structure in the discarding if plaice in the Irish Sea should be further investigated using data from all relevant nations.

10) A sex-separated assessment methodology for this stock, which can incorporate the complex spatial issues regarding this stock, would merit further study.

3.12 Implications for management (plans)

No management plan is currently in place for Irish Sea plaice. Sole and plaice are taken in the same fisheries and while the plaice stock appears healthy the sole stock is depressed. Any management plan developed for sole in the Irish Sea should consider the effect on catches of plaice.

3.13 References

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Table 3.1. Model output.

note: **(1) model takes log(Ftrend #) as input;**

(2) The log.recruitments 1–7 are merely to providing initial cohorts for each entry in the num bers-at-age matrix.

Age range for fishery selectivity: 1 to 8

Age range for discard fraction: 1 to 5

Age range for UK-BTS: 1 to 6

Sun Feb 06 15:25:00 2011

SEL_MODEL	TV
DISC_MODEL	PTVS
INCL_EGG	FALSE
INCL_RELBIO	TRUE
INCL_PLUSGROUP_NIGFS	TRUE
EST_SD_BIO	TRUE
firstoptMETHOD	Nelder-Mead
firstoptMAXIT	1000
mainMETHOD	BFGS
BFGS_MAXIT	800
BFGS_RELTOL	1.00E-20
n.tries for uncertainty	1000
eigenvalues Hessian positive?	TRUE
negative log.likelihood	71.97260756
negative log.likelihood Landings	-7.445493145
negative log.likelihood Discards	24.02801584
negative log.likelihood UK-BTS	-8.475548556
negative log.likelihood NI-GFSs	63.86563342
AIC	297.9452151
Nparameters	77
Nobservations	320
Final parameter values	
Ftrend 1	0.711015452
Ftrend 2	0.734287638
Ftrend 3	0.639082894
Ftrend 4	0.409961057
Ftrend 5	0.514633673
Ftrend 6	0.408293896
Ftrend 7	0.260500342
Ftrend 8	0.224510356
Ftrend 9	0.217347278
Ftrend 10	0.205928284
Ftrend 11	0.203729257
Ftrend 12	0.160825934
Ftrend 13	0.207500079

Ftrend 14	0.21207253
Ftrend 15	0.257926717
Ftrend 16	0.201958918
Ftrend 17	0.244847069
sel.C 1	-0.688650145
sel.C 2	8.175360902
sel.C 3	-4.999779473
sel.C 4	1.128878455
sel.C 5	-0.398637977
sel.C 6	1.096609026
sel.C 7	-0.625990149
sel.C 8	-0.304938681
logrecruitment 1	21.1133414
logrecruitment 2	19.24760026
logrecruitment 3	17.37155761
logrecruitment 4	15.64892115
logrecruitment 5	15.2008426
logrecruitment 6	14.23385976
logrecruitment 7	12.82879824
logrecruitment 8	10.64346612
logrecruitment 9	10.4601184
logrecruitment 10	10.31681305
logrecruitment 11	10.42760333
logrecruitment 12	10.5488144
logrecruitment 13	10.19158227
logrecruitment 14	10.06194796
logrecruitment 15	10.38904223
logrecruitment 16	10.37133432
logrecruitment 17	10.46848025
logrecruitment 18	10.21293755
logrecruitment 19	10.40857825
logrecruitment 20	10.00414571
logrecruitment 21	10.22465302
logrecruitment 22	10.47453118
logrecruitment 23	9.932946424
logrecruitment 24	10.02020724
Catchability 1	6.84260618
sel.U 1	-15.20217806
sel.U 2	-14.83557682
sel.U 3	-16.37524728
sel.U 4	-16.25976645
b1	6.344650714
b2	-1.342116781
b3	1.569814571
b4	-3.671899114
b5	0.070538967

b6	0.51602855
b7	-0.418041603
b8	1.45049432
b9	0.005353581
b10	0.028714735
b11	0.061653287
b12	-0.119551238
sds.land1	-2.371457097
sds.land2	-1.905729339
sds.land3	3.174456023
sds.disc1	-0.861155837
sds.disc2	-1.211736435
sds.disc3	1.004165024
sds.tun1	-2.210493314
sds.tun2	1.715552265
sds.tun3	-0.306311217
sds.biotun1	1.034726908
sds.biotun2	-23.99951112

Table 3.2. Modelled mean (50th percentile) spawning–stock biomass (SSB, tonnes), mean fishing mortality (F) for ages 3–6, Discard tonnage (D) and recruitment (R, 000s) with 5th (lower) and 95th (upper) percentiles indicating the 90% CI.

Year	SSB (t) lower	SSB (t) mean	SSB (t) upper	F lower	F mean	F upper	D (t) lower	D (t) mean	D (t) upper	R(000s) lower	R(000s) mean	R(000s) upper
1993	3208	5130	6697	0.502	0.565	0.665	2039	2955	4456	32132	41918	56734
1994	3701	4879	6246	0.472	0.523	0.795	1776	2549	3760	27110	34896	44928
1995	3826	5075	6065	0.396	0.452	0.53	1213	1714	2300	24639	30237	36928
1996	4610	5796	6902	0.292	0.343	0.412	942	1361	1843	28447	33779	40300
1997	5227	6219	7357	0.333	0.381	0.585	1466	1977	2691	32426	38132	45380
1998	5917	7339	8752	0.24	0.296	0.371	894	1273	1712	22725	26678	31684
1999	6737	8372	10187	0.172	0.222	0.28	545	851	1202	20061	23434	27724
2000	7901	9625	11689	0.139	0.168	0.245	568	810	1121	28083	32502	37838
2001	10214	12451	15141	0.119	0.158	0.2	501	822	1158	27408	31931	37595
2002	12368	14917	17880	0.129	0.175	0.218	582	1013	1456	30514	35189	41453
2003	14954	18003	21557	0.126	0.15	0.207	811	1085	1413	23625	27254	31715
2004	15519	18601	22177	0.083	0.115	0.142	544	830	1068	28938	33143	38765
2005	16913	20081	23809	0.122	0.173	0.213	823	1336	1686	18911	22118	25693
2006	17420	20787	24515	0.133	0.154	0.195	989	1206	1451	23453	27575	32252
2007	16171	19237	22548	0.119	0.18	0.223	744	1108	1344	29851	35402	42032
2008	16653	19876	23507	0.101	0.165	0.208	701	1222	1517	16852	20598	24934
2009	15442	18515	22008	0.135	0.174	0.237	983	1235	1515	17282	22476	28918

Table 3.3. Modelled numbers-at-age in the stock (thousands).

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	41918	34896	30237	33779	38132	26678	23434	32502	31931	35189	27254	33143	22118	27575	35402	20598	22476
2	23827	17931	14831	15145	20586	21807	17674	17431	25355	25797	28969	22862	28533	19045	23942	30883	18094
3	7962	11233	8482	7812	9210	11578	13716	12242	12600	18634	18722	21242	17586	20582	13798	16821	22315
4	3417	4171	5904	4727	4787	5291	7290	9332	8806	9166	13203	13579	16157	12331	14709	9505	11813
5	1300	1839	2296	3418	2972	2869	3427	5045	6836	6494	6565	9713	10411	11411	8916	10226	6700
6	1142	656	985	1325	2194	1855	1936	2478	3842	5247	4906	5075	7746	7862	8779	6675	7763
7	737	518	323	537	841	1374	1274	1449	1953	3075	4219	4033	4272	6429	6622	7382	5687
8	363	310	233	161	325	497	902	937	1131	1557	2490	3503	3431	3622	5525	5705	6427
9+																	

Table 3.4. Modelled F at-age.

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.729	0.736	0.571	0.375	0.439	0.292	0.176	0.128	0.093	0.074	0.056	0.030	0.030	0.021	0.017	0.010	0.008
2	0.632	0.629	0.521	0.377	0.456	0.344	0.247	0.205	0.188	0.201	0.190	0.142	0.207	0.202	0.233	0.205	0.238
3	0.527	0.523	0.465	0.370	0.434	0.343	0.265	0.210	0.198	0.225	0.201	0.154	0.235	0.216	0.253	0.233	0.254
4	0.500	0.477	0.427	0.344	0.392	0.314	0.248	0.191	0.184	0.214	0.187	0.146	0.228	0.204	0.243	0.230	0.243
5	0.564	0.504	0.430	0.323	0.351	0.273	0.204	0.152	0.145	0.161	0.137	0.106	0.161	0.142	0.169	0.156	0.163
6	0.670	0.588	0.486	0.334	0.348	0.255	0.170	0.118	0.103	0.098	0.076	0.052	0.066	0.052	0.053	0.040	0.036
7	0.746	0.678	0.576	0.383	0.407	0.301	0.187	0.128	0.107	0.091	0.066	0.042	0.045	0.032	0.029	0.018	0.015
8	0.729	0.675	0.586	0.374	0.405	0.306	0.183	0.127	0.109	0.089	0.066	0.042	0.044	0.032	0.030	0.018	0.015
9+	0.729	0.675	0.586	0.374	0.405	0.306	0.183	0.127	0.109	0.089	0.066	0.042	0.044	0.032	0.030	0.018	0.015

Table 3.5. Modelled numbers-at-age landed (thousands).

L	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	28	97	21	37	28	6	68	0	14	1	0	8	6	5	0	1	0
2	910	1146	961	856	830	691	803	450	374	206	286	198	228	180	64	99	13
3	1649	2173	1703	1345	1590	1739	1505	1174	1138	940	1031	967	708	620	351	386	204
4	1357	1309	1936	1196	1513	1025	1294	1284	1083	1482	1314	1104	1177	550	860	389	374
5	474	644	764	943	1003	612	696	686	767	842	707	705	890	684	507	409	351
6	556	318	318	370	482	476	280	212	409	539	415	247	461	346	401	215	272
7	377	245	138	128	285	403	196	219	179	318	253	114	204	220	151	141	117
8	179	134	70	44	139	177	117	102	90	96	127	88	92	87	114	61	73
9+	123	129	87	91	118	208	125	101	76	74	94	99	121	131	50	58	46

Table 3.6. Modelled numbers-at-age discarded (thousands).

D	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	20553	17213	12445	9975	12792	6366	3561	3685	2679	2378	1390	915	607	546	548	185	167
2	9415	6935	4918	3847	6071	5122	3151	2660	3649	4013	4380	2697	4812	3192	4603	5331	3586
3	1518	2016	1338	1008	1363	1450	1445	1117	1183	2136	2128	2060	2720	3163	2577	3054	4490
4	1	3	8	11	26	46	96	171	254	456	809	851	1837	1454	2231	1463	2002
5	0	0	0	0	0	0	0	1	5	23	70	206	587	791	845	937	620
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.7. Plaice landed in VIIa, where rows are years 1964–2009 and columns are ages 1 to 15.

IRISH SEA PLAICE, 2010 updated WKFLAT

1 2

1964 2009

1 15

1

0	997	1911	1680	446	851	480	140	26	155	30	2	1	1	10
28	1416	3155	2841	1115	555	309	300	17	20	5	2	1	1	1
0	120	4303	3605	2182	620	588	386	181	13	20	7	7	3	6
0	164	1477	5593	4217	995	642	267	210	176	86	35	5	6	1
0	171	1961	3410	4641	1611	319	113	135	24	17	3	4	1	1
59	430	2317	2932	2080	2227	779	184	58	100	80	22	9	4	1
9	803	2278	2179	1877	1028	899	239	64	29	52	51	20	3	2
0	427	3392	3882	1683	1371	491	497	244	60	65	36	11	9	1
0	142	3254	5136	1461	752	555	627	353	169	55	40	38	19	12
0	925	4091	5233	2682	642	345	238	183	238	129	40	14	11	17
7	1200	2530	2694	2125	1045	191	139	56	47	95	40	5	5	5
18	1370	4313	1902	1158	933	152	119	81	94	47	72	18	16	4
23	2553	4333	2425	902	563	391	198	59	79	47	22	58	11	5
565	4124	2767	2470	839	236	150	112	63	21	15	8	8	10	3
22	3063	5169	1535	542	202	98	54	52	43	10	9	4	4	2
12	3380	5679	1835	363	187	109	61	68	68	17	5	6	4	6
3	2783	6738	2560	646	312	125	64	24	54	16	13	7	5	5
22	1742	5939	2984	837	222	105	53	52	41	28	35	13	3	11
27	715	3288	3082	1358	330	137	69	44	36	11	15	11	14	13
51	2924	2494	3211	1521	648	211	110	53	30	13	15	9	11	11
41	3159	5179	1182	1054	459	299	113	60	13	22	15	10	6	13
4	2357	6152	3301	614	429	262	181	78	36	21	8	7	3	6
31	1652	5280	2942	1287	344	371	112	92	54	24	9	5	3	9
62	3717	5317	5252	1341	1072	123	121	75	74	25	8	10	12	13
46	2923	5040	2552	1400	750	316	84	112	44	41	28	38	21	37
24	1735	5945	2671	854	436	214	153	56	47	26	38	18	7	19
15	1019	2715	2935	1132	465	259	98	51	22	15	15	9	6	7
180	2008	1506	1929	1205	465	182	122	49	34	5	6	3	3	4
151	1958	3209	1435	1358	903	388	118	74	44	27	15	9	3	4
28	910	1649	1357	474	556	377	179	42	50	16	8	2	3	2
97	1146	2173	1309	644	318	245	134	86	18	6	9	6	1	3
21.2	960.8	1702.7	1935.7	764.1	318.2	137.9	70	46.7	22.6	8.9	4.5	0.8	0.7	2.9
37	855.7	1345.2	1196.2	943.4	370	128.3	43.9	25.1	36.7	14	7	4.8	1.1	2.5
27.8	829.6	1589.6	1513.4	1002.6	482.3	285.1	139.1	42.3	52.6	12.3	6.7	1.3	2.2	0.8
5.5	691.4	1739.2	1024.7	611.6	475.7	403	176.9	91.2	51.6	24.7	17.5	19.2	2.1	1.3
68.2	802.6	1504.8	1293.6	695.5	280.4	196.4	117	68.9	43.4	5.6	4.3	1.2	0.4	1
0	450	1174.3	1283.7	685.5	211.8	219.3	101.9	55.5	19.1	13.7	7.1	2.4	1.6	2
13.9	374.2	1138.1	1083	767	408.6	178.5	90.3	45.4	17.6	6.3	2.4	3.7	0.3	0.4

1.1	205.6	939.8	1481.7	842.2	538.9	317.7	95.9	48.4	17.3	4.4	3.1	0.3	0.2	0.3
0	285.7	1030.9	1314.1	706.7	415	252.7	127.2	48.4	22.3	12.4	7.4	1	2.6	0.2
7.5	198.3	966.8	1104.2	705	246.5	114.3	87.7	74.2	10.7	10.8	1.1	1	0.4	0.3
6.4	228.4	708.4	1177.2	889.5	461.1	204	91.8	54.6	36.7	11.5	11.5	4.4	1.5	0.8
4.5	180.3	619.8	550.2	684	346.4	220	86.9	53.4	46.4	20.2	6.5	1.8	1.3	1.1
0	64.2	350.5	859.9	506.6	401.2	150.5	114.2	27	14.3	5	2.9	0.5	0.4	0.02
0.6	98.5	385.5	388.6	409.3	214.6	141.3	61	36.4	9.2	6.9	3.3	0.8	1.2	0
0	12.6	204.3	373.9	351.2	272.4	116.5	73.3	26	12.1	3.6	2	0.9	1.1	0.7

Table 3.8. Plaice VIIa: weight-at-age in the landings (unsmoothed from 1995, bold).

Plaice in VIIa, 2010 # wkflat2011

1 3

1964 2009

1 15

1

0.000	0.190	0.292	0.413	0.463	0.597	0.831	1.042	1.155	0.552	1.358	1.015	1.544	1.605	1.654
0.070	0.177	0.269	0.388	0.556	0.653	0.690	0.719	0.801	1.198	1.167	0.971	1.477	1.535	1.581
0.000	0.152	0.223	0.316	0.418	0.532	0.697	0.691	0.939	0.983	1.074	1.071	1.233	1.281	1.320
0.000	0.133	0.218	0.299	0.382	0.516	0.518	0.759	0.791	0.682	0.783	0.514	1.152	1.198	1.234
0.000	0.149	0.213	0.313	0.413	0.509	0.584	0.777	0.893	0.957	1.017	0.887	1.174	1.220	1.257
0.056	0.146	0.215	0.311	0.405	0.541	0.643	0.787	0.897	0.744	0.723	1.097	1.185	1.231	1.269
0.058	0.149	0.219	0.324	0.417	0.523	0.648	0.685	0.908	0.925	0.877	0.603	1.231	1.279	1.318
0.000	0.140	0.207	0.295	0.396	0.489	0.595	0.753	0.654	0.852	0.731	1.079	1.153	1.198	1.235
0.000	0.143	0.235	0.332	0.432	0.560	0.737	0.712	0.959	1.071	1.144	1.208	1.288	1.339	1.379
0.000	0.143	0.218	0.316	0.415	0.491	0.645	0.694	0.791	0.898	0.927	0.863	1.204	1.252	1.290
0.063	0.158	0.246	0.334	0.445	0.514	0.686	0.847	0.964	1.052	1.108	1.048	1.326	1.378	1.420
0.072	0.185	0.275	0.398	0.531	0.644	0.749	0.924	1.147	1.169	1.359	1.360	1.533	1.593	1.641
0.060	0.150	0.228	0.323	0.419	0.525	0.590	0.719	0.797	0.842	0.834	1.003	1.267	1.317	1.357
0.059	0.153	0.226	0.340	0.430	0.510	0.592	0.738	0.840	1.016	0.945	1.100	1.252	1.301	1.340
0.071	0.185	0.268	0.391	0.525	0.672	0.720	0.910	1.035	1.049	1.264	1.329	1.497	1.556	1.603
0.069	0.176	0.262	0.376	0.557	0.668	0.794	0.915	0.997	0.968	1.274	1.227	1.471	1.529	1.575
0.066	0.177	0.255	0.365	0.483	0.517	0.671	0.884	1.047	1.072	1.259	1.273	1.403	1.458	1.503
0.069	0.176	0.267	0.376	0.512	0.592	0.678	0.863	1.097	0.804	1.276	1.310	1.309	1.509	1.554
0.201	0.274	0.284	0.348	0.421	0.545	0.650	0.651	0.780	0.777	1.185	1.164	1.147	1.164	1.744
0.232	0.261	0.290	0.319	0.368	0.426	0.484	0.552	0.629	0.716	0.803	0.910	1.026	1.161	1.316
0.260	0.290	0.330	0.380	0.470	0.560	0.660	0.760	0.870	0.980	1.100	1.240	1.420	1.630	1.940
0.290	0.310	0.340	0.390	0.470	0.540	0.630	0.730	0.840	0.940	1.060	1.200	1.380	1.600	1.900
0.270	0.280	0.340	0.420	0.500	0.540	0.630	0.830	0.920	1.020	1.210	1.480	1.420	1.720	1.610
0.260	0.290	0.315	0.370	0.440	0.520	0.610	0.720	0.820	0.950	1.080	1.210	1.360	1.520	1.700
0.230	0.260	0.300	0.370	0.460	0.550	0.680	0.820	0.960	1.120	1.300	1.480	1.690	1.900	2.130
0.227	0.272	0.321	0.374	0.430	0.491	0.555	0.623	0.694	0.770	0.849	0.932	1.019	1.109	1.205
0.200	0.257	0.316	0.376	0.439	0.504	0.570	0.639	0.709	0.781	0.856	0.932	1.010	1.091	1.173
0.247	0.267	0.295	0.332	0.377	0.431	0.494	0.566	0.646	0.735	0.832	0.938	1.053	1.176	1.309
0.169	0.218	0.274	0.337	0.407	0.484	0.568	0.658	0.756	0.860	0.971	1.089	1.213	1.345	1.483
0.260	0.270	0.292	0.328	0.375	0.436	0.508	0.594	0.691	0.802	0.925	1.060	1.208	1.368	1.541
0.156	0.207	0.268	0.338	0.416	0.504	0.600	0.706	0.821	0.945	1.077	1.219	1.370	1.530	1.698
0.189	**0.224**	**0.262**	**0.329**	**0.353**	**0.406**	**0.461**	**0.619**	**0.682**	**0.734**	**0.851**	**1.020**	**1.101**	**1.077**	**1.468**
0.204	**0.223**	**0.270**	**0.333**	**0.398**	**0.493**	**0.584**	**0.712**	**0.748**	**0.712**	**1.204**	**1.272**	**1.306**	**1.770**	**1.186**
0.205	**0.233**	**0.241**	**0.286**	**0.354**	**0.410**	**0.510**	**0.513**	**0.709**	**0.610**	**0.976**	**1.389**	**1.288**	**1.027**	**1.162**
0.185	**0.226**	**0.249**	**0.316**	**0.353**	**0.410**	**0.468**	**0.506**	**0.647**	**0.784**	**0.861**	**1.105**	**0.888**	**1.629**	**1.302**
0.205	**0.236**	**0.250**	**0.300**	**0.375**	**0.457**	**0.483**	**0.556**	**0.632**	**0.602**	**1.187**	**1.011**	**1.130**	**1.159**	**1.280**
0.000	**0.259**	**0.270**	**0.307**	**0.337**	**0.429**	**0.437**	**0.492**	**0.580**	**0.796**	**1.007**	**1.030**	**1.408**	**1.221**	**1.314**
0.232	**0.233**	**0.271**	**0.334**	**0.396**	**0.439**	**0.571**	**0.666**	**0.785**	**0.934**	**1.155**	**1.228**	**1.024**	**0.945**	**1.505**
0.228	**0.271**	**0.267**	**0.308**	**0.386**	**0.476**	**0.518**	**0.585**	**0.730**	**0.838**	**1.014**	**0.944**	**1.206**	**1.488**	**1.196**
0.000	**0.235**	**0.289**	**0.335**	**0.383**	**0.458**	**0.567**	**0.566**	**0.779**	**0.912**	**0.861**	**0.675**	**0.797**	**1.313**	**1.304**
0.214	**0.239**	**0.258**	**0.297**	**0.347**	**0.416**	**0.543**	**0.544**	**0.515**	**0.760**	**0.751**	**0.817**	**1.693**	**2.000**	**2.327**
0.235	**0.245**	**0.265**	**0.292**	**0.322**	**0.394**	**0.441**	**0.536**	**0.648**	**0.691**	**0.678**	**0.913**	**0.974**	**0.807**	**0.982**
0.200	**0.256**	**0.265**	**0.282**	**0.321**	**0.378**	**0.425**	**0.462**	**0.553**	**0.611**	**0.732**	**0.838**	**1.415**	**1.139**	**1.277**
0.000	**0.280**	**0.266**	**0.281**	**0.320**	**0.371**	**0.416**	**0.411**	**0.621**	**0.530**	**0.900**	**0.846**	**0.976**	**0.878**	**1.016**
0.246	**0.228**	**0.257**	**0.281**	**0.311**	**0.364**	**0.431**	**0.445**	**0.570**	**0.700**	**0.833**	**1.122**	**0.430**	**1.320**	**0.000**
0.000	**0.257**	**0.256**	**0.265**	**0.305**	**0.330**	**0.395**	**0.467**	**0.465**	**0.537**	**0.571**	**0.591**	**0.760**	**0.576**	**0.475**

Table 3.9. Plaice VIIa: weight-at-age in the discards (unsmoothed).

IRISH SEA PLAICE, 2010 WG, COMBSEX, PLUSGROUP, Discard weights-at-age (age 0 exc, age 9+ set to age 8).

1 3 db 26/1/2011

2004 2009

1 15

1

0.081	0.115	0.141	0.167	0.206	0.383	0.392	0.486	0.486	0.486	0.486	0.486	0.486	0.486	0.486
0.059	0.119	0.145	0.15	0.173	0.328	0.582	0.485	0.485	0.485	0.485	0.485	0.485	0.485	0.485
0.082	0.12	0.14	0.143	0.148	0.215	0.24	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
0.046	0.081	0.116	0.144	0.151	0.192	0.221	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279
0.072	0.104	0.12	0.13	0.157	0.186	0.267	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198
0.036	0.082	0.117	0.152	0.178	0.209	0.227	0.302	0.302	0.302	0.302	0.302	0.302	0.302	0.302

Table 3.10. Plaice VIIa: weight-at-age in the stock (unsmoothed from 1995, bold).

Plaice in VIIa: Mean Weight in Stock #wkflat11

1 4

1964 2009

1 15

1

0.024	0.109	0.226	0.348	0.412	0.545	0.767	0.981	1.085	0.540	1.311	0.991	1.508	1.544	1.630
0.023	0.105	0.213	0.327	0.480	0.587	0.641	0.680	0.769	1.152	1.128	0.948	1.442	1.477	1.558
0.019	0.087	0.177	0.266	0.366	0.480	0.643	0.652	0.881	0.947	1.036	1.038	1.204	1.233	1.301
0.018	0.082	0.169	0.251	0.336	0.464	0.482	0.716	0.747	0.660	0.758	0.509	1.125	1.152	1.216
0.018	0.083	0.168	0.263	0.360	0.458	0.541	0.732	0.838	0.921	0.982	0.862	1.146	1.174	1.238
0.019	0.084	0.170	0.261	0.355	0.485	0.593	0.742	0.841	0.719	0.701	1.062	1.157	1.185	1.250
0.019	0.087	0.175	0.272	0.365	0.472	0.599	0.647	0.854	0.891	0.848	0.594	1.201	1.231	1.298
0.018	0.082	0.164	0.249	0.346	0.442	0.550	0.709	0.625	0.821	0.708	1.044	1.126	1.153	1.217
0.020	0.091	0.186	0.280	0.379	0.504	0.678	0.672	0.902	1.031	1.103	1.168	1.258	1.288	1.359
0.019	0.085	0.173	0.267	0.363	0.445	0.596	0.655	0.748	0.866	0.895	0.840	1.176	1.204	1.271
0.021	0.094	0.192	0.282	0.390	0.468	0.634	0.798	0.906	1.014	1.070	1.018	1.295	1.326	1.399
0.024	0.109	0.218	0.336	0.463	0.582	0.695	0.873	1.078	1.127	1.311	1.317	1.497	1.533	1.617
0.020	0.090	0.181	0.272	0.368	0.475	0.548	0.679	0.757	0.812	0.808	0.974	1.237	1.267	1.337
0.020	0.089	0.179	0.286	0.375	0.461	0.550	0.696	0.794	0.978	0.914	1.065	1.222	1.252	1.321
0.024	0.106	0.213	0.330	0.457	0.602	0.668	0.859	0.977	1.011	1.220	1.286	1.462	1.497	1.580
0.023	0.104	0.208	0.317	0.481	0.599	0.733	0.862	0.941	0.935	1.230	1.190	1.436	1.471	1.552
0.022	0.099	0.201	0.307	0.422	0.474	0.623	0.833	0.983	1.032	1.215	1.232	1.370	1.403	1.480
0.023	0.103	0.210	0.318	0.446	0.537	0.630	0.814	1.030	0.777	1.231	1.268	1.280	1.452	1.532
0.020	0.090	0.209	0.309	0.408	0.478	0.568	0.658	0.747	0.847	0.946	1.046	1.146	1.255	1.365
0.019	0.087	0.213	0.300	0.348	0.397	0.455	0.523	0.590	0.677	0.765	0.861	0.968	1.094	1.239
0.020	0.100	0.230	0.350	0.430	0.520	0.610	0.710	0.820	0.930	1.040	1.170	1.330	1.530	1.790
0.020	0.100	0.240	0.360	0.430	0.510	0.590	0.680	0.790	0.890	1.000	1.130	1.290	1.490	1.750
0.020	0.120	0.260	0.380	0.440	0.520	0.610	0.720	0.830	0.960	1.120	1.260	1.410	1.560	1.720
0.020	0.100	0.240	0.345	0.405	0.480	0.560	0.660	0.770	0.885	1.010	1.150	1.290	1.440	1.610
0.245	0.258	0.288	0.335	0.401	0.484	0.585	0.704	0.841	0.995	1.168	1.358	1.565	1.791	2.034
0.206	0.249	0.296	0.347	0.402	0.460	0.522	0.588	0.658	0.732	0.809	0.890	0.975	1.064	1.156
0.173	0.229	0.286	0.346	0.408	0.471	0.537	0.604	0.674	0.745	0.818	0.894	0.971	1.050	1.132
0.241	0.256	0.280	0.312	0.353	0.403	0.462	0.529	0.605	0.689	0.782	0.884	0.994	1.114	1.241
0.147	0.193	0.245	0.305	0.372	0.445	0.525	0.612	0.706	0.807	0.914	1.029	1.150	1.278	1.413
0.259	0.263	0.280	0.308	0.350	0.404	0.470	0.549	0.641	0.745	0.862	0.991	1.132	1.287	1.453
0.133	0.180	0.236	0.302	0.376	0.459	0.551	0.652	0.762	0.882	1.010	1.147	1.293	1.449	1.613
0.189	**0.224**	**0.262**	**0.329**	**0.353**	**0.406**	**0.461**	**0.619**	**0.682**	**0.734**	**0.851**	**1.020**	**1.101**	**1.077**	**1.468**
0.204	**0.223**	**0.270**	**0.333**	**0.398**	**0.493**	**0.584**	**0.712**	**0.748**	**0.712**	**1.204**	**1.272**	**1.306**	**1.770**	**1.186**
0.205	**0.233**	**0.241**	**0.286**	**0.354**	**0.410**	**0.510**	**0.513**	**0.709**	**0.610**	**0.976**	**1.389**	**1.288**	**1.027**	**1.162**
0.185	**0.226**	**0.249**	**0.316**	**0.353**	**0.410**	**0.468**	**0.506**	**0.647**	**0.784**	**0.861**	**1.105**	**0.888**	**1.629**	**1.302**
0.205	**0.236**	**0.250**	**0.300**	**0.375**	**0.457**	**0.483**	**0.556**	**0.632**	**0.602**	**1.187**	**1.011**	**1.130**	**1.159**	**1.280**
0.000	**0.259**	**0.270**	**0.307**	**0.337**	**0.429**	**0.437**	**0.492**	**0.580**	**0.796**	**1.007**	**1.030**	**1.408**	**1.221**	**1.314**
0.232	**0.233**	**0.271**	**0.334**	**0.396**	**0.439**	**0.571**	**0.666**	**0.785**	**0.934**	**1.155**	**1.228**	**1.024**	**0.945**	**1.505**
0.228	**0.271**	**0.267**	**0.308**	**0.386**	**0.476**	**0.518**	**0.585**	**0.730**	**0.838**	**1.014**	**0.944**	**1.206**	**1.488**	**1.196**
0.000	**0.235**	**0.289**	**0.335**	**0.383**	**0.458**	**0.567**	**0.566**	**0.779**	**0.912**	**0.861**	**0.675**	**0.797**	**1.313**	**1.304**
0.214	**0.239**	**0.258**	**0.297**	**0.347**	**0.416**	**0.543**	**0.544**	**0.515**	**0.760**	**0.751**	**0.817**	**1.693**	**2.000**	**2.327**
0.235	**0.245**	**0.265**	**0.292**	**0.322**	**0.394**	**0.441**	**0.536**	**0.648**	**0.691**	**0.678**	**0.913**	**0.974**	**0.807**	**0.982**
0.200	**0.256**	**0.265**	**0.282**	**0.321**	**0.378**	**0.425**	**0.462**	**0.553**	**0.611**	**0.732**	**0.838**	**1.415**	**1.139**	**1.277**
0.000	**0.280**	**0.266**	**0.281**	**0.320**	**0.371**	**0.416**	**0.411**	**0.621**	**0.530**	**0.900**	**0.846**	**0.976**	**0.878**	**1.016**
0.246	**0.228**	**0.257**	**0.281**	**0.311**	**0.364**	**0.431**	**0.445**	**0.570**	**0.700**	**0.833**	**1.122**	**0.430**	**1.320**	**0.000**
0.000	**0.257**	**0.256**	**0.265**	**0.305**	**0.330**	**0.395**	**0.467**	**0.465**	**0.537**	**0.571**	**0.591**	**0.760**	**0.576**	**0.475**

Table 3.11. Tuning index of the extended UK (E&W) September survey (UK-BTS-ext). Effort (km towed) and numbers-at-age.

year	distance towed (kms)	0	1	2	3	4	5	6	7	8	9+
1993	292.77	56	1413	1153	248	116	14	16	22	2	9
1994	281.66	179	1119	719	399	105	45	11	9	8	26
1995	281.66	328	1418	690	245	112	27	19	8	1	8
1996	277.95	107	1458	715	154	56	54	17	11	2	6
1997	281.66	471	1421	902	377	101	45	46	23	5	14
1998	281.66	135	1244	1243	309	123	59	18	19	5	13
1999	277.95	792	1089	1073	568	195	88	36	30	1	40
2000	281.66	466	2404	828	409	310	132	53	6	0	9
2001	281.66	218	1610	1103	322	172	149	29	25	3	7
2002	281.66	108	1640	1526	698	225	157	151	25	10	18
2003	277.95	875	1694	1589	739	453	155	151	70	5	17
2004	281.66	266	2157	1511	1243	536	334	64	72	39	6
2005	281.66	572	975	1277	593	486	263	150	18	34	14
2006	281.66	929	1567	917	671	299	217	104	61	10	14
2007	281.66	529	2086	1323	476	353	185	122	48	43	34
2008	270.54	252	1271	1563	558	325	258	110	40	30	7
2009	281.66	362	1341	954	897	273	185	185	75	32	115

Table 3.12. Biomass tuning indices from the NI-GFS: DARDS is the spring index and DARDA the autumn index.

Irish Sea Plaice SSB indices. Updated by CPL 21_04_10

2 18 2

Year	DARDS	DARDA
1992	9.59	4.83
1993	13.27	4.64
1994	10.09	9.2
1995	7.59	4.77
1996	7.96	8.69
1997	13.73	8.22
1998	12.5	5.39
1999	9.37	6.9
2000	15.79	10.5
2001	13.52	13.93
2002	13.36	9.98
2003	26.79	18.65
2004	10.55	8.49
2005	15.86	11.58
2006	9.57	7.2
2007	8.73	8.48
2008	6.33	11.28
2009	11	14.83

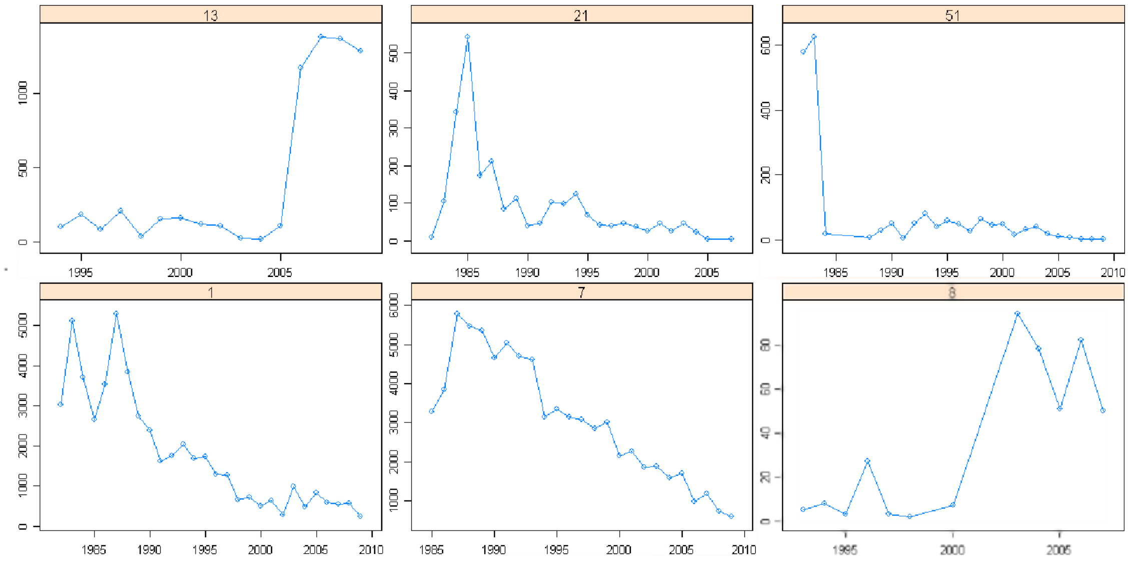

Figure 3.1a. Number of trips per year in ICES Division VIIa conducted by UK (E&W) fleets. Gear 1 = Beam trawl, 7 = Otter trawl for demersal fish, 8 Twin otter trawl for demersal fish, 13 *Nephrops* otter trawl, 21 purse-seine and 51 gillnets.

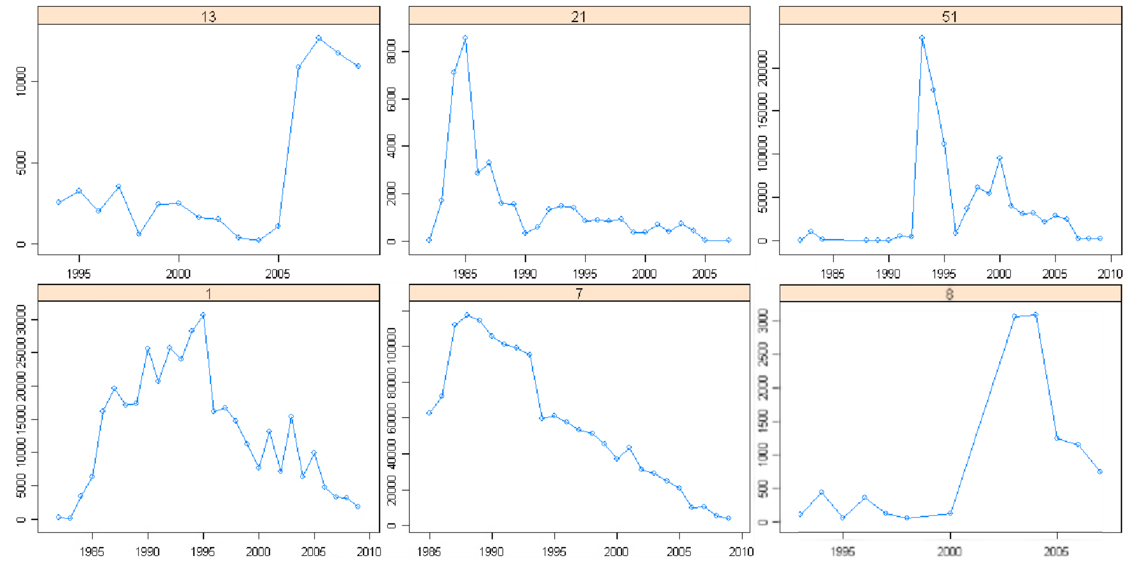

Figure 3.1b. Effort (hours fished for trawl gear and seine, or average length of gillnet) per year in ICES Division VIIa conducted by UK (E&W) fleets. Gear 1 = Beam trawl, 7 = Otter trawl for demersal fish, 8 Twin otter trawl for demersal fish, 13 *Nephrops* otter trawl, 21 purse-seine and 51 gillnets.

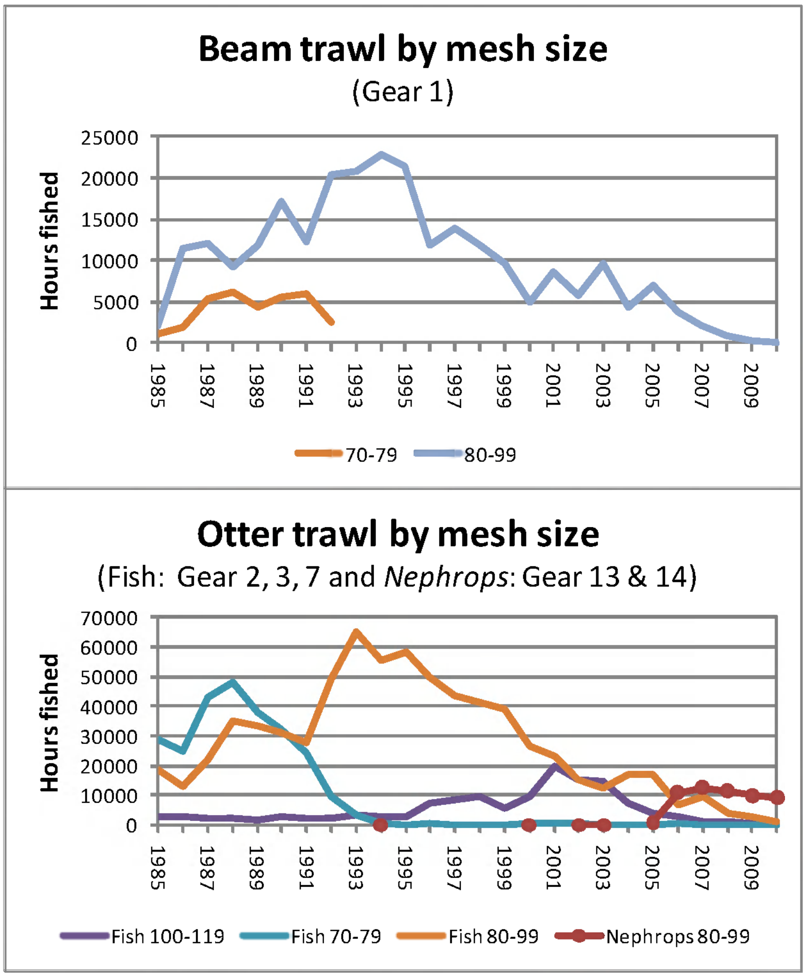

Figure 3.2. Hours fished by UK (E&W) fleets in VIIa by gear and mesh.

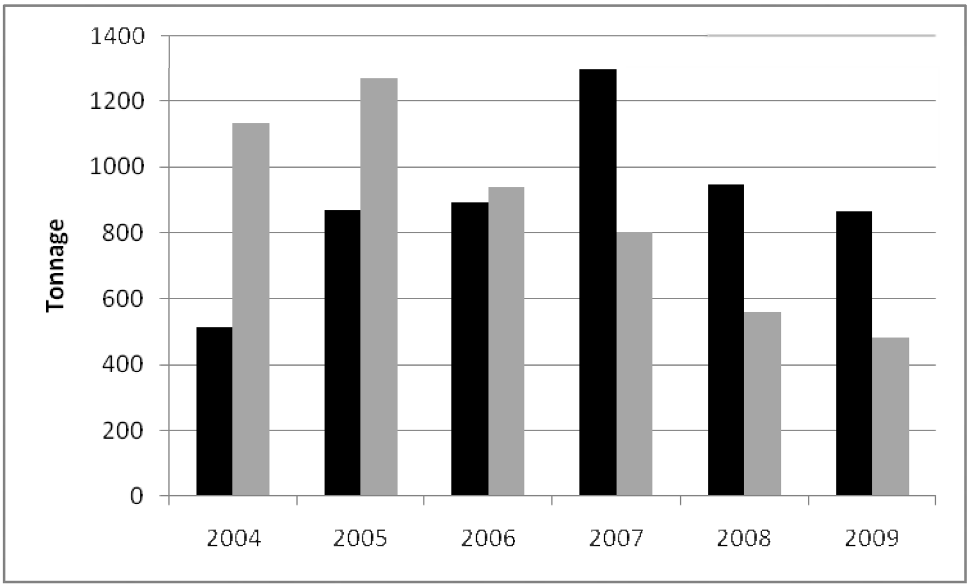

Figure 3.3. Total international discard tonnage (black) and landed tonnage (grey) of plaice VIIa 2004–2009.

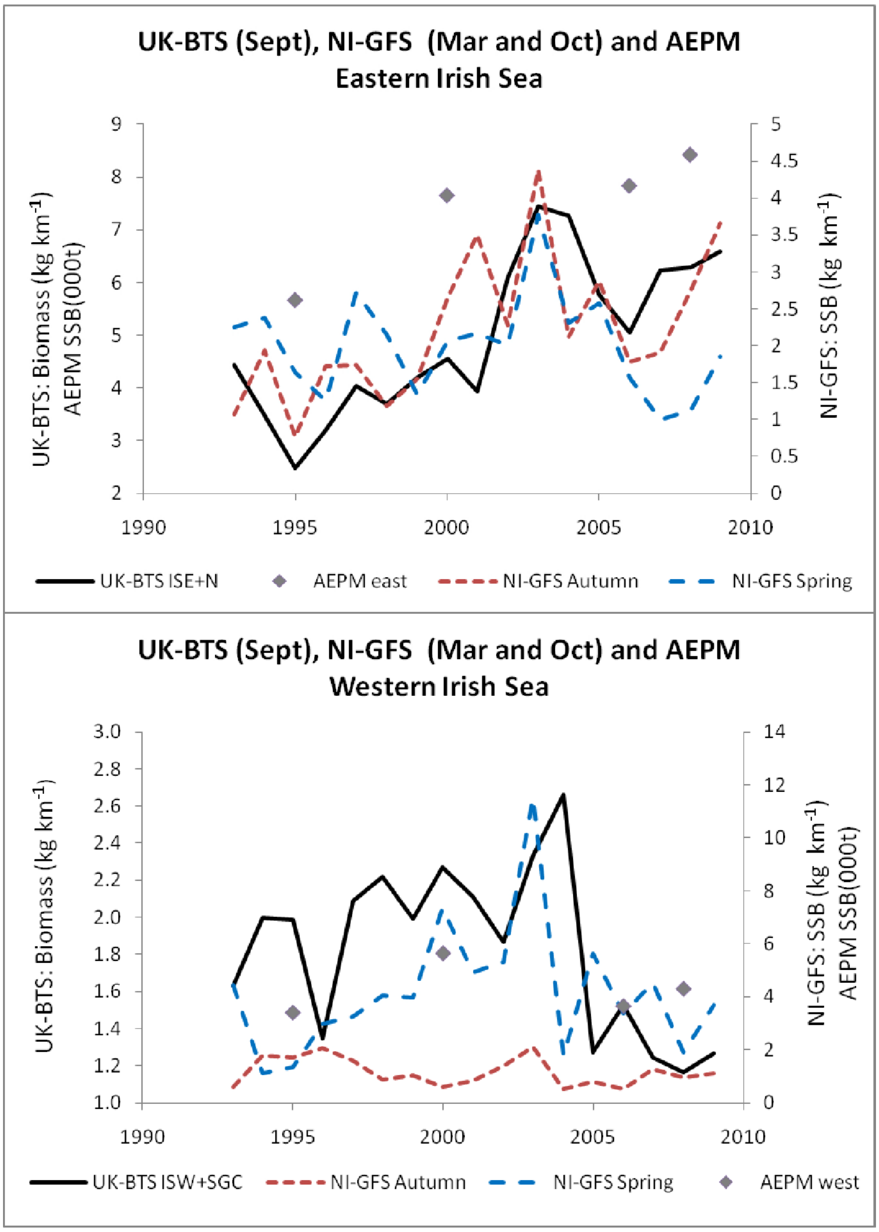

Figure 3.4. Trends in SSB indices (kg per km towed) from the UK(E&W) Beam Trawl Survey in September (heavy black line) and the N. Irish Groundfish Survey in March and October (blue and red dashed lines respectively) in the eastern Irish Sea (top) and the western and southern Irish Sea (bottom). Also shown (grey diamonds, left axis top and right axis bottom) the estimates of SSB from the Annual Egg Production Method from Armstrong *et al.* (2010).

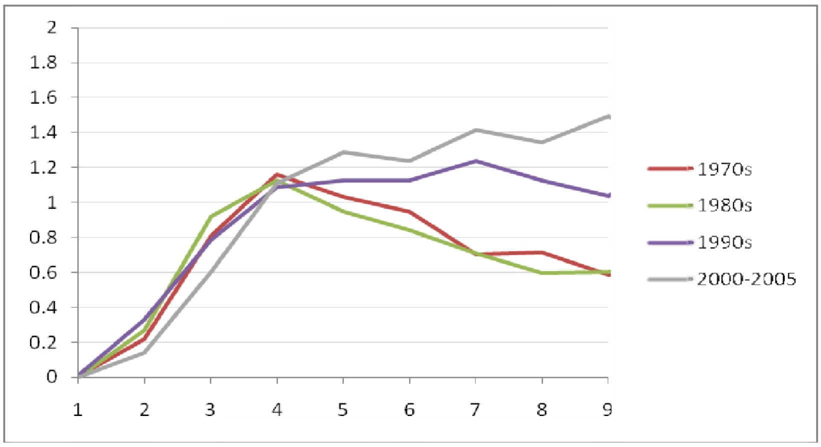

Figure 3.5. Change in decadal averaged selectivity of the fishery from an untuned ('user-defined' - Terminal F values set to 0.1) converged VPA based on landings only data. Model fitted using the Lowestoft Virtual Population Analysis (VPA) assessment suite (Darby and Flatman, 1994).

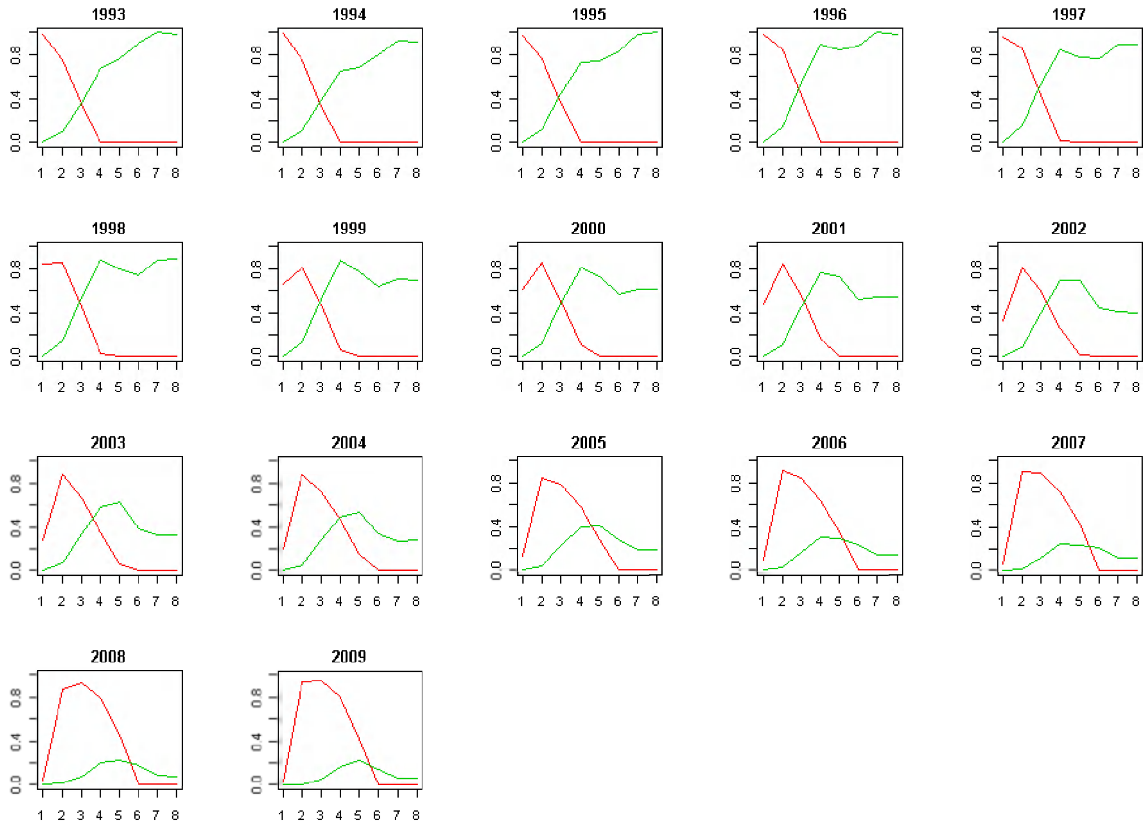

Figure 3.6. Selectivity of the fishery split into the landed (green) and discarded (red) components as estimated by the AP model.

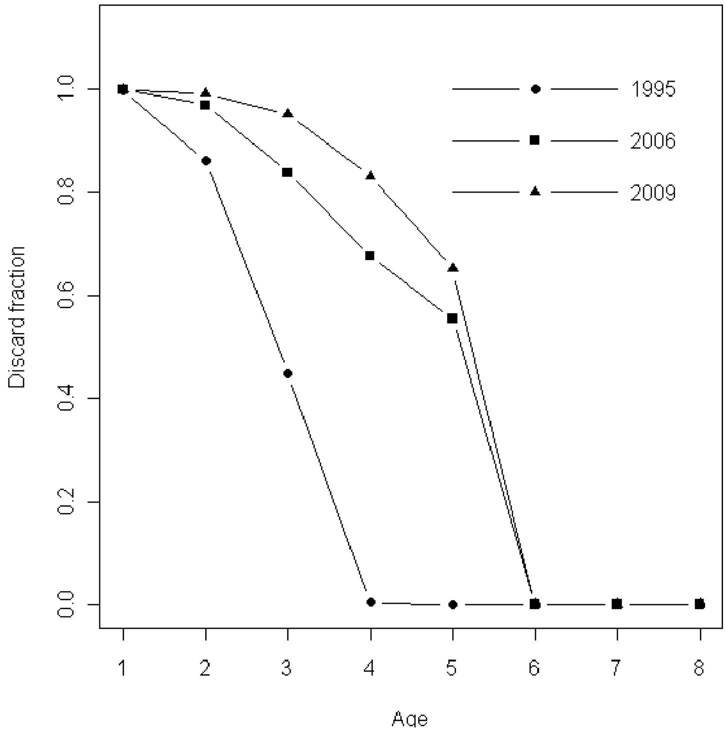

Figure 3.7. Change in the discard fraction-at-age over time as estimated by the AP model.

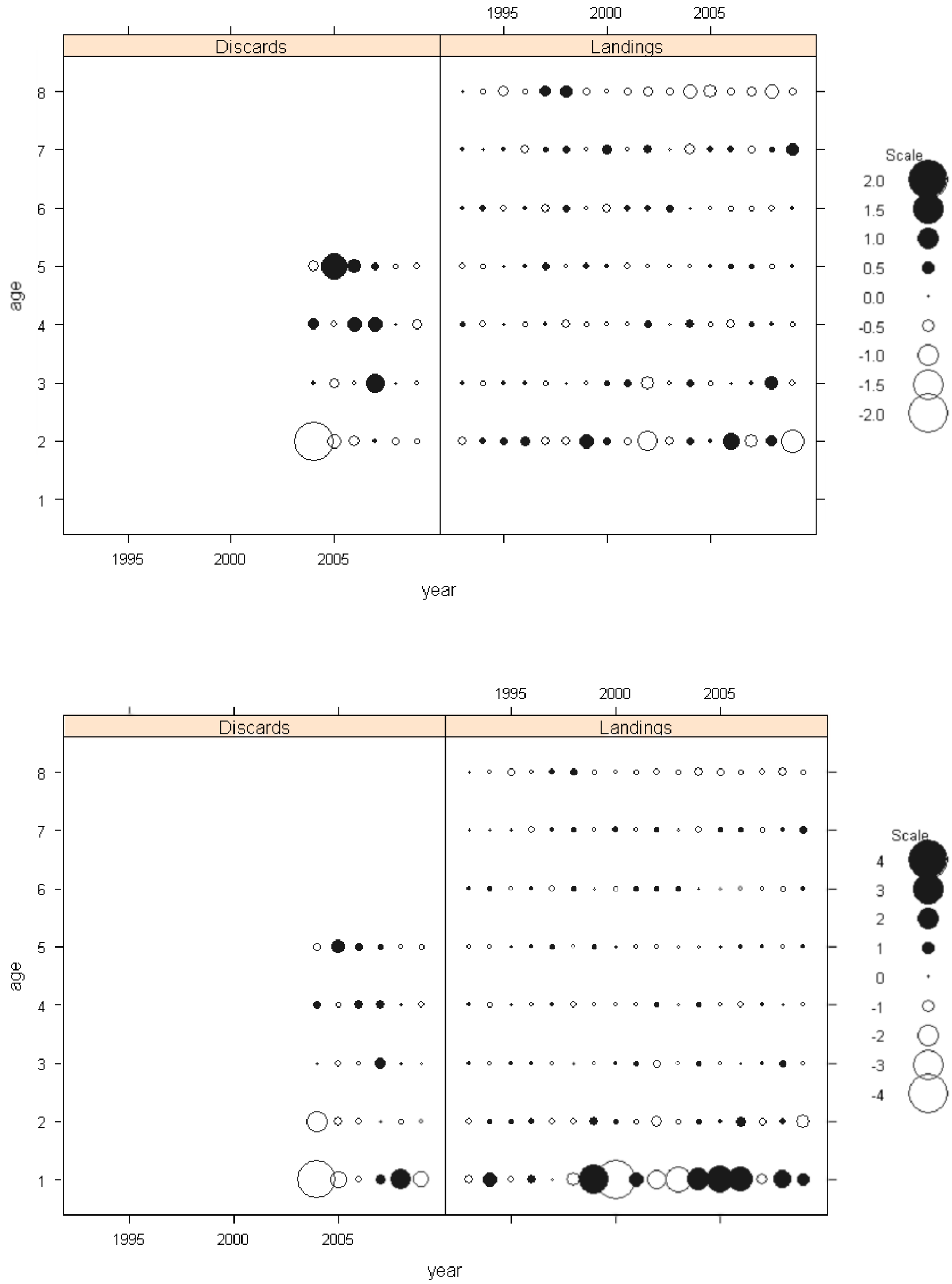

Figure 3.8. Residual plots for discards (left) and landings (right) with (bottom) and without (top) bubbles drawn for age 1. Bubbles are log(observed) – log(expected). Expected values were estimated by the AP model.

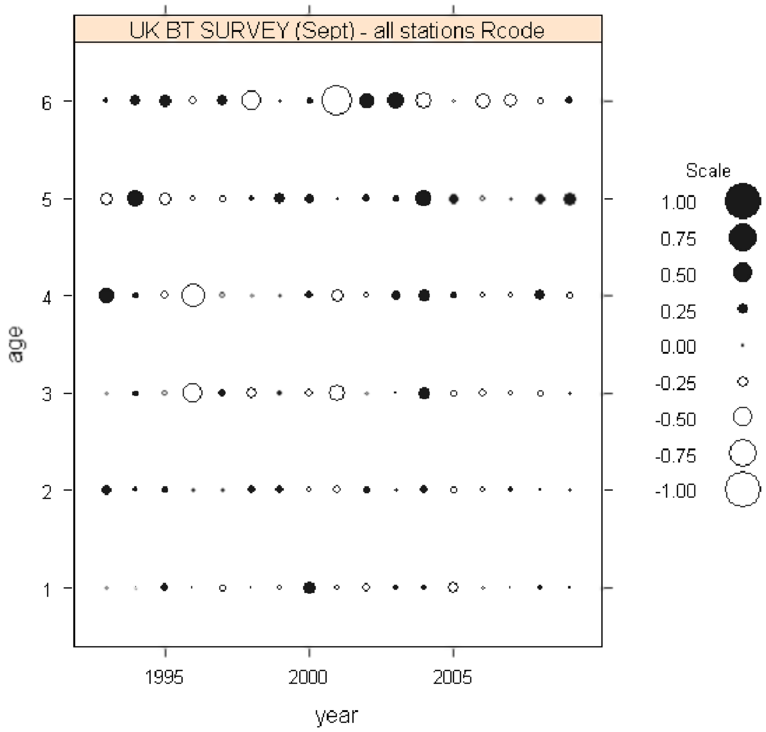

Figure 3.9. Residual plots for the UK(E&W) BTS extended index. Bubbles are log(observed) – log(expected). Expected values were estimated by the AP model.

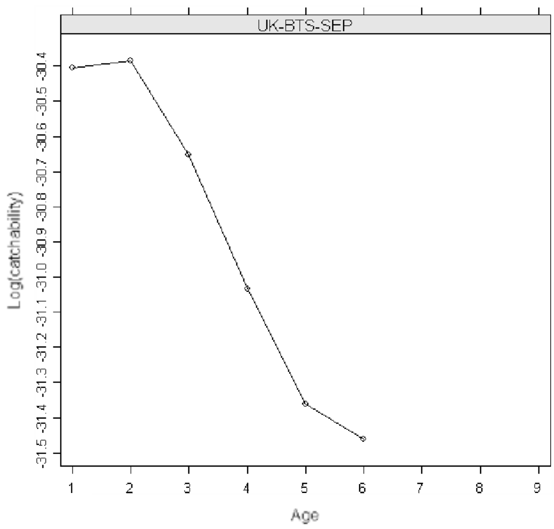

Figure 3.10. Log-catchability for the UK(E&W) BTS extended index as estimated by the AP model.

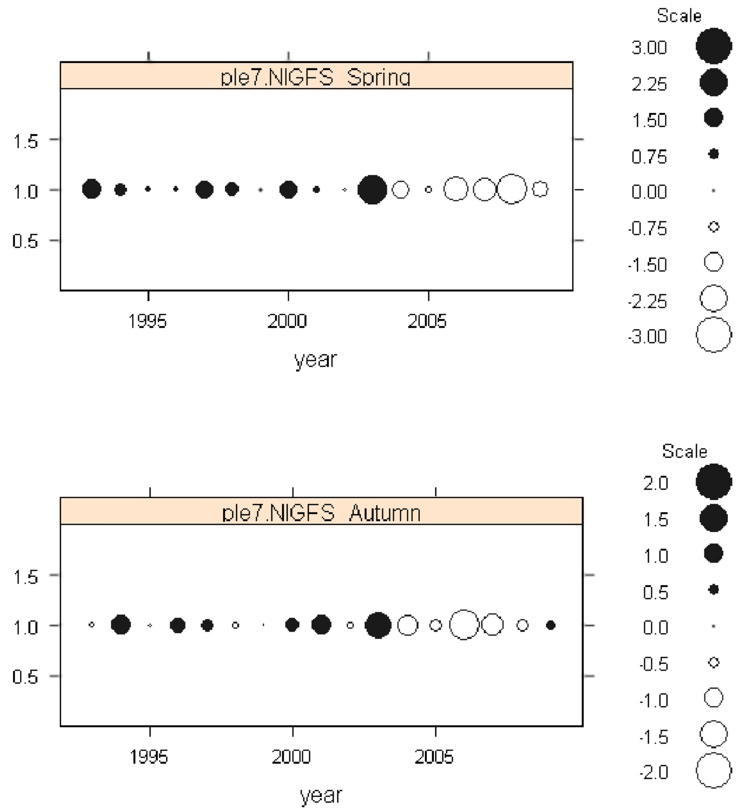

Figure 3.11. Residual plots for the NI-GFS in spring (top) and autumn (bottom). Bubbles are (observed mean standardized SSB) – (expected mean standardized SSB). Expected values were estimated by the AP model.

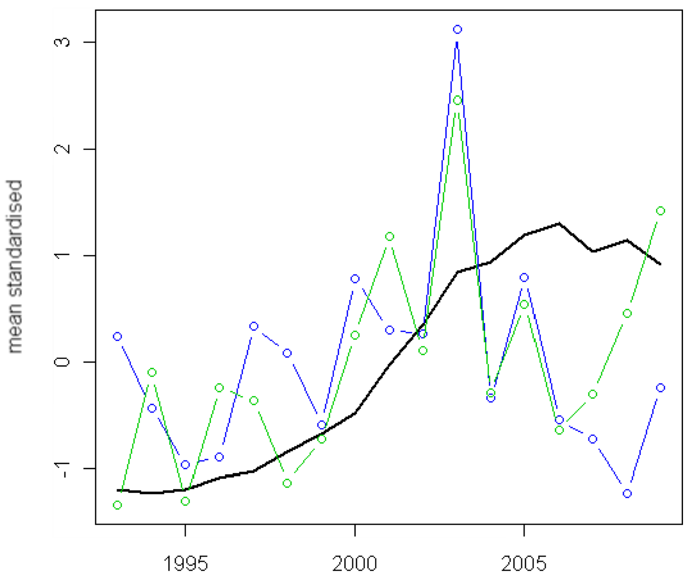

Figure 3.12. AP model estimates of mean standardized SSB (black line) overlain with mean standardized NI-GFS in spring (blue) and autumn (green) relative biomass indices.

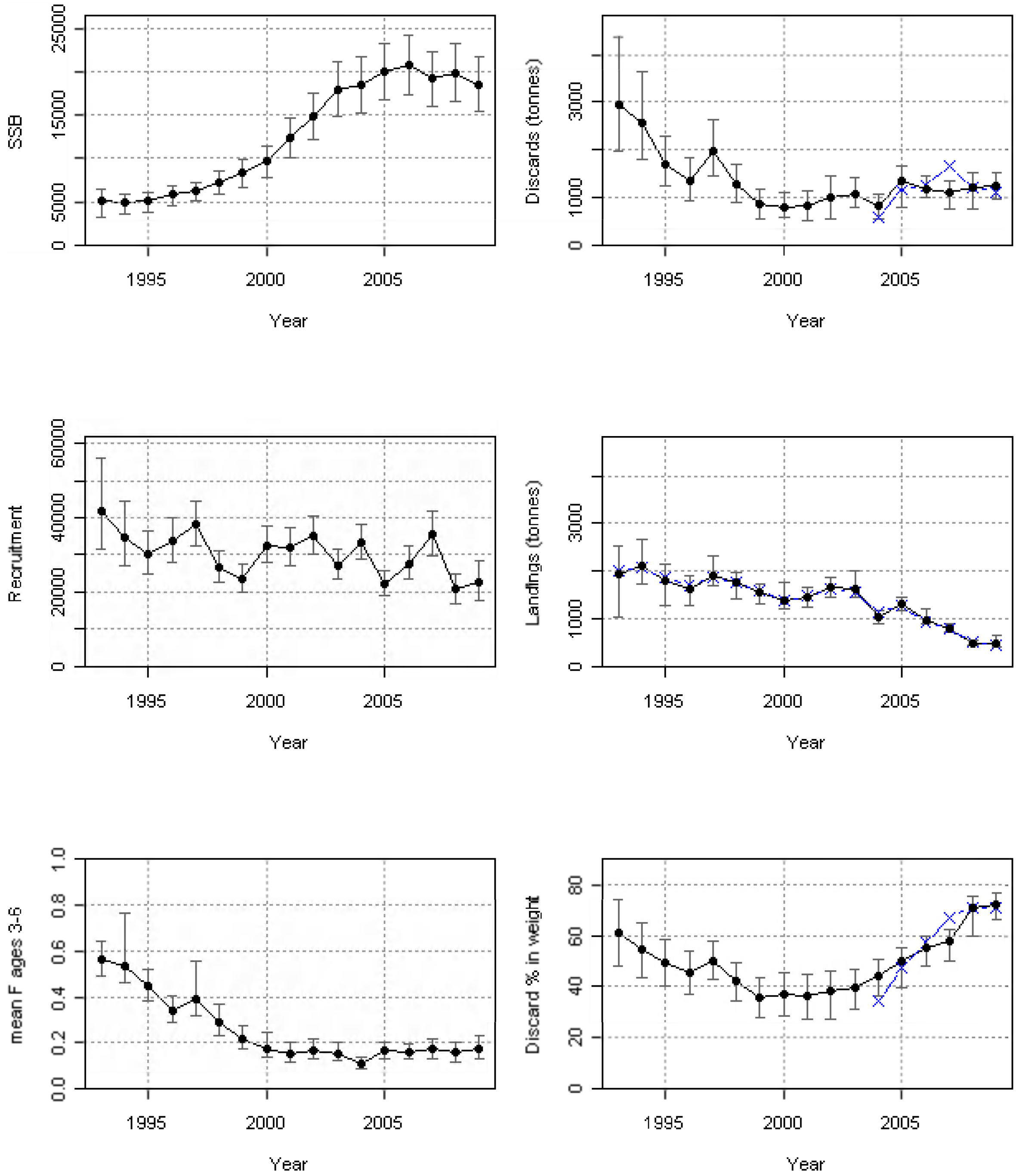

Figure 3.13. Modelled SSB (tonnes, top left), recruitment (thousands, centre left), F_{bar} (ages 3–6, bottom left) discard tonnage (top right), landed tonnage (centre right) and % catch discarded in weight. Also shown by blue crosses: observed discard tonnages, reported landings and estimated % catch discarded in weight from observations. Modelled using the AP model.

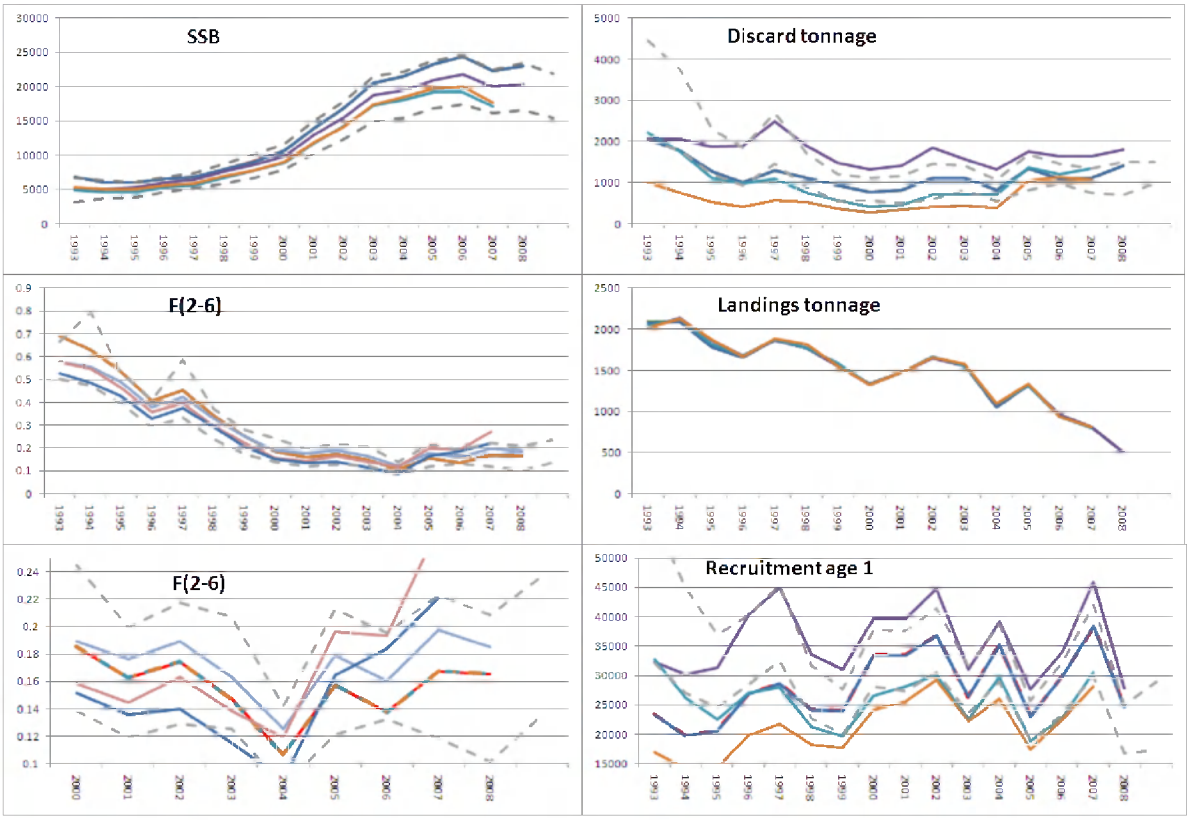

Figure 3.14. Tentative retrospective run of the AP model for VIIa plaice. SSB, estimated discards and landings in tonnes, F_{bar}(note the age range here is 2–6 but the final assessment used ages 3–6 as in previous WGs), recruitment-at-age 1 in thousands. The dashed lines show the 90% CI for a single run of the model with the full age range.

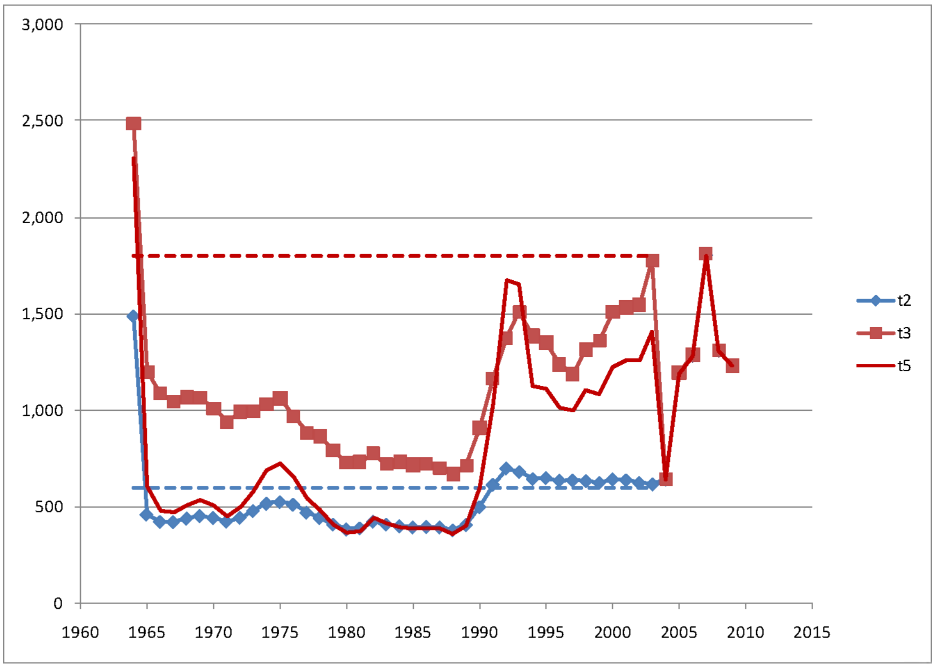

Figure 3.15. Annual discards (tons) input (dashed lines) or estimated by ASAP (solid lines) under different input values of discards prior to 2004 (blue=600 tons, red=1800 tons) and two CVs (t2 and t3 CV=0.3, t5 CV=0.6).

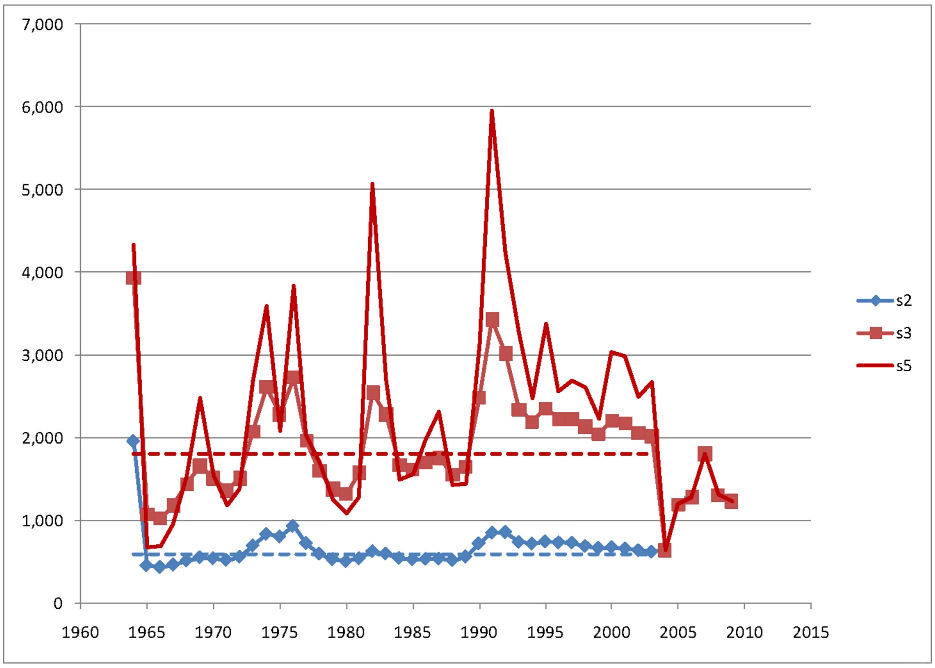

Figure 3.16. Annual discards (tons) input or estimated by ASAP. See Figure 6.15 for description of lines.

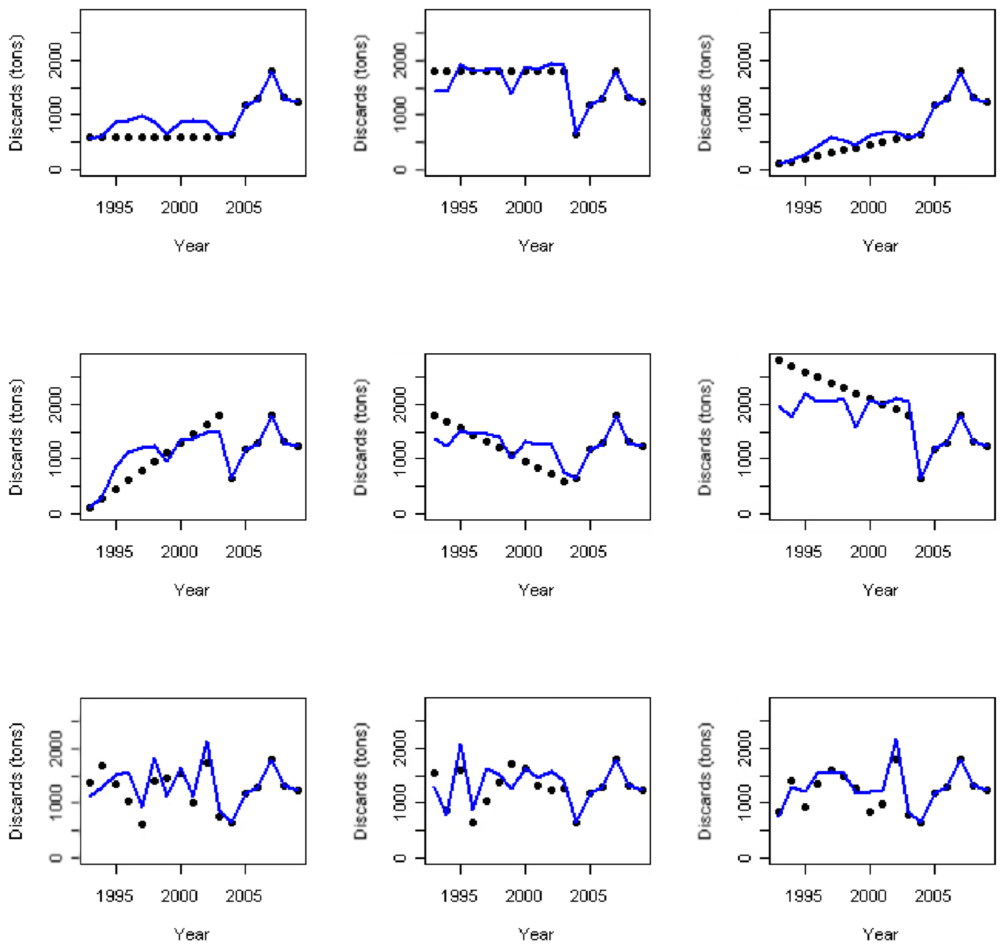

Figure 3.17. Annual discards (tons) input (symbols) or estimated by ASAP (lines) for a range of flat, linearly increasing, linearly decreasing, or random sequence of input discards.

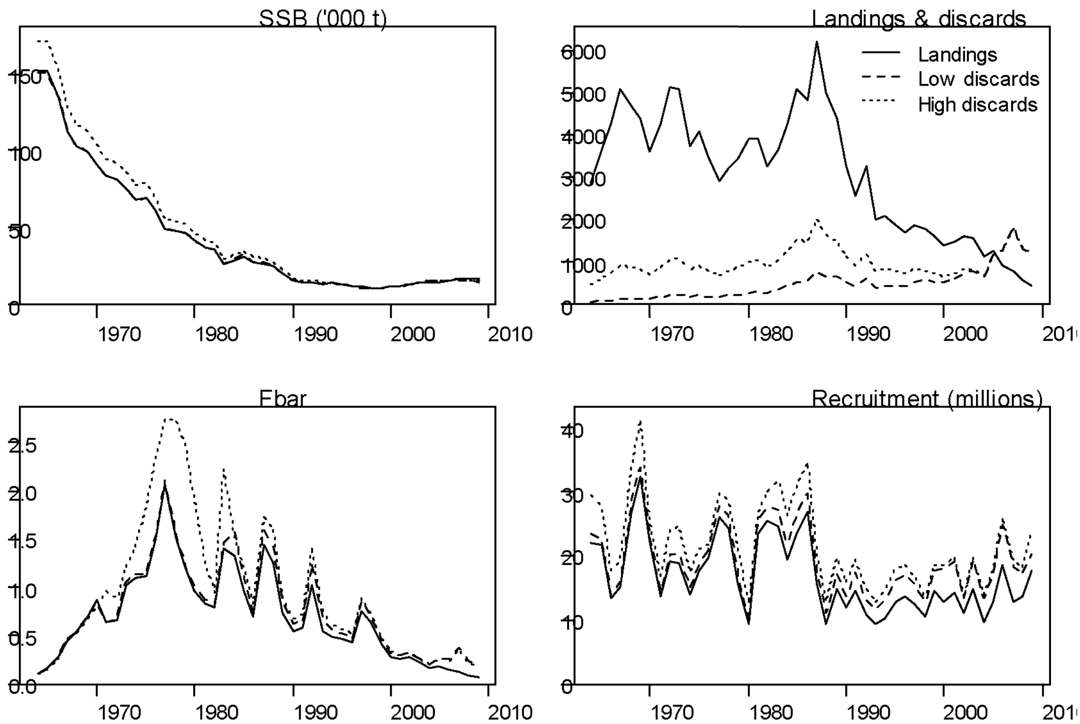

Figure 3.18a. Results from three initial runs: SSBs (top left); landings and discards (top right); F_{bar} (for ages 3–6, bottom left); and recruitment (bottom right).

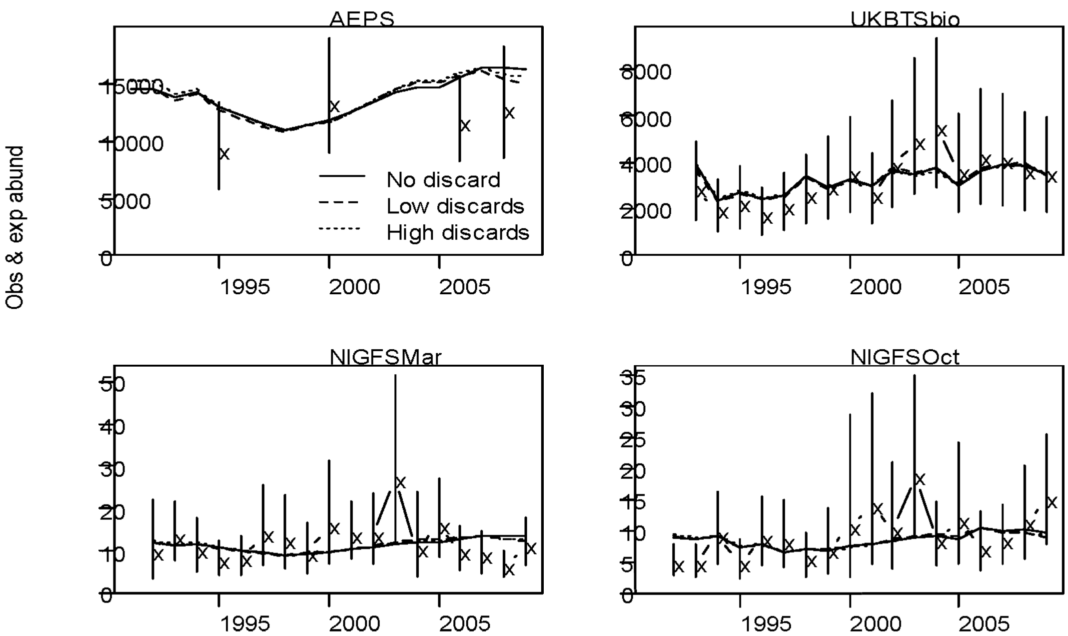

Figure 3.18b. Observed ('x', with 95% confidence intervals as vertical lines) and expected (lines) biomass values from the three initial runs.

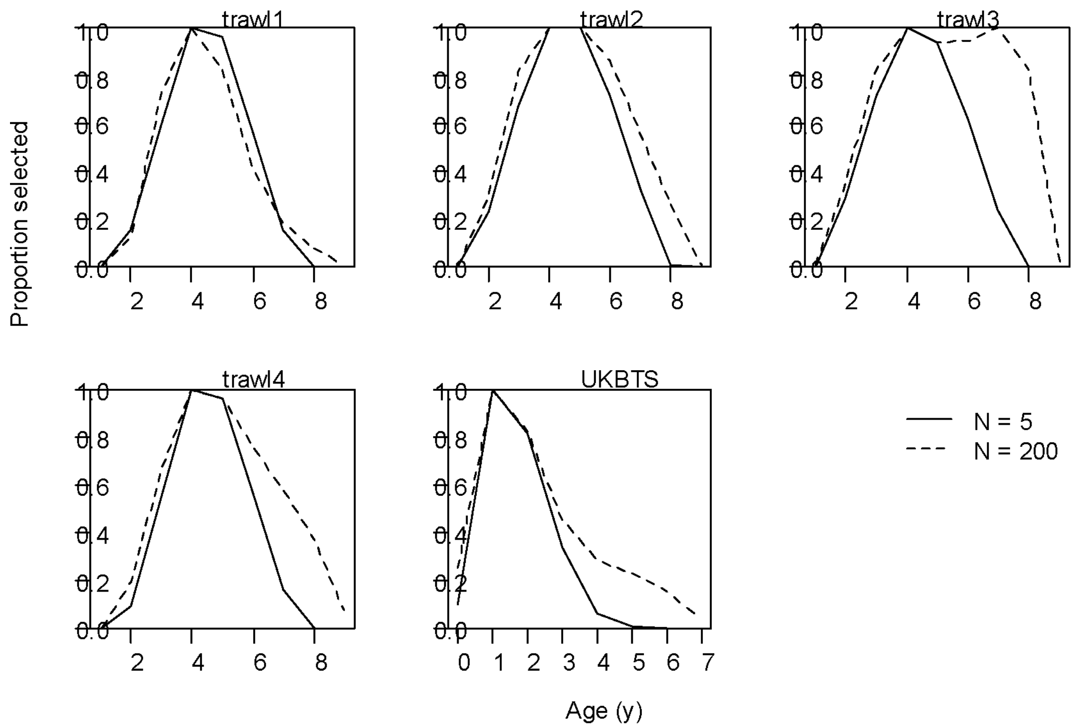

Figure 3.19. Estimated selectivity curves for the four periods of the trawl fishery and the UKBTS survey. These estimates came from model runs like the initial no discard run, but with the model age range reduced to 0–9 and allvalues ogives used to increase flexibility. [Input files for the N = 5 run are given in an Appendix].

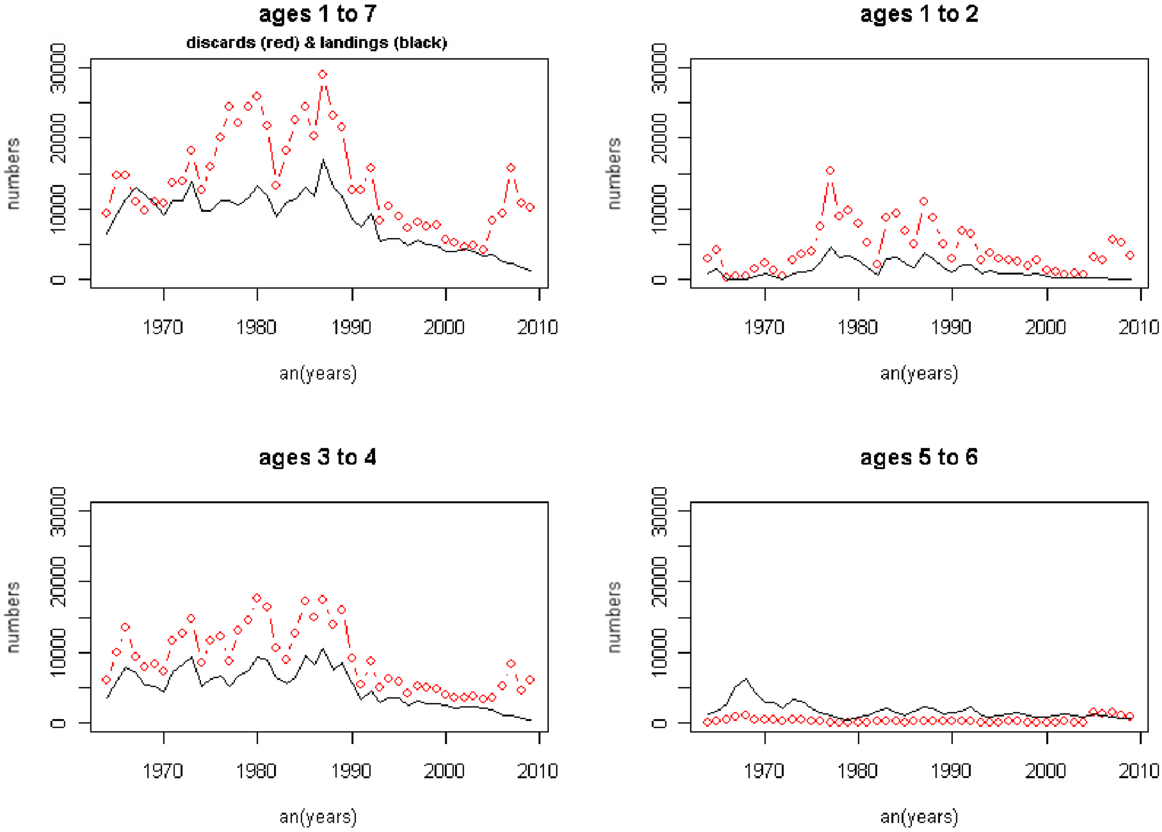

Figure 3.20. Discard reconstruction assuming the discard proportions of the catch-at-age in 2004 was constant backward in time. Discards were reconstructed from landings number-at-age.

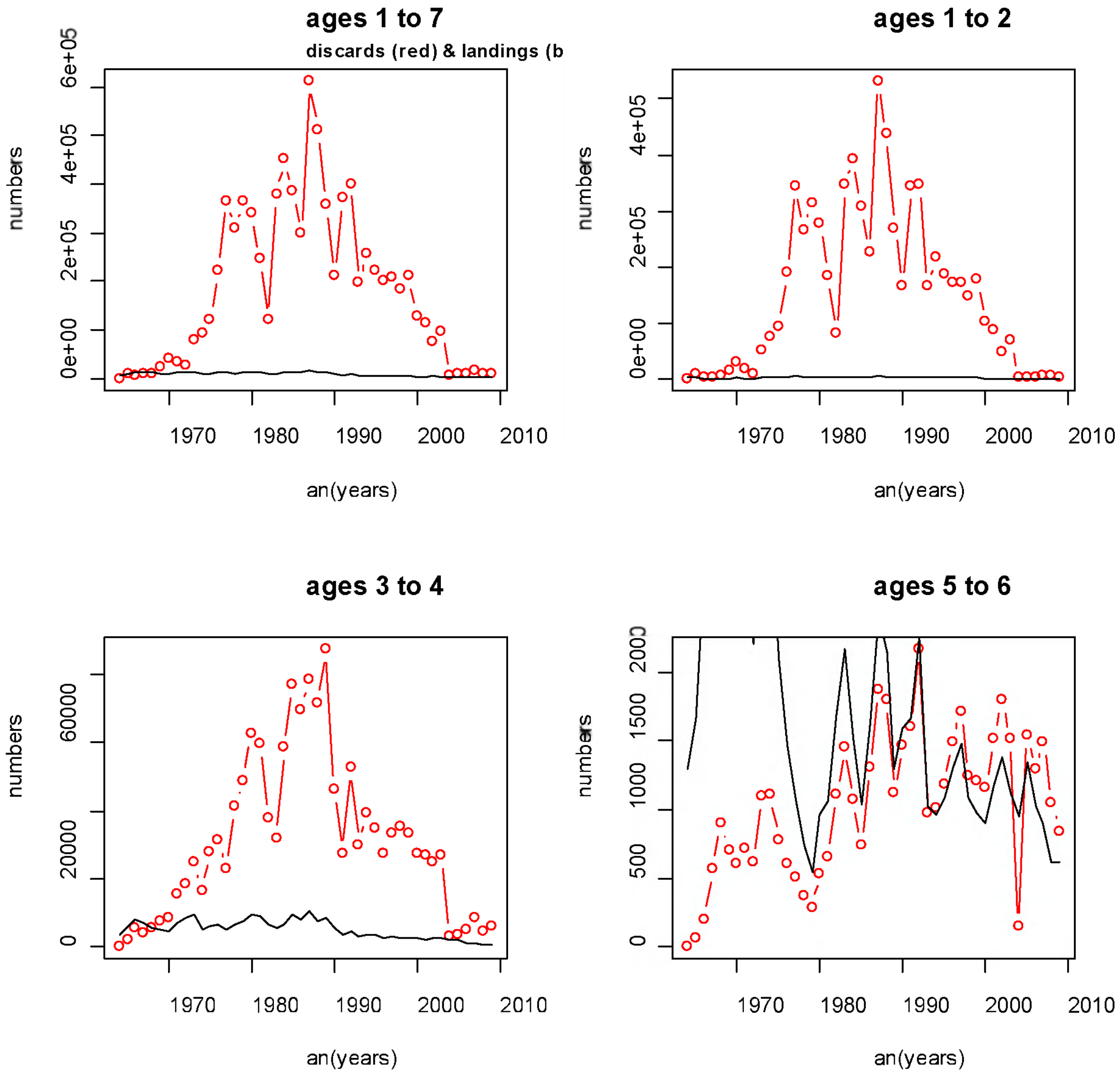

Figure 3.21. Reconstructed discards backwards from landings number-at-age using the 2009 (high discarding year) discard proportions of the catch and including a linear trend to zero discards in 1964 (because without trend numbers unreasonably high, not shown).

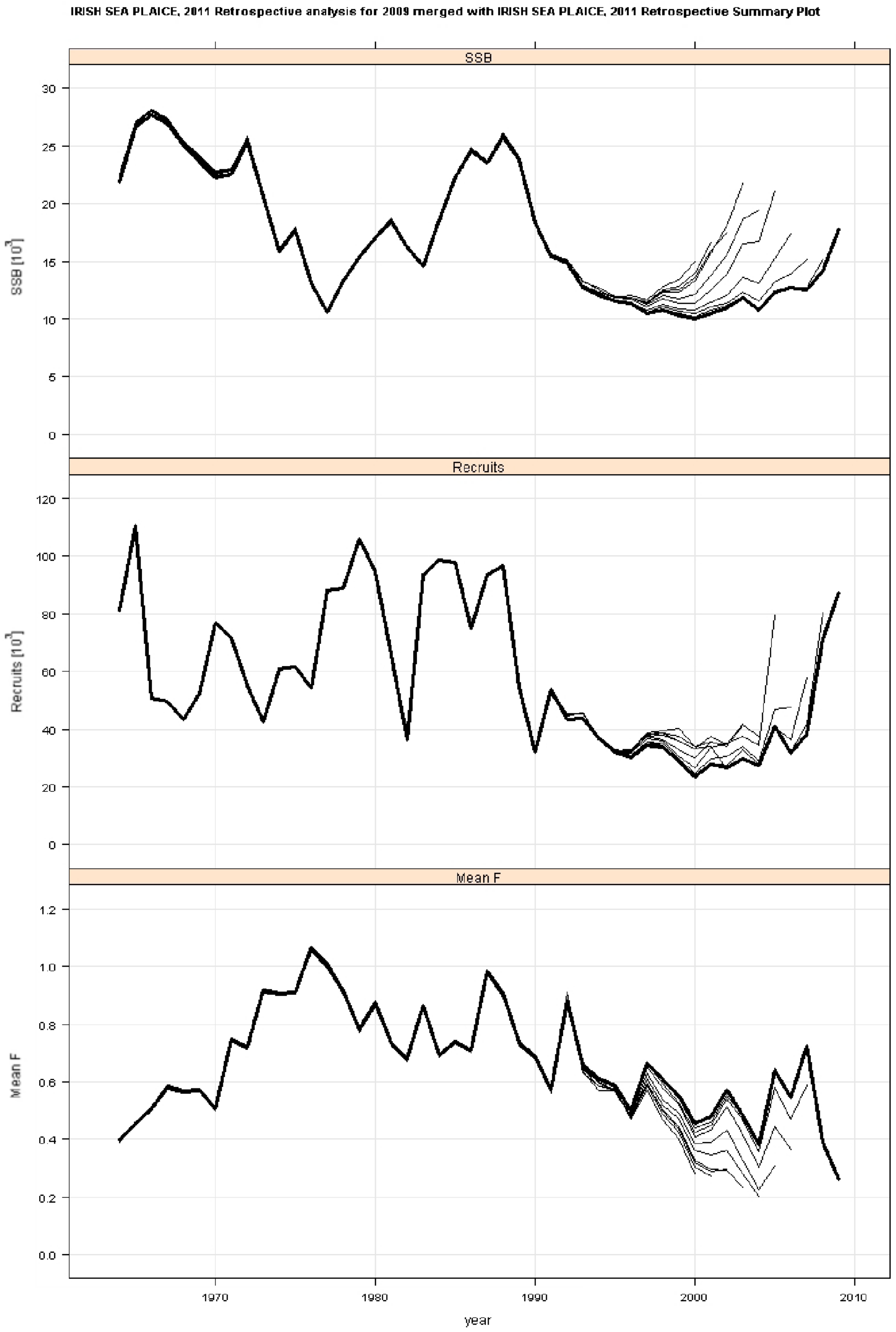

Figure 3.22. Retrospective pattern from an ICA including a discard reconstruction backwards from landings number-at-age and a constant discard fraction equal to that observed in 2004.

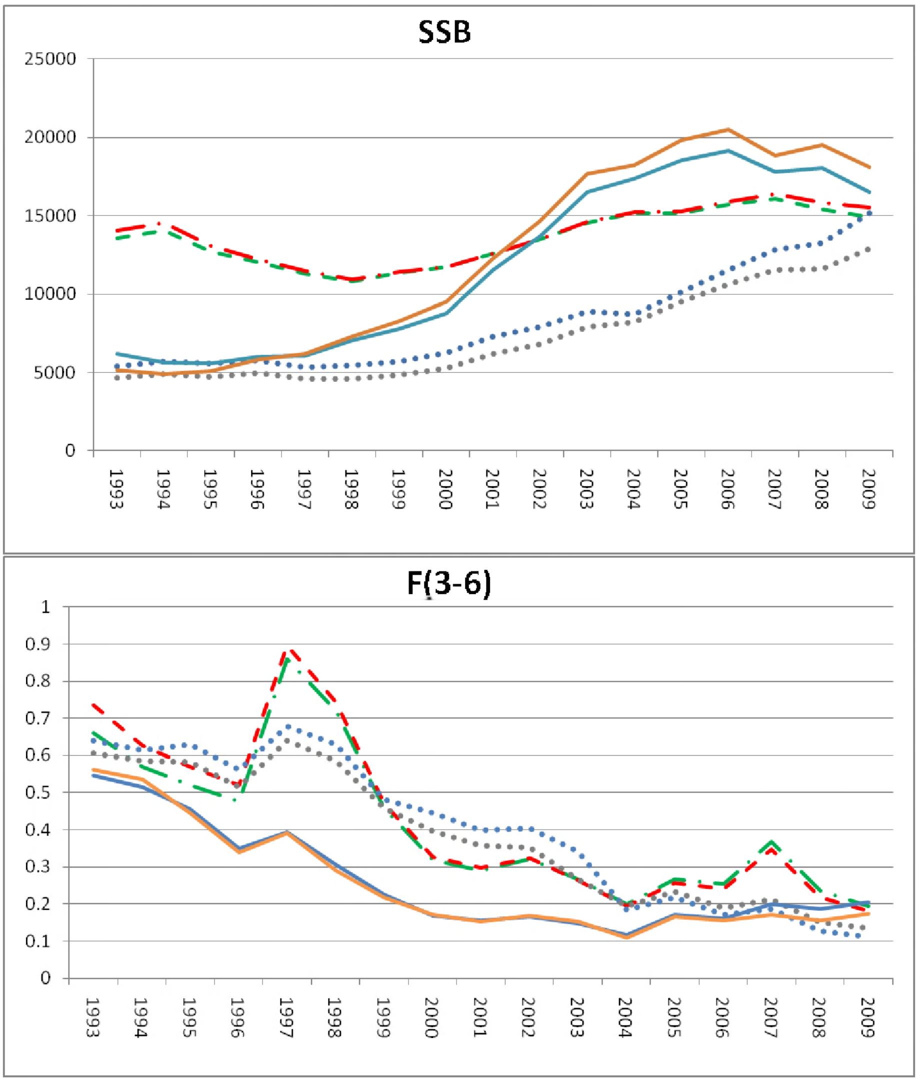

Figure 3.23. Comparative model output from AP (solid blue and orange lines), CASAL (dashed lines in red and green) and ASAP (dotted lines in blue and grey).

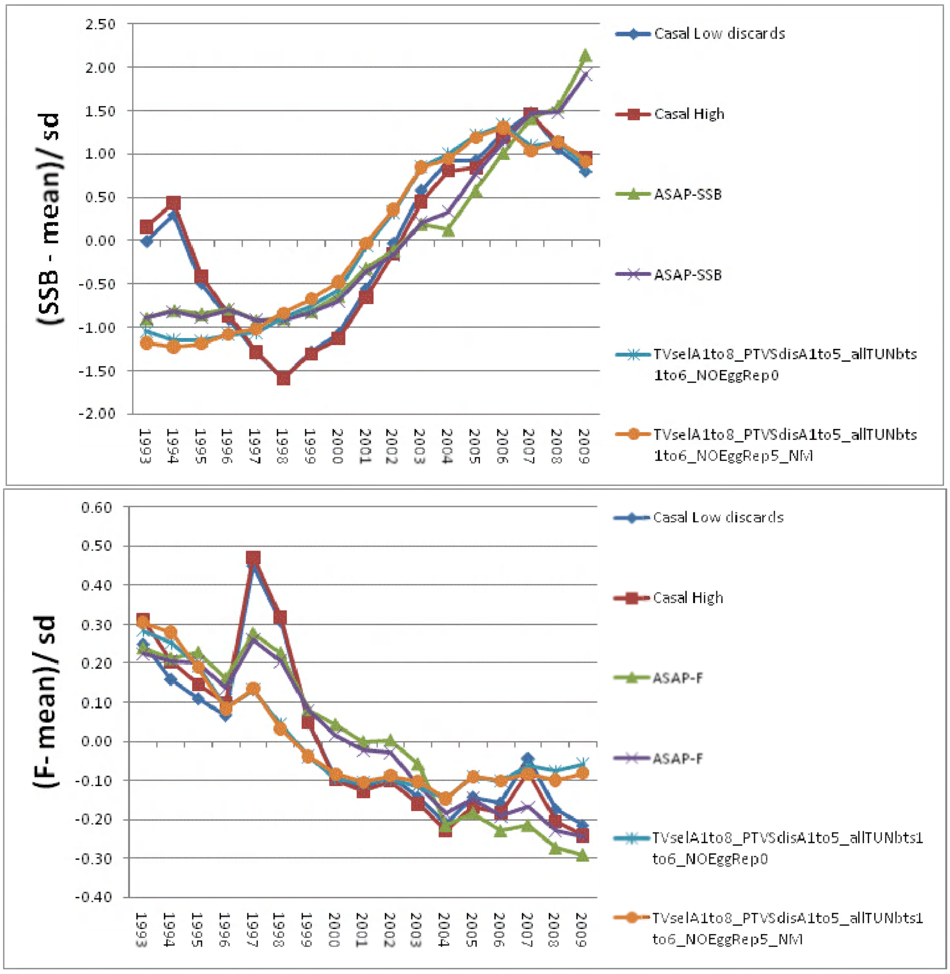

Figure 3.24. Mean standardized SSB and F(3–6) from comparative model output using AP (solid blue line with stars and orange lines with circles), CASAL (red lines and squares and blue lines and diamonds) and ASAP (green lines and triangles and purple lines and crosses).

4 Plaice in Divisions VIIf and g (Celtic Sea)

4.1 Current assessment and issues with data and assessment

In 2010, ICES WGCSE assessed the stock of plaice in Divisions VIIf and g (Celtic Sea) recording that the spawning-stock biomass (SSB) had peaked in 1988–1990, following a series of good year classes, then declined rapidly to its lowest level in 2004/5 following which it has gradually increased. Fishing mortality is estimated to have declined since 2004, but is likely to be underestimated due to the absence of discards from the assessed data. Recruitment was relatively high in most years during the 1980s, but has been lower since then.

The WGCSE considered that the stock should be benchmarked on the basis of a number of issues, including the lack of discards in the assessed data, the availability of a new survey-series and anomalies in the calculation of weight-at-age introduced by smoothing.

4.2 Catch data

Plaice are taken mainly as a bycatch in beam trawl fisheries directed at sole and anglerfish, and as part of a mixed demersal fishery (rays, gadoids, flatfish and squid) by otter trawlers. The main fleets are from Belgium, France and the UK (England & Wales). Otter trawling predominated until the mid-1970s when it began to decline steadily replaced by beam trawl effort, which increased rapidly. The main fishery occurs in the spawning area off the north Cornish coast, at depths greater than 40 m, about 20 to 25 miles offshore. Although plaice are taken throughout the year, landings are heaviest in the first and third quarters.

4.2.1 Landings data

Landings (Table 4.1) rose to a maximum in the late 1980s, declined during the early 1990s, then fluctuated around 1000 t. The decline reach a low at 390 t in 2005 following which there has been a gradual increase. Estimates of the level of discarding have been collected since 2004 and have demonstrated a consistent increase, apart from 2007 when a substantial increase occurred by all fleets, followed by a return to the previously lower levels.

International landings-at-age data based on quarterly market sampling and annual landings figures are available from 1977. For the period 1991 to 2005 quarterly age compositions have typically represented around 70% of the total international landings, though in 2002 this fell to around 25% when age compositions were not available for the Belgian fleet. Belgian age sampling in 1993 was at a reduced level and was augmented with UK data. There was no UK sampling in the 4th quarter of 1994 and landings of 1 year olds by the UK otter trawl fleet may be underestimated in this year. Sampling levels during the earlier years in the time-series are considered to be low for all fleets and the quality of the catch data, particularly for older ages, up until around 1992 is believed to be poor. In 1995 UK age compositions for the period 1984–1988 were revised using new ALKs which used data from adjacent time periods where necessary. In the 2005 benchmark assessment, it was noted that numbers-at-age 1 in the landings data were very sparse and variable, reflecting the selection on this age (and especially considering the probable substantial discarding), so the values were replaced by zero to avoid fitting to noise. Keeping age 1 in the assessment allows the survey data at age 1 to contribute.

4.2.2 Revised international landings weights-at-age

Historically, landings weights-at-age were constructed by fitting a quadratic smoother through the aggregated catch weights for each year. WKFLAT decided not to continue with this approach, following concerns raised by WGCSE that the quadratic smoothing was resulting in the youngest ages having heavier weights than older ages. WKFLAT 2011 rejected the use of the polynomial smoother for weights-at-age and suggested that raw catch weights are used in future. Raw data back to 1995 was obtained by WKFLAT and used to update the catch weights and stock weights files (Table 4.4–4.6).

4.2.3 Discard data

Discard rates, although variable, are substantial in some fleets/periods (Figure 4.1a and 4.1b). Total raised discard information is available for some fleets, and data raised to sampled vessels for others. WG estimates of the combined, raised, level of discards are available from 2004, they have demonstrated a consistent increase apart from 2007 when a substantial increase occurred in the discarding by all fleets followed by a return to the previously lower levels.

Discard weight-at-age data (Table 4.5) was available for Belgium and UK(E+W). The UK weight-at-age data were derived from data collected by Cefas for each year (2002–2009). The Belgian weight-at-age data were derived using estimates of total catch biomass and total numbers-at-age for years 2004–2009. These values were used to derive a weight-at-age matrix in grammes for an individual fish. The two national weight-at-age matrices were 'combined' to a total international matrix by weighting the individual weights-at-age for each year, by the total discard tonnages from the two countries for that year. Where only one estimate of weight was available for an age/year, then that estimate was used.

The above processes also produced estimates of discard numbers-at-age for the two countries. The UK estimates were raised to incorporate equivalent levels of discards for the 'un-sampled' countries of France, Ireland and N Ireland (on the basis of similar gear types). A raising factor based on tonnages 'landed' for these countries was calculated and applied to the UK(E+W) estimates of discard numbers. Finally, these estimates were added to those calculated for Belgium to give total international discard numbers-at-age estimates (Table 4.3).

4.2.4 Revised International Stock weights-at-age –including discards

For the years 2004–2009 where discard estimates were available, a revised set of stock weights-at-age were calculated. The stock weights-at-age based on landings; with SOP correction but no 'fitting' were combined with the international discard weights-at-age data. These were weighted by the relative landed or discarded international annual tonnages. The international annual discard tonnage was not readily available, as the 'unsampled' countries did not have estimates. These were derived using the ratio of UK(E+W) tonnages of landings and discards and this ratio was applied to these un-sampled nations landings to produce an estimate of total discard biomass for each of these countries. For the years prior to 2004, a revised set of stock weights-at-age data based on the international landings only was produced. These new values were based on the 'observed' weight data, but were SOP corrected. For this series of data, the 'smoothing' of the data by fitting a curve through the observed data were removed. The revised time-series of stock weights-at-age is presented in Table 4.6.

4.3 Biological data

Natural mortality and maturity

Initial estimates of natural mortality (0.12 yr all years and all ages, from tagging studies) and maturity were based on values estimated for Irish Sea plaice. A new maturity ogive based on UK(E&W) VIIfg survey data for March 1993 and March 1994 (Pawson and Harley, 1997) was produced in 1997 and is applied to all years in the assessment.

AGE	1	2	3	4	5+
Historical maturity	0	0.15	0.53	0.96	1.00
Revised maturity	0	0.26	0.52	0.86	1.00

The proportion of mortality before spawning was originally set at 0.2 because approximately 20% of the total catch was taken prior to late February–early March, considered to be the time of peak spawning activity. The proportion of F and M before spawning was changed to zero at the request of ACFM in 1996 as it was considered that these settings were more robust to seasonal changes in fishing patterns, especially with respect to the medium-term projections. No updated information was provided to WKFLAT and the estimates were retained.

4.4 Assessment calibration time-series

4.4.1 Survey tuning data

Indices of abundance from the UK (BTS-Q3) beam trawl survey in VIIf and the Irish Celtic Explorer IBTS survey (IBTS-EA-4Q) are presented in Table 4.7. Both surveys are detailed in the stock annex. The IGFS is a demersal trawl survey which started in 2003. It is coordinated through the ICES International Bottom Trawl (IBTS) working group, providing annual indices of abundance for commercially exploited groundfish stocks on the Irish continental shelf (ICES VIa, VIIb,g&j) for Q3–4. Plaice are caught by the survey off the SE coast up to, and just over, the border of VIIg with VIIa (ICES rectangles (32E2, 32E3).

Figure 4.2a presents the log survey indices-at-age for the UK (BTS-Q3) beam trawl survey plotted against year and cohort on the top row and log catch curves and the negative gradient of the catch curves - an indication of total mortality trends. The plots illustrates the historical consistency of year-class abundance estimates at each age, there are no major year effects. Recent data have demonstrated less correlation between ages than the historical time-series which should be monitored in case it is a developing problem. The log catch curves demonstrate good consistency over time and the reduction through time of the negative slope indicates that mortality rates have been declining.

Figure 4.2b presents the log survey indices-at-age for the Irish groundfish survey (IGFS) plotted against year and cohort on the top row and log catch curves and the negative gradient of the catch curves. Year effects in the survey catch rates dominate the abundance indices. The year-class and catch curve plots illustrates that the consistency of plaice year-class abundance estimates at each age is relatively poor. The survey was not fitted within the assessment model, but will be monitored as the time-series progresses.

4.4.2 Commercial tuning data

Commercial tuning indices of abundance from the UK(E&W) beam trawl and otter trawl data are also presented in Table 4.8. Historically, only ages 4–8 have been used to calibrate the assessment because of concerns about the level of discarding at the youngest ages.

Figures 4.3a,b present the log commercial cpue indices plotted against the year and year class, the log catch curves for each cohort and the negative gradient of the catch curves. The plots illustrate the historical consistency of year-class estimates from the commercial data - throughout the time-series for the beam trawls but with more noise resulting from two major year effects in the otter trawl data.

4.4.3 Comparison between tuning dataseries

Figures 4.4–4.6 show within tuning-series consistency (in cohort strength) for the beam trawl survey and the two commercial dataseries, while Figure 4.7 and 4.8 show between series consistency (for each age). The series demonstrate generally good consistency, justifying their use for survey tuning. Correlations begin to deteriorate at the oldest ages for the beam trawl survey but are still high. There is a relatively low correlation between the commercial data cpue data at age 4 and the survey-series, compared to age 5, which may indicate discarding could be influencing the youngest age commercial cpue data but the correlation is still sufficiently high to maintain the commercial time-series at these ages in the initial model fits and to examine the residuals for each series.

4.4.4 Industry/stakeholder data inputs

There was no industry/stakeholder data available at this benchmark meeting.

4.4.5 Environmental data

There was no further environmental data available at this benchmark meeting.

4.5 Stock identity, distribution and migration issues

No information other than the historical tagging studies of Dunn and Pawson (2002) was available at this benchmark meeting. Limited mixing is considered to occur between the VIIf&g, Irish Sea and Channel stocks (Pawson, 1995). The management unit corresponds to the stock unit for VIIF&g plaice.

4.6 Influence of environmental drivers on the stock dynamic

No further information on the influence of the environmental drivers on the stock dynamic was available at this benchmark meeting. Time-series of recruitment estimates for all stocks in waters around the UK (Irish Sea, Celtic Sea, western and eastern Channel, North Sea) demonstrate a significant level of synchrony (Fox *et al.*, 2000). This could indicate that the stocks are subject to similar large-scale environmental forces and respond similarly to them.

4.7 Role of multispecies interactions

4.7.1 Trophic interactions

No analysis on trophic interactions was carried out at this benchmark meeting.

4.7.2 Fishery interactions

No analysis on fishery interactions was carried out at this benchmark meeting.

4.8 Impacts of the fishery on the ecosystem

No further information on the impact of the fishery on the ecosystem was available at this benchmark meeting.

4.9 Stock assessment methods

4.9.1 Model selection

The model used as a temporary basis for the assessment and provision of advice for the Celtic Sea plaice is AP; the 'Aarts and Poos' model (Aarts and Poos, 2009). This was selected on the basis that it was the only model available that the group could fit, in the time available, which reconstructs the historical discarding rates (derived from the survey dataseries).

The AP statistical catch-at-age model allows for four types of discard selectivity pattern. Discard selectivity can be modelled as a linear function of age and or as a more flexible function of age. Two functions allow the landings and discard proportions to change in time. Although a good start, the AP model is not considered the definitive assessment structure for the Celtic Sea plaice but a temporary solution to the fitting of datasets which include recent discards estimates but for which historical discard information is not available. The model reconstructs historical discard rates as time invariant (having similar rates to those estimated for the period for which discard data are available) or using a time variant spline. Given that the spline extrapolates beyond the range of the recent data to which it is fitted it can potentially result in spurious estimates of historical discarding, which may change markedly as new discard data are added to the short time-series. In addition is highly likely that the discard patterns currently observed differ from those that would have been observed historically as a result of substantial changes in the composition of the gear types that have been used to prosecute the fisheries in which plaice is caught. A model which incorporates estimates of historical discards that are derived from the proportional allocation of the effort deployed by the dominant gear types is considered more appropriate in the long term.

4.9.2 Model fitting

The AP model allows the fitting of either a time variant (TV) or time invariant (TI) selection pattern for landings at the same time as fitting one of four models for discarding a Polynomial Time Variant Spline (PTVS), Time Variant Spline (TVS), Time Invariant Spline (TIS) and a Time Invariant Linear Logistic (TIL). This provides eight models that can be fitted to the Celtic Sea plaice data, models will subsequently be referred to by the acronyms of the combination fitted to landings and discards e.g. TV_PTVS.

The AP model estimates historical population numbers-at-age from which discard selection estimates are derived from a fit to the survey data, consequently the estimation model was constructed from 1993–2009 to allow all cohorts to be associated with survey data; as for the previously fitted XSA model the age range was 1–9+. The tuning-series fitted within the model were the beam trawl survey ages 1–5, and the beam trawl and otter trawl surveys with ages 4–8. The text table below compares the log likelihood, the significance, number of observations and the Akaike Information Criteria (AICs) of the fit.

Selection	Discards	– log.likelihood	AIC	N_param	N_obs
TI	PTVS	193.229	560.46	87	456
TI	TVS	195.431	556.86	83	456
TV	PTVS	190.598	563.20	91	456
TI	TIL	No fit achieved			
TV	TIL	No fit achieved			
TI	TIS	201.952	561.90	79	456
TV	TIS	211.334	588.67	83	456
TV	TVS	188.624	551.25	87	456

Ideally the model with the lowest AIC would be retained for further analysis and inference of the population and fishery trends, however, the different model structures resulted in very similar fits to the data and therefore selection between the models was made on the basis of residual patterns and the perceived realism of estimated time-series of the changes in discard and landings selectivity-at-age and through time. These are discussed below.

Models which consider the discard selection pattern to be constant in time (TI_TIS & TV_TIS, TI_TIL & TV_TIL) were rejected; the TIL models had both failed to achieve a solution. Discarding patterns are known to have changed as the types of gear used in the fishery have evolved. The TIS models had poor fits to the discard data in the recent years with an estimated declining trend in discards whereas the data indicates increasing levels of discards. The TV_TVS model which fits a time variant selection pattern to the landings and a time variant spline for the discard selection resulted in the lowest AIC value for all of the model fits. However, examination of the fitted selection patterns established that the improvement in the fit resulted from estimates of selection at age seven that increased historically in time, independent of the adjacent ages (Figure 4.9); consequently this model was rejected as a plausible fit to the data. This did not occur for estimated selection pattern of the TI_TVS model.

For each of the remaining three models (TI_PTVS, TI_TVS and TV_PTVS), Figures 4.10–4.12 present the estimated time-series of SSB, recruitment, fishing mortality, total discard and landings weight and the proportion of discards by weight (Figure a); the estimated relative selection pattern (Figure b), the log residuals for the discard-at-age data (Figure c), the log survey (Figure d) and commercial fleet catchability residuals (Figures e and f) and the log residuals for the landings-at-age data (Figure f). As would be expected from the similar log likelihood values the models all have very similar fits in terms of the residual patterns in the fits to the data. All of the model fits indicate mostly negative residuals at oldest survey ages in the earliest part of the time-series and positive residuals in the most recent years. None of the models fit the large increase in the discard data in 2007 well; producing a very strong year effect in the discard residuals in that year and negative year effects in the adjacent years. This strong increase was observed for a number of fleets and is therefore considered to be a real effect; modelling a smooth transitions in the discard selection does not match the observed discard pattern in 2007 but does seem applicable to the other years which have treasonable fits. The fit to the landings at age data is reasonable apart from the first age, which is poor for all models.

4.9.3 Conclusions from the model fitting

The elimination process leaves three models which cannot be distinguished in terms of the AIC and have very similar residual patterns and fits to the dataseries; the TI_PTVS, TI_TVS and TV_PTVS models. The TV_PTVS model which allows for variation in time in the selection patterns of both landings and discards would seem to be the most plausible model; given the known changes in gear types and discarding. However, statistically it is not distinguishable from the models which maintain the landings selection pattern as constant throughout the time-series.

Comparison of the management and stock metrics from the three model fits demonstrates very similar time-series trends in the estimates from the three models (Figure 4.13); estimates of fishing mortality, SSB and total estimated discards are very similar. In all model fits SSB is increasing and total fishing mortality is decreasing, the fitted models result in similar outcomes in terms of the advice that would be derived from them.

WKFLAT concluded that:

1. Due to the change in estimated fishing mortality when discards are included within the model fit, that discards should be retained within the assessment model structure.
2. Given that the time-series of discard data to which the models are fitted is short and that, consequently, there are likely to be changes in the management estimates as discard data are added in subsequent years, no definitive model structure can be recommended at this stage in the development process.
3. The most flexible of the models TVS_PTVS should be used as the basis for advice; in terms of relative changes in estimated total fishing mortality and biomass.
4. The other two models which provide similar structures should continue to be fitted at the WG to provide sensitivity comparisons.
5. As the dataseries are extended a final model selection can be then determined.

The settings and data for the model fits are set out in the table below:

Assessment year		2010 WGCSE	2011 WKFLAT
Assessment model		XSA	AP
Catch data		Excluding discards 1977–2009	Including discards 1990–2009
Tuning fleets	UK(E&W)-BTSurvey	1990–2009 ages 1–5	1990–2009 ages 1–5
	UK commercial beam trawl	1990–2009 ages 4–8	1990–2009 ages 4–8
	UK commercial otter trawl	1990–2009 ages 4–8	1990–2009 ages 4–8
	Ire GFS Q3/4	Series omitted	Series omitted
Selectivity model		n/a	Linear Time Varying Spline at age (TVS)
Discard fraction		n/a	Polynomial Time Varying Spline at age (PTVS)
Landings number-at-age, range:		1–9+	1–9+
Discards number-at-age, year range, age range		n/a	2004–2009, ages 1–8+

4.9.4 Retrospective patterns

Retrospective runs were not attempted as they were considered to be too sensitive to the short time-series of discard data.

4.10 Short-term and medium-term forecasts

4.10.1 Input data

Previous approaches are given in the stock annex. No medium-term forecasts were explored at WKFLAT 2011.

4.10.2 Model and software

The MFDP, FLR approaches are suited to the illustrative approaches required for the short-term forecast.

4.10.3 Conclusion

No work was done by WKFLAT 2011 in relation to medium-term forecasts for Celtic Sea plaice. Details on the methodology used in previous years can be found in the stock annex.

For short-term forecasts based on the revised assessment it is recommended that those methods be applied to the populations and fishing mortalities (separated into discard and landings mortalities) derived from the PV_TVS model (assuming that the previously discussed sensitivity analyses do not indicate a change of model); in order to provide indications of the expected trends in discards, landings and spawning biomass.

4.11 Biological reference points

Comparisons with the estimates of fishing mortality and spawning biomass are presented in Figure13. The addition of discards increases the estimates of spawning biomass in the most recent years following the increased estimates of discards in time. Similarly fishing mortality averaged across ages 3–6, which include ages that are discarded also increases. Previous BRPs may therefore not be consistent with new assessment methodology and should not be used until the assessment methodology is considered sufficiently stable (a longer time-series of discard data) to evaluate new reference levels.

4.12 Recommendations on the procedure for assessment updates and further work

WKFLAT recommends that future assessments are carried out following the methodology proposed during this meeting and described in the Stock Annex.

WKFLAT recommended that the AP model should be tested against a stock for which there was a time-series of discarding available.

BRPs require revision and any new BRPs proposed will require evaluation.

4.13 Implications for management (plans)

No management plan is currently in place for Celtic Sea plaice. Sole and plaice taken in the same fisheries.

Table 4.1. Plaice in Divisions VIIf&g: Total landings and discards (tonnes) as reported to ICES, and used by the WKFLAT 2011 Benchmark group.

year	landings	discards
1977	753.07	0
1978	852.62	0
1979	843.976	0
1980	1354.751	0
1981	1371.309	0
1982	1286.94	0
1983	1146.538	0
1984	1209.963	0
1985	1743.795	0
1986	1691.512	0
1987	1894.647	0
1988	2110.874	0
1989	2149.637	0
1990	2080.079	0
1991	1484.164	0
1992	1185.381	0
1993	1115.058	0
1994	1069.804	0
1995	1027.688	0
1996	951.2452	0
1997	1217.794	0
1998	1067.112	0
1999	968.0549	0
2000	717.1386	0
2001	713.2496	0
2002	641.7833	0
2003	594.5219	0
2004	510.0094	255.699
2005	385.6487	299.267
2006	403.6723	522.271
2007	409.7696	1340.989
2008	436.8852	636.309
2009	463.0663	595.219

Table 4.2. Plaice in Divisions VIIf&g: Landings numbers-at-age as reported to ICES and used by the WKFLAT 2011 Benchmark group.

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977	1	989	426	411	105	72	37	59	28	15	9	12	0	10	1
1978	1	851	903	291	136	76	47	23	33	36	8	8	7	2	4
1979	1	877	673	638	72	70	34	8	7	18	8	3	3	3	4
1980	1	1921	1207	658	146	21	16	16	8	5	7	3	2	2	5
1981	1	822	2111	681	109	54	53	11	13	11	5	4	3	2	6
1982	1	300	1180	955	443	86	51	14	14	10	18	9	1	2	6
1983	1	750	560	827	372	92	44	27	6	6	1	4	1	1	4
1984	1	704	918	343	373	209	70	41	15	7	8	3	5	1	3
1985	1	1461	2503	393	102	177	62	25	26	3	2	3	2	0	2
1986	1	703	2595	1332	156	59	48	32	10	5	2	1	5	0	1
1987	1	434	1883	1812	772	156	22	125	45	13	9	0	0	7	2
1988	1	967	2099	1568	612	413	65	16	24	23	9	9	0	0	8
1989	1	797	3550	1807	741	160	98	24	7	8	2	2	2	0	2
1990	1	164	2078	2427	655	242	86	70	13	17	6	5	3	0	2
1991	1	279	1072	1193	578	179	94	78	47	8	0	6	10	1	7
1992	1	800	526	357	471	275	80	21	35	16	32	5	0	0	8
1993	24.7	1018.7	1179.4	283.8	138.6	185.2	114.8	61.5	25.6	13.7	6.4	6.9	0.5	2.1	3.8
1994	100.2	427.5	935.5	730	164.1	116.5	85.7	92	32.1	13.1	3.1	10.7	0	2.5	3
1995	42.6	488.3	572.1	742.9	334.3	116.8	57.4	47.7	51.9	36.5	15.4	13.1	4.9	1.2	8.8
1996	0	811.7	734.2	514.5	219	136.9	58.7	36.8	42.3	24.9	12.9	6.1	2.5	1.1	6
1997	8.3	420.3	1318	928.9	272.4	121.2	59.7	20.2	17.3	21.2	22.3	10.6	4.1	4.6	2.2
1998	16.9	426	921.2	849.1	287	96.3	81.6	38.9	15	8.1	11.4	8.4	6.7	1.5	5.2
1999	22.2	243	981.6	801.8	372.2	116.3	45.1	27.4	14.9	10.7	5.8	13.4	13.6	6	4.4
2000	18.5	320.1	605.8	481.6	203.2	145.1	53	21.7	12.2	5.3	2.8	2	3.4	5.1	1.2
2001	74.5	651.1	370.7	322.5	198.6	108	61.5	22.6	7.1	8.4	3.8	1.8	0.3	3.8	3
2002	3	169.5	660.6	543.3	182.9	112.9	65	24.2	11.1	7.3	2.9	0.9	1.2	0.5	3.7
2003	14.9	239.1	570.7	464.5	149.6	85.1	34.2	26.1	13.5	5.2	1.4	2.1	0.9	0.4	0.7
2004	5.5	126.3	578.4	428	261.3	45.7	26.7	15.2	7.5	5.2	1.1	0.9	0.3	0.4	1.3
2005	23.5	201.4	327.3	265.1	133.6	72.7	24.3	13.7	7.1	4.5	2.8	0.8	0.4	0.4	0.4
2006	12.2	331.3	458.1	139.7	133.8	75.8	50.3	12.3	6.3	4.6	3.4	0.6	0.2	0.03	0.1
2007	8.1	130.1	513.4	340.3	104.2	76.1	46	26.2	6.6	2.4	2.9	0.5	0.1	0.2	0.1
2008	14.6	269.5	341	443	145	47	28.7	11	10.3	2.4	1.3	0.4	0.1	0.2	0.04
2009	2.4	122.6	593.8	332.9	261.9	67.4	20.7	9.8	8.1	1.2	1	1.1	0.1	0.1	0

Table 4.3. Plaice in Divisions VIIf&g: Discards numbers-at-age as reported to ICES and used by the WKFLAT 2011 Benchmark group.

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	394	402	542	165	73	5	3	0	0	0	0	0	0	0	0
2005	448	1205	445	133	38	21	4	0	0	0	0	0	0	0	0
2006	546	3086	814	84	52	16	1	0	0	0	0	0	0	0	0
2007	1880	3290	3768	860	118	53	12	0	0	0	0	0	0	0	0
2008	52	4037	658	395	81	4	1	0	0	0	0	0	0	0	0
2009	660	780	2261	832	281	34	2	0	0	0	0	0	0	0	0

Table 4.4. Plaice in Divisions VIIf&g: Landings weight-at-age as reported to ICES and used by the WKFLAT 2011 Benchmark group.

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977	0.078	0.205	0.323	0.43	0.528	0.615	0.693	0.76	0.818	0.866	0.903	0.931	0.949	0.957	0.955
1978	0.194	0.258	0.323	0.389	0.457	0.525	0.595	0.666	0.738	0.812	0.886	0.962	1.039	1.117	1.197
1979	0.076	0.203	0.325	0.44	0.55	0.652	0.749	0.839	0.923	1.001	1.073	1.138	1.197	1.25	1.297
1980	0.118	0.238	0.354	0.467	0.576	0.682	0.784	0.882	0.977	1.069	1.157	1.241	1.322	1.4	1.474
1981	0.185	0.255	0.33	0.412	0.5	0.595	0.695	0.802	0.915	1.034	1.16	1.292	1.43	1.574	1.725
1982	0.151	0.245	0.339	0.433	0.526	0.62	0.714	0.808	0.902	0.996	1.09	1.184	1.278	1.373	1.467
1983	0.178	0.274	0.369	0.464	0.559	0.654	0.749	0.844	0.939	1.034	1.129	1.224	1.319	1.414	1.509
1984	0.276	0.324	0.384	0.455	0.538	0.633	0.739	0.857	0.986	1.127	1.28	1.444	1.62	1.807	2.006
1985	0.135	0.251	0.363	0.47	0.572	0.67	0.763	0.851	0.935	1.014	1.089	1.159	1.224	1.284	1.34
1986	0	0.16	0.301	0.434	0.559	0.677	0.787	0.889	0.983	1.069	1.148	1.218	1.281	1.336	1.384
1987	0.129	0.208	0.288	0.368	0.449	0.53	0.612	0.694	0.777	0.86	0.944	1.029	1.113	1.199	1.285
1988	0.26	0.288	0.325	0.37	0.423	0.484	0.554	0.633	0.72	0.815	0.918	1.03	1.15	1.278	1.415
1989	0.102	0.176	0.255	0.337	0.423	0.514	0.608	0.706	0.809	0.915	1.025	1.14	1.258	1.38	1.507
1990	0.24	0.27	0.309	0.358	0.416	0.483	0.56	0.646	0.741	0.846	0.959	1.083	1.215	1.357	1.508
1991	0.2	0.26	0.327	0.4	0.481	0.567	0.661	0.761	0.868	0.981	1.101	1.228	1.362	1.502	1.649
1992	0.148	0.257	0.362	0.464	0.563	0.658	0.75	0.839	0.924	1.006	1.084	1.159	1.231	1.299	1.364
1993	0.172	0.247	0.326	0.407	0.492	0.58	0.671	0.765	0.863	0.963	1.066	1.173	1.282	1.395	1.511
1994	0.145	0.24	0.331	0.42	0.506	0.589	0.67	0.747	0.822	0.894	0.963	1.03	1.094	1.154	1.213
1995	0.22	0.264	0.319	0.382	0.456	0.539	0.632	0.735	0.847	0.969	1.1	1.242	1.392	1.553	1.723
1996	0.222	0.26	0.309	0.368	0.438	0.519	0.609	0.711	0.823	0.945	1.078	1.221	1.375	1.54	1.714
1997	0.181	0.248	0.318	0.392	0.469	0.55	0.634	0.723	0.814	0.91	1.009	1.112	1.218	1.328	1.441
1998	0.188	0.248	0.316	0.39	0.471	0.559	0.655	0.757	0.867	0.983	1.106	1.237	1.374	1.519	1.67
1999	0.096	0.188	0.279	0.369	0.457	0.545	0.631	0.716	0.799	0.882	0.963	1.043	1.121	1.199	1.275
2000	0.145	0.226	0.309	0.394	0.481	0.57	0.661	0.753	0.847	0.943	1.041	1.141	1.242	1.345	1.451
2001	0.248	0.299	0.354	0.414	0.478	0.547	0.62	0.697	0.778	0.864	0.954	1.049	1.147	1.25	1.358
2002	0.132	0.202	0.278	0.358	0.444	0.535	0.631	0.733	0.84	0.952	1.069	1.191	1.319	1.452	1.59
2003	0.183	0.24	0.305	0.38	0.463	0.556	0.657	0.767	0.886	1.014	1.151	1.296	1.451	1.614	1.787
2004	0.14	0.204	0.273	0.347	0.426	0.511	0.602	0.697	0.798	0.904	1.016	1.132	1.254	1.382	1.515
2005	0.176	0.229	0.293	0.366	0.449	0.542	0.645	0.757	0.879	1.011	1.153	1.305	1.467	1.638	1.819
2006	0.257	0.261	0.284	0.326	0.386	0.465	0.563	0.68	0.815	0.97	1.143	1.335	1.545	1.775	2.023
2007	0.163	0.212	0.267	0.33	0.399	0.476	0.56	0.651	0.749	0.854	0.966	1.085	1.212	1.345	1.486
2008	0.314	0.292	0.294	0.321	0.371	0.446	0.544	0.666	0.813	0.983	1.177	1.396	1.638	1.904	2.195
2009	0.358	0.314	0.297	0.308	0.345	0.41	0.502	0.621	0.768	0.941	1.142	1.37	1.625	1.907	0

Table 4.5. Plaice in Divisions VIIf&g: Discard weight-at-age as reported to ICES and used by the WKFLAT 2011 Benchmark group.

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0.124	0.144	0.18	0.201	0.218	0.312	0.252	0.538	0.538	0.538	0.538	0.538	0.538	0.538	0.538
2005	0.088	0.127	0.15	0.181	0.202	0.321	0.392	0.425	0.425	0.425	0.425	0.425	0.425	0.425	0.425
2006	0.066	0.107	0.155	0.183	0.203	0.22	0.415	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358
2007	0.084	0.125	0.158	0.161	0.191	0.213	0.349	0.649	0.649	0.649	0.649	0.649	0.649	0.649	0.649
2008	0.075	0.108	0.162	0.183	0.198	0.288	0.342	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276
2009	0.085	0.126	0.127	0.127	0.146	0.192	0.237	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22

Table 4.6. Plaice in Divisions VIIf&g: Stock weight-at-age as reported to ICES and used by the WKFLAT 2011 Benchmark group.

Year/Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1977	0.112	0.216	0.315	0.406	0.492	0.57	0.642	0.707	0.766	0.818	0.864	0.903	0.935	0.961	0.98
1978	0.086	0.17	0.252	0.334	0.414	0.493	0.57	0.646	0.721	0.794	0.866	0.936	1.005	1.073	1.14
1979	0.107	0.212	0.313	0.412	0.507	0.599	0.689	0.775	0.859	0.939	1.016	1.091	1.162	1.231	1.296
1980	0.109	0.217	0.322	0.426	0.528	0.628	0.727	0.823	0.918	1.011	1.102	1.191	1.279	1.365	1.449
1981	0.082	0.167	0.257	0.35	0.447	0.548	0.653	0.762	0.875	0.992	1.112	1.236	1.365	1.497	1.633
1982	0.096	0.192	0.288	0.383	0.479	0.574	0.668	0.763	0.857	0.951	1.045	1.138	1.232	1.325	1.418
1983	0.103	0.206	0.307	0.408	0.507	0.606	0.704	0.801	0.897	0.993	1.087	1.181	1.273	1.365	1.456
1984	0.256	0.298	0.352	0.418	0.495	0.584	0.685	0.797	0.92	1.055	1.202	1.361	1.531	1.712	1.905
1985	0.075	0.193	0.307	0.417	0.521	0.621	0.717	0.808	0.894	0.975	1.052	1.124	1.192	1.255	1.313
1986	0	0.087	0.232	0.369	0.498	0.619	0.733	0.839	0.937	1.027	1.109	1.184	1.251	1.31	1.361
1987	0.089	0.168	0.248	0.328	0.408	0.489	0.571	0.653	0.736	0.819	0.902	0.986	1.071	1.156	1.242
1988	0.249	0.273	0.305	0.346	0.395	0.453	0.518	0.593	0.675	0.766	0.865	0.973	1.089	1.213	1.345
1989	0.066	0.139	0.215	0.295	0.38	0.468	0.56	0.657	0.757	0.861	0.97	1.082	1.198	1.319	1.443
1990	0.228	0.254	0.288	0.332	0.386	0.448	0.52	0.602	0.692	0.792	0.901	1.02	1.148	1.285	1.431
1991	0.173	0.229	0.293	0.363	0.44	0.523	0.613	0.71	0.813	0.924	1.04	1.164	1.294	1.431	1.574
1992	0.092	0.203	0.31	0.414	0.514	0.611	0.705	0.795	0.882	0.965	1.045	1.122	1.196	1.266	1.332
1993	0.135	0.209	0.286	0.366	0.45	0.536	0.625	0.718	0.813	0.912	1.014	1.119	1.227	1.338	1.453
1994	0.097	0.193	0.286	0.376	0.463	0.548	0.63	0.709	0.785	0.858	0.929	0.997	1.062	1.124	1.184
1995	0.201	0.241	0.29	0.349	0.418	0.496	0.585	0.682	0.79	0.907	1.033	1.17	1.316	1.471	1.637
1996	0.207	0.24	0.284	0.338	0.402	0.477	0.563	0.659	0.765	0.882	1.01	1.148	1.297	1.456	1.626
1997	0.149	0.214	0.282	0.354	0.43	0.509	0.592	0.678	0.768	0.862	0.959	1.06	1.164	1.272	1.384
1998	0.161	0.217	0.281	0.352	0.43	0.514	0.606	0.705	0.811	0.924	1.044	1.171	1.305	1.446	1.594
1999	0.049	0.142	0.234	0.324	0.413	0.501	0.588	0.673	0.758	0.841	0.922	1.003	1.082	1.16	1.237
2000	0.105	0.185	0.268	0.352	0.438	0.525	0.615	0.707	0.8	0.895	0.992	1.091	1.191	1.294	1.398
2001	0.224	0.273	0.326	0.384	0.446	0.512	0.583	0.658	0.737	0.821	0.909	1.001	1.097	1.198	1.304
2002	0.099	0.167	0.239	0.317	0.401	0.489	0.583	0.682	0.786	0.895	1.01	1.13	1.255	1.385	1.521
2003	0.158	0.21	0.271	0.341	0.42	0.508	0.605	0.711	0.825	0.949	1.081	1.222	1.372	1.531	1.699
2004	0.11	0.171	0.238	0.309	0.386	0.468	0.556	0.649	0.747	0.85	0.959	1.073	1.193	1.318	1.448
2005	0.153	0.201	0.26	0.328	0.406	0.494	0.592	0.7	0.817	0.944	1.081	1.228	1.385	1.551	1.727
2006	0.262	0.257	0.27	0.303	0.353	0.423	0.512	0.619	0.745	0.89	1.054	1.236	1.438	1.658	1.896
2007	0.142	0.187	0.239	0.298	0.364	0.437	0.517	0.604	0.699	0.8	0.909	1.025	1.148	1.277	1.414
2008	0.334	0.3	0.29	0.305	0.343	0.405	0.492	0.602	0.736	0.895	1.077	1.283	1.514	1.768	2.046
2009	0.39	0.332	0.302	0.299	0.323	0.374	0.453	0.558	0.691	0.851	1.038	1.252	1.494	1.762	0

Table 4.7. Plaice in Divisions VIIf&g: Survey abundance indices (figures used in the assessment shown in bold).

IRGFS : Irish Groundfish Survey (IBTS 4th qtr VIIg)
2003 2008
1 1 0.79 0.92
2 7

832	45	84	37	8	3	1
980	6	31	51	20	13	1
845	63	83	19	9	3	3
1046	105	80	22	18	11	12
1168	51	166	68	22	9	8
1139	113	106	72	19	8	5
1018	199	548	247	100	21	16

E+W B/T Survey
1990 2009 (Effort in Km towed, Numbers caught; all stations)
1 1 0.75 0.85 (Revised 2008 – Indices automated 1995 on)
1 5

69.86	161	215	64	15	6
123.41	841	33	65	21	12
125.08	487	307	13	5	15
127.67	120	107	44	2	5
120.82	127	40	20	11	1
114.9	275	103	19	3	8
118.6	265	342	37	1	3
114.9	259	117	40	5	2
114.9	272	144	54	10	2
118.6	181	94	34	23	8
118.6	403	75	37	8	7
118.6	251	185	19	10	5
118.6	162	208	95	7	7
118.6	117	95	72	26	3
114.9	297	38	31	15	3
118.6	228	89	25	10	13
118.6	102	121	41	11	2
118.6	178	109	56	18	2
118.6	167	257	57	19	6
118.6	192	66	93	25	13

Table 4.8. Plaice in Divisions VIIf&g: Commercial tuning data available to the working group (figures used in the assessment shown in bold).

UK (E+W) BEAM TRAWL VIIF.
1990 2009 Thousands of hours, numbers in thousands.
1 1 0 1
1 8

30.8	0.0	1.6	68.2	159.5	46.3	26.6	11.0	9.2
40.8	9.4	22.6	74.4	141.5	87.1	29.0	15.1	14.1
35.8	1.6	39.9	27.3	32.0	46.7	27.4	7.5	2.3
39.6	1.0	40.9	139.5	25.0	15.5	24.6	15.1	7.3
37	12.6	31.7	52.4	49.1	9.2	9.1	7.6	9.8
37.6	1.0	28.3	30.0	39.5	29.7	9.9	5.8	6.4
39.8	0.0	74.6	53.8	13.6	13.6	12.8	3.8	4.4
43	0.6	40.7	112.3	23.7	8.4	6.7	4.5	0.7
47.8	2.7	54.1	73.9	63.1	17.5	3.6	4.3	2.7
50.8	0.8	22.1	64.2	52.5	25.8	7.7	2.4	1.9
51.2	0.6	11.9	26.0	26.9	17.8	12.7	4.9	1.8
49.3	2.8	42.5	27.7	27.5	17.7	10.1	5.9	2.4
37.5	0.5	19.4	40.3	16.5	7.6	7.2	3.7	2.0
40.7	1.6	27.7	43.2	33.8	9.9	4.9	3.4	2.4
32.4	0.9	12.2	34.5	25.8	17.5	3.4	2.5	2.0
27.7	1.5	12.0	9.1	12.7	7.5	5.0	1.9	1.1
18.6	0.6	10.2	17.7	4.5	4.4	3.0	1.6	0.4
15.4	0.5	9.3	24.6	12.0	3.2	2.0	1.4	0.6
13.8	0.2	10.8	16.1	18.1	5.2	1.9	1.4	0.9
12.2	0.3	10.4	30.1	15.2	10.6	3.0	1.0	0.6

UK(E+W) OTTER TRAWL VIIF
1989 2009 Thousands of hours, numbers in thousands.
1 1 0 1
1 8

17.6	0.8	91.2	256.0	62.0	23.1	7.4	5.1	0.4
22.6	0.1	6.4	97.0	129.1	34.2	13.3	4.1	4.4
18.6	5.2	13.6	46.9	78.8	36.9	16.5	4.4	5.0
16.0	3.6	68.2	14.6	12.5	18.5	8.5	1.4	0.4
13.8	1.3	25.3	42.1	8.8	3.9	6.3	4.1	2.7
9.5	4.2	11.7	20.5	15.1	2.7	3.1	1.4	1.7
8.5	5.1	37.8	18.2	14.5	5.5	1.6	0.8	0.7
8.7	0.0	35.8	20.6	4.3	3.4	2.5	1.0	1.1
8.1	0.4	16.5	33.7	5.5	1.2	0.7	0.4	0.1
7.1	0.4	7.8	11.0	8.6	2.0	0.5	0.7	0.2
5.7	1.0	8.3	12.2	7.9	3.8	0.9	0.2	0.1
4.1	0.5	9.3	11.4	6.5	2.5	1.3	0.4	0.1
4.4	1.4	11.1	4.9	4.0	2.4	1.3	0.6	0.2
6.1	0.0	4.4	8.3	2.9	1.5	1.1	0.5	0.2
9.9	0.6	11.9	16.2	9.3	2.1	1.3	0.9	0.6
9.4	0.3	4.3	14.3	10.4	5.8	0.9	0.5	0.3
12.1	1.5	10.0	5.4	5.5	2.8	1.5	0.5	0.3
13.0	0.7	12.8	23.3	6.8	6.4	4.5	2.3	0.6
10.6	0.2	5.2	14.8	7.4	2.2	1.4	1.0	0.5
10.1	0.3	5.8	16.5	8.2	2.4	1.6	1.1	0.6
9.0	0.2	5.6	7.8	7.3	2.3	0.9	0.5	0.3

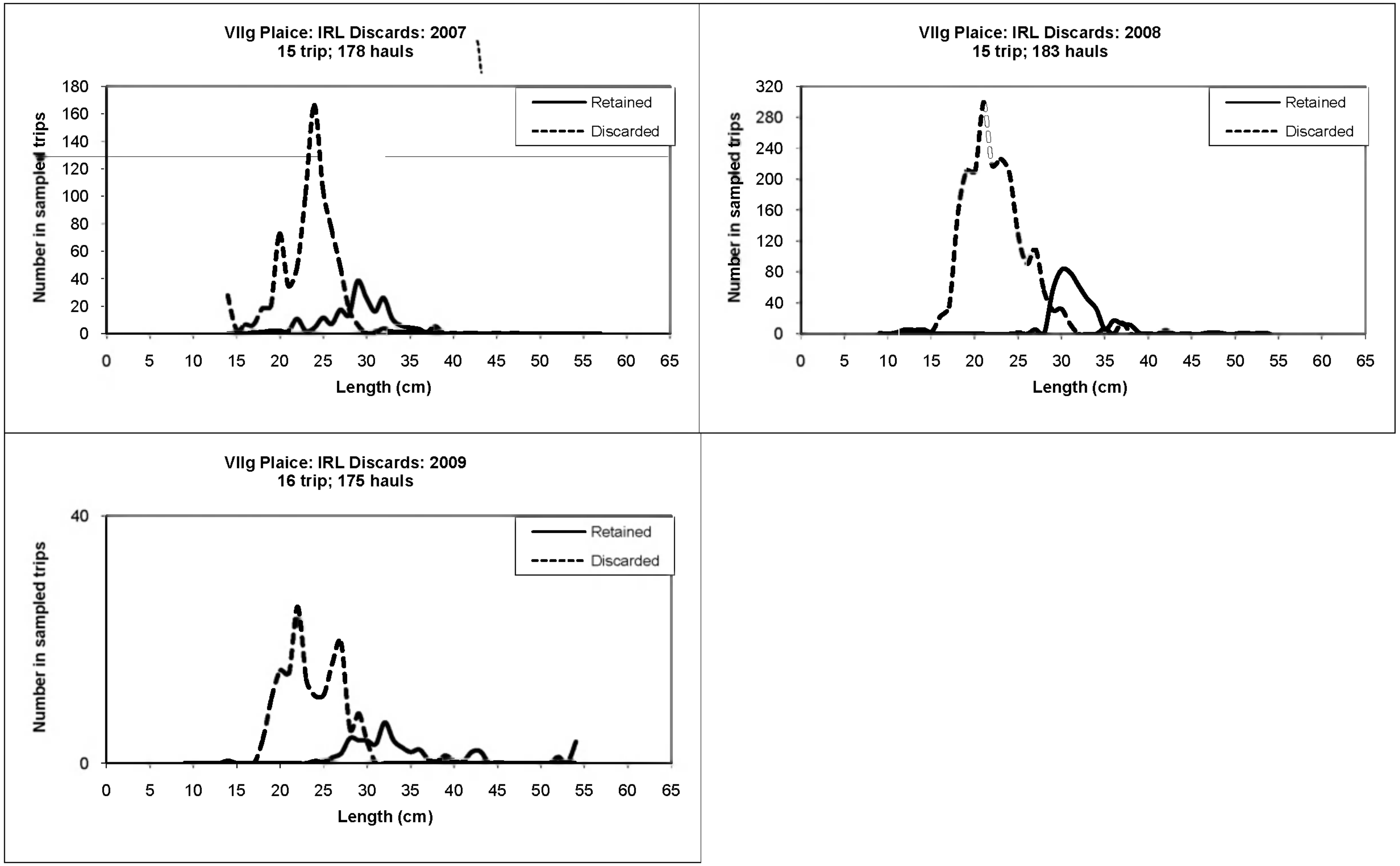

Figure 4.1a. Plaice in Division VIIf&g: Ireland otter trawl discard sampling results in 2007–2009: raised to sampled trips.

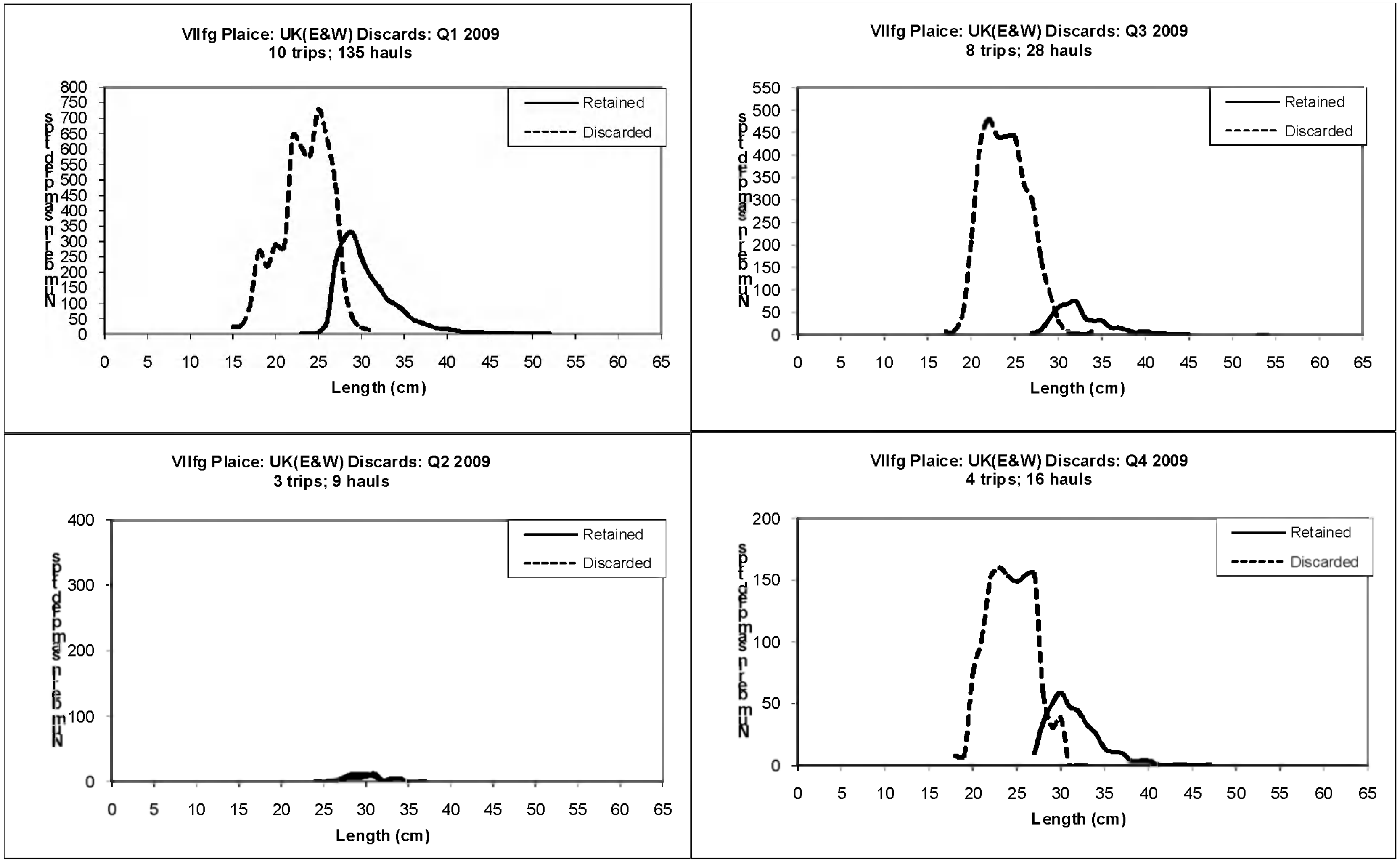

Figure 4.1b. Plaice in Division VIIf&g: UK (E&W) Discard sampling results in 2009: raised to sampled trips. All gears.

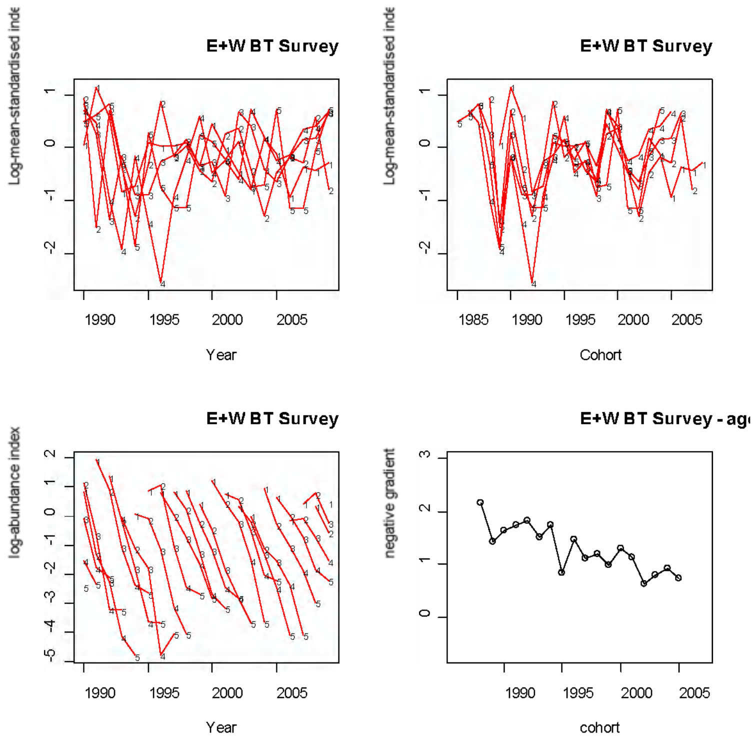

Figure 4.2a. Plaice in Division VIIf&g: UK (BTS-Q3) Beam trawl survey log cpue at age; by year and year class (top row), with log catch curves and the negative slope of the catch curves; ~Z (bottom row).

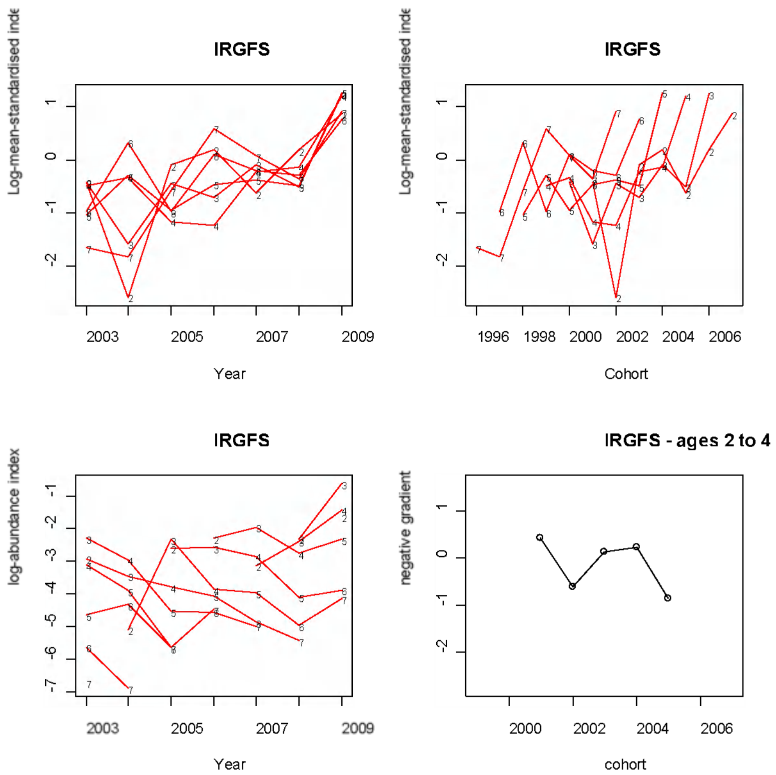

Figure 4.2b. Plaice in Division VIIf&g: Irish groundfish survey log cpue at age; by year and year class (top row), with log catch curves and the negative slope of the catch curves; ~Z (bottom row).

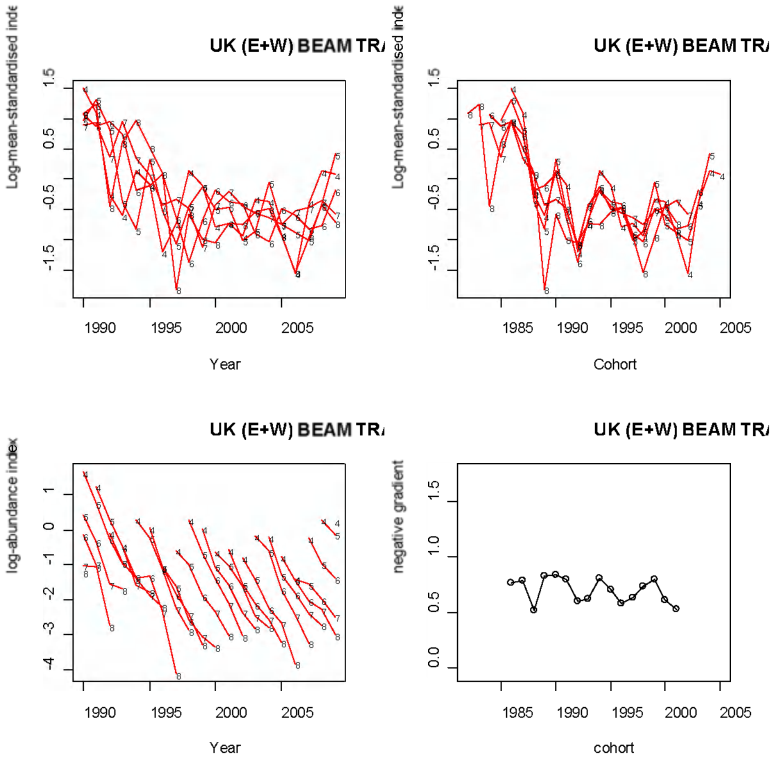

Figure 4.3a. Plaice in Division VIIf&g: UK EW commercial beam trawl fleet log cpue at age (4–8); by year and year class (top row), with log catch curves and the negative slope of the catch curves; ~Z (bottom row).

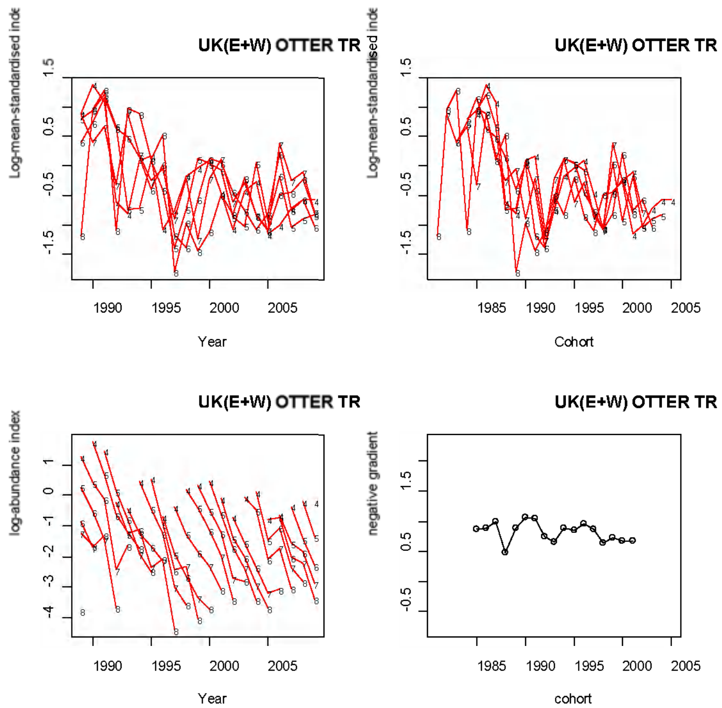

Figure 4.3b. Plaice in Division VIIf&g: UK EW Otter trawl fleet log cpue at age (4–8); by year and year class (top row), with log catch curves and the negative slope of the catch curves; ~Z (bottom row).

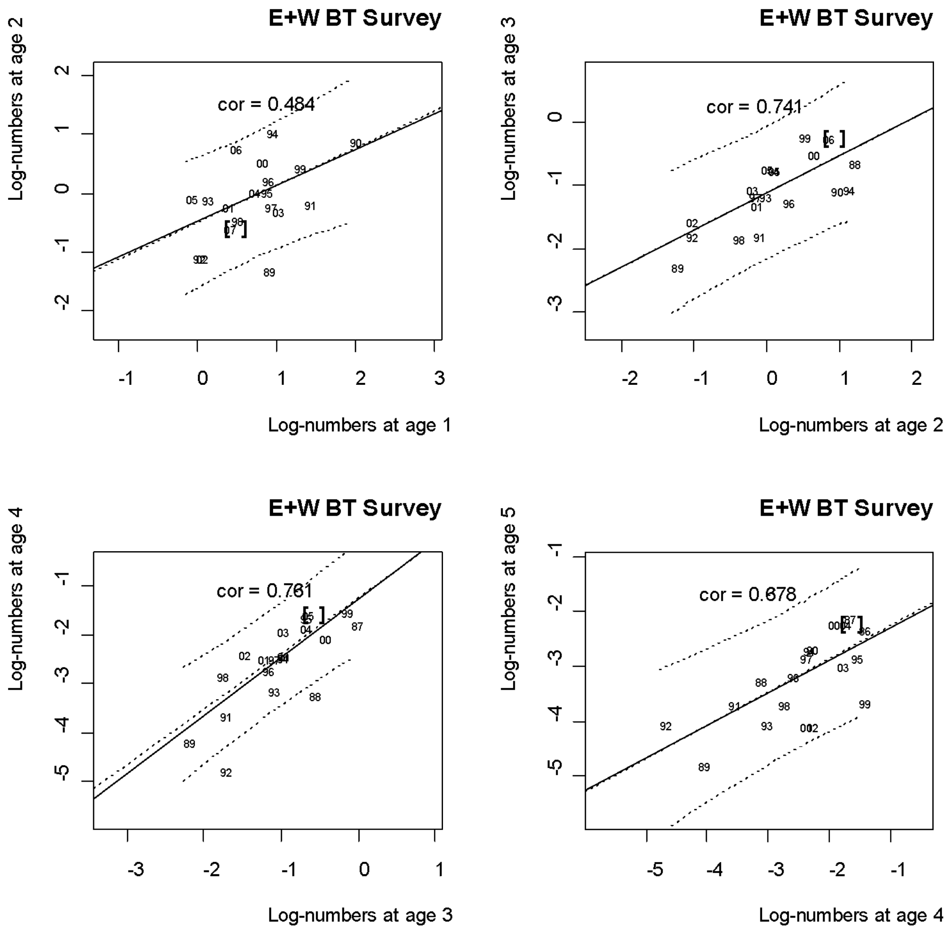

Figure 4.4a. Plaice in Division VIIf&g: Within series correlations for the UK (E&W) beam trawl survey for the period 1990–2009. Individual points are given by cohort (year class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicates prediction intervals. The most recent data point appears in square brackets.

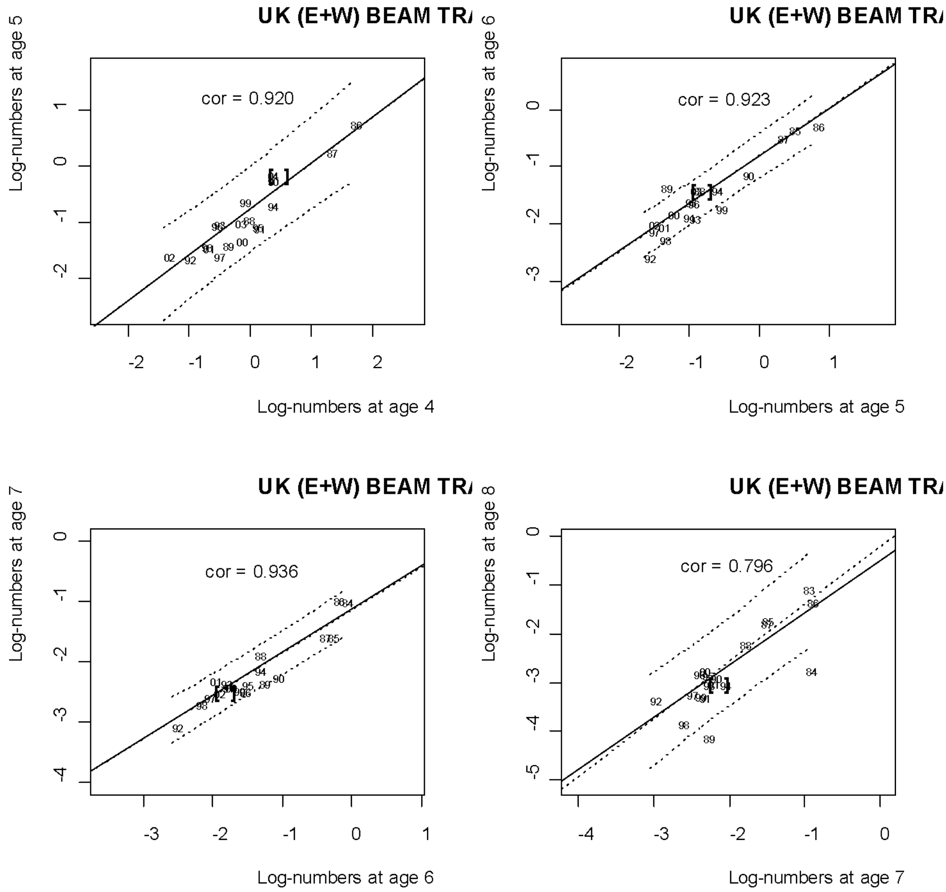

Figure 4.5. Plaice in Division VIIf&g: Within series correlations for the UK commercial beam trawl fleet for the period 1990–2009. Individual points are given by cohort (year class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicates prediction intervals. The most recent data point appears in square brackets.

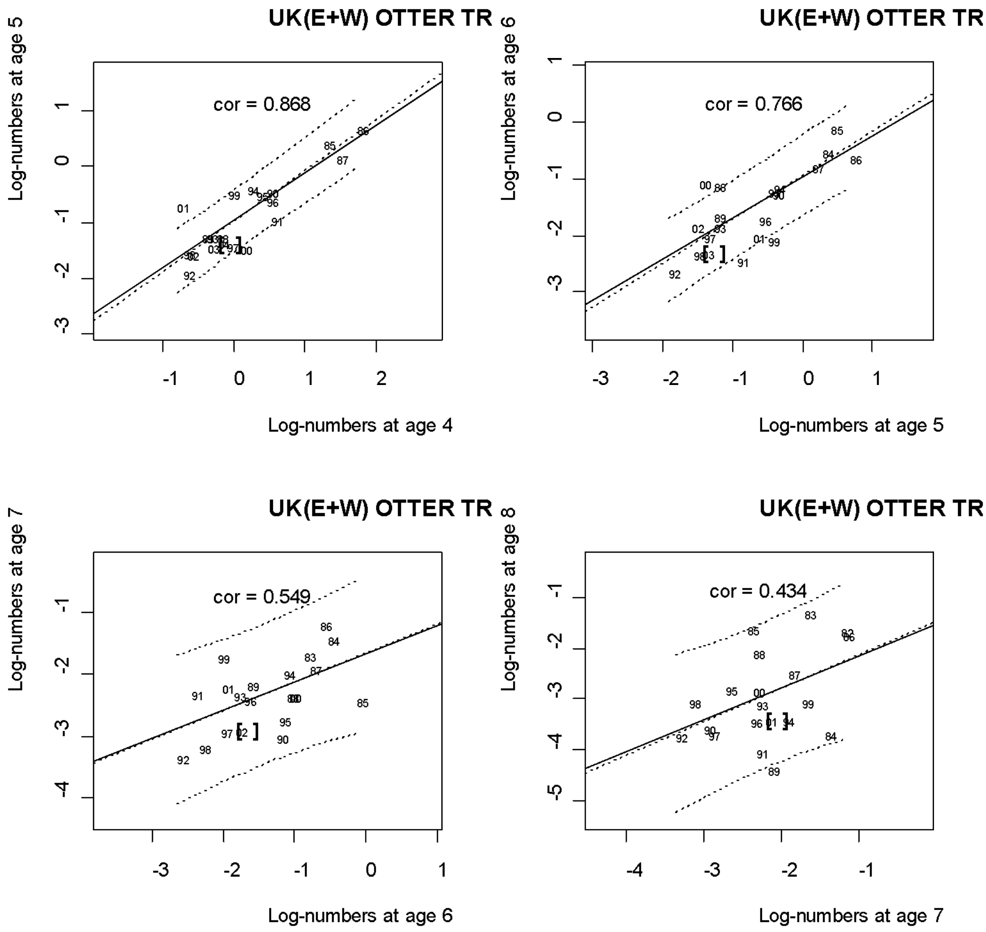

Figure 4.6. Plaice in Division VIIf&g: Within series correlations for the UK commercial otter trawl fleet for the period 1990–2009. Individual points are given by cohort (year class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicates prediction intervals. The most recent data point appears in square brackets.

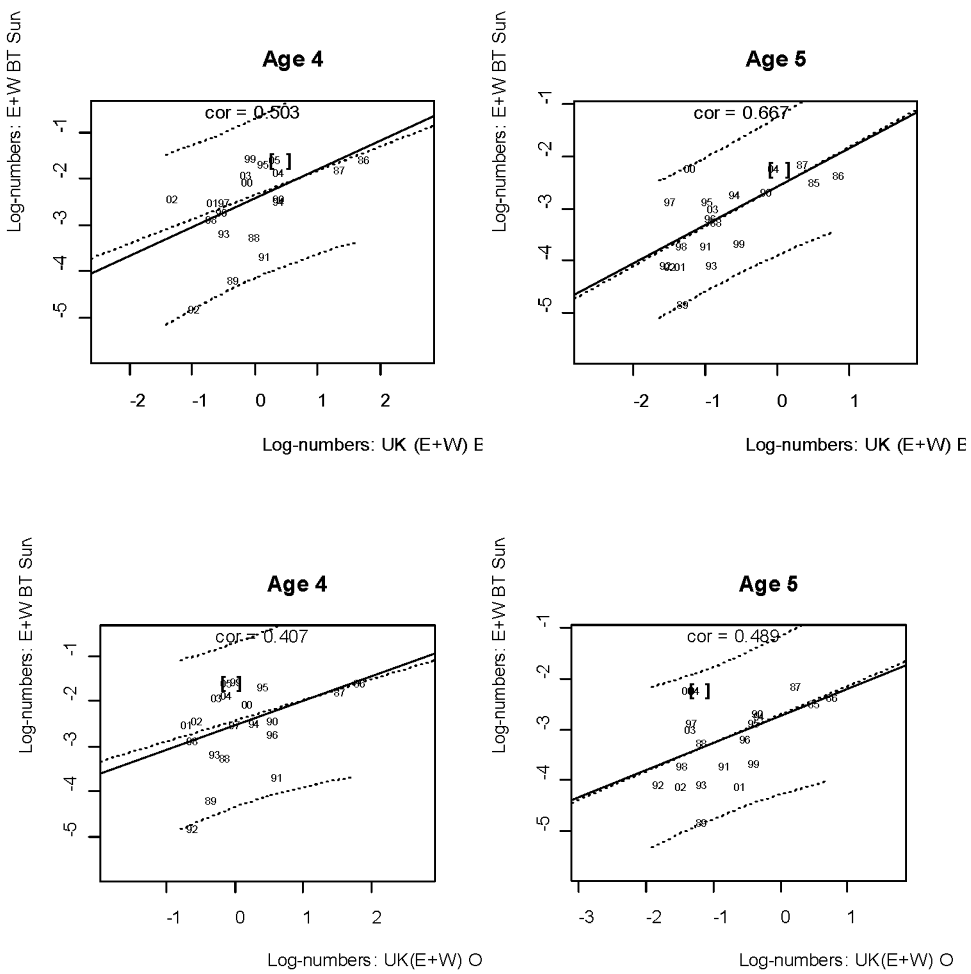

Figure 4.7. Plaice in Division VIIf&g: Between series correlations for UK commercial beam trawl (row 1) and otter trawl (row 2) cpue series at ages 4 and 5 and the UK (E&W) beam trawl survey. Individual points are given by cohort (year class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicates prediction intervals. The most recent data appear in square brackets.

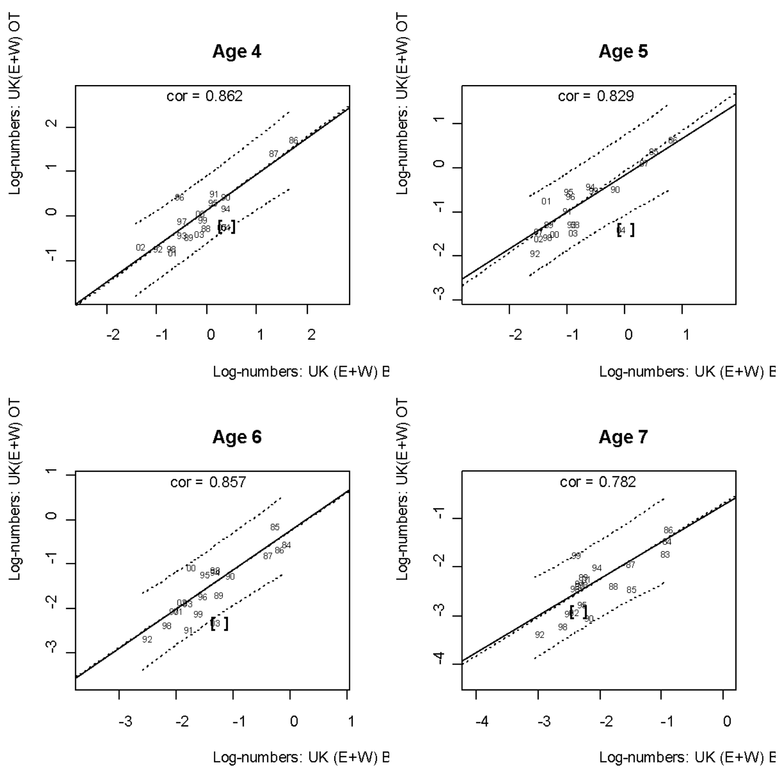

Figure 4.8. Plaice in Division VIIf&g: Between series correlations for UK commercial beam trawl and otter trawl cpue series. Individual points are given by cohort (year class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicates prediction intervals. The most recent data appear in square brackets.

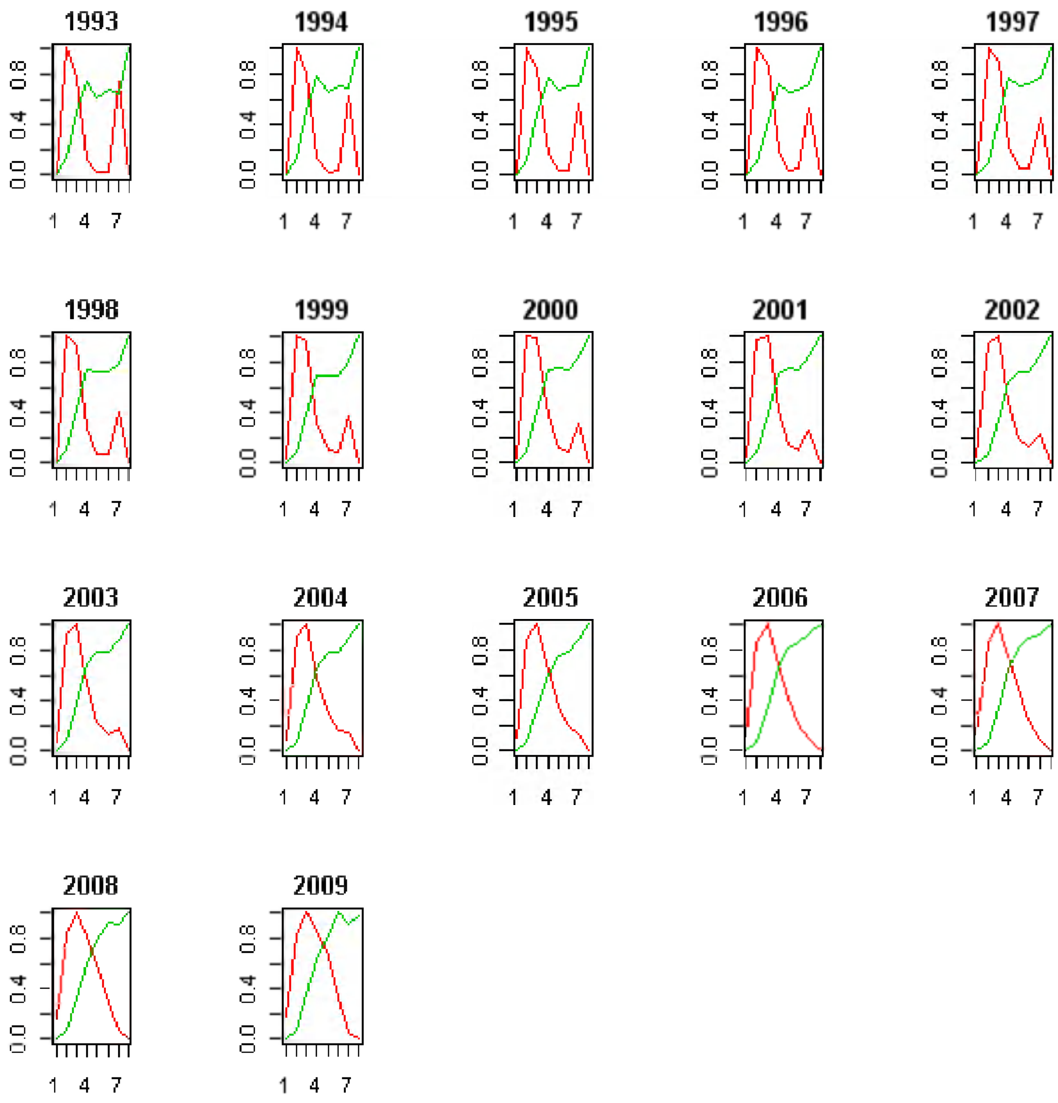

Figure 4.9. Plaice in Division VIIf&g: The estimated selection pattern at age for landings (green) and discards (red) scaled to a highest value = 1.0 for the TV_TVS model which fits a time variant selection pattern to the landings and a time variant spline for the discard selection. The model was rejected on the basis of the changes in the estimates of selection at age seven that increased historically in time, independent of the adjacent ages.

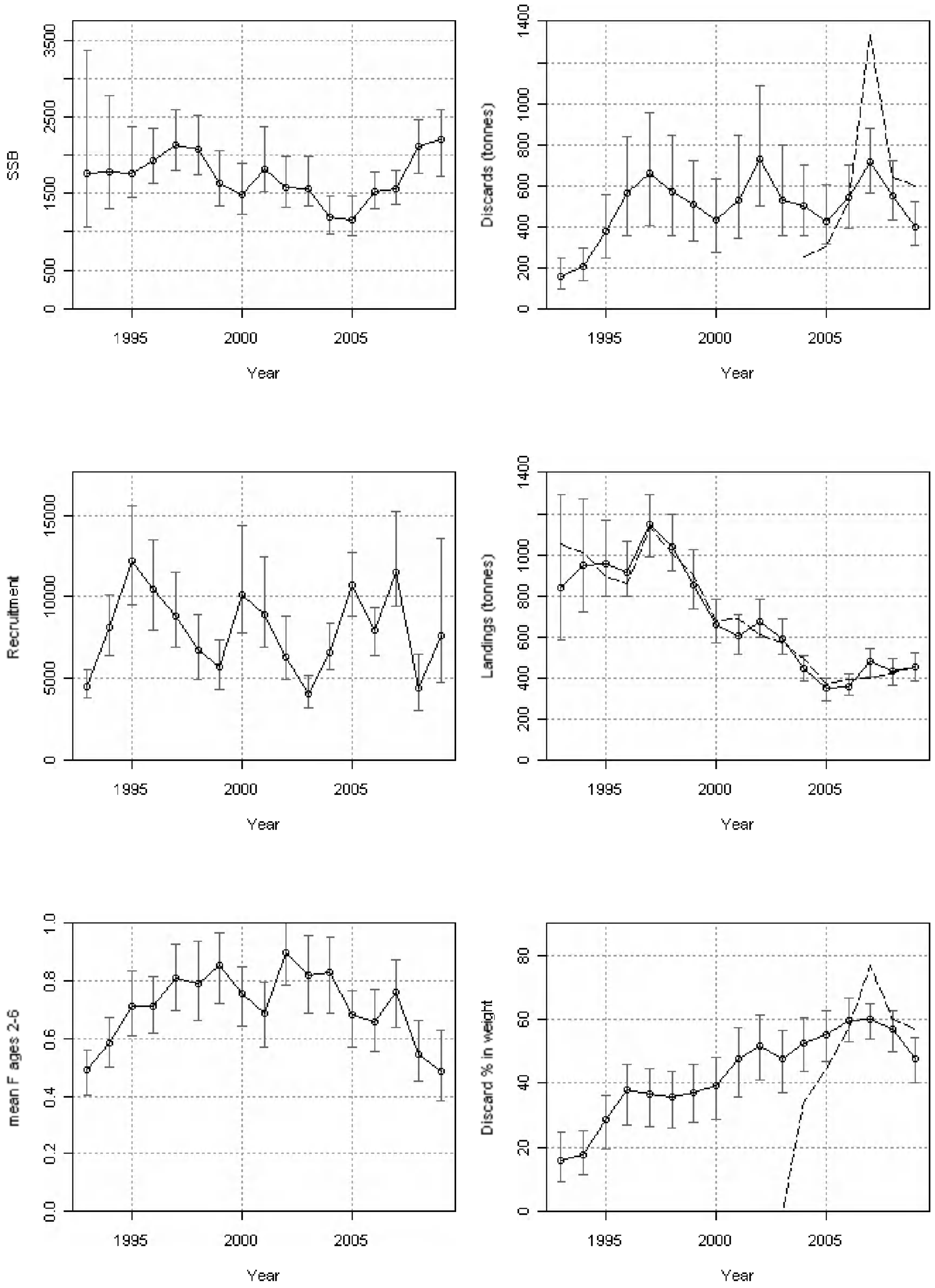

Figure 4.10a. Plaice in Division VIIf&g: The estimated time-series of spawning–stock biomass, recruitment, average fishing mortality-at-ages 2–6, total discard weight, total landings weight and the discard percentage in weight with standard error bars derived from bootstrapping the hessian matrix, for the fit of the TV_PTVS model.

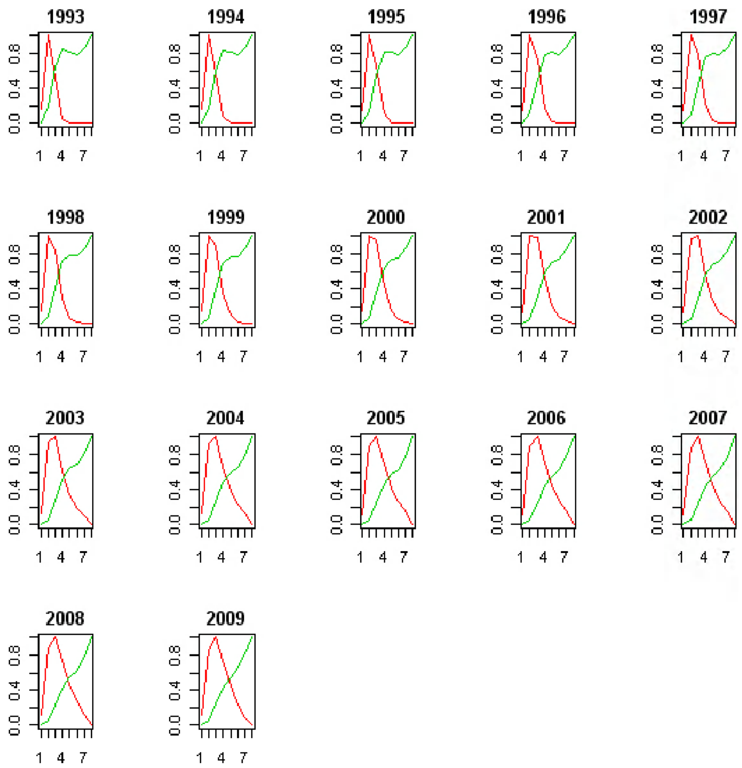

Figure 4.10b. Plaice in Division VIIf&g: The estimated selection pattern at age for landings (green) and discards (red) scaled to a highest value = 1.0 for the TV_PTVS model which fits a time variant selection pattern to the landings and a polynomial time variant spline for the discard selection.

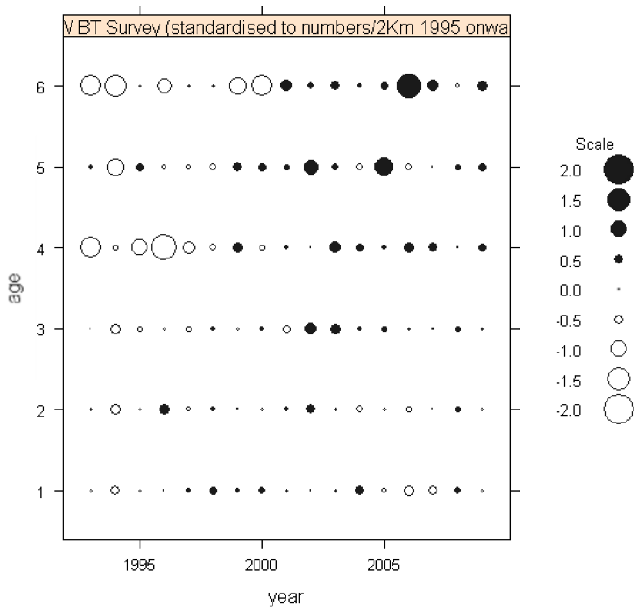

Figure 4.10c. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TV_PTVS model fit to the UKBT survey.

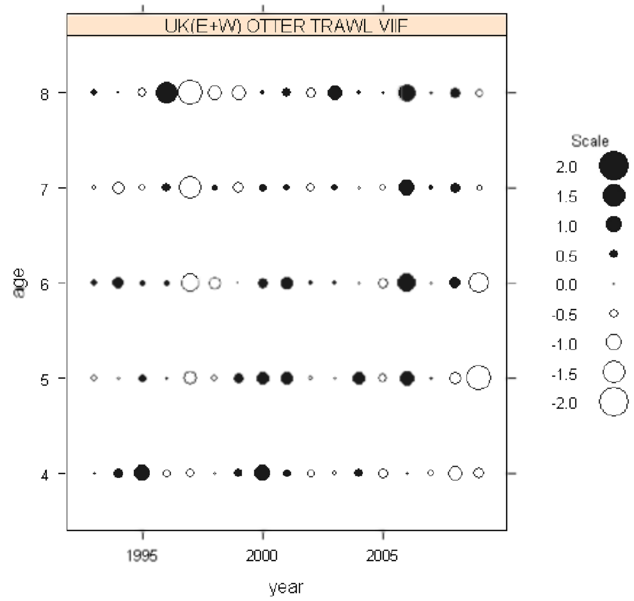

Figure 4.10d. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TV_PTVS model fit to the UK commercial otter trawl data.

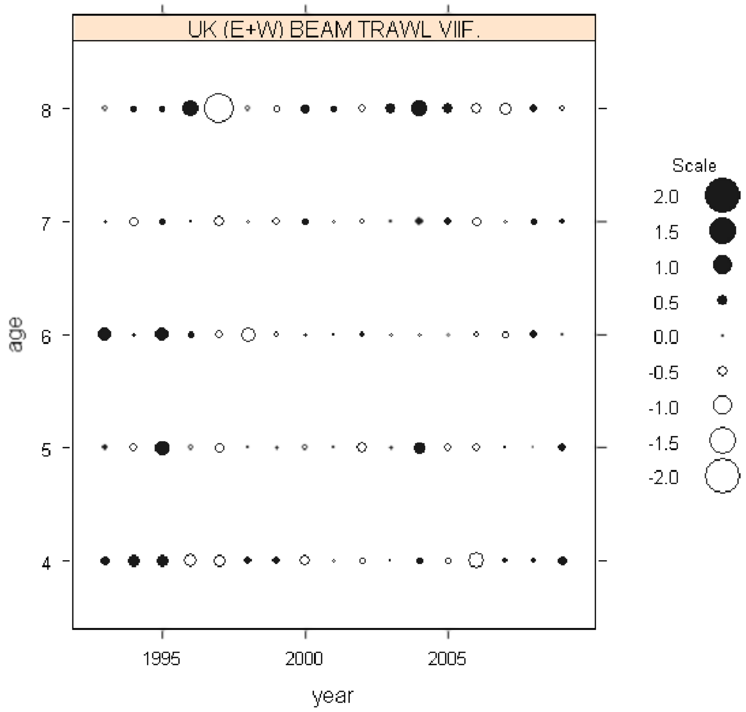

Figure 4.10e. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TV_PTVS model fit to the UK commercial beam trawl data.

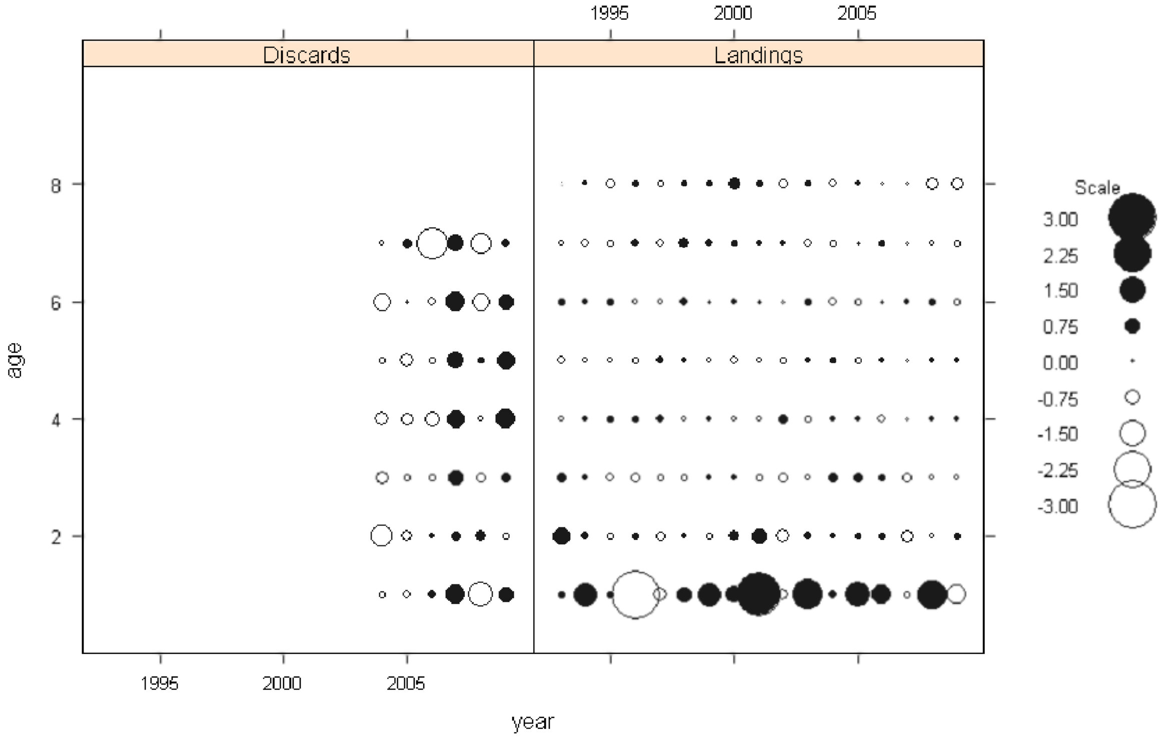

Figure 4.10f. Plaice in Division VIIf&g: The Log residuals for the fit TV_PTVS model fit to the discard and landings numbers-at-age data.

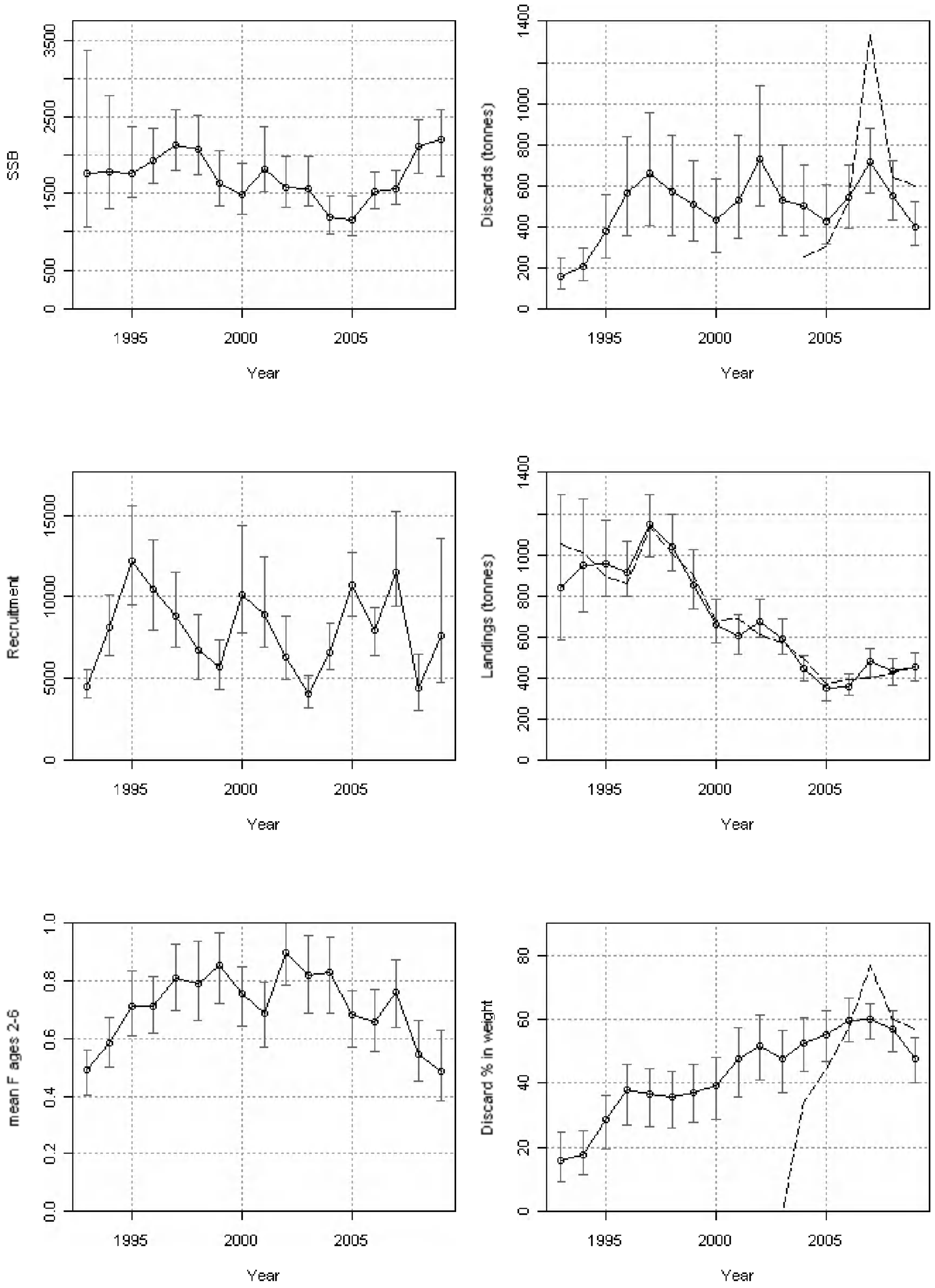

Figure 4.10a. Plaice in Division VIIf&g: The estimated time-series of spawning–stock biomass, recruitment, average fishing mortality-at-ages 2–6, total discard weight, total landings weight and the discard percentage in weight with standard error bars derived from bootstrapping the hessian matrix, for the fit of the TV_PTVS model.

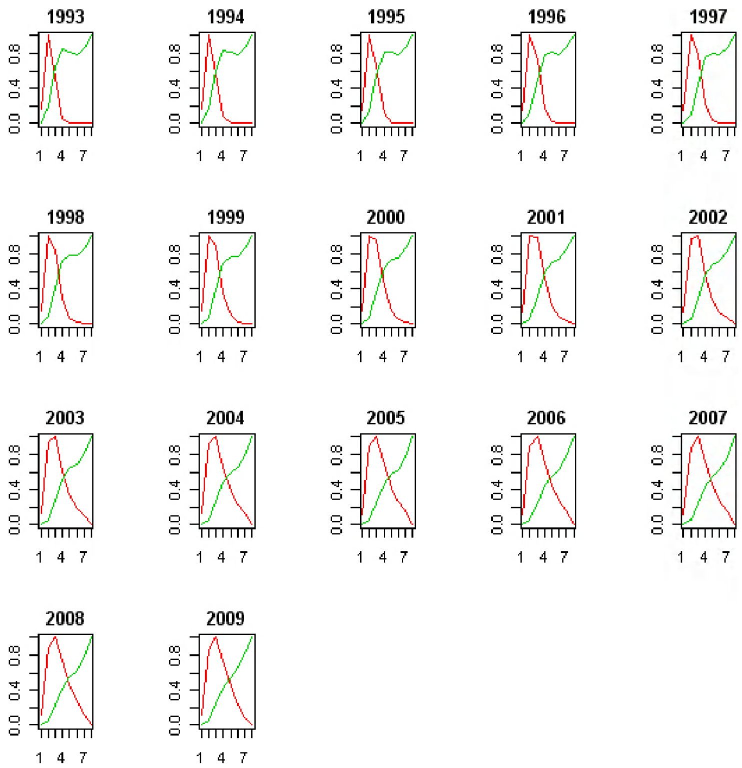

Figure 4.10b. Plaice in Division VIIf&g: The estimated selection pattern at age for landings (green) and discards (red) scaled to a highest value = 1.0 for the TV_PTVS model which fits a time variant selection pattern to the landings and a polynomial time variant spline for the discard selection.

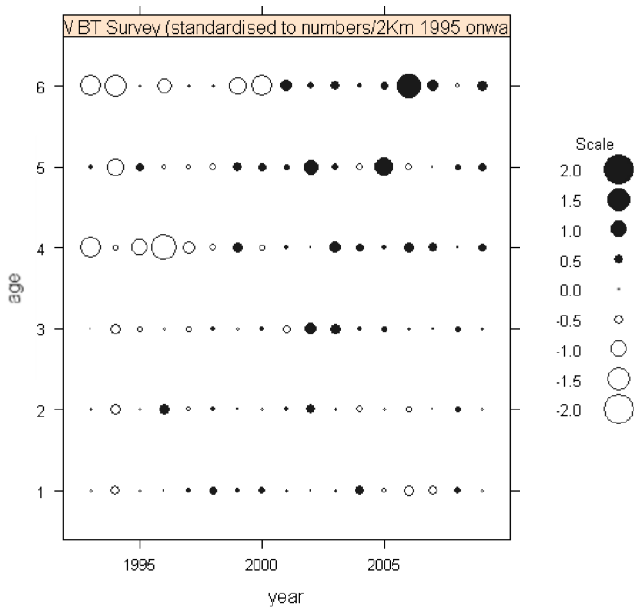

Figure 4.10c. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TV_PTVS model fit to the UKBT survey.

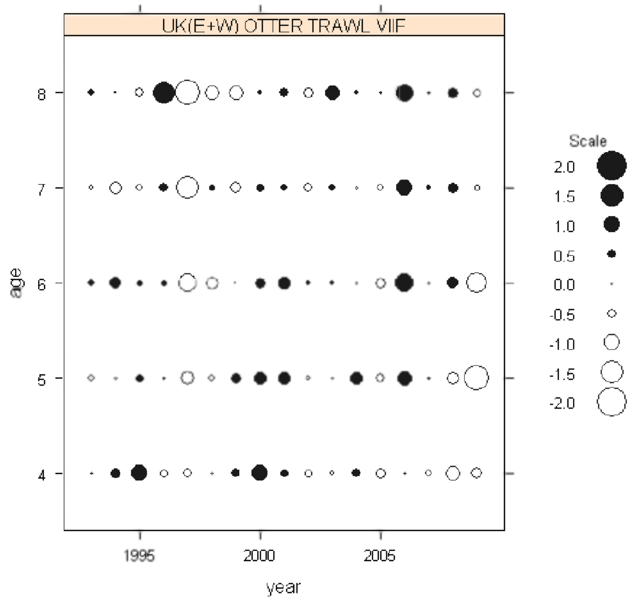

Figure 4.10d. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TV_PTVS model fit to the UK commercial otter trawl data.

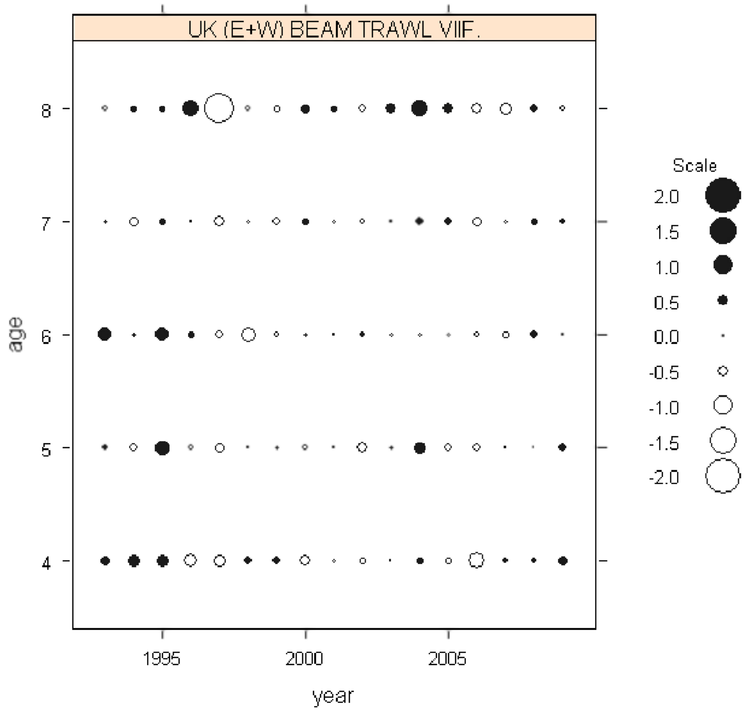

Figure 4.10e. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TV_PTVS model fit to the UK commercial beam trawl data.

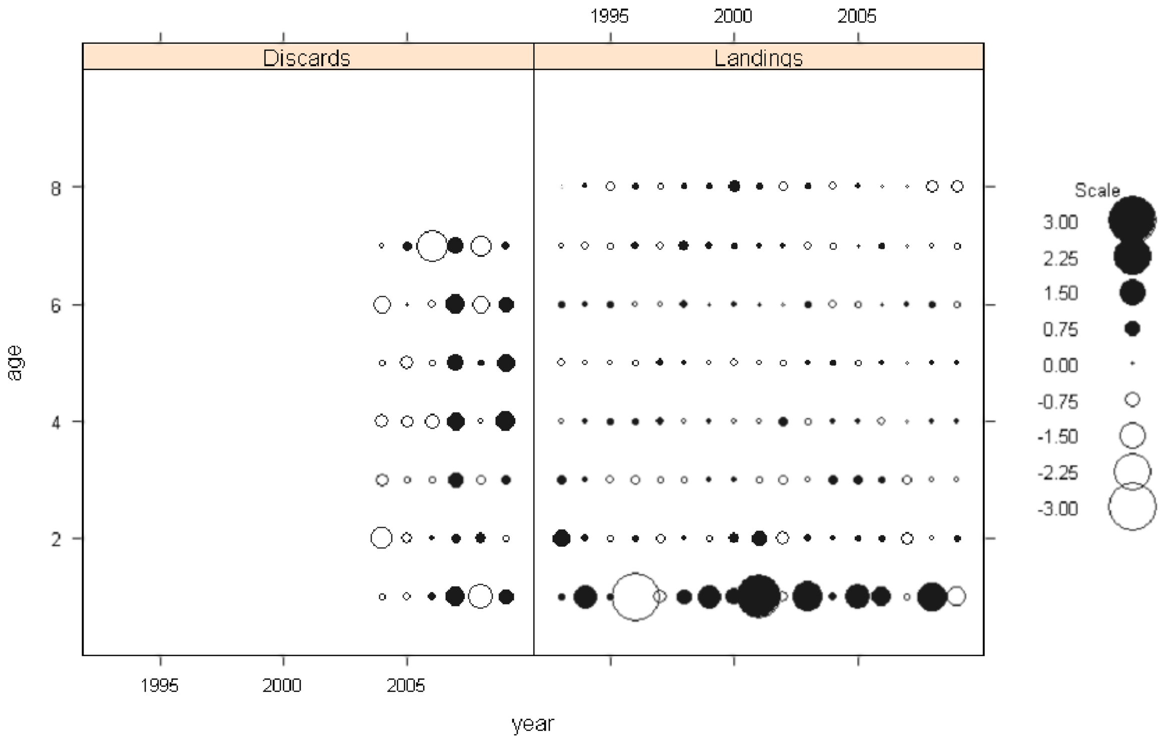

Figure 4.10f. Plaice in Division VIIf&g: The Log residuals for the fit TV_PTVS model fit to the discard and landings numbers-at-age data.

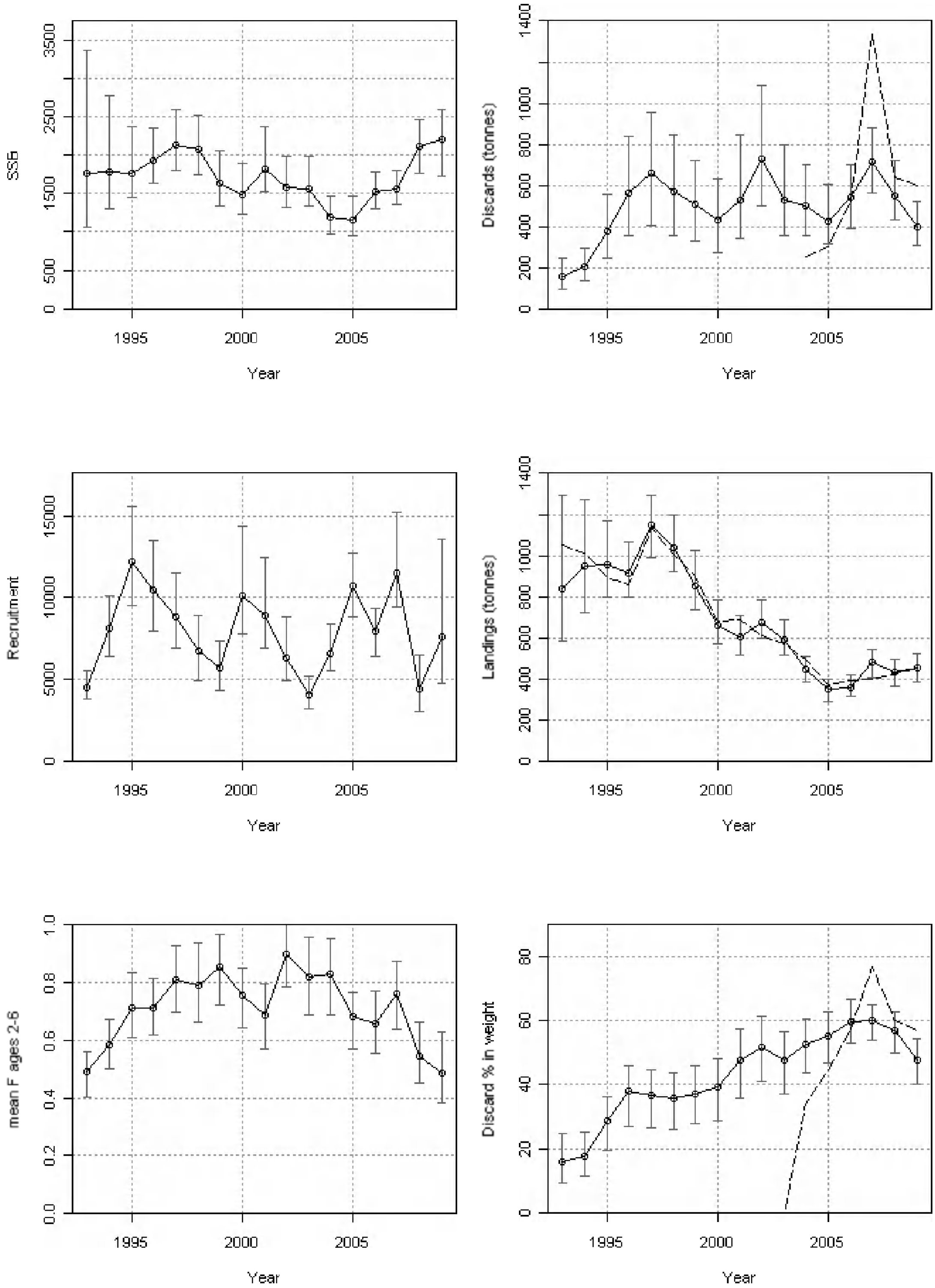

Figure 4.11a. Plaice in Division VIIf&g: The estimated time-series of spawning–stock biomass, recruitment, average fishing mortality-at-ages 2–6, total discard weight, total landings weight and the discard percentage in weight with standard error bars derived from bootstrapping the hessian matrix, for the fit of the TI_PTVS model.

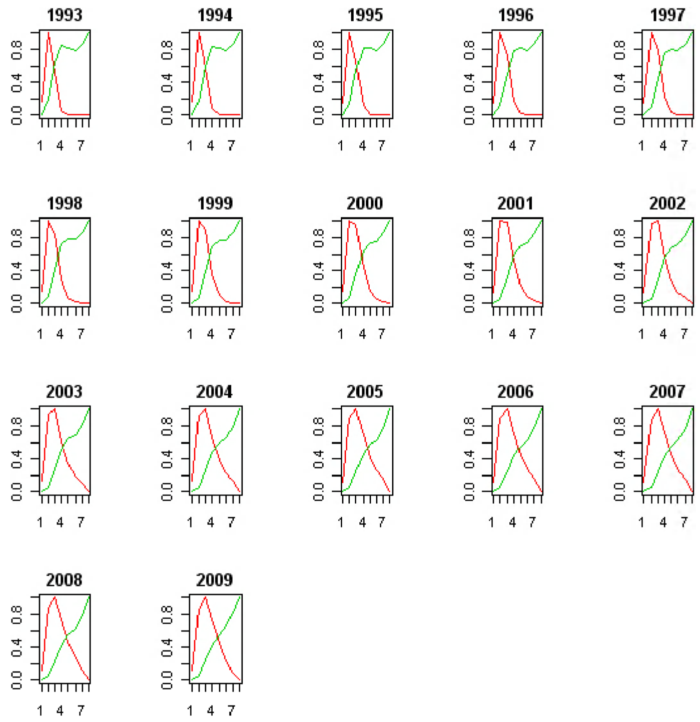

Figure 4.11b. Plaice in Division VIIf&g: The estimated selection pattern at age for landings (green) and discards (red) scaled to a highest value = 1.0 for the TI_PTVS model which fits a time variant selection pattern to the landings and a polynomial time variant spline for the discard selection.

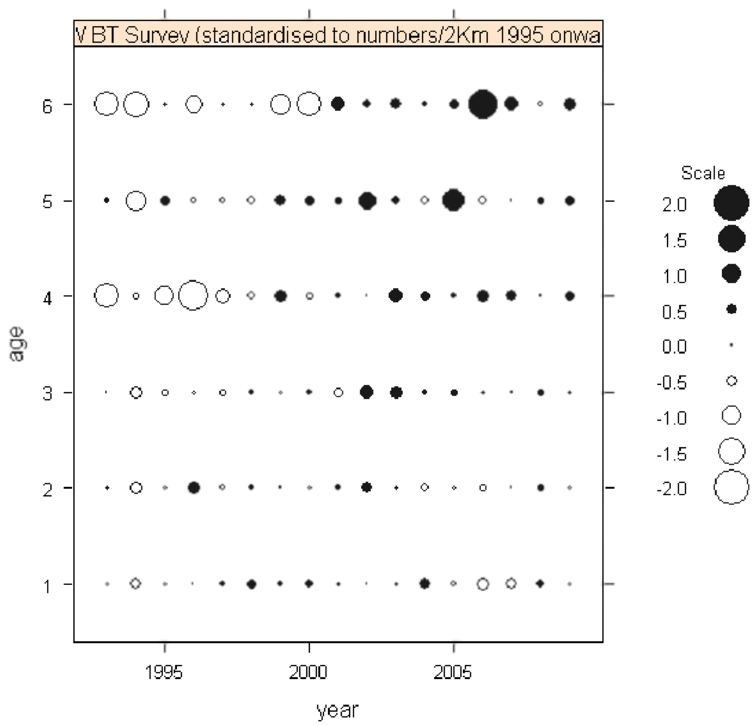

Figure 4.11c. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TI_PTVS model fit to the UKBT survey.

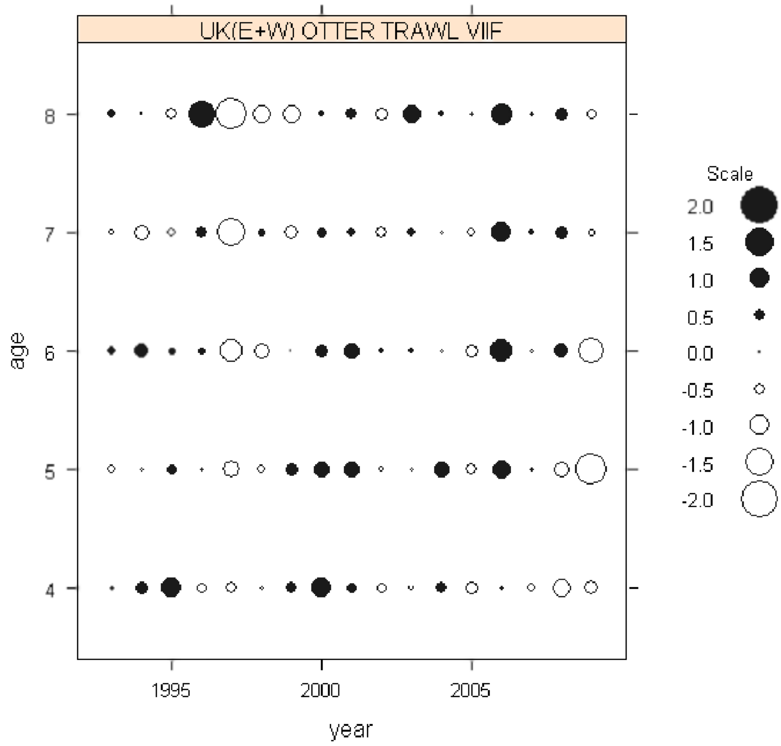

Figure 4.11d. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TI_PTVS model fit to the UK commercial otter trawl data.

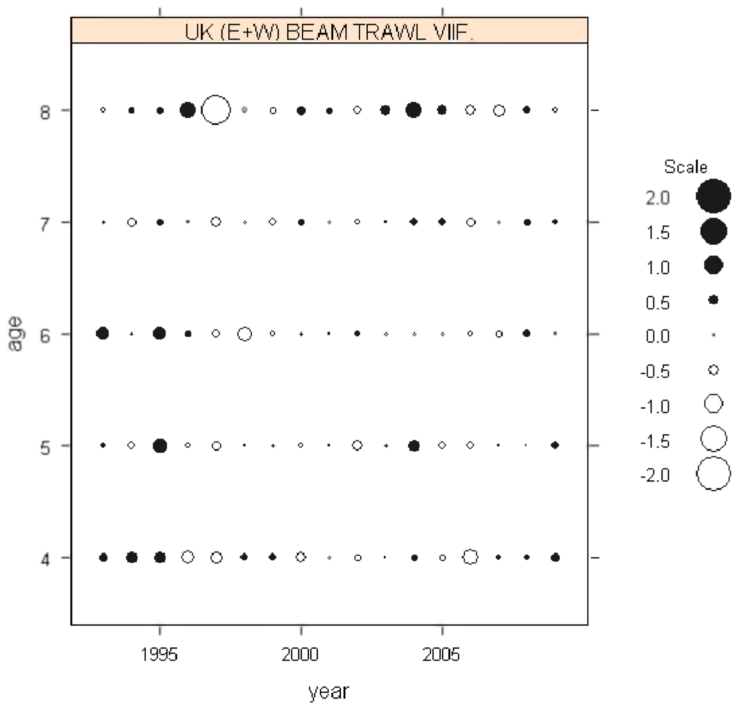

Figure 4.11e. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TI_PTVS model fit to the UK commercial beam trawl data.

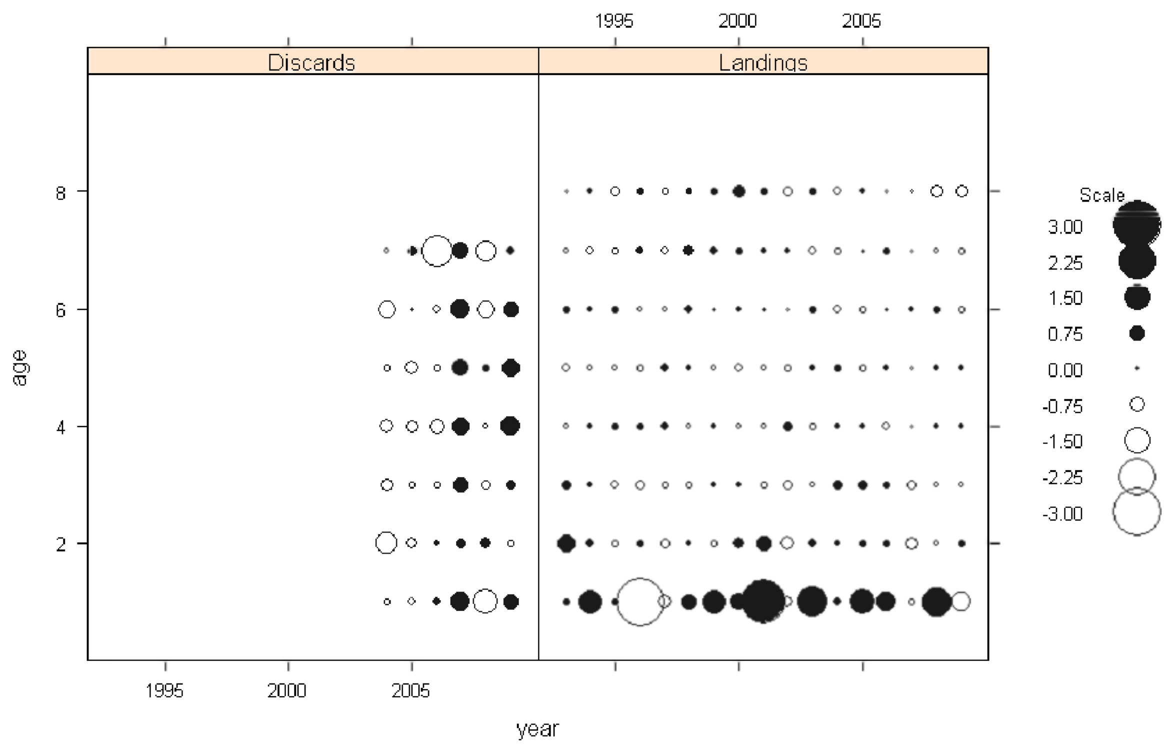

Figure 4.11f. Plaice in Division VIIf&g: The Log residuals for the fit TI_PTVS model fit to the discard and landings numbers-at-age data.

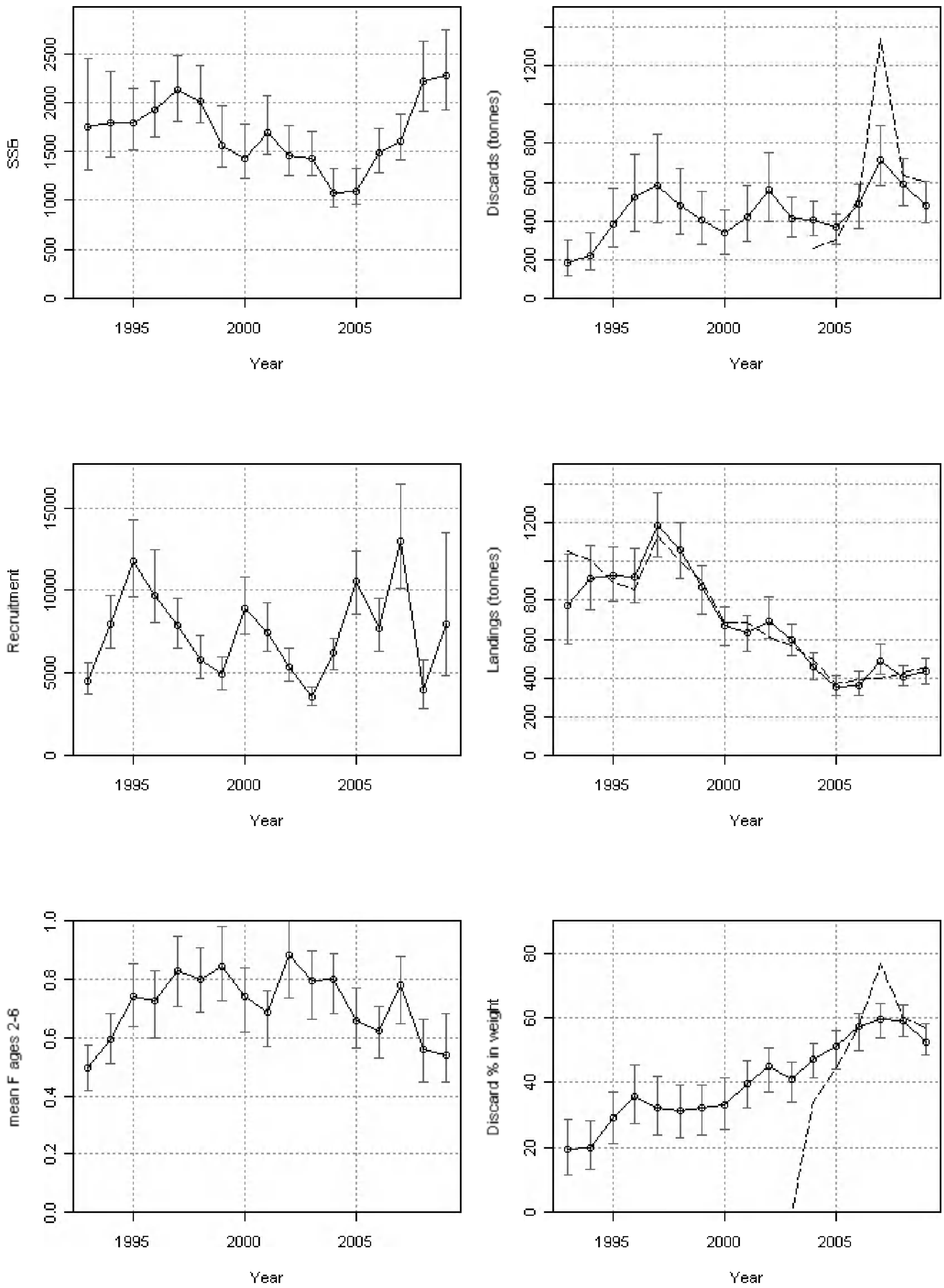

Figure 4.12a. Plaice in Division VIIf&g: The estimated time-series of spawning–stock biomass, recruitment, average fishing mortality-at-ages 2–6, total discard weight, total landings weight and the discard percentage in weight with standard error bars derived from bootstrapping the hessian matrix, for the fit of the TI_TVS model.

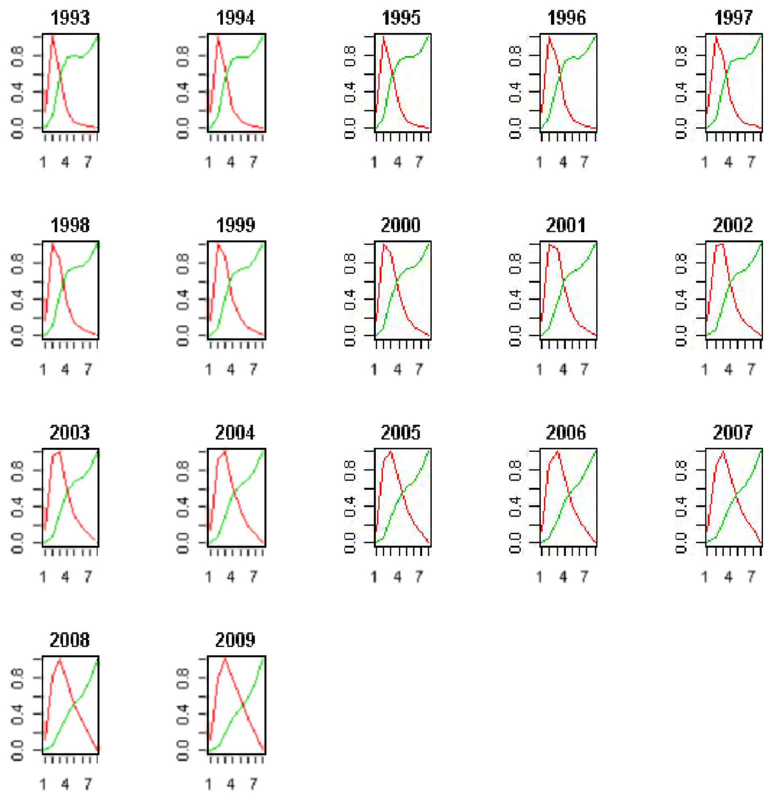

Figure 4.12b. Plaice in Division VIIf&g: The estimated selection pattern at age for landings (green) and discards (red) scaled to a highest value = 1.0 for the TI_TVS model which fits a time variant selection pattern to the landings and a polynomial time variant spline for the discard selection.

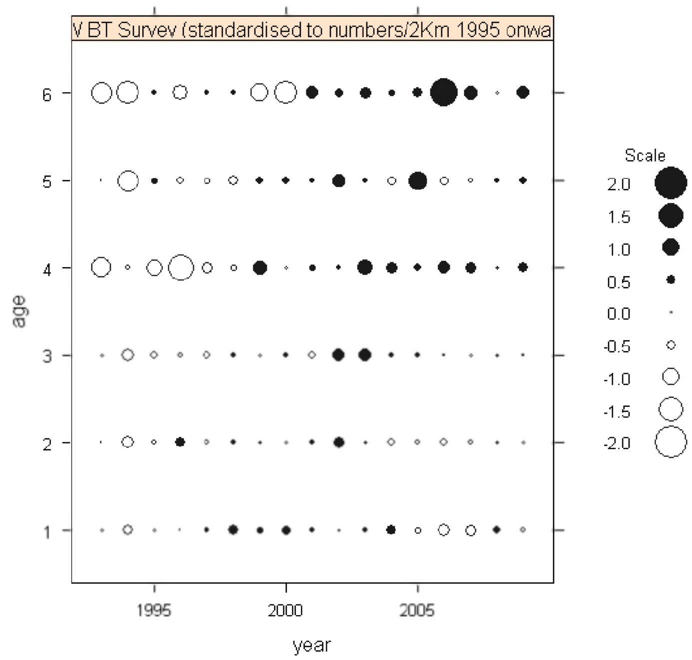

Figure 4.12c. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TI_TVS model fit to the UKBT survey.

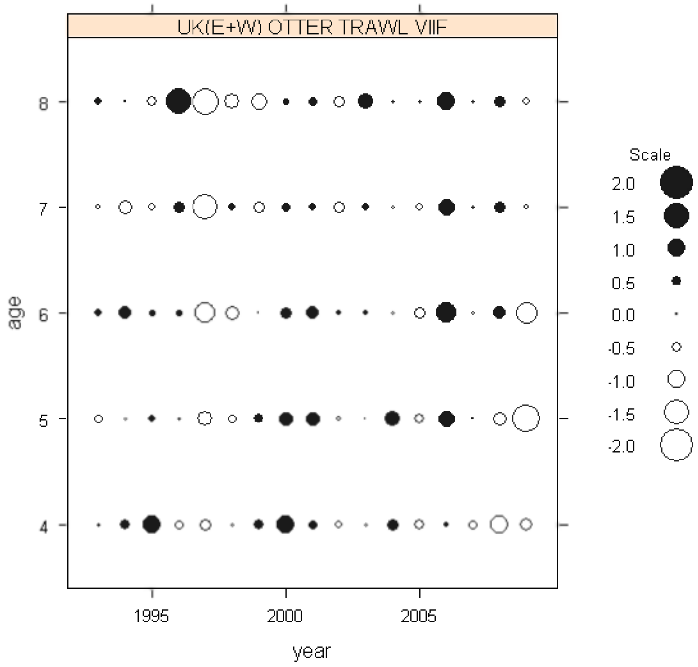

Figure 4.12d. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TI_TVS model fit to the UK commercial otter trawl data.

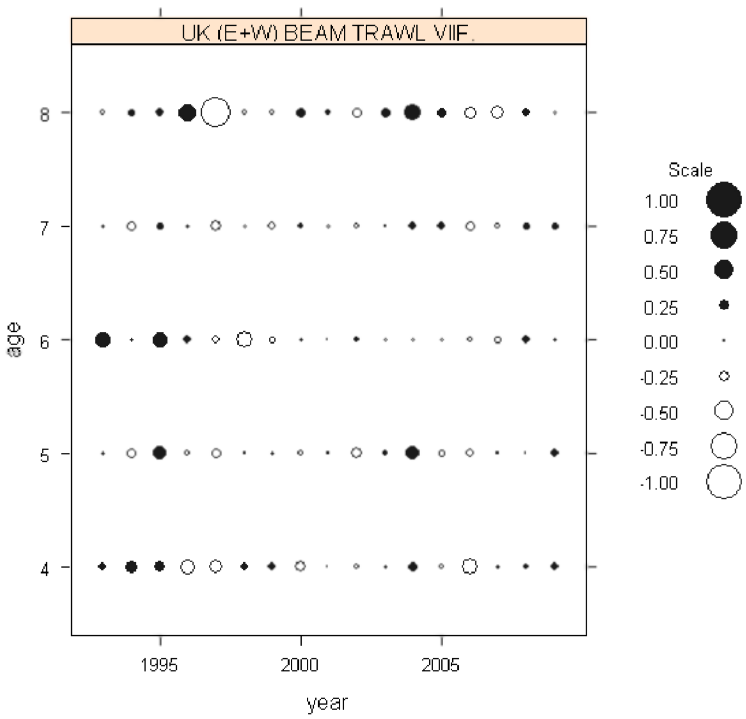

Figure 4.12e. Plaice in Division VIIf&g: The Log-catchability residuals for the fit TI_TVS model fit to the UK commercial beam trawl data.

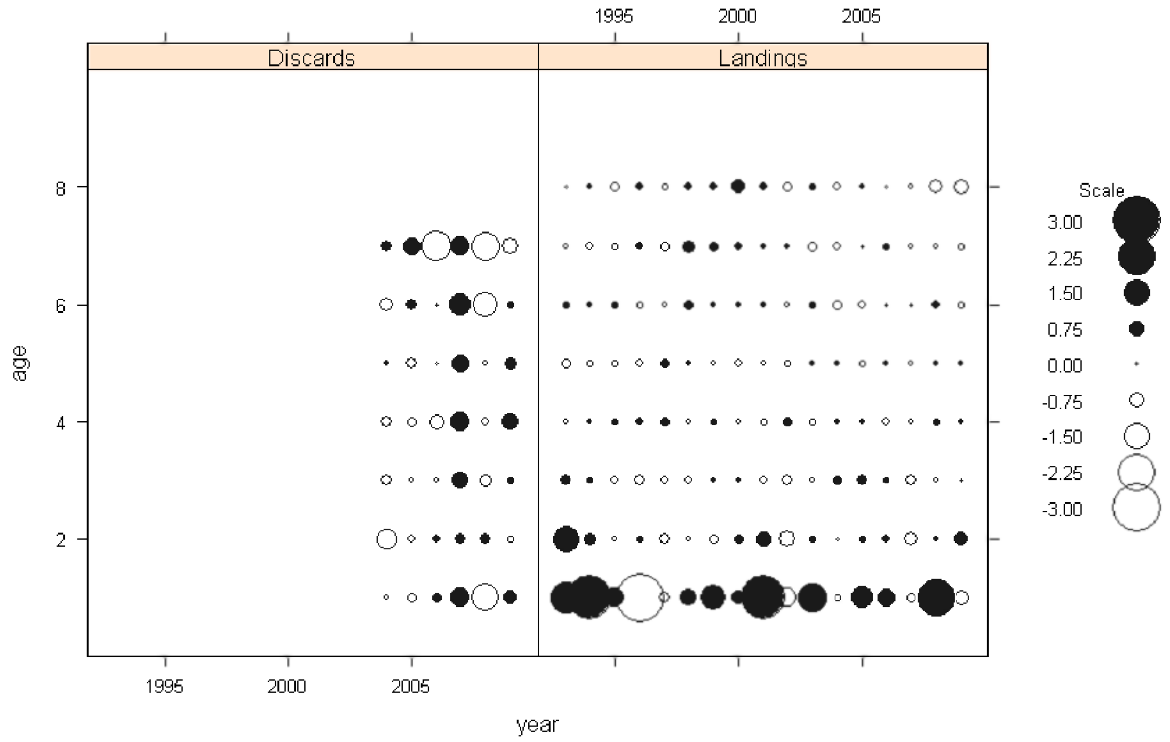

Figure 4.12f. Plaice in Division VIIf&g: The Log residuals for the fit TI_TVS model fit to the discard and landings numbers-at-age data.

Figure 4.13. Plaice in Division VIIf&g: The estimated time-series of spawning–stock biomass, average fishing mortality-at-ages 2–6, recruitment, total discard weight and total landings weight for the fit of the three models. Stock and fishery metrics are very similar apart from the TV_PTVS model which estimates higher levels of historical discards and recruitment at the youngest age.

5 Irish Sea Sole

5.1 Current assessment and issues with data and assessment

Sole in the Irish Sea can be classified as a stock in poor condition. SSB and recruitment have revealed continued decline since 2001 and SSB is currently estimated to be below B_{lim} and substantially below $MSY_{Btrigger}$. The reproductive capacity of the stock has been much reduced in recent years and the stock is considered to be at an increased risk of collapse.

The assessment of sole in the Irish Sea (VIIa) is conducted using the XSA model. Up until 2004 there were four tuning fleets used to tune the assessment, these comprised of two commercial fleets (BEL-CBT and UK-CBT) l and 2 surveys (UK (BTS-3Q) and UK (BTS-1Q)). The addition of one more year of data in 2005 led to an assessment which was not accepted. Therefore a Surba-analysis was carried out using only the survey tuning-series. From then onwards, only two survey indices were used in the assessment (UK (BTS-1Q) and UK (BTS-3Q)). Both demonstrated a very good cohort tracking ability over the years, no substantial patterns in residuals, and were generally considered to perform well. As the UK march survey (UK (BTS-1Q)) was halted in 1999, the assessment depends almost entirely on the UK September survey (UK (BTS-3Q)) for which tuning data are available from 1988 until present. The catches of the Belgian commercial beam trawl fleet are still representative for the sole fisheries in VIIa and the possibility to reintroduce this commercial fleet in the assessment remains. The reintroduction of the UK commercial trawl fleet is not considered appropriate as their catches of sole are minimal and are not likely to be representative of the sole fishery.

The main problem that has been identified for the assessment of sole in VIIa relates to the quality of the catch numbers-at-age data used in the assessment. The deteriorating quality of these data is considered to be a consequence of low sampling intensity, and in particular limited sampling in the first quarter. It is therefore necessary to investigate alternative methods for raising the international catch numbers-at-age for recent years.

Poor sampling coverage in the first quarter may also undermine the estimation of the stock weights which have previously been derived directly from the raw data in the first quarter. Until now, the catch weights were taken from a quadratic smoothed catch weight curve using the aggregated AWK's from the three countries involved (BEL, UK(E&W), IRE) and the stock weights obtained by back calculation to the first of January using the same quadratic smoother. This approach can lead to spurious estimates of weight-at-age, particularly at the youngest ages and a more appropriate method for estimating stock weight-at-age is required.

Discard observation data from on-board sampling schemes suggest that discarding is not a major problem in the Irish Sea sole fishery. Consequently a detailed investigation of discards and discarding practices was not an objective of WKFLAT 2011. Discard rates in the various fisheries targeting sole are generally less than 8.8% (and often even smaller than 2%). Table 5.1 shows the discard rates of the major fleets operational in the Irish Sea. It should be noted that the 56 % discard rate of the Irish *Nephrops* fleet only accounts for about 0.4% of the total international landings. However, it has been suggested by previous review groups that in future work discards are included within the assessment. When dealing with a stock in such a depleted state (very low abundance levels) discards can be an important mortality component.

In addition, attempts should be made to obtain better discard estimates from the various fisheries.

Although the development of a sex-separated assessment of Irish Sea sole could be taken into account, WKFLAT 2011 was not able to address this issue because the work required to raise the historical catch series was too great. To be able to address this in future, lengths and ages must be provided for the sexes separately by IRL, BEL and UK (E&W) (the latter two already provide sex-separated data).

5.2 Compilation of available data

5.2.1 Catch and landings data

The total international landings have gradually decreased over the time-series from around 2000 t in the late eighties to a record low of 324 t in 2009, of which 79% (257 t) was landed by Belgium, 15% (47 t) by Ireland, 3% (10 t) by the UK (England & Wales) and the remainder by Northern Ireland and France. These landing-figures correspond to an international uptake of only 65% of the agreed TAC in 2009 (502 t).

In previous years, Belgium, Ireland and UK constructed three separate national age–length keys that were combined afterwards to create an international catch-at-age matrix. Because of poor biological sampling in some years by some countries, WKFLAT 2011 investigated possibilities to realize a combined age–length key by pooling the raw data of the three countries for direct raising on an international level (see WD1).

Length frequency and age data were supplied by Belgium, UK and Ireland for the years 2000–2009. All UK data (England, Scotland, Wales) were combined. The length frequency data were raised to the catch weight for each trip if catch weight and sample weight were available (UK data since 2003 and Belgian data excluding 2003) and summed by country and year. The relative length distributions for each country and year indicate that there are some differences apparent between countries, for example Belgium and the UK tend to land more small sole than Ireland (Figures 5.1).

Because the sample weights were not available for all data, these weights were estimated for all samples using an annual, international length–weight relationship. The data for the length–weight relationship were visually screened for outliers and unrealistic values were removed. The ratio of the landings weight and total estimated sample weight was used to raise the length frequency distribution data to the total annual landings of each country. Landings in tonnes, supplied by Belgium, UK and Ireland (Table 5.2) were used to raise the data. Note that these are not the same as the WG estimate and an additional raising factor needs to be applied.

The annual age data were combined for all countries without weighting. The ALKs demonstrated no consistent differences between countries (Figure 5.2 and details in WD1 Figures 2–11). In 2002 the Irish data seem to be quite different from other countries (and other years) and was therefore removed from the dataset. The combined annual ALKs performed better in tracking cohorts than country-specific annual ALKs or the quarterly ALKs used by WGCSE 2010 (Figure 5.3). The figure also suggests that the plus group might be extended to older ages as the cohorts can be tracked to older ages than 8 years (the current plus group). The raised catch numbers-at-age resulting from combined, annual ALKs are similar to the numbers-at-age used by WGCSE 2010, but presumably more precise and, judging by the cohort-tracking, also probably more accurate. It is possible though that a bias results from combining data that were stratified by country and quarter if sampling is not proportional to the landings. The combined ALK was applied to the separate length distributions of the national catches to obtain catch numbers-at-age for each individual country. Table 5.3 shows the numbers and catch weights-at-age, raised up to the WG estimates of the landings.

Cohort analysis of the catch curves for the different countries was conducted (Figures 5.4–5.6). The slopes of the cohorts are similar over time for the three countries, although the Irish data were noisier (Figure 5.7).

Investigation of the spatial distribution of the fisheries by country indicates that the different fleets are operating in a broader area range (Figures 5.8–5.9, it should be noted that the scales of the different fleets are not the same). However, the main sole fishery is situated in the Liverpool and Morecambe Bay. This suggests that a combined ALK could be applied. Taking into account the minor differences in the length distributions and the better cohort tracking using a combined ALK, the WKFLAT2011 accepted the use of the combined ALK for use in future assessments of Irish Sea sole.

Derivation of catch weight and stock weight-at-age

Historically, catch weights-at-age were constructed by fitting a quadratic smoother through the aggregated catch weights for each year. WKFLAT 2011 decided not to continue with this approach, but to make use of the mean catch weights from the combined age–weight key of the three countries (Table 5.4 and Figures 5.10–5.11).

Because there are generally insufficient data from quarter 1 to allow a direct calculation of stock weights-at-age, these were previously constructed by back-calculating to the 1st of January from the aggregated catch weights for each year. Up till 2010, a quadratic smoother (the same as above for catch weights-at-age) was used for this purpose, with exception of the 2009 data which resemble the first quarter catch weights.

WKFLAT 2011 discussed the potential use of other interpolation methods to construct stock weights-at-age (Table 5.5 and Figures 5.12–5.13) and decided to proceed with a cohort interpolation using the Rivard Weights Calculator, a NOAA Fisheries Toolbox (accessible at http://nft.nefsc.noaa.gov./, the algorithm used can be consulted in the accompanying Help-file) that allows the user to convert a matrix of mid-year weights-at-age for a number of years to January-1 or other times of the year.

Discard rates of sole are low in Irish Sea fisheries (generally less than 8% and often even smaller than 2%), suggesting that discarding is not a major problem in the Irish Sea sole stock.

There is no accurate information on the level of misreporting, but given the partial uptake of the agreed TAC in recent years, it is not considered to be a significant problem for this stock.

5.2.2 Biological data

Currently there are no direct (e.g. from tagging) or independent (e.g. from survey information) estimates of natural mortality. Annual natural mortality (M) is assumed to be constant over ages and years, at 0.1 yr-1.

The maturity ogive used is based on survey information for this stock:

Age	1	2	3	4	5	6 and older

Mat.	0.00	0.38	0.71	0.97	0.98	1.00

Proportions of M and F before spawning are set to zero.

Sole exhibit a high degree of sexual dimorphism in growth. Males display much reduced rates of growth after reaching maturity, whereas females continue to grow. The minimum landing size for sole is 24 cm. Consequently the majority of landings represent mature females.

5.2.3 Survey tuning data

Two research survey tuning indices (UK (BTS-3Q) and UK (BTS-1Q)) were used in the 2010 WG assessment. A Surba-analysis of both UK (BTS-1Q) and UK (BTS-3Q) illustrates the good cohort tracking, year-class strength estimation and consistency between ages (Figures 5.14–5.19). The UK (BTS-1Q) was cancelled from the European survey programme after 1999. Despite being discontinued, the survey was retained in the assessment but no longer contributes to the final survivor estimates. The UK September survey (UK (BTS-3Q)) provides information on year-class strength from 1988 up to present day. By omitting the UK (BTS-1Q) from the XSA there were hardly any differences in catchability residuals between runs with and without the UK (BTS-1Q). The retrospective pattern demonstrated a slight improvement excluding the UK (BTS-1Q) survey. Therefore, the WKFLAT 2011 decided to omit the spring survey from further analysis.

The UK (BTS-3Q) demonstrates very good consistency in tracking year-class strengths throughout its time-series WKFLAT 2011 found no reason to recommend alterations or modifications to the survey design or raising procedure of the data. Details are provided in the stock annex.

5.2.4 Commercial tuning data

Up to 2004 the Belgian commercial beam trawl fleet (BEL-CBT) was one of the commercial tuning fleets in the assessment, giving information on the older ages. In 2005, the BEL-CBT was omitted from the assessment as XSA results demonstrated unexplainable shifts in fishing mortality and SSB by adding one additional annual dataset.

WKFLAT 2011 considered the possibility of reintroducing the Belgian commercial tuning-series in the assessment of Irish Sea sole. The effort series used to calculate cpue for the index is corrected for HP. The original effort correction is based on a study carried out by IMARES and Cefas in the mid 1990s (no reference available). The study calculated an effort correction for HP applicable to sole and plaice effort in the beam trawl fisheries. The corresponding equations for sole is P = 0.000204 BHP^1.23. This equation was estimated some 20 years ago, when the horse power deployed was substantially less than at the present time. Therefore the working group decided to investigate a more realistic horse power correction for the Belgian beam trawl fleet (WD2). The detailed data, needed to investigate a more realistic horse power correction, was only available from 1997 up to 2009. Therefore a possible new correction for the tuning-series could only be calculated for those years.

The commercial tuning-series demonstrates a high correlation with the catch-at-age matrix (the Belgian beam trawl is responsible for 60–80% of the total uptake). Furthermore, XSA assumes a constant catchability over all years in the tuning fleets whereas commercial fleets may be subject to changing catchabilities over time (e.g. management restrictions and changes in fleet behaviour). In addition, there are, currently, no major concerns of the ability of the UK (BTS-3Q) survey to provide a fishery-independent index with which to tune the assessment and therefore the WKFLAT 2011 decided not to include the Belgian beam trawl fleet again in the assessment of Irish Sea sole.

5.2.5 Industry/stakeholder data inputs

There was no industry/stakeholder data available at this benchmark meeting.

5.2.6 Environmental data

There was no environmental data available at this benchmark meeting.

5.3 Stock identity, distribution and migration issues

Sole occur throughout the Irish Sea, but are found more abundant in depth less than 60 m.

Cuveliers *et al*. (2011) combined the results obtained from ten microsatellite markers (long-term estimate of population structure) with results from otolith microchemistry analyses (short-term estimate of connectivity) on adult sole populations in the North-east Atlantic area. Major large-scale differentiation was detected between three distinct regions (Baltic transition area, North Sea, Irish/Celtic Seas) with both types of markers. The assignment success of individuals to their collection location was much higher based on otolith edge microchemistry compared to the genetic assignments at all sampling locations, except for the Irish Sea. Only 28.6% of individuals (n = 30) caught in the Irish Sea could be assigned to their catch location based on otolith edge microchemistry, whereas this region revealed high genetic self-assignment scores (ca. 60% of 91 individuals) suggesting a spawning population that is genetically distinct. 32% of the misclassifications based on otolith microchemistry were allocated to the neighbouring Celtic Sea.

These results are consistent with tagging studies of sole in the Irish Sea and Bristol Channel, revealing mainly local recruitment and limited movement of sole outside the management areas (Horwood *et al*., 1993). Therefore, the management unit is considered to correspond to the stock unit for Irish Sea sole.

5.4 Influence of the fishery on the stock dynamic

No information on the influence of the fishery on the stock dynamic was available at this benchmark meeting.

5.5 Influence of environmental drivers on the stock dynamic

No information on the influence of the environmental drivers on the stock dynamic was available at this benchmark meeting.

5.6 Role of multispecies interactions

5.6.1 Trophic interactions

No analysis on trophic interactions was carried out at this benchmark meeting.

5.6.2 Fishery interactions

No analysis on fishery interactions was carried out at this benchmark meeting.

5.7 Impacts of the fishery on the ecosystem

No information on the impact of the fishery on the ecosystem was available at this benchmark meeting.

5.8 Stock assessment methods

5.8.1 Models

The model used for the assessment of sole in the Irish Sea is XSA. This method has been used to assess the stock for a number of years. No alternative assessment method was presented to WKFLAT 2011 although comparative analyses were conducted using the statistical catch-at-age model ASAP. Time restrictions during the meeting prevented the development of a final ASAP model that could be recommended to the working group, although the analyses conducted allowed for confirmation of the population trends estimated from the XSA assessment. Much of the work during the meeting focused on investigations of the parameter settings of the existing XSA assessment.

5.8.1.1 Brief description of ASAP

The Age Structured Assessment Program (ASAP) is an age-structured model that uses forward computations assuming separability of fishing mortality into year and age components to estimate population sizes given observed catches, catch-at-age, and indices of abundance. Both total catch in weight and catch proportions-at-age are assumed to be measured with error. Discards can be treated explicitly as either a component of a fleets catch or as a separate fleet. The separability assumption is relaxed by allowing for fleet-specific computations and by allowing the selectivity-at-age to change over time or in blocks of years. The software can also allow the catchability associated with each abundance index to vary smoothly with time. The problem's dimensions (number of ages, years, fleets and abundance indices) are defined at input and limited by hardware only. The input is arranged assuming data are available for most years, but missing years are allowed. The model currently does not allow use of length data nor indices of survival rates. Diagnostics include index fits, residuals in catch and catch-at-age, and effective sample size calculations. Weights are input for different components of the objective function and allow for relatively simple age-structured production model type analyses up to fully parameterized models. The calculation engine is built in AD Model Builder while the graphical user interface is written in Visual Basic. The program has been used as an assessment tool for a wide range of species and locations including Atlantic herring, Atlantic mackerel, red grouper, yellowtail flounder, Pacific sardine, Pacific mackerel, Greenland halibut, Northern Gulf of St Lawrence cod, Gulf of Maine cod, Florida lobster, and summer flounder. Both the User Manual and Technical Manual, which includes the source code, are distributed with the program when it is downloaded from the NOAA Fisheries Toolbox (http://nft.nefsc.noaa.gov/).

5.8.2 Sensitivity analysis

Using the combined ALK as described in Section 5.2.1, new catch numbers-at-age and catch weights-at-age were obtained for the years 2000–2009. The stock weights-at-age for these years were derived from the catch weights using the Rivard weight calculator described in Section 5.2.1. For the years prior to 2000, the original 2010 WG estimates were used.

The linear time weighting (over 20 years) applied in previous assessments of Irish Sea sole produced a moderate retrospective pattern in F and SSB. As there is no reason to question the quality of the survey-indices over time and year-class strength, WKFLAT 2011 decided to investigate other taper time weightings. Bisquare, tricubic and uniform (no taper) time weightings were tested. Retrospective runs produced the best results when no taper weighting was applied. Therefore WKFLAT 2011 decided to use no taper for further analysis (Figures 5.20–5.22).

Further investigations were focused on the appropriateness of the age at which catchability was set independent of stock size for all ages and the setting of catchability independent of age for ages >= 7, as used in the 2010WG. Diagnostics from the UK (BTS-3Q) indicate that the use of a power model is not justified. Therefore the catchability independent of stock size for all ages as used in the 2010 WG is still valid.

Figure 5.23 shows that the catchability at age for the UK (BTS-3Q) tuning fleet stabilizes at age 4 and therefore WKFLAT 2011 decided to change the Q-plateau from age 7 to age 4.

Since 2006 the plus group was set at age 8. Although the WD1 suggests that the plus group might be extended to older ages as the cohorts can be tracked to older ages than 8, the WKFLAT 2011 noted that there are relatively few fish older than age 8 (Figure 5.24). Furthermore, the UK (BTS-3Q) tuning series only providing information on ages 2–7 and therefore an extension of the plus group above age 8 is not desirable. The Working Group therefore proposed to keep the plus group on age 8.

The full range of the age composition of the landings is presented in Table 5.6. Weight-at-age in the catch of the full series is displayed in Table 5.7 and the weight-at-age in the stock in Table 5.8. The tuning indices of the UK September survey (UK (BTS-3Q)) are presented in Table 5.9.

The final XSA diagnostics are demonstrated in Table 5.10. The final XSA output is given in Table 5.11 (fishing mortalities), Table 5.12 (stock numbers) and Table 5.13 (summary table). Residual plots and retrospective of the final XSA run are presented in Figures 5.25–5.27. Figure 5.28 shows very little difference between the fishing mortalities, SSB and recruitment from the 2010 WG and the final XSA run.

5.8.2.1 Comparative analysis in ASAP

The Irish Sea sole landings data were treated as a single fleet in ASAP with selectivity either constant over the time period 1970–2009 or else separated into four blocks by decade. The selectivity pattern was assumed to be flat-topped through either the use of a logistic curve or by estimating ages 2–4 and fixing selectivity for ages 5+ at one. The UK (BTS-3Q) index was treated as either a set of numbers-at-age indices or else as a biomass index with associated proportions-at-age.

5.8.3 Retrospective patterns

Retrospective analyses were conducted using XSA for the period 1997 to 2009 (Figure 5.27). The results display very strong consistency in estimates of SSB, recruitment-at-age 2 and $F_{bar(4–7)}$, with almost no retrospective pattern apparent.

5.8.4 Evaluation of the models

A number of combinations of settings were explored in the ASAP assessment for this stock but there was insufficient time to fully explore a sufficient number of possibilities to arrive at a final model setting. Instead, a range of possible model results are shown to demonstrate the robustness of the estimated F (Figure 5.29(a)), SSB (Figure 5.29(b)), and recruitment-at-age 2 (Figure 5.29(c)) time-series to these model settings. The consistency of the estimates to the model settings and with the main assessment model (XSA) demonstrates that there is no indication of any problems with the main assessment model.

5.8.5 Conclusion

Due to the poor biological sampling in some years by some countries, the raising procedure based on three separate national age–length keys (Belgium, Ireland and UK) is replaced by a combined age–length key. The mean catch weights from this combined key are taken instead of the quadratic smoother used in previous assessments. The stock weights-at-age are obtained using a cohort interpolation method (Rivard weight calculator) from the catch weights-at-age.

The UK(BTS-1Q) survey was omitted as it did not contribute to the final survivor estimates. The linear taper weighting over 20 years is changed to a non taper as there is no reason to question the quality of the survey indices over time and year-class strength. The catchabililty was considered to be independent of stock size for all ages as used in the 2010 WG. The XSA diagnostics indicate that the Q-plateau should be set at age 4 instead of age 7. Changing the plus group from age 8 to age 9 or 10, give worse retrospective bias and therefore the plus group is kept at age 8.

5.9 Short-term and medium-term forecasts

5.9.1 Input data

See stock annex for initial stock size, natural mortality, maturity-at-age, F and M before spawning, weight-at-age in the catch and weight-at-age in the stock.

Exploitation pattern: Average of the three last years, scaled by the $F_{bar\,(4\text{–}7)}$ unscaled to the last year if there is no trend in fishing mortality in the last three years and scaled to the last year if a trend in fishing mortality is observed in the last three years.

Intermediate year assumptions: *Status quo* F.

5.9.2 Model and software

Model used: Age structured deterministic projection

Software used: MFDP

5.9.3 Conclusion

The exploitation pattern for the short-term forecast should take into account trends in fishing mortality by scaling the three year average F's to the last year or not. The other input data are calculated as described in the stock annex.

No work was done by WKFLAT 2011 in relation to medium-term forecasts for Irish Sea sole. Details on the methodology used in previous years can be found in the stock annex.

5.10 Biological reference points

Figure 5.28 shows very little difference between the fishing mortalities, SSB and recruitment from the 2010 WG and the final XSA, and therefore there is no need to revise current biological reference points.

5.11 Recommendations on the procedure for assessment updates and further work

WKFLAT 2011 recommends that future assessments are carried out following the methodology that was fine-tuned during this meeting and described in the Stock Annex.

Further investigations should include monitoring discard practises that would justify the inclusion of discards into the assessment. Another issue could be the development of a sex-separated assessment methodology for this stock.

5.12 Implications for management (plans)

No management plan is currently in place for Irish Sea sole. However, because the fishery appears to be at a level much greater than is sustainable and the stock is at higher risk of collapse, the development of a management plan for this stock is highly desirable.

5.13 References

Cuveliers EL, Volckaert FAM, Raeymaekers JAM, Geffen AJ, Maes GE and FishPopTrace consortium. 2011. The power of integrating genetics and otolith microchemistry into the management of exploited marine fishes: the case of sole (*Solea solea*) in the Northeast Atlantic. Chapter 5 in PhD-thesis E Cuveliers, Catholic University Leuven, Belgium, January 2011.

Horwood J, Blaxter JHS, Southward AJ. 1993. The Bristol Channel sole (*Solea solea* (L.)): A fisheries case study. Advances in Marine Biology, 29, 215–367.

Rivard. 2008. Rivard Weights Calculator, Version 2.0.0.0, NEFSC; http://nft.nefsc.noaa.gov.

Table 5.1. Discard rates for the main fleets operational in the Irish Sea (Belgian, UK and Irish beam trawl, UK otter trawl, UK and Irish *Nephrops* trawl). * It should be noted that the 56.3% discard rate of the Irish *Nephrops* fleet only accounts for about 0.4% of the total international landings.

Country	Gear	Landings (t)	Ratio discarded/landed	years
BEL	TBB	716	5.3	2007–2009
UK	TBB	284	8.8	2002,2005–2007
	OTB	61	5.8	2002–2009
	TWIN OTB	4	0.9	2003,2004,2007
	NEPH OTB	25	8.2	2003,2006–2009
	TWIN *NEPH*	6	1.8	2002,2003,2008
IRL	TBB	427	2.3	2003–2009
	NEPH OTB	16	56.3*	2003–2009

Table 5.2. Landings by country and raising factors to obtain the final WG estimates (2000–2009).

Year	BEL	GB	IRL	Total BEL GB IRL	WG estimate	Raising Factor
2000	494	142	135	771	818	1.0616
2001	680	199	135	1014	1053	1.0386
2002	804	168	96	1068	1087	1.0177
2003	687	218	103	1008	1014	1.0060
2004	524	106	77	707	699	0.9887
2005	665	102	85	852	855	1.0035
2006	404	69	85	558	569	1.0197
2007	305	67	116	488	492	1.0082
2008	229	37	66	332	333	1.0030
2009	257	20	47	324	324	1.0000

Table 5.3. Numbers-at-age, raised up to the WG estimates of the landings (2000–2009).

N@age										
Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0	0	0	9	0	0	14	3	2	1
2	178	240	148	436	295	536	111	171	99	91
3	908	1438	927	824	850	1052	666	356	354	413
4	909	822	1618	965	337	626	645	348	191	331
5	601	717	738	794	363	271	202	243	196	146
6	150	511	573	302	300	314	112	86	157	131
7	55	80	253	217	137	279	150	41	56	127
8	70	65	79	205	56	141	132	63	31	14
9	53	67	30	29	53	75	86	68	45	18
10	24	58	48	14	14	77	59	53	42	37
11	45	28	24	24	12	13	41	25	35	26
12	21	20	12	15	10	7	14	34	8	25
13	6	8	13	13	9	18	5	10	24	12
14	13	6	4	18	4	15	9	5	5	13
15	26	20	6	26	20	22	31	40	20	17

Table 5.4. Catch weight-at-age (2000–2009).

CW@age										
Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.000	0.000	0.000	0.132	0.000	0.000	0.141	0.121	0.118	0.150
2	0.140	0.175	0.162	0.160	0.170	0.160	0.179	0.172	0.148	0.141
3	0.189	0.180	0.172	0.187	0.219	0.203	0.194	0.224	0.189	0.195
4	0.250	0.271	0.211	0.247	0.289	0.256	0.224	0.296	0.248	0.229
5	0.311	0.293	0.283	0.294	0.338	0.286	0.297	0.360	0.279	0.279
6	0.368	0.326	0.328	0.342	0.371	0.312	0.293	0.380	0.291	0.277
7	0.428	0.420	0.333	0.326	0.383	0.326	0.318	0.429	0.386	0.261
8	0.384	0.465	0.417	0.350	0.383	0.334	0.302	0.415	0.397	0.340
9	0.456	0.382	0.277	0.594	0.459	0.340	0.315	0.467	0.373	0.289
10	0.613	0.415	0.309	0.505	0.504	0.331	0.337	0.461	0.368	0.281
11	0.533	0.459	0.290	0.576	0.551	0.337	0.390	0.428	0.350	0.229
12	0.412	0.378	0.338	0.230	0.416	0.388	0.391	0.513	0.451	0.251
13	0.517	0.532	0.602	0.480	0.365	0.364	0.768	0.540	0.340	0.312
14	0.631	0.381	0.459	0.632	0.489	0.335	0.395	0.642	0.588	0.242
15	0.784	0.615	0.691	0.455	0.506	0.572	0.517	0.588	0.540	0.315

Table 5.5. Stock weight-at-age (2000–2009).

SW@age										
Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.112	0.117	0.117	0.117	0.117	0.111	0.128	0.109	0.107	0.175
2	0.124	0.151	0.145	0.144	0.150	0.144	0.152	0.156	0.134	0.129
3	0.158	0.159	0.174	0.174	0.187	0.186	0.177	0.200	0.181	0.170
4	0.230	0.226	0.195	0.207	0.232	0.237	0.213	0.240	0.236	0.208
5	0.303	0.271	0.277	0.249	0.289	0.288	0.276	0.284	0.288	0.263
6	0.345	0.318	0.310	0.311	0.331	0.325	0.289	0.336	0.324	0.278
7	0.410	0.393	0.330	0.327	0.362	0.348	0.315	0.354	0.383	0.276
8	0.385	0.446	0.419	0.341	0.353	0.358	0.314	0.363	0.413	0.363
9	0.478	0.383	0.359	0.498	0.401	0.361	0.324	0.376	0.393	0.339
10	0.707	0.435	0.344	0.374	0.547	0.390	0.339	0.381	0.415	0.323
11	0.633	0.531	0.347	0.422	0.528	0.412	0.360	0.380	0.402	0.290
12	0.362	0.449	0.394	0.258	0.490	0.462	0.363	0.447	0.439	0.296
13	0.602	0.468	0.477	0.403	0.290	0.389	0.546	0.459	0.417	0.375
14	0.571	0.444	0.495	0.617	0.484	0.350	0.380	0.702	0.564	0.287
15	0.784	0.615	0.691	0.455	0.506	0.572	0.518	0.588	0.540	0.315

Table 5.6. Catch numbers-at-age final XSA.

Run title : IRISH SEA SOLE 2011 WKFLAT COMBSEX PLUSGROUP.

At 8/02/2011 10:20

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
2	29	113	31	368	25	262	29	221	65	108
3	895	434	673	363	891	733	375	416	958	1027
4	1009	2097	730	2195	576	2386	1332	1292	649	3433
5	467	1130	1537	557	1713	539	2330	774	1009	829
6	1457	232	537	815	383	842	247	1066	442	637
7	289	878	172	267	422	157	544	150	638	326
+gp	2537	1887	1500	1143	971	1006	739	648	587	620
0 TOTALNUM	6683	6771	5180	5708	4981	5925	5596	4567	4348	6980
TONSLAND	1785	1882	1450	1428	1307	1441	1463	1147	1106	1614
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
2	187	70	8	37	651	154	141	189	32	179
3	939	580	346	165	786	1601	3336	3348	444	771
4	1968	1668	1241	998	380	1086	3467	4105	4752	775
5	3055	1480	1298	758	610	343	961	3185	2102	3978
6	521	1640	711	757	343	334	235	844	1310	1178
7	512	114	641	416	424	164	277	307	203	552
+gp	1145	865	397	709	557	739	848	808	516	255
0 TOTALNUM	8327	6417	4642	3840	3751	4421	9265	12786	9359	7688
TONSLAND	1941	1667	1338	1169	1058	1146	1995	2808	1999	1833
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
2	564	1317	363	83	122	132	60	789	167	301
3	1185	1270	2433	543	1342	920	469	713	1728	1069
4	986	841	918	1966	1069	1444	1188	474	466	1258
5	598	300	556	559	1578	737	741	710	256	297
6	2319	226	190	251	394	1010	430	408	315	115
7	592	1173	156	199	133	179	509	258	191	136
+gp	466	459	929	686	524	350	347	531	423	232
0 TOTALNUM	6710	5586	5545	4287	5162	4772	3744	3883	3546	3408
TONSLAND	1583	1212	1259	1023	1374	1266	1002	1003	911	863
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
2	178	240	148	436	295	536	111	171	99	91
3	908	1438	927	824	850	1052	666	356	354	413
4	909	822	1618	965	337	626	645	348	191	331
5	601	717	738	794	363	271	202	243	196	146
6	150	511	573	302	300	314	112	86	157	131
7	55	80	253	217	137	279	150	41	56	127
+gp	258	272	216	344	178	368	377	298	210	162
0 TOTALNUM	3059	4080	4473	3882	2460	3446	2263	1543	1263	1401
TONSLAND	818	1053	1090	1014	709	855	569	492	332	324
SOPCOF %	100	100	100	100	101	100	101	100	100	100

Table 5.7. Catch weights-at-age final XSA.

Run title : IRISH SEA SOLE 2011 WKFLAT COMBSEX PLUSGROUP.

At 8/02/2011 10:20

Table 2 Catch weights at age (kg)

YEAR		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE											
	2	0.13	0.152	0.126	0.151	0.138	0.13	0.12	0.085	0.093	0.134
	3	0.153	0.178	0.164	0.178	0.174	0.172	0.161	0.146	0.147	0.165
	4	0.178	0.204	0.201	0.204	0.209	0.21	0.2	0.202	0.197	0.199
	5	0.204	0.23	0.237	0.23	0.241	0.244	0.239	0.251	0.243	0.234
	6	0.232	0.257	0.272	0.256	0.272	0.275	0.276	0.293	0.286	0.271
	7	0.26	0.284	0.306	0.283	0.301	0.303	0.313	0.33	0.326	0.311
+gp		0.3769	0.4194	0.4169	0.3918	0.3956	0.3671	0.4574	0.387	0.4294	0.4507
0 SOPCOFAC		1	0.9997	1.0004	0.9999	1	0.9999	0.9996	0.9996	0.9997	0.9997

Table 2 Catch weights at age (kg)

YEAR		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE											
	2	0.146	0.162	0.112	0.189	0.191	0.144	0.122	0.135	0.111	0.125
	3	0.169	0.183	0.171	0.212	0.225	0.189	0.164	0.164	0.147	0.163
	4	0.193	0.207	0.225	0.238	0.257	0.231	0.203	0.196	0.183	0.201
	5	0.219	0.234	0.275	0.266	0.288	0.272	0.241	0.231	0.218	0.237
	6	0.247	0.264	0.321	0.298	0.318	0.31	0.277	0.268	0.252	0.271
	7	0.275	0.296	0.362	0.332	0.347	0.346	0.311	0.308	0.286	0.304
+gp		0.3801	0.452	0.4564	0.4577	0.4085	0.4296	0.4071	0.4615	0.4188	0.3887
0 SOPCOFAC		1.0007	1.0002	1.0002	0.9997	0.9998	0.9994	0.9994	0.9998	0.999	1.0001

Table 2 Catch weights at age (kg)

YEAR		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE											
	2	0.135	0.133	0.149	0.102	0.175	0.129	0.156	0.154	0.187	0.179
	3	0.162	0.172	0.177	0.156	0.198	0.182	0.193	0.197	0.209	0.217
	4	0.192	0.208	0.207	0.205	0.227	0.232	0.228	0.237	0.234	0.252
	5	0.227	0.241	0.239	0.248	0.261	0.277	0.263	0.275	0.263	0.285
	6	0.265	0.272	0.274	0.285	0.301	0.318	0.296	0.311	0.295	0.314
	7	0.307	0.3	0.31	0.318	0.346	0.356	0.327	0.345	0.331	0.341
+gp		0.414	0.3452	0.3788	0.3701	0.5093	0.4507	0.4104	0.4068	0.4399	0.3992
0 SOPCOFAC		1.0004	0.9995	0.9992	0.9994	1.0007	0.9998	1.0003	1.0015	1	1.0005

Table 2 Catch weights at age (kg)

YEAR		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE											
	2	0.14	0.175	0.162	0.16	0.17	0.16	0.179	0.172	0.148	0.141
	3	0.189	0.18	0.172	0.187	0.219	0.203	0.194	0.224	0.189	0.195
	4	0.25	0.271	0.211	0.247	0.289	0.256	0.224	0.296	0.248	0.229
	5	0.311	0.293	0.283	0.294	0.338	0.286	0.297	0.36	0.279	0.279
	6	0.368	0.326	0.328	0.342	0.371	0.312	0.293	0.38	0.291	0.277
	7	0.428	0.42	0.333	0.326	0.383	0.326	0.318	0.429	0.386	0.261
+gp		0.5042	0.438	0.3746	0.415	0.4436	0.3515	0.3494	0.4785	0.3919	0.2767
0 SOPCOFAC		0.9981	1	1.003	1.0015	1.0141	0.9996	1.0057	0.9989	0.9963	0.9995

Table 5.8. Stock weights-at-age final XSA.

Run title : IRISH SEA SOLE 2011 WKFLAT COMBSEXPLUSGROUP.

At 8/02/2011 10:20

Table 3 Stock weights at age (kg)

YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE										
2	0.13	0.152	0.126	0.151	0.138	0.13	0.12	0.085	0.093	0.134
3	0.153	0.178	0.164	0.178	0.174	0.172	0.161	0.146	0.147	0.165
4	0.178	0.204	0.201	0.204	0.209	0.21	0.2	0.202	0.197	0.199
5	0.204	0.23	0.237	0.23	0.241	0.244	0.239	0.251	0.243	0.234
6	0.232	0.257	0.272	0.256	0.272	0.275	0.276	0.293	0.286	0.271
7	0.26	0.284	0.306	0.283	0.301	0.303	0.313	0.33	0.326	0.311
+gp	0.3769	0.4194	0.4169	0.3918	0.3956	0.3671	0.4574	0.387	0.4294	0.4507

Table 3 Stock weights at age (kg)

YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE										
2	0.146	0.162	0.112	0.189	0.191	0.144	0.122	0.135	0.111	0.125
3	0.169	0.183	0.171	0.212	0.225	0.189	0.164	0.164	0.147	0.163
4	0.193	0.207	0.225	0.238	0.257	0.231	0.203	0.196	0.183	0.201
5	0.219	0.234	0.275	0.266	0.288	0.272	0.241	0.231	0.218	0.237
6	0.247	0.264	0.321	0.298	0.318	0.31	0.277	0.268	0.252	0.271
7	0.275	0.296	0.362	0.332	0.347	0.346	0.311	0.308	0.286	0.304
+gp	0.3801	0.452	0.4564	0.4577	0.4085	0.4296	0.4071	0.4615	0.4188	0.3887

Table 3 Stock weights at age (kg)

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE										
2	0.135	0.133	0.149	0.102	0.175	0.129	0.156	0.154	0.187	0.179
3	0.162	0.172	0.177	0.156	0.198	0.182	0.193	0.197	0.209	0.217
4	0.192	0.208	0.207	0.205	0.227	0.232	0.228	0.237	0.234	0.252
5	0.227	0.241	0.239	0.248	0.261	0.277	0.263	0.275	0.263	0.285
6	0.265	0.272	0.274	0.285	0.301	0.318	0.296	0.311	0.295	0.314
7	0.307	0.3	0.31	0.318	0.346	0.356	0.327	0.345	0.331	0.341
+gp	0.414	0.3452	0.3788	0.3701	0.5093	0.4507	0.4104	0.4068	0.4399	0.3992

Table 3 Stock weights at age (kg)

YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AGE										
2	0.124	0.151	0.145	0.144	0.15	0.144	0.152	0.156	0.134	0.129
3	0.158	0.159	0.174	0.174	0.187	0.186	0.177	0.2	0.181	0.17
4	0.23	0.226	0.195	0.207	0.232	0.237	0.213	0.24	0.236	0.208
5	0.303	0.271	0.277	0.249	0.289	0.288	0.276	0.284	0.288	0.263
6	0.345	0.318	0.31	0.311	0.331	0.325	0.289	0.336	0.324	0.278
7	0.41	0.393	0.33	0.327	0.362	0.348	0.315	0.354	0.383	0.276
+gp	0.5301	0.4501	0.3971	0.383	0.419	0.3832	0.3484	0.4193	0.4244	0.3189

Table 5.9. Tuning-series-UK September survey (UK (BTS-3Q))- final XSA.

IRISH SEA SOLE.2011 WKFLAT.VPA TUNING DATA

101						
UK(BTS-3Q)						
1988	2009					
1	1	0.75	0.85			
2	7					
100.062	196	180	410	76	40	4
129.71	304	180	74	284	56	32
128.969	534	122	42	88	194	40
123.78	1286	122	26	16	14	55
129.525	309	657	142	34	22	7
131.192	330	143	211	40	17	7
124.892	408	203	73	132	49	11
126.004	154	253	110	30	67	12
126.004	126	32	76	46	23	31
126.004	577	72	24	55	27	16
126.004	716	292	18	6	24	23
126.004	293	255	203	29	8	26
126.004	464	147	219	91	13	2
126.004	284	192	65	96	64	6
126.004	61	121	126	42	79	49
126.004	210	51	97	81	40	43
126.004	240	119	27	77	45	41
122.298	165	69	25	13	35	25
126.004	110	90	45	36	9	16
126.004	93	49	57	41	11	4
122.298	125	60	21	43	23	6
126.004	150	68	39	23	30	12

Table 5.10. XSA diagnostics of the final run.

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

IRISH SEA SOLE 2011 WKFLAT COMBSEX PLUSGROUP.

CPUE data from file sol7atun.txt

Catch data for 40 years. 1970 to 2009. Ages 2 to 8.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
UK(BTS-3Q)	1988	2009	2	7	0.75	0.85

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 4

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.500

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning converged after 22 iterations

1

Regression weights

	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0.026	0.055	0.068	0.159	0.086	0.178	0.074	0.095	0.052	0.043
3	0.228	0.272	0.276	0.57	0.466	0.438	0.312	0.319	0.259	0.28
4	0.218	0.297	0.493	0.454	0.426	0.66	0.466	0.238	0.252	0.364
5	0.217	0.239	0.42	0.424	0.273	0.639	0.405	0.284	0.183	0.277
6	0.459	0.258	0.272	0.269	0.249	0.357	0.526	0.268	0.267	0.16
7	0.7	0.421	0.176	0.14	0.168	0.344	0.257	0.328	0.25	0.319

Table 5.10. XSA diagnostics of the final run. Continued.

XSA population numbers (Thousands)

YEAR \ AGE	2	3	4	5	6	7
2000	7.19E+03	4.67E+03	4.88E+03	3.24E+03	4.28E+02	1.15E+02
2001	4.72E+03	6.34E+03	3.37E+03	3.55E+03	2.36E+03	2.45E+02
2002	2.36E+03	4.05E+03	4.37E+03	2.26E+03	2.53E+03	1.65E+03
2003	3.11E+03	1.99E+03	2.78E+03	2.41E+03	1.35E+03	1.74E+03
2004	3.76E+03	2.40E+03	1.02E+03	1.60E+03	1.43E+03	9.31E+02
2005	3.45E+03	3.12E+03	1.36E+03	6.03E+02	1.10E+03	1.01E+03
2006	1.63E+03	2.61E+03	1.82E+03	6.37E+02	2.88E+02	6.97E+02
2007	1.99E+03	1.37E+03	1.73E+03	1.03E+03	3.85E+02	1.54E+02
2008	2.07E+03	1.63E+03	9.03E+02	1.23E+03	7.05E+02	2.66E+02
2009	2.27E+03	1.78E+03	1.14E+03	6.35E+02	9.30E+02	4.88E+02

Estimated population abundance at 1st Jan 2010

0.00E+00	1.97E+03	1.22E+03	7.18E+02	4.36E+02	7.17E+02

Taper weighted geometric mean of the VPA populations:

5.19E+03	4.65E+03	3.45E+03	2.14E+03	1.30E+03	7.54E+02

Standard error of the weighted Log(VPA populations) :

0.6655	0.6717	0.7178	0.7256	0.7286	0.7515

Log catchability residuals.

Fleet : UK(BTS-3Q)

Age	1988	1989
2	0.05	0.04
3	0.62	0.4
4	0.13	0.19
5	-0.28	0.07
6	-0.16	-0.18
7	-0.1	0.07

Age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2	0.41	0.51	-0.05	-0.27	0.16	0.2	-0.27	0.07	0.4	-0.16
3	-0.09	-0.28	0.5	-0.24	-0.01	0.32	-0.63	-0.04	0.1	-0.01
4	-0.13	-0.8	0.55	0.01	-0.16	0.16	-0.15	-0.02	-0.65	0.38
5	1.06	-0.52	0.07	-0.25	0.11	-0.48	-0.14	0.09	-0.64	0.42
6	0.34	-0.15	0.23	-0.03	0.54	0	-0.12	-0.13	-0.27	0.42
7	0.15	-0.25	-0.25	-0.15	0.15	-0.42	-0.22	0.22	0.16	0.15

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	0	-0.05	-0.88	0.15	0.04	-0.15	0.08	-0.27	-0.02	0.04
3	-0.2	-0.2	-0.21	-0.13	0.45	-0.35	-0.04	0	0.01	0.04
4	0.39	-0.39	0.17	0.32	0.02	-0.12	-0.01	0.09	-0.21	0.23
5	-0.08	-0.1	-0.33	0.26	0.5	0.02	0.77	0.32	0.14	0.22
6	0.19	-0.08	0.07	0.02	0.06	0.18	0.27	-0.02	0.14	0.01
7	-0.17	-0.06	-0.06	-0.27	0.33	-0.07	-0.25	-0.07	-0.25	-0.13

Table 5.10. XSA diagnostics of the final run. Continued.

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

Age	2	3	4	5	6	7
Mean Log q	-7.4732	-7.8342	-8.073	-8.073	-8.073	-8.073
S.E(Log q)	0.2881	0.3016	0.3246	0.4149	0.2182	0.207

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.82	2.128	7.62	0.87	22	0.22	-7.47
3	0.91	0.828	7.86	0.8	22	0.28	-7.83
4	0.88	1.329	8.05	0.87	22	0.28	-8.07
5	1.1	-0.759	8.07	0.75	22	0.46	-8.02
6	1.08	-1.259	8.09	0.93	22	0.22	-8.01
7	0.99	0.269	8.12	0.95	22	0.2	-8.14
1							

Fleet disaggregated estimates of survivors :

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2007

UK(BTS-3Q)

Age	2
Survivors	2036
Raw Weights	10.643

Fleet	Estima Survivc	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
UK(BTS-3Q)	2036	0.3	0	0	1	0.96	0.042
F shrinkage mea	849	1.5				0.04	0.097

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1966	0.29	0.18	2	0.596	0.043

1

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2006

UK(BTS-3Q)

Age	3	2
Survivors	1263	1194
Raw Weights	7.953	7.979

Table 5.10. XSA diagnostics of the final run. Continued.

Fleet	Estima Survivo	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
UK(BTS-3Q)	1228	0.215	0.028	0.13	2	0.973	0.278
F shrinkage mea	908	1.5				0.027	0.36

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1218	0.21	0.04	3	0.189	0.28

1
Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2005

UK(BTS-3Q)			
Age	4	3	2
Survivors	905	725	549
Raw Weights	6.309	5.645	5.424

Fleet	Estima Survivo	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
UK(BTS-3Q)	720	0.183	0.145	0.79	3	0.975	0.363
F shrinkage mea	622	1.5				0.025	0.409

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
718	0.18	0.12	4	0.645	0.364

1
Age 5 Catchability constant w.r.t. time and age (fixed at the value for age) 4

Year class = 2004

UK(BTS-3Q)				
Age	5	4	3	2
Survivors	543	352	436	471
Raw Weights	4.215	5.352	4.51	4.424

Fleet	Estima Survivo	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
UK(BTS-3Q)	439	0.171	0.092	0.54	4	0.977	0.275
F shrinkage mea	323	1.5				0.023	0.358

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
436	0.17	0.08	5	0.482	0.277

Table 5.10. XSA diagnostics of the final run. Continued.

Age 6 Catchability constant w.r.t. time and age (fixed at the value for age) 4

Year class = 2003

UK(BTS-3Q)

Age	6	5	4	3	2
Survivors	725	821	788	689	617
Raw Weights	9.466	3.944	5.079	4.308	3.807

Fleet	Estima Survivc	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
UK(BTS-3Q)	727	0.154	0.044	0.29	5	0.984	0.158
F shrinkage mea	314	1.5				0.016	0.334

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
717	0.15	0.06	6	0.404	0.16

1

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 4

Year class = 2002

UK(BTS-3Q)

Age	7	6	5	4	3	2
Survivors	281	368	440	317	226	332
Raw Weights	8.073	6.182	2.328	2.387	1.785	1.73

Fleet	Estima Survivc	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
UK(BTS-3Q)	320	0.151	0.08	0.53	6	0.981	0.321
F shrinkage mea	394	1.5				0.019	0.267

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
321	0.15	0.07	7	0.486	0.319

Table 5.11. Fishing mortalities of the final XSA run.

Run title : IRISH SEA SOLE 2011 WKFLAT COMBSEX PLUSGROUP.

At 8/02/2011 10:19

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
AGE											
	2	0.0083	0.0117	0.0103	0.0299	0.0045	0.0421	0.0079	0.0148	0.0076	0.0129
	3	0.1196	0.148	0.0809	0.1436	0.0847	0.1575	0.0704	0.135	0.0743	0.1426
	4	0.2956	0.3988	0.3518	0.3621	0.3157	0.3032	0.4193	0.3255	0.2866	0.3644
	5	0.4445	0.5545	0.5057	0.4394	0.4722	0.4844	0.4816	0.4072	0.4036	0.6322
	6	0.4292	0.3671	0.493	0.4873	0.5435	0.3972	0.3792	0.3752	0.3815	0.426
	7	0.3909	0.4416	0.4517	0.431	0.4453	0.3961	0.4281	0.3704	0.3582	0.4758
+gp		0.3909	0.4416	0.4517	0.431	0.4453	0.3961	0.4281	0.3704	0.3582	0.4758
0 FBAR 4- 7		0.39	0.4405	0.4506	0.4299	0.4442	0.3952	0.427	0.3695	0.3575	0.4746

Table 8 Fishing mortality (F) at age

YEAR		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
AGE											
	2	0.0395	0.0164	0.0034	0.007	0.0446	0.0098	0.0061	0.0578	0.0095	0.0432
	3	0.1331	0.1485	0.0948	0.0806	0.1796	0.1323	0.2703	0.1748	0.1678	0.292
	4	0.3924	0.3279	0.4757	0.3813	0.2405	0.3574	0.4131	0.5484	0.3562	0.4346
	5	0.5664	0.5097	0.4061	0.5296	0.3763	0.3164	0.5449	0.7325	0.5334	0.504
	6	0.9478	0.6014	0.4353	0.3899	0.4295	0.3236	0.331	1.2147	0.6755	0.5735
	7	0.6382	0.4814	0.4405	0.435	0.3497	0.3334	0.4311	0.836	0.9936	0.5967
+gp		0.6382	0.4814	0.4405	0.435	0.3497	0.3334	0.4311	0.836	0.9936	0.5967
0 FBAR 4- 7		0.6362	0.4801	0.4394	0.4339	0.349	0.3327	0.43	0.8329	0.6397	0.5272

Terminal Fs derived using XSA (With F shrinkage)

Table 8 Fishing mortality (F) at age

YEAR		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
AGE											
	2	0.109	0.1122	0.0783	0.0138	0.0239	0.071	0.025	0.0987	0.0241	0.0594
	3	0.3897	0.3377	0.2777	0.1446	0.2861	0.2251	0.3409	0.4051	0.289	0.1893
	4	0.6526	0.468	0.3871	0.3366	0.4134	0.5006	0.4466	0.6045	0.4475	0.3142
	5	0.6241	0.3704	0.5729	0.3829	0.4385	0.4944	0.4595	0.465	0.6844	0.5067
	6	0.5485	0.4493	0.3766	0.4875	0.4515	0.4932	0.5317	0.4385	0.3429	0.6692
	7	0.5623	0.5251	0.5669	0.7536	0.4587	0.3377	0.4386	0.6263	0.3351	0.2171
+gp		0.5623	0.5251	0.5669	0.7536	0.4587	0.3377	0.4386	0.6263	0.3351	0.2171
0 FBAR 4- 7		0.5969	0.4532	0.4758	0.4901	0.4405	0.4565	0.4691	0.5336	0.4525	0.4268

Table 8 Fishing mortality (F) at age

YEAR		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR 07-09
AGE												
	2	0.0264	0.0549	0.0682	0.1594	0.0862	0.1783	0.0741	0.0949	0.0515	0.0431	0.0632
	3	0.2284	0.2724	0.2755	0.5697	0.4659	0.4379	0.3121	0.3185	0.2585	0.2795	0.2855
	4	0.218	0.2967	0.4932	0.454	0.4262	0.6597	0.4658	0.2376	0.2516	0.3637	0.2843
	5	0.2168	0.2387	0.4196	0.4243	0.273	0.6392	0.4052	0.2837	0.1827	0.2766	0.2477
	6	0.4593	0.2582	0.2719	0.2689	0.2494	0.3568	0.5256	0.268	0.2669	0.1602	0.2317
	7	0.7002	0.421	0.1758	0.1402	0.168	0.344	0.2566	0.3282	0.25	0.3194	0.2992
+gp		0.7002	0.421	0.1758	0.1402	0.168	0.344	0.2566	0.3282	0.25	0.3194	
0 FBAR 4- 7		0.3986	0.3036	0.3401	0.3219	0.2792	0.5	0.4133	0.2794	0.2378	0.28	

Table 5.12. Stock numbers of the final XSA run.

Run title : IRISH SEA SOLE 2011 WKFLAT COMBSEX PLUSGROUP.

At 8/02/2011 10:19

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
	AGE										
	2	3695	10178	3186	13137	5872	6682	3858	15779	9048	8866
	3	8349	3316	9102	2853	11536	5290	5797	3463	14067	8125
	4	4145	6703	2587	7596	2237	9591	4089	4889	2738	11817
	5	1368	2791	4071	1647	4785	1476	6409	2433	3194	1860
	6	4389	794	1451	2221	960	2700	823	3582	1465	1931
	7	939	2586	498	802	1235	505	1642	509	2228	905
	+gp	8213	5534	4321	3418	2829	3221	2222	2193	2043	1714
0	TOTAL	31098	31902	25215	31674	29454	29465	24840	32849	34783	35218

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
	AGE										
	2	5080	4517	2483	5593	15699	16525	24399	3538	3571	4454
	3	7919	4419	4021	2239	5025	13586	14806	21943	3021	3201
	4	6375	6272	3447	3309	1869	3799	10770	10223	16670	2311
	5	7427	3896	4089	1938	2045	1329	2405	6448	5346	10563
	6	894	3814	2118	2465	1033	1270	877	1262	2804	2837
	7	1141	314	1891	1240	1510	608	832	570	339	1291
	+gp	2537	2370	1167	2105	1977	2732	2536	1488	854	593
0	TOTAL	31374	25603	19215	18888	29159	39850	56623	45471	32605	25251

Terminal Fs derived using XSA (With F shrinkage)

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	AGE										
	2	5741	13044	5066	6355	5432	2025	2550	8827	7377	5483
	3	3860	4658	10550	4239	5671	4799	1707	2250	7237	6516
	4	2163	2365	3007	7231	3319	3855	3467	1098	1358	4904
	5	1354	1019	1340	1847	4673	1986	2114	2007	543	785
	6	5774	656	637	684	1140	2727	1096	1208	1141	248
	7	1447	3019	379	395	380	657	1507	583	705	733
	+gp	1133	1176	2246	1353	1491	1280	1023	1193	1557	1247
0	TOTAL	21472	25937	23224	22105	22106	17329	13465	17167	19917	19916

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST 70-07	AMST 70-07
	AGE													
	2	7194	4725	2360	3110	3757	3450	1633	1985	2072	2269	0	5435	6744
	3	4675	6340	4047	1995	2399	3119	2612	1372	1633	1780	1966	4903	6056
	4	4879	3366	4369	2780	1021	1362	1821	1730	903	1141	1218	3683	4619
	5	3241	3550	2264	2414	1597	603	637	1034	1234	635	718	2242	2856
	6	428	2361	2530	1347	1429	1100	288	385	705	930	436	1334	1707
	7	115	245	1650	1744	931	1008	697	154	266	488	717	784	998
	+gp	535	829	1406	2761	1208	1325	1747	1116	996	621	729		
0	TOTAL	21067	21415	18626	16150	12342	11966	9434	7776	7808	7865	5784		

Table 5.13. Summary of the final XSA.

Run title : IRISH SEA SOLE 2011 WKFLAT COMBSEX PLUSGROUP.

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Table 16 Summary (without SOP correction)

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4- 7
1970	3695	7133	6437	1785	0.2773	0.39
1971	10178	7406	6222	1882	0.3025	0.4405
1972	3186	5727	5011	1450	0.2894	0.4506
1973	13137	6555	5123	1428	0.2787	0.4299
1974	5872	6190	5069	1307	0.2579	0.4442
1975	6682	6231	5361	1441	0.2688	0.3952
1976	3858	5503	4890	1463	0.2992	0.427
1977	15779	5512	4492	1147	0.2554	0.3695
1978	9048	6247	5094	1106	0.2171	0.3575
1979	8866	6893	5688	1614	0.2837	0.4746
1980	5080	6436	5519	1941	0.3517	0.6362
1981	4517	5921	5176	1667	0.3221	0.4801
1982	2483	4763	4345	1338	0.3079	0.4394
1983	5593	4944	4117	1169	0.2839	0.4339
1984	15699	6859	4645	1058	0.2277	0.349
1985	16525	7964	5711	1146	0.2007	0.3327
1986	24399	9704	7077	1995	0.2819	0.43
1987	3538	8770	7340	2808	0.3825	0.8329
1988	3571	6218	5728	1999	0.349	0.6397
1989	4454	5439	4878	1833	0.3758	0.5272
1990	5741	4566	3886	1583	0.4074	0.5969
1991	13044	4764	3436	1212	0.3527	0.4532
1992	5066	4707	3673	1259	0.3428	0.4758
1993	6355	4072	3424	1023	0.2987	0.4901
1994	5432	5281	4319	1374	0.3182	0.4405
1995	2025	4257	3804	1266	0.3328	0.4565
1996	2550	3311	2934	1002	0.3415	0.4691
1997	8827	3677	2687	1003	0.3733	0.5336
1998	7377	4607	3301	911	0.276	0.4525
1999	5483	4680	3620	863	0.2384	0.4268
2000	7194	4213	3393	818	0.2411	0.3986
2001	4725	4664	3888	1053	0.2709	0.3036
2002	2360	4413	3958	1090	0.2754	0.3401
2003	3110	4018	3610	1014	0.2809	0.3219
2004	3757	3027	2531	709	0.2801	0.2792
2005	3450	2789	2300	855	0.3718	0.5
2006	1633	2186	1882	569	0.3023	0.4133
2007	1985	1945	1655	492	0.2973	0.2794
2008	2072	1895	1623	332	0.2045	0.2378
2009	2269	1591	1311	324	0.2471	0.28
Arith. Mean	6515	5127	4229	1258	0.2967	0.4357
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

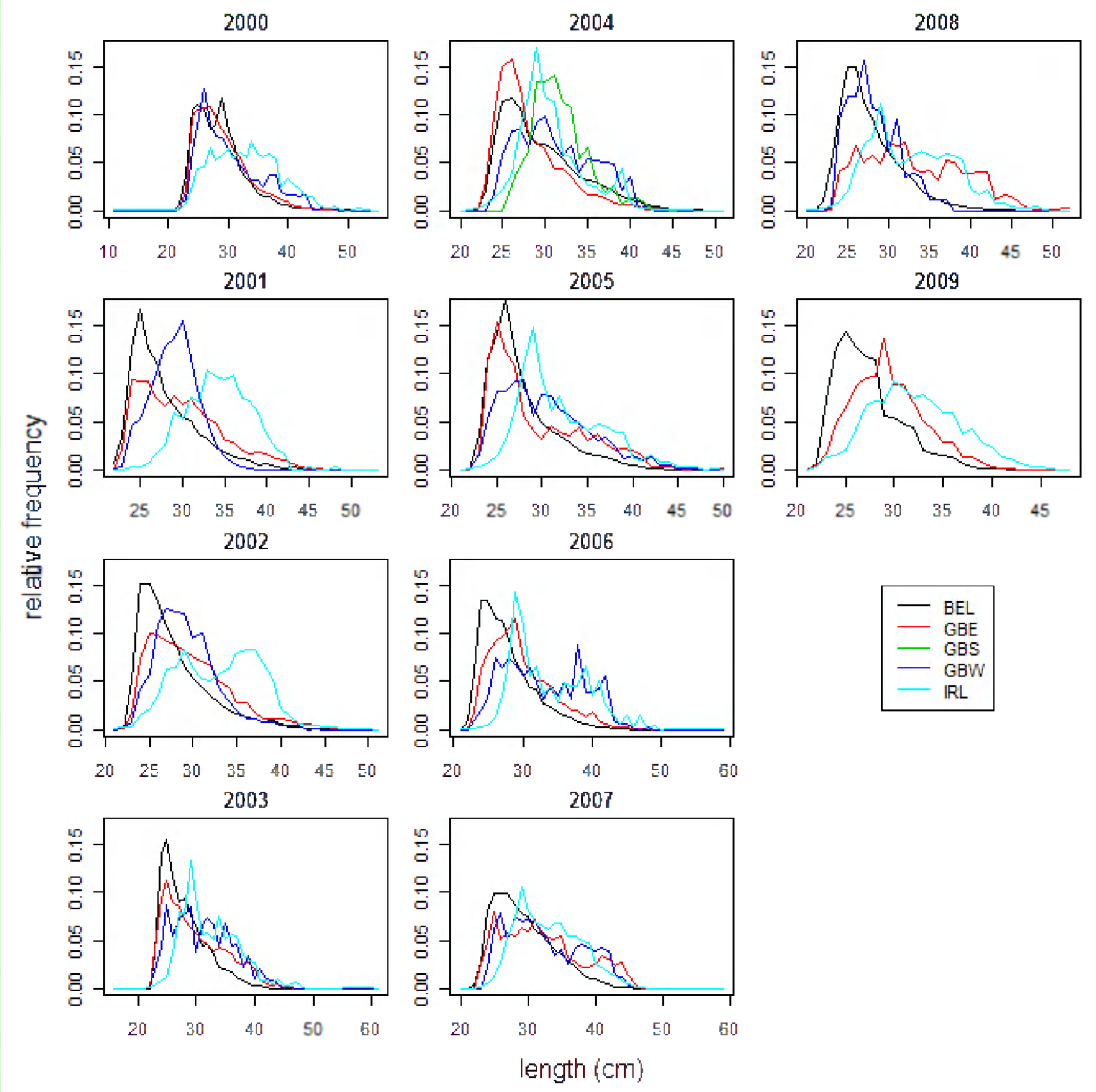

Figure 5.1. The relative length distributions for each country and year (2000–2009).

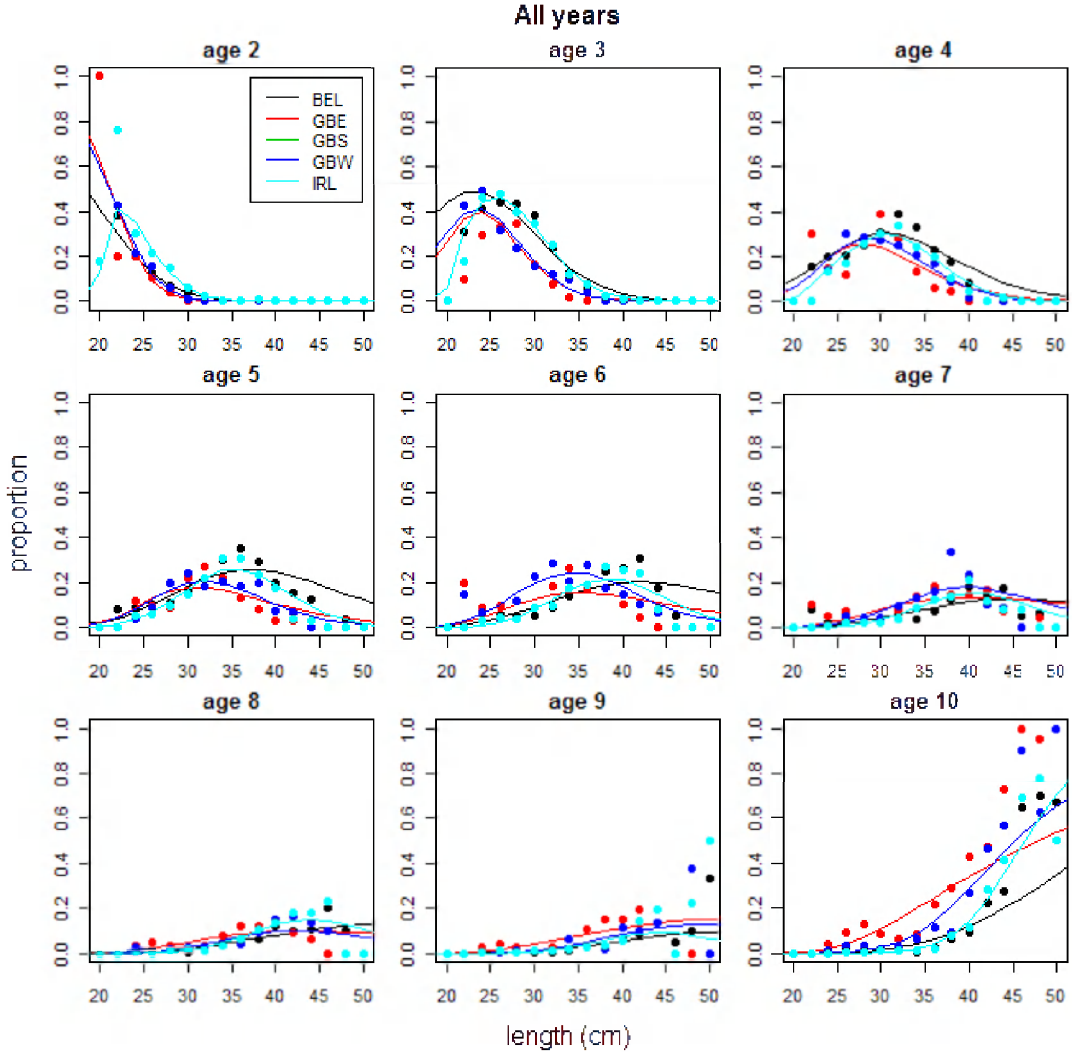

Figure 5.2. The proportions-at-age and length (ALKs) for all years (2000–2009) by country.

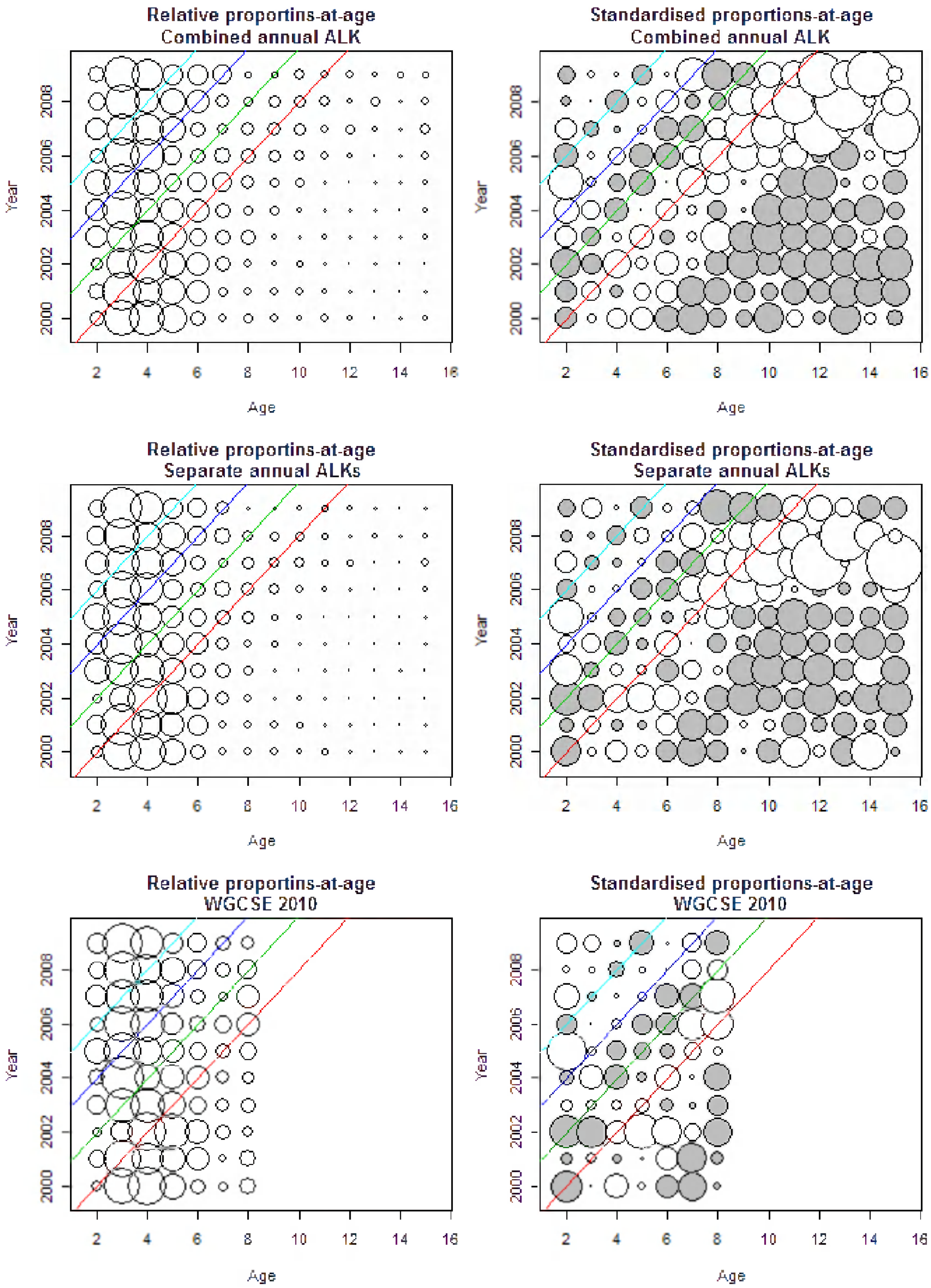

Figure 5.3. Cohort tracking by the combined annual ALKs and separate annual ALKs for each country and the catch numbers used by WGCSE 2010 (2000–2009). The coloured lines follow particularly weak or strong year classes.

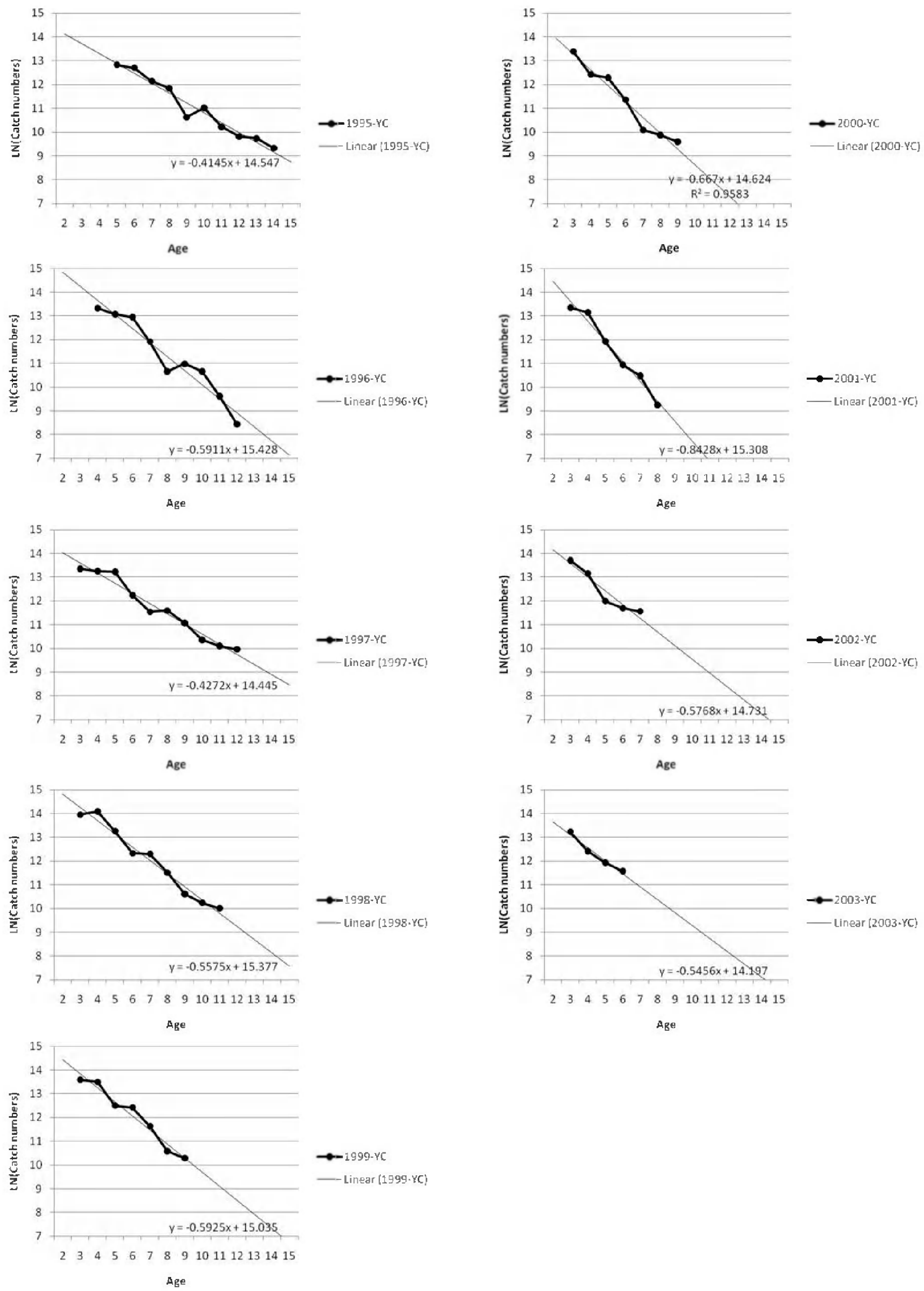

Figure 5.4. Log catch numbers-at-age for year classes 1995–2003 resulting from the combined ALK applied to the Belgian length distributions.

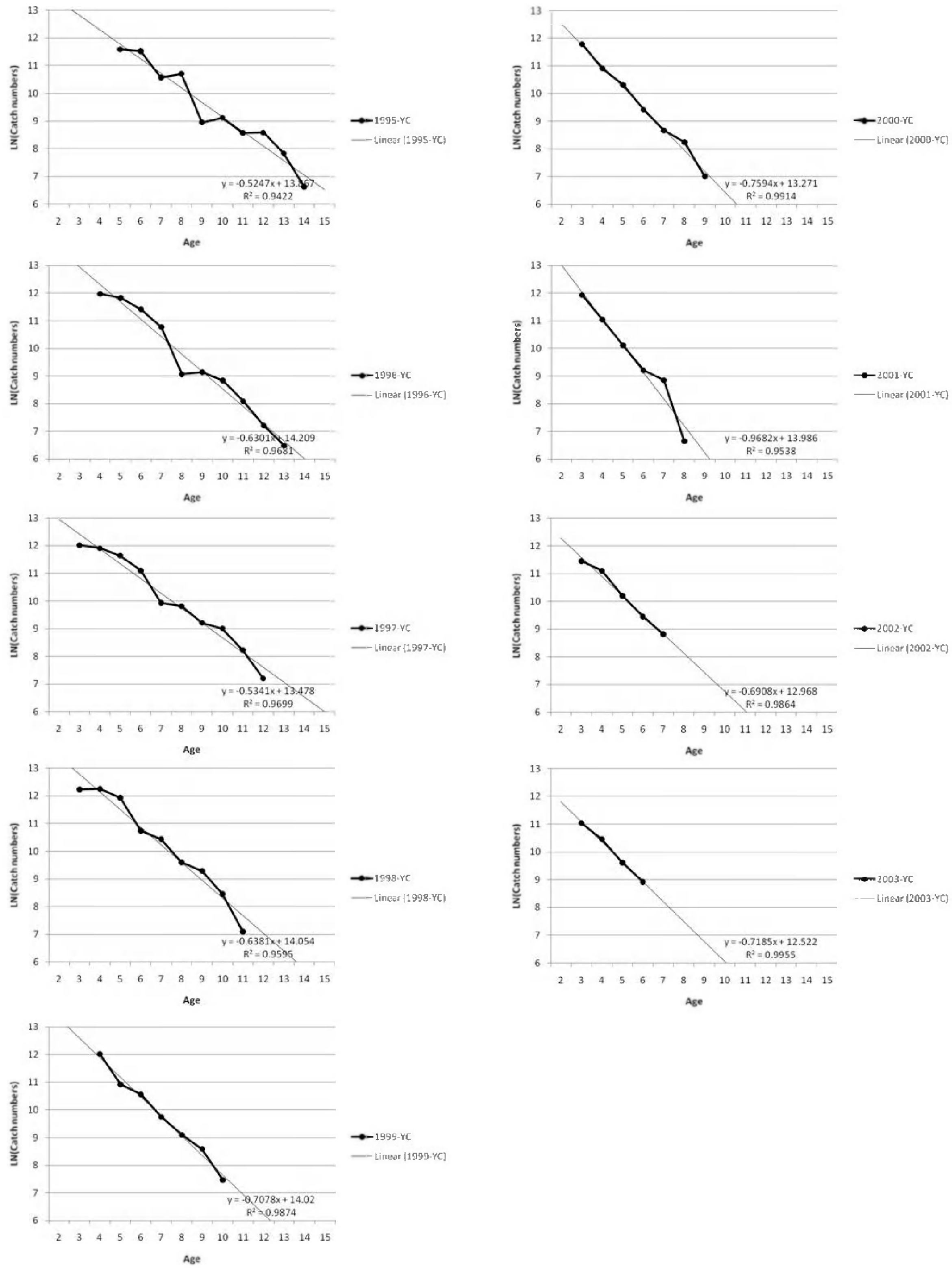

Figure 5.5. Log catch numbers-at-age for year classes 1995–2003 resulting from the combined ALK applied to the UK length distributions.

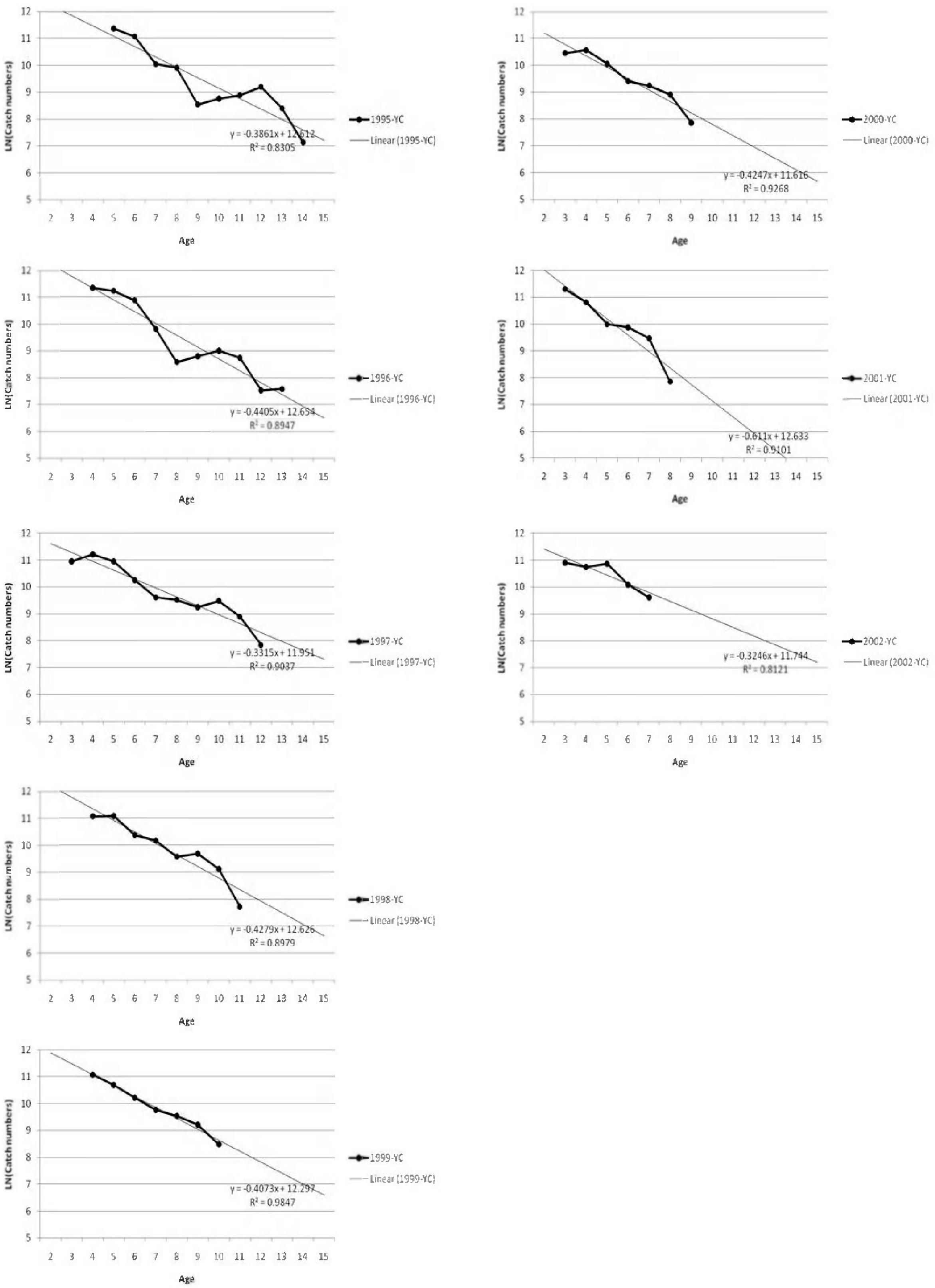

Figure 5.6. Log catch numbers-at-age for year classes 1995–2002 resulting from the combined ALK applied to the Irish length distributions.

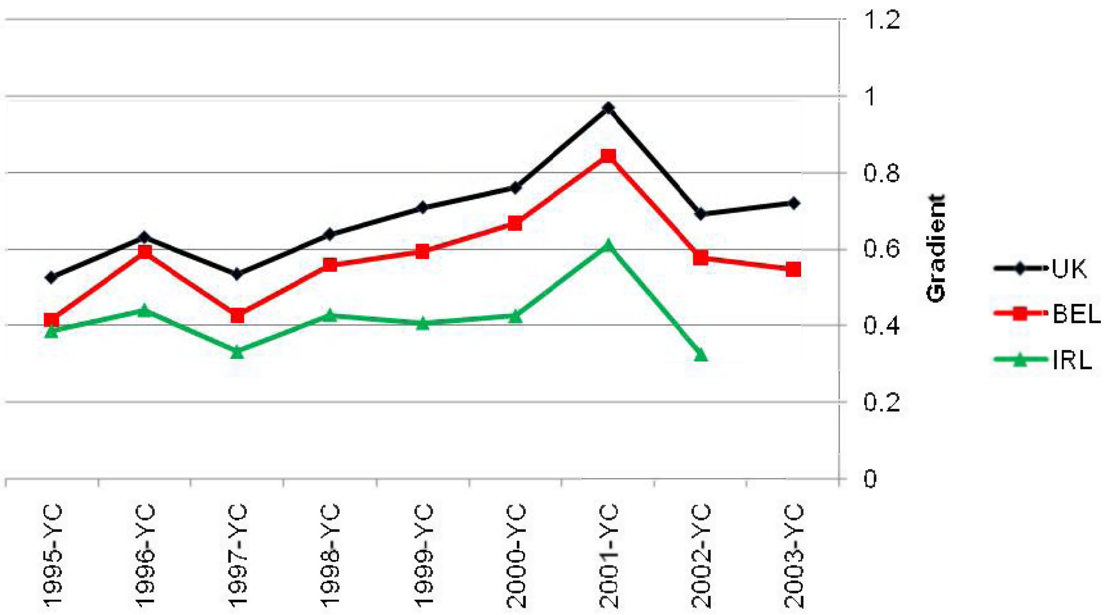

Figure 5.7. Gradient of the linear fit through cohorts of catch numbers-at-age from the three main countries (UK, Belgium and Ireland).

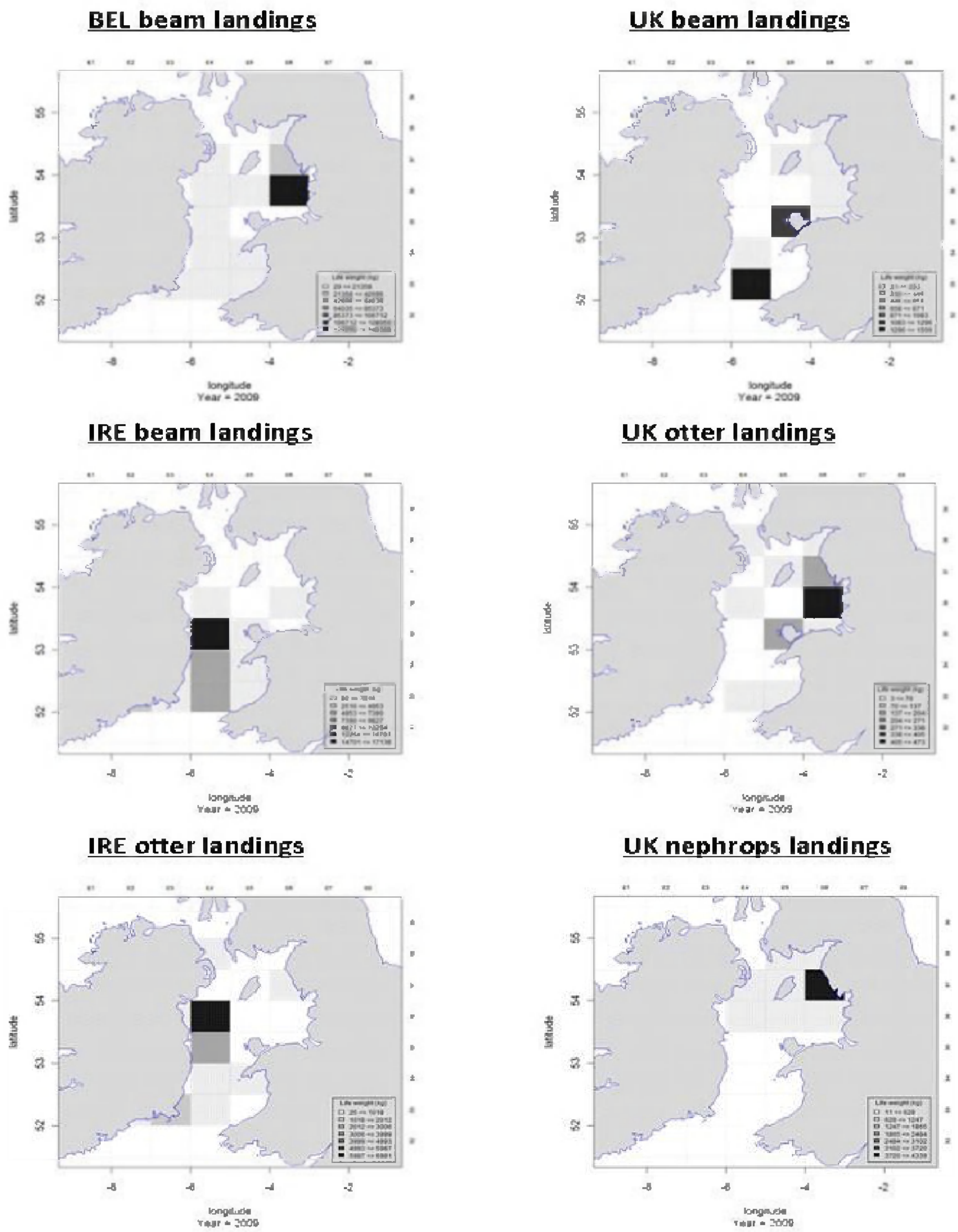

Figure 5.8. Spatial distribution plots of the sole landings (tonnes) in 2009 for the major fleets catching sole in the Irish Sea (BEL-CBT, UK-CBT, IRL-CBT, UK-COTB, IRL-COTB, UK-CNEP). It should be noted that the scales of the different fleets are not the same.

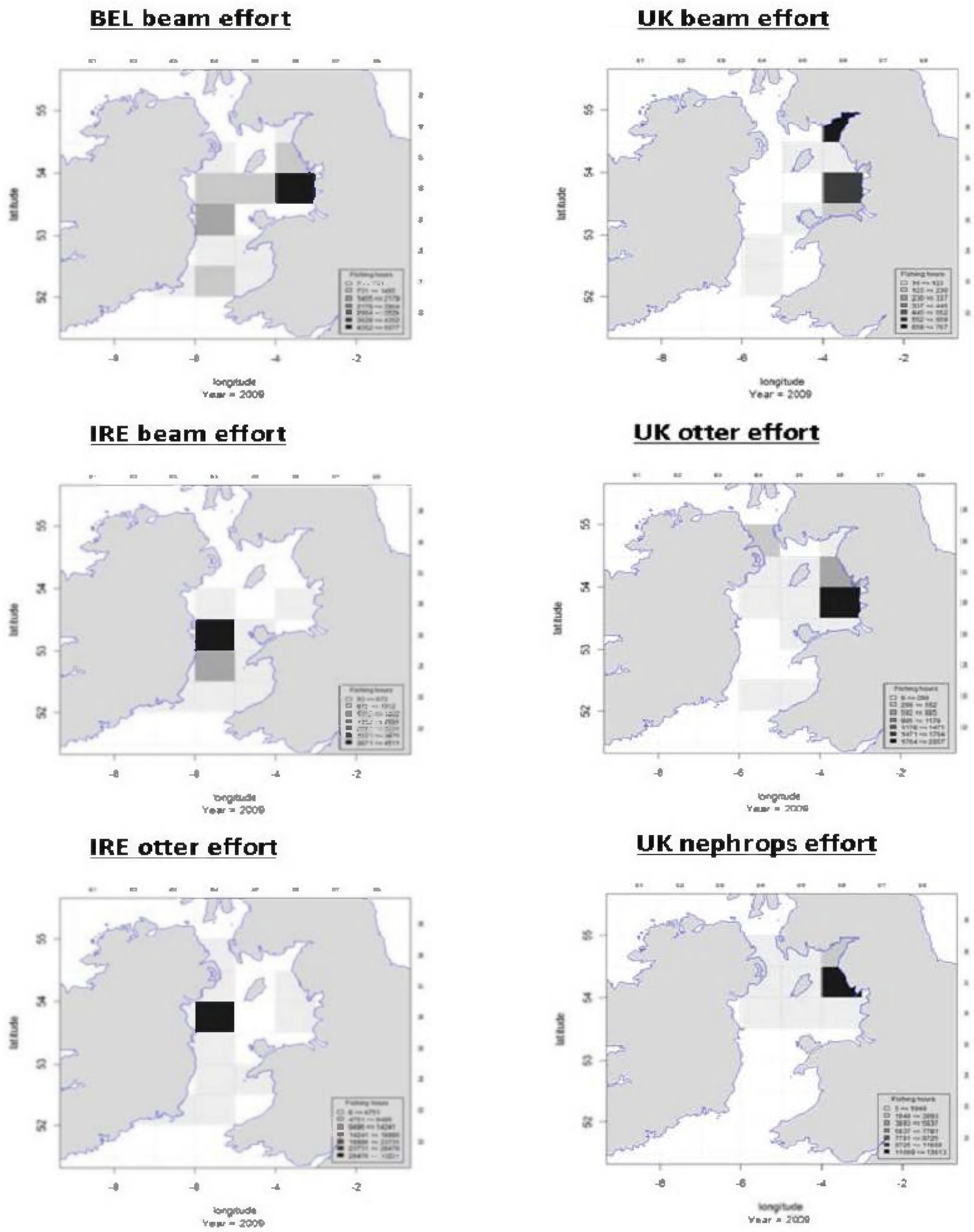

Figure 5.9. Spatial distribution plot of the effort deployed (hours fishing) in 2009 for the major fleets catching sole in the Irish Sea (BEL-CBT, UK-CBT, IRL-CBT, UK-COTB, IRL-COTB, UK-CNEP). It should be noted that the scales of the different fleets are not the same.

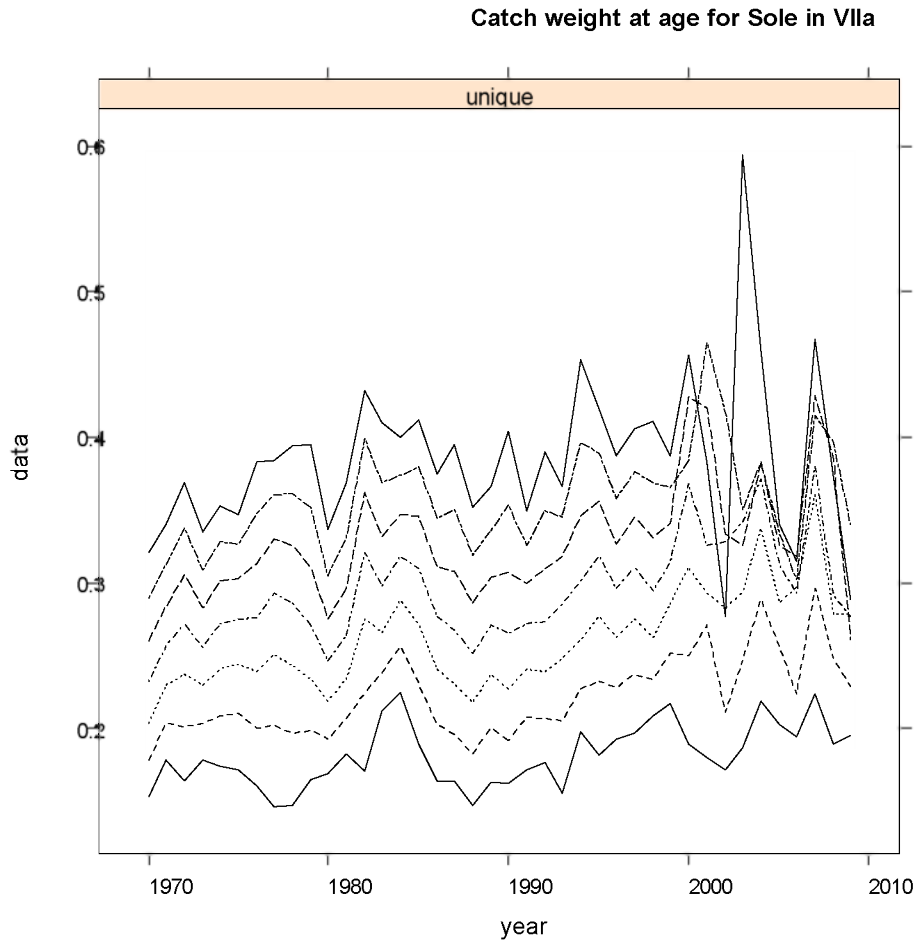

Figure 5.10. Catch weight-at-age for ages 2–8.

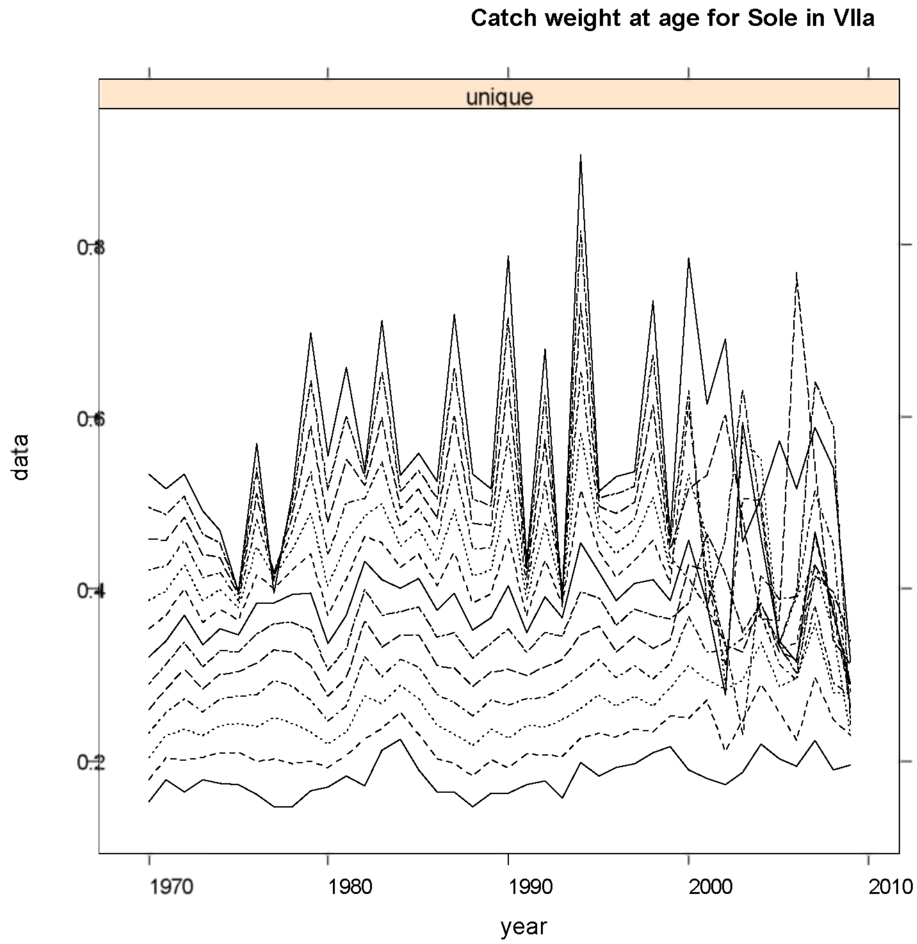

Figure 5.11. Catch weight-at-age for ages 2–14.

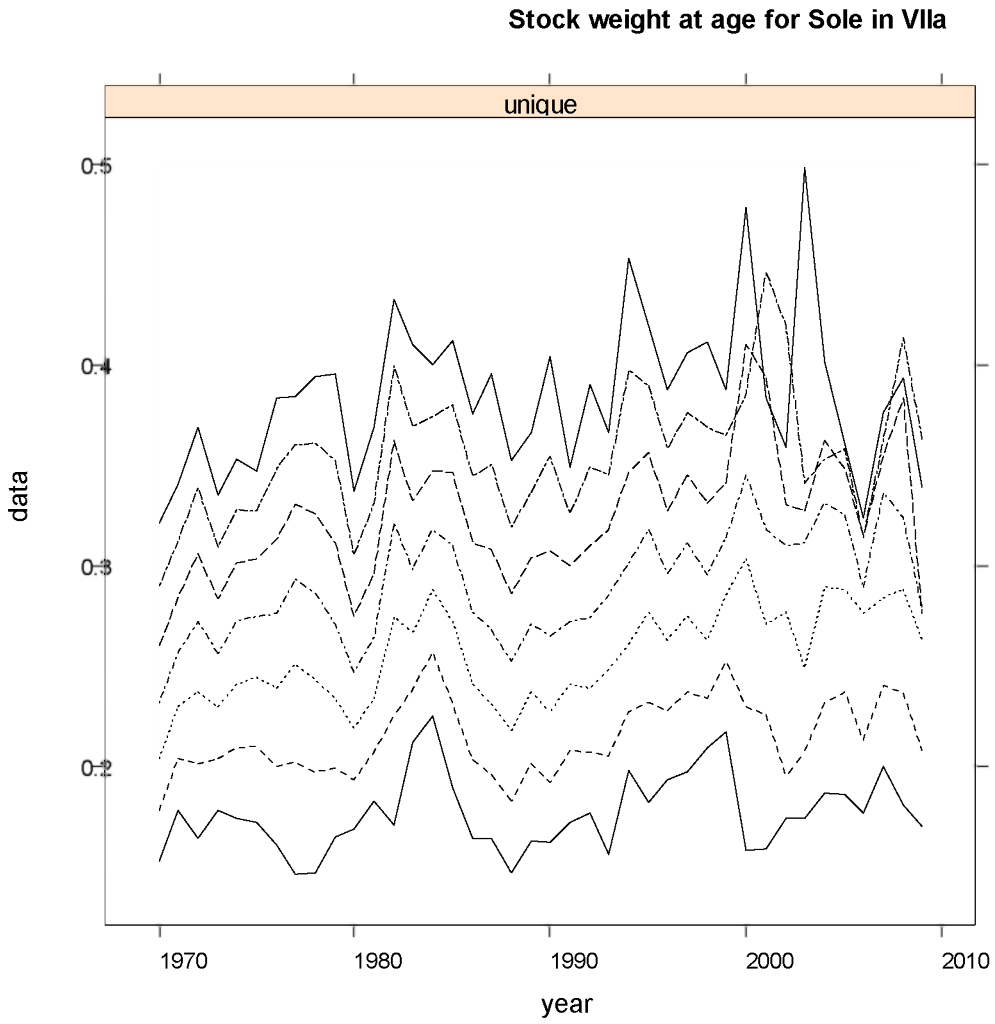

Figure 5.12. Stock weight-at-age for ages 2–8.

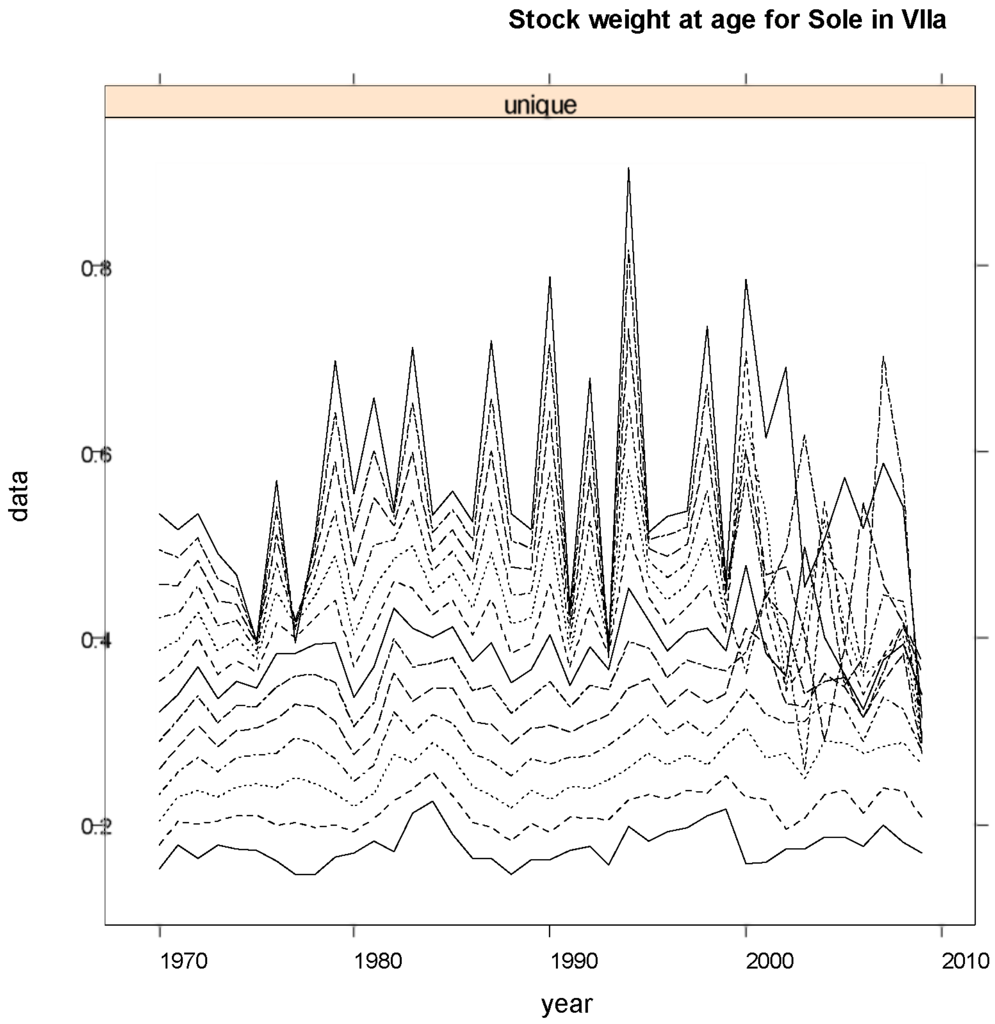

Figure 5.13. Stock weight-at-age for ages 2–14.

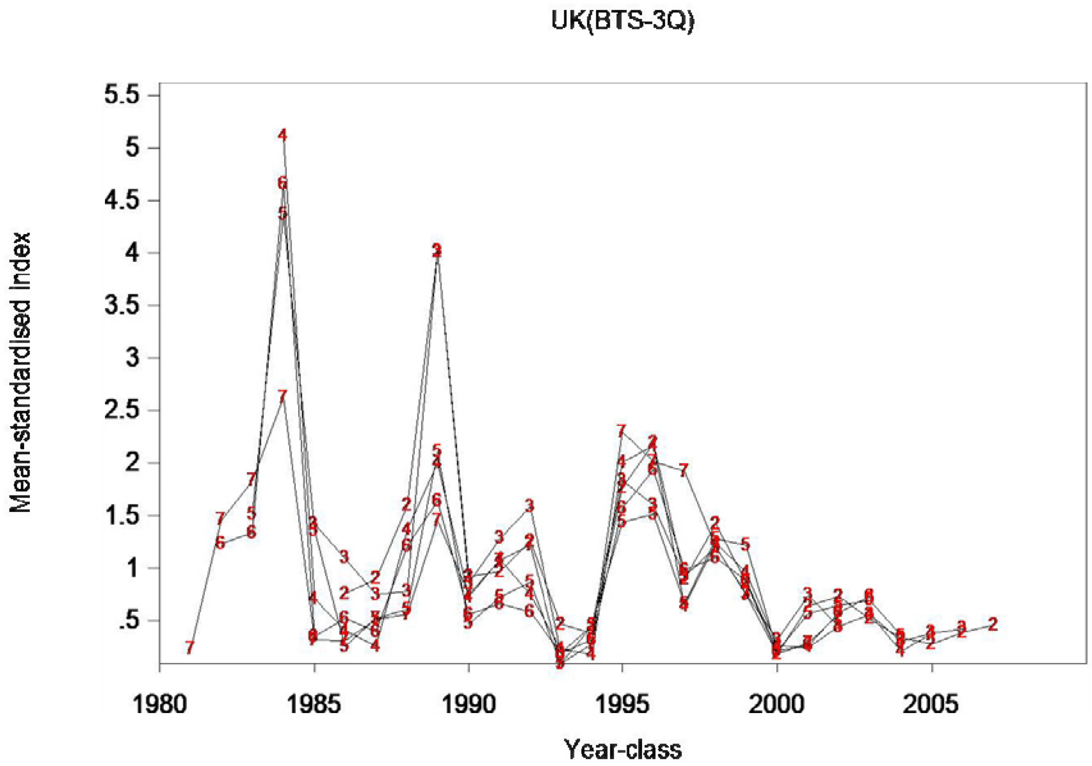

Figure 5.14. Mean standardized indices of year-class strenght from the UK(BTS-3Q).

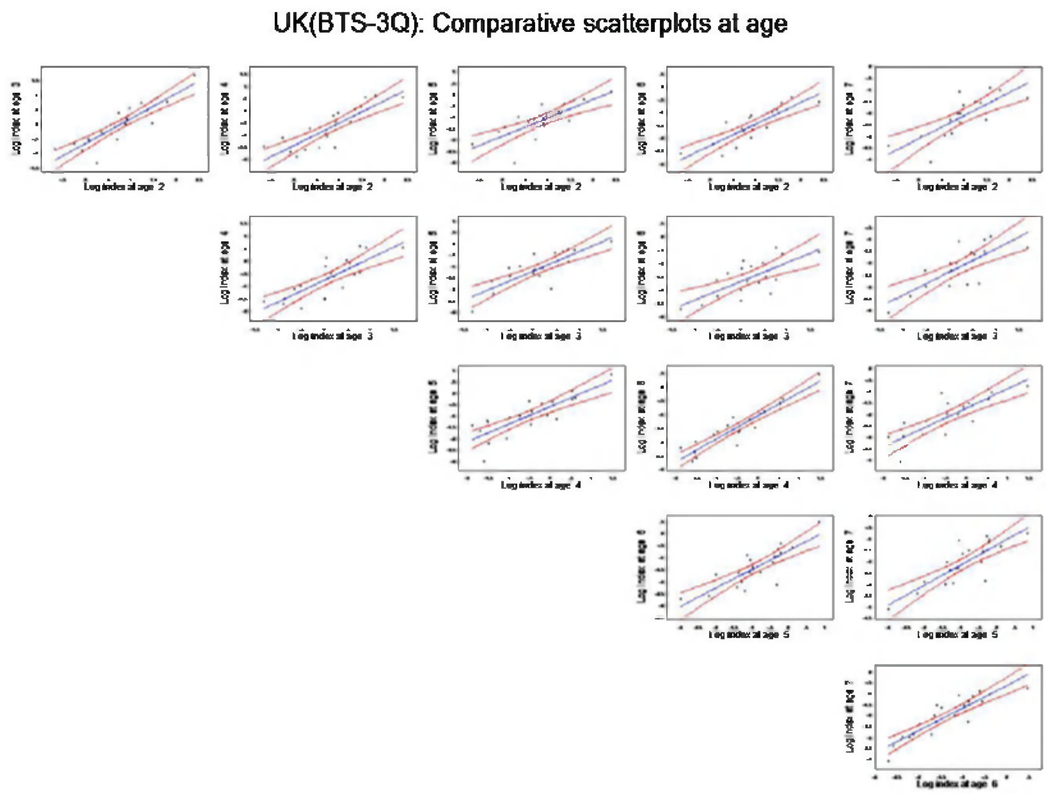

Figure 5.15. Internal consistency plot for the UK(BTS-3Q).

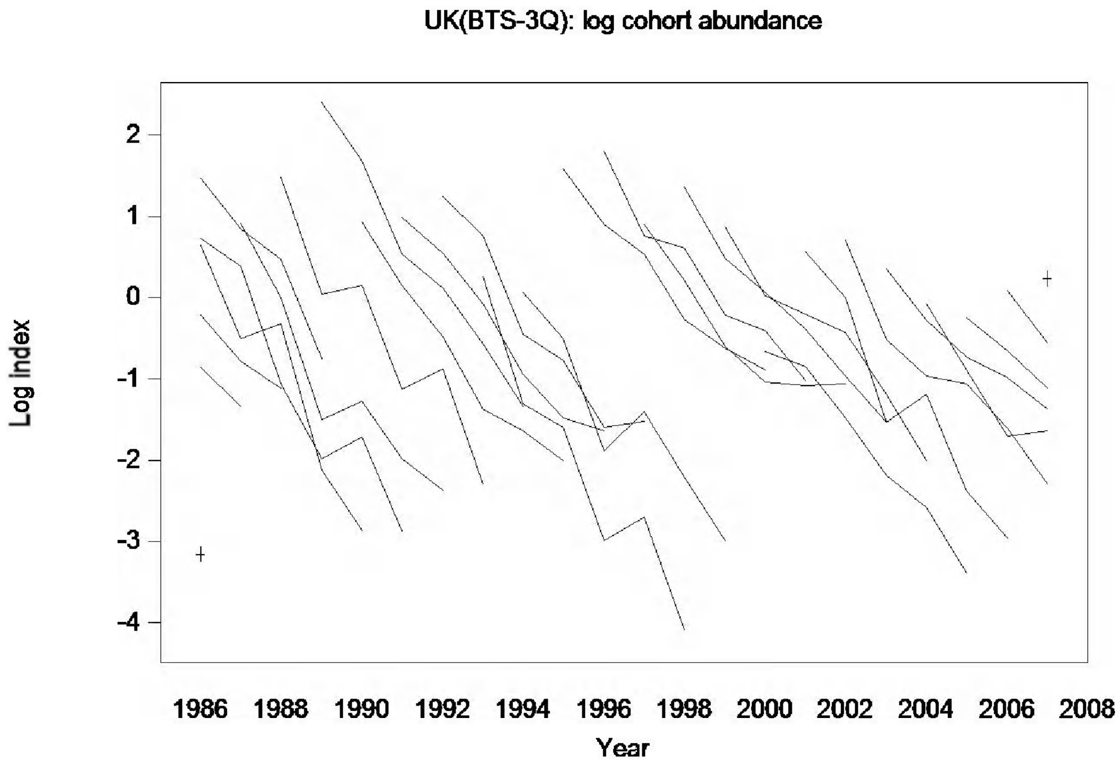

Figure 5.16. Log cohort abundance plot of UK(BTS-3Q).

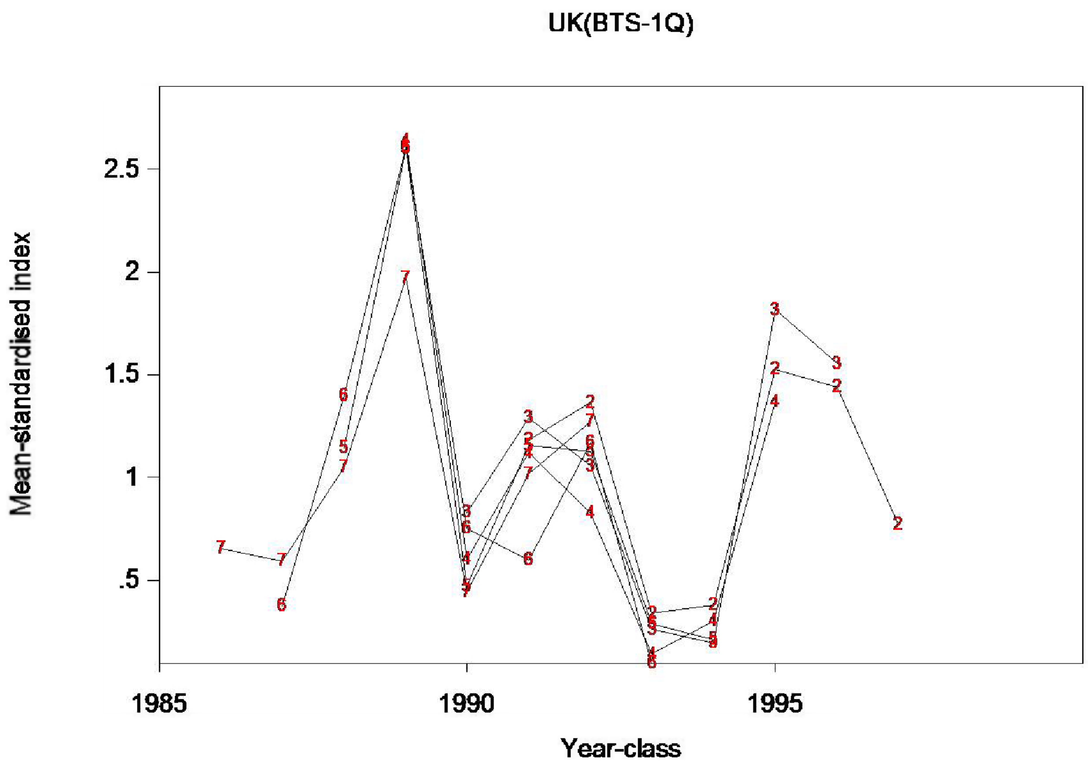

Figure 5.17. Standardized indices of year-class strenght from the UK(BTS-1Q).

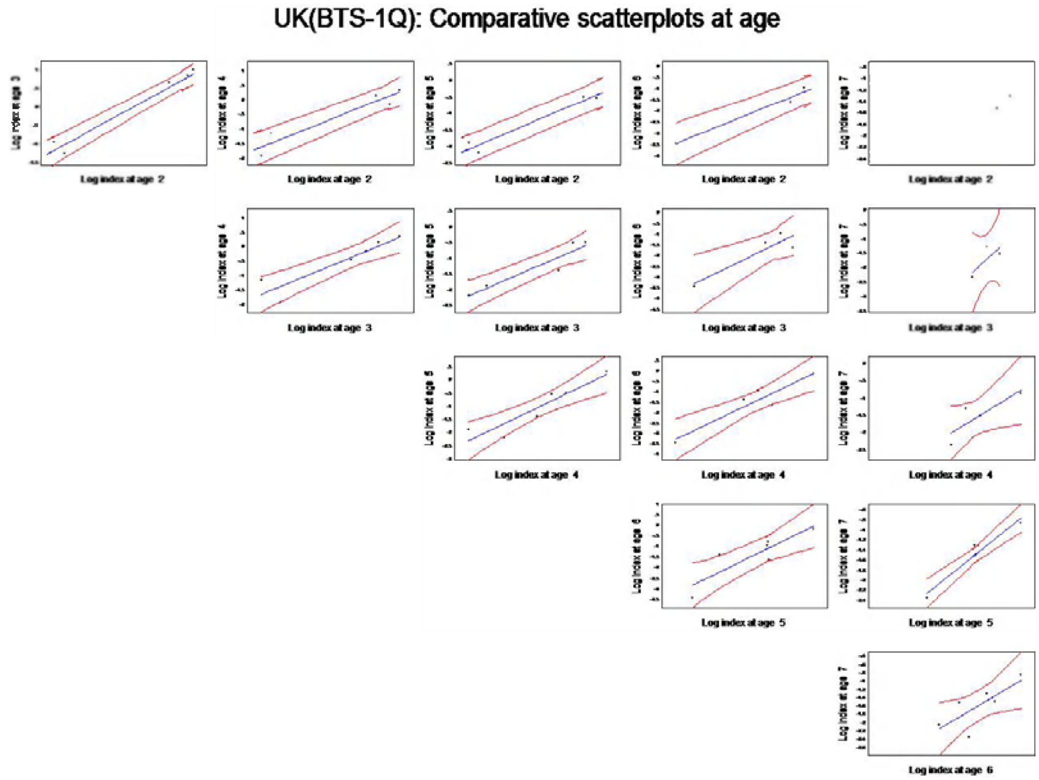

Figure 5.18. Internal consistency plot for the UK(BTS-1Q).

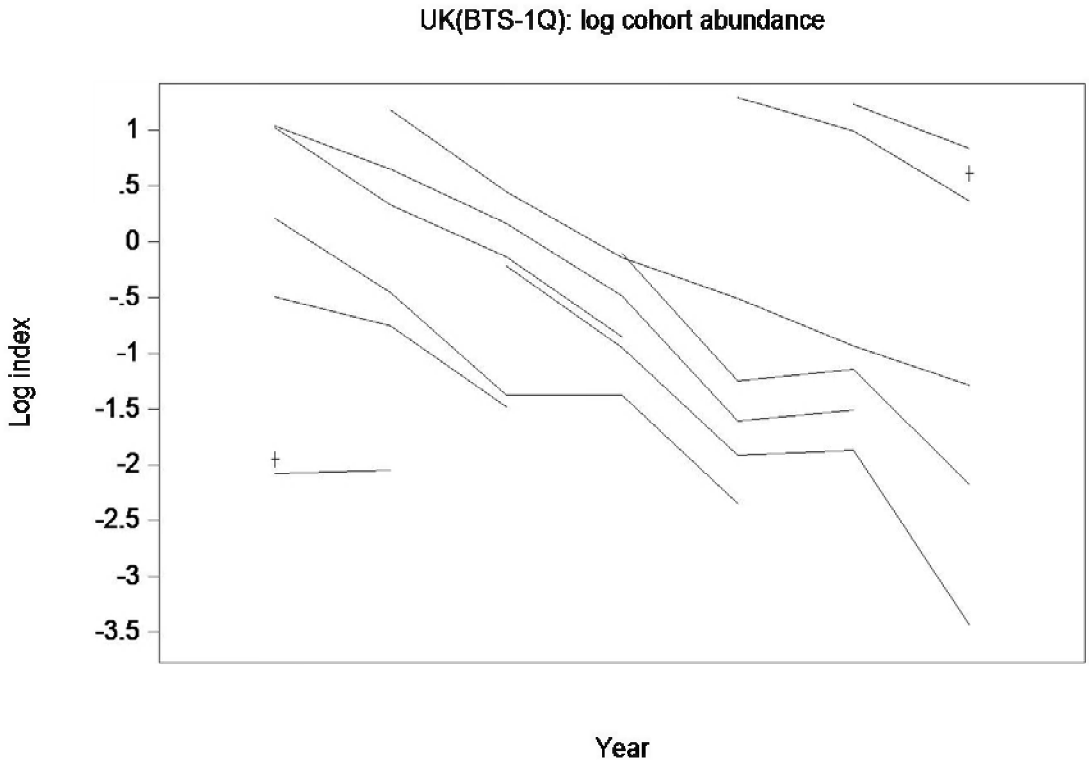

Figure 5.19. Log cohort abundance plot of UK(BTS-1Q).

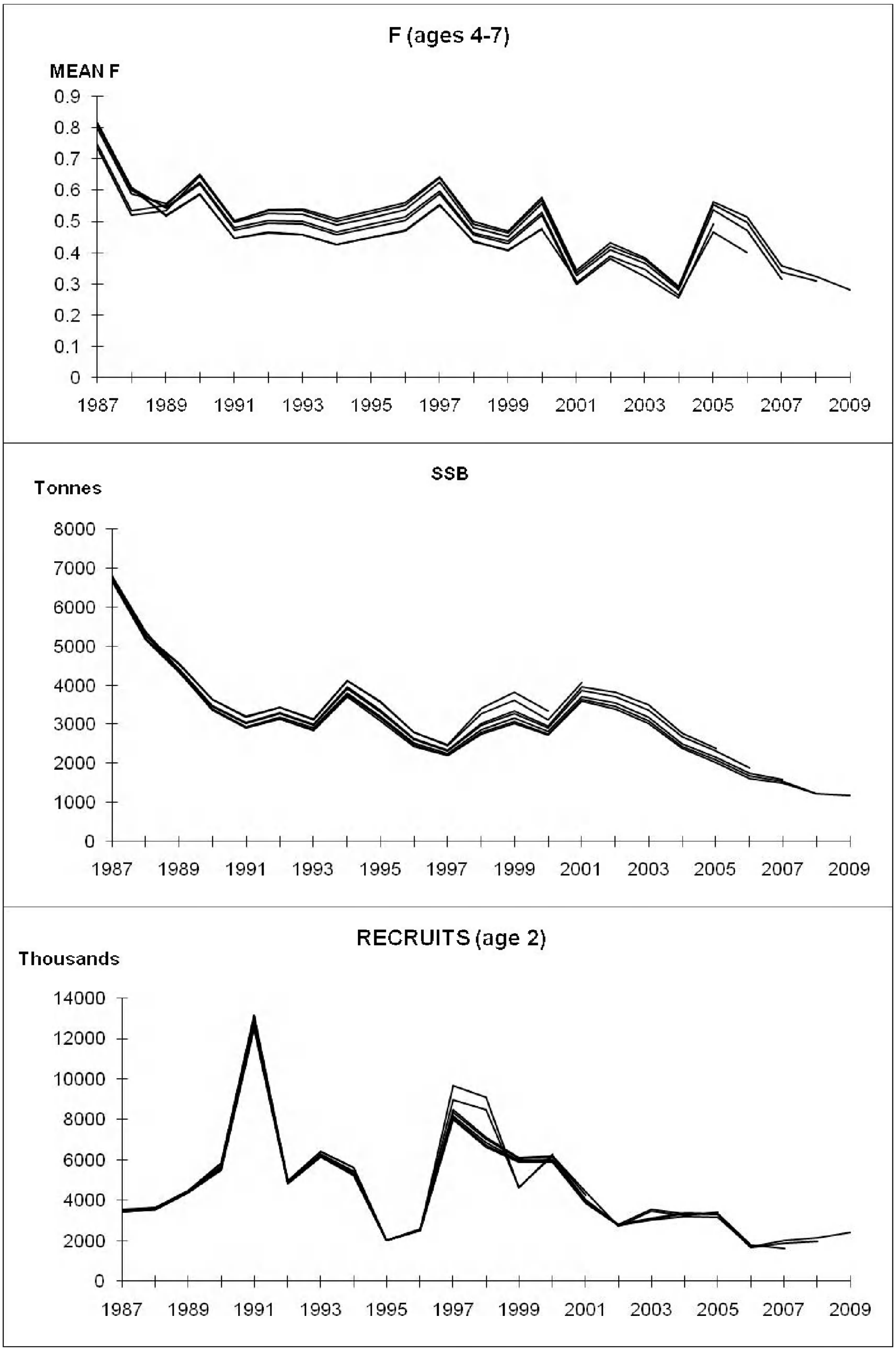

Figure 5.20. Retrospective plots of $F_{BAR\ 4\text{–}7}$, SSB and recruitment using shrinkage se=1.5 and taper 1 over 20 years.

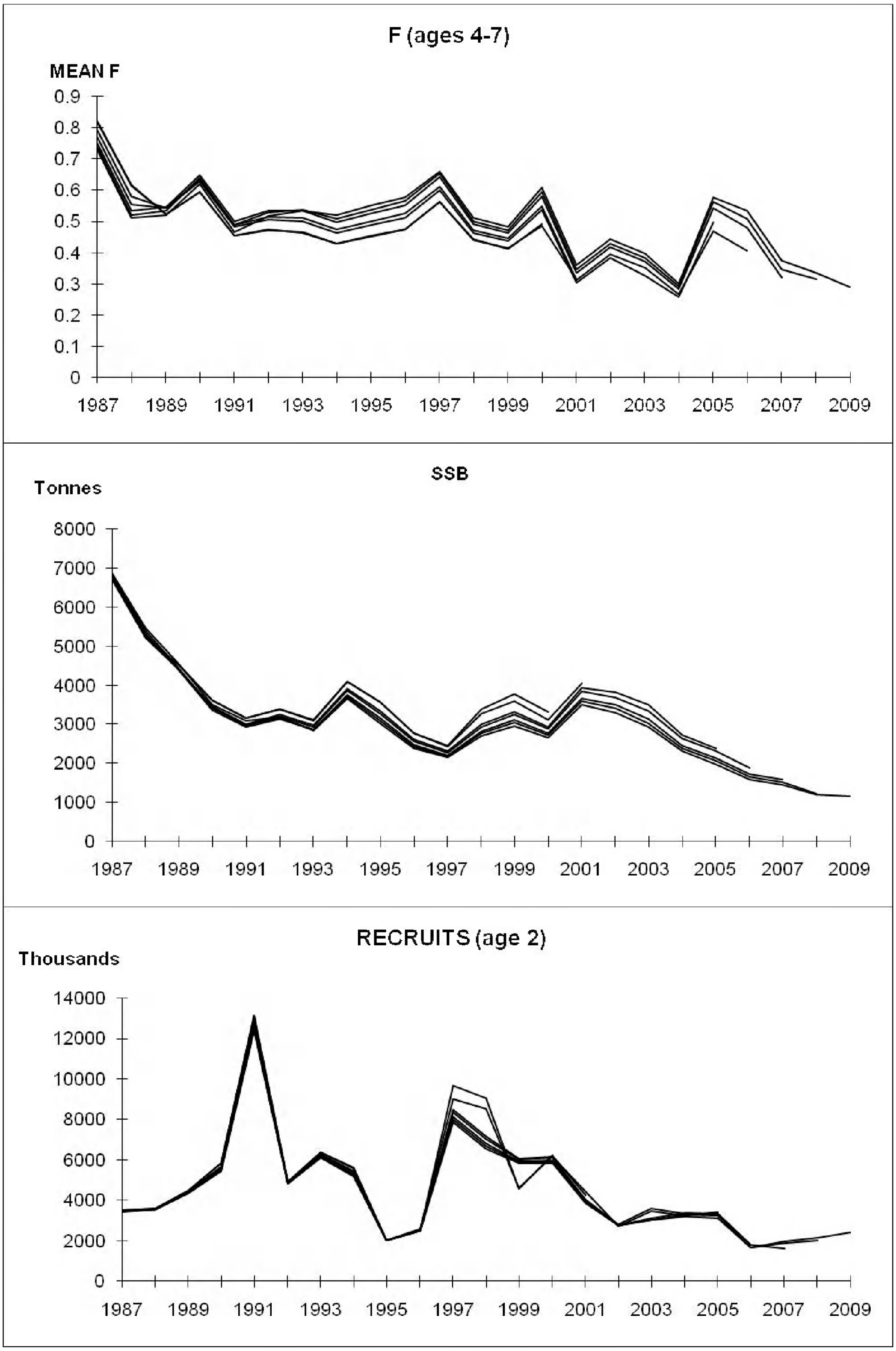

Figure 5.21. Retrospective plots of $F_{BAR\ 4-7}$, SSB and recruitment using shrinkage se=1.5 and taper 3 over 20 years.

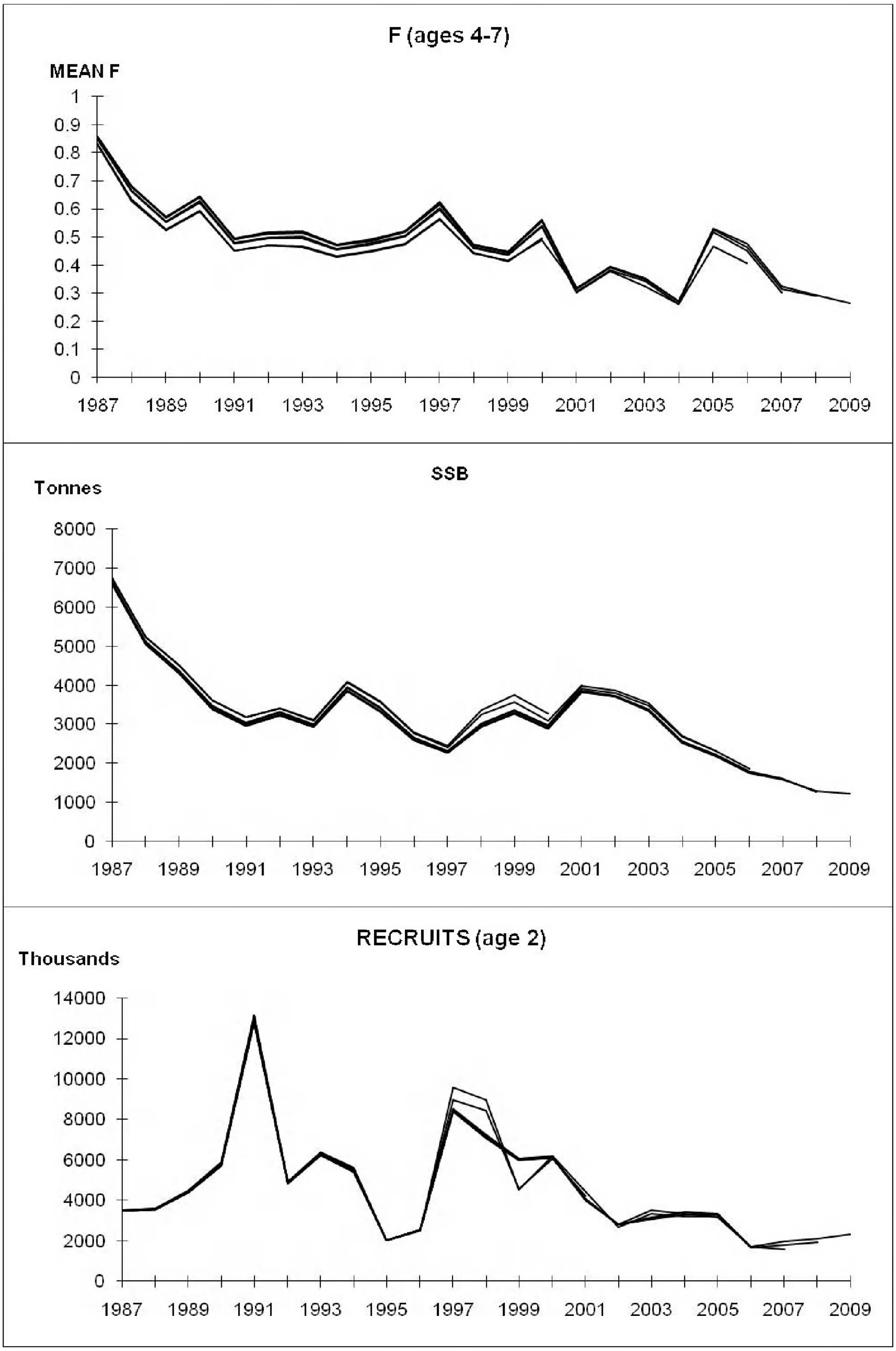

Figure 5.22. Retrospective plots of $F_{BAR\ 4\text{-}7}$, SSB and recruitment using shrinkage se=1.5 and no taper.

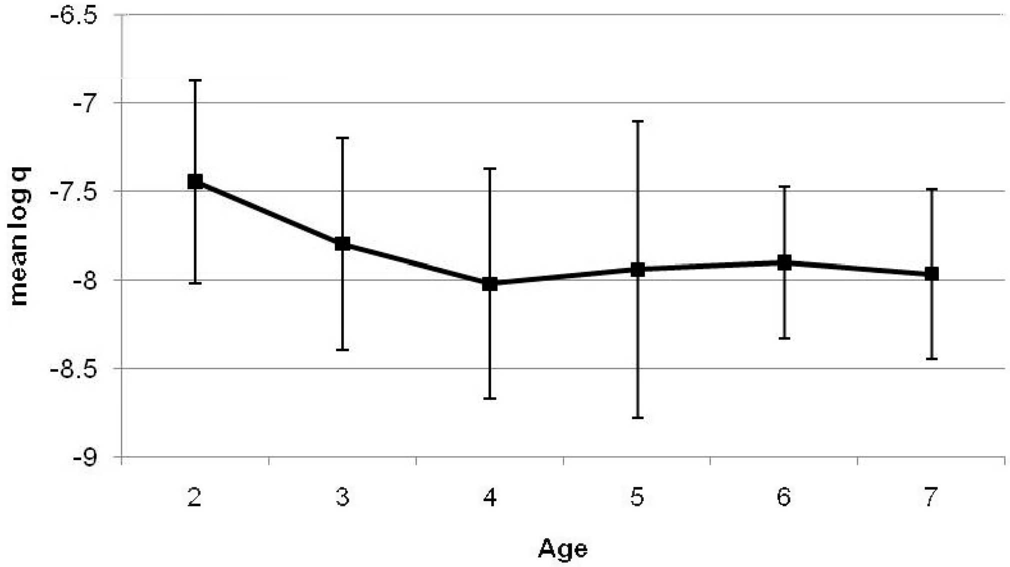

Figure 5.23. Catchability-at-age for UK(BTS-3Q).

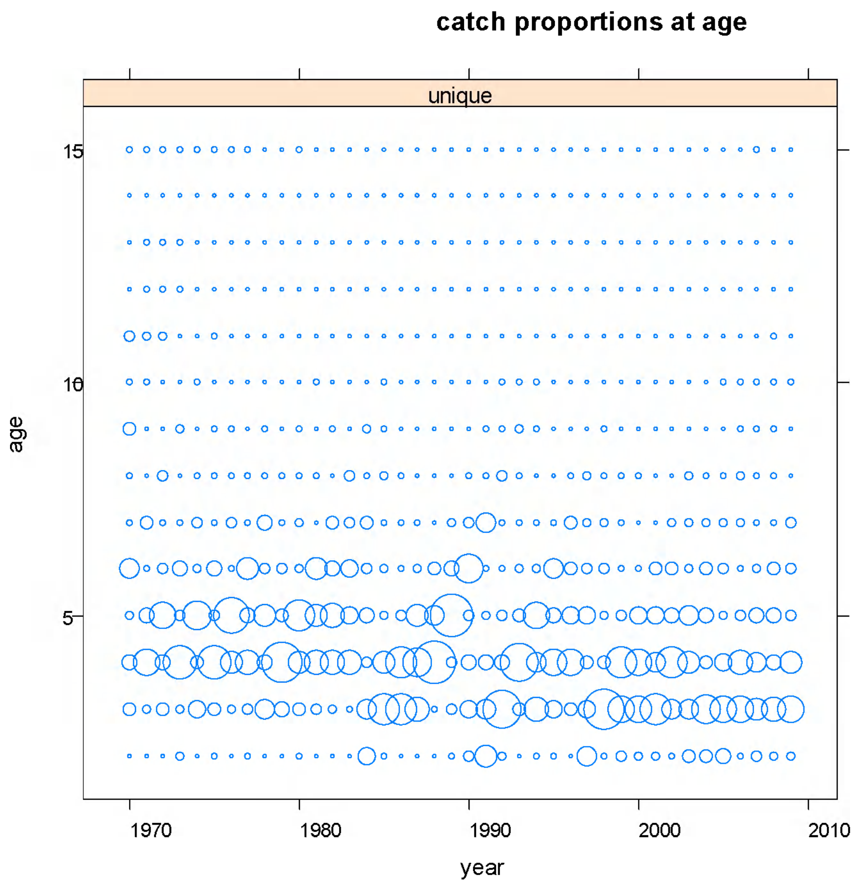

Figure 5.24. Catch proportions-at-age of the total international landings.

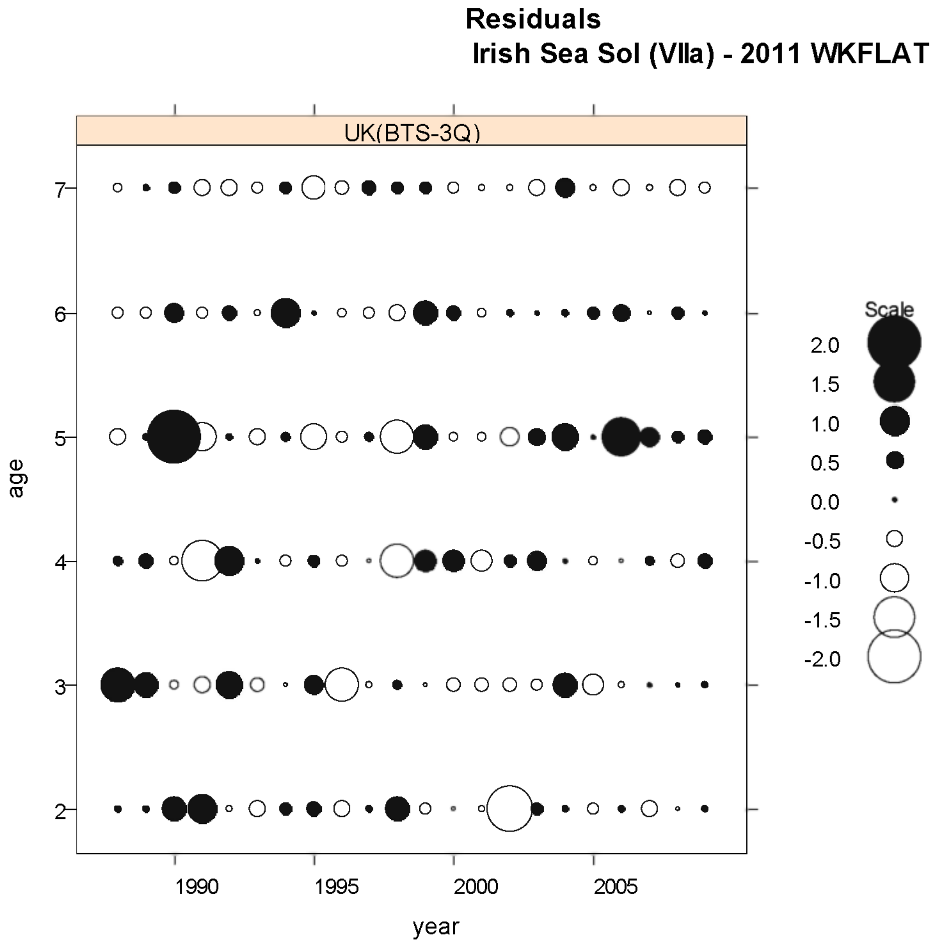

Figure 5.25. Residual plots of UK(BTS-3Q) from final XSA run.

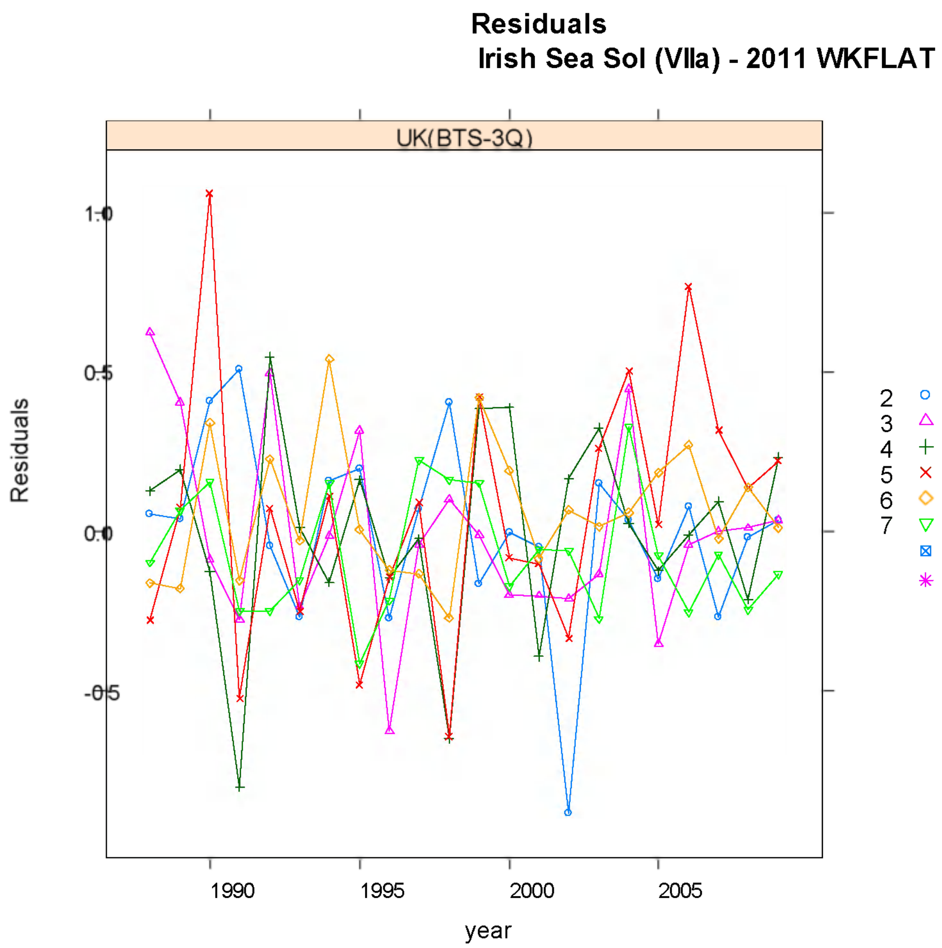

Figure 5.26. Residual plots of UK(BTS-3Q) from final XSA run.

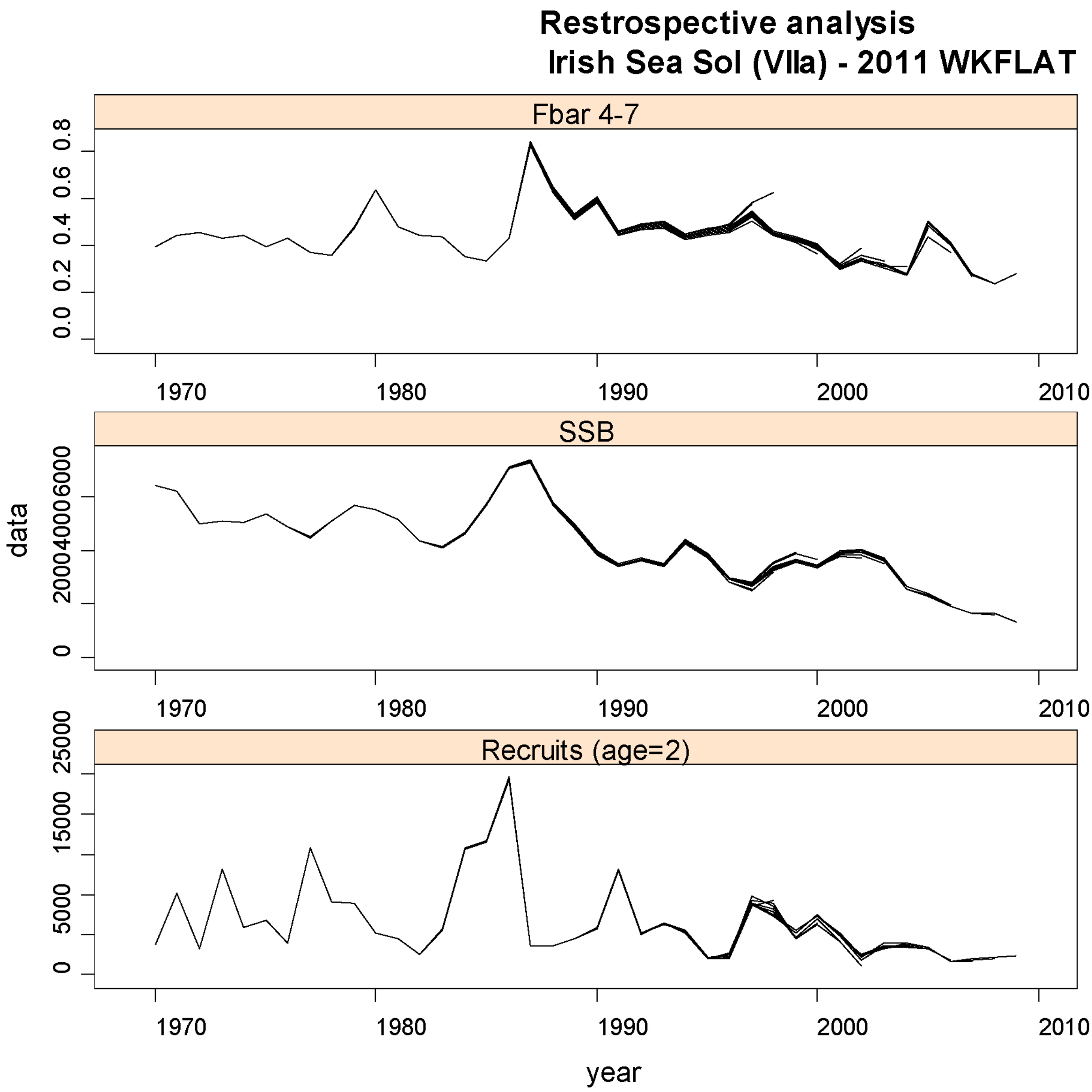

Figure 5.27. Retrospective plots from the final XSA run.

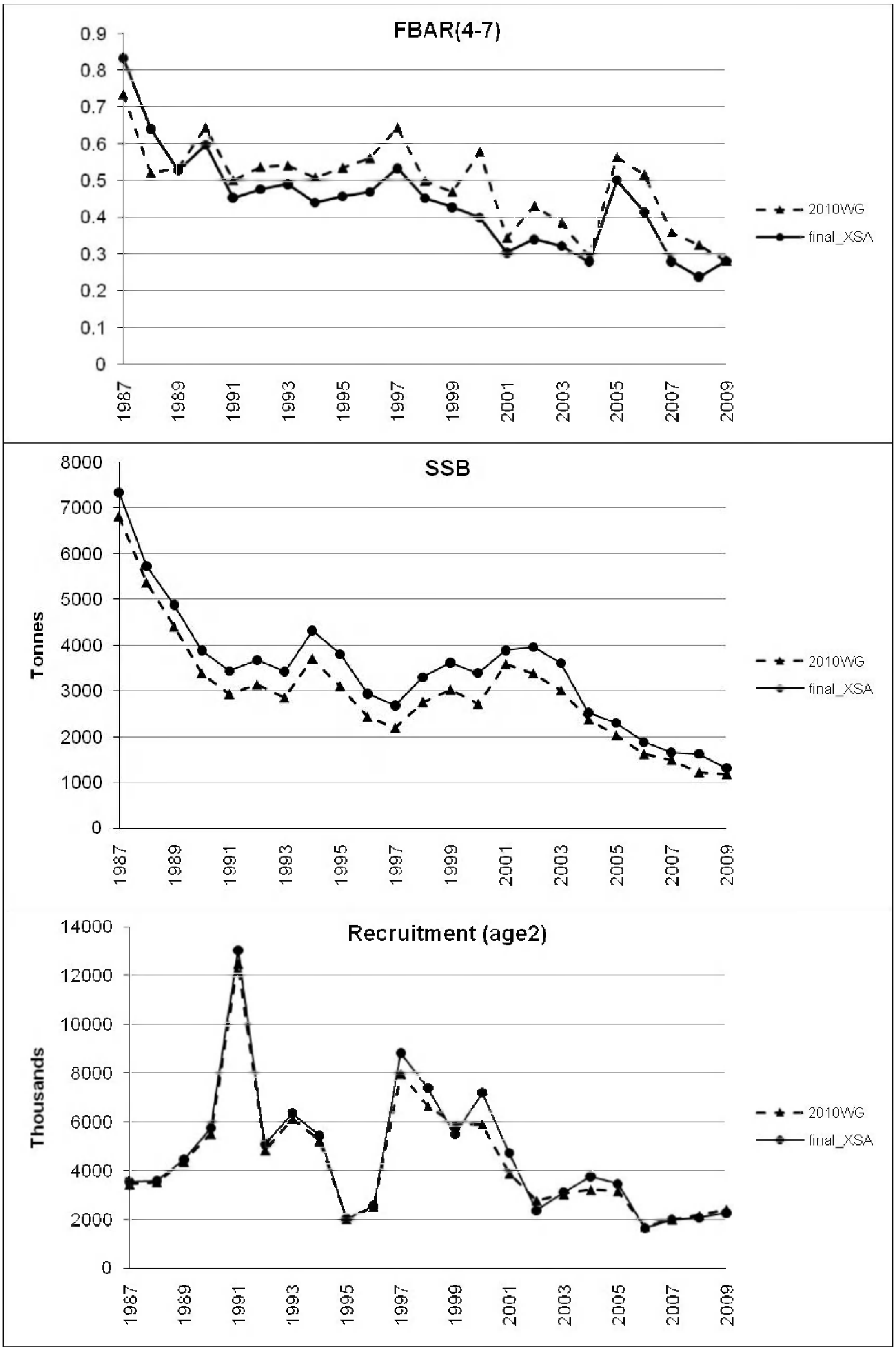

Figure 5.28. Comparison between the WG 2010 XSA run and the final XSA run on fishing mortality, SSB and recruitment.

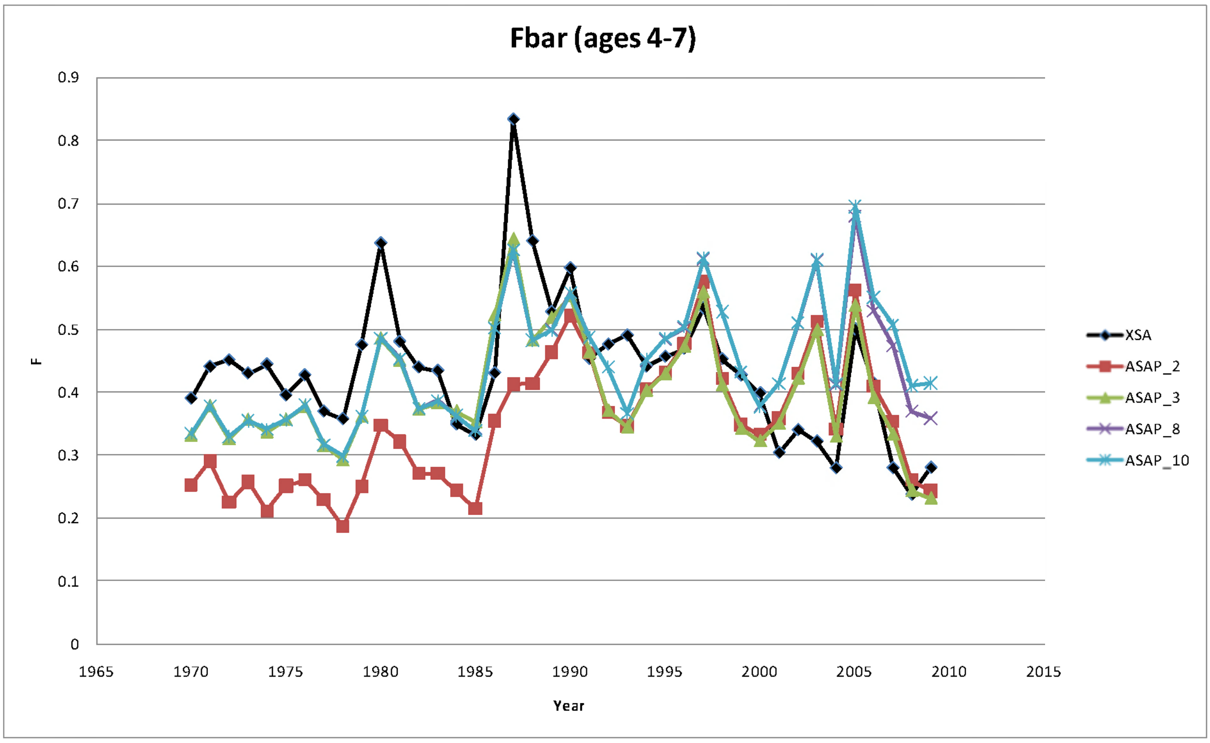

Figure 5.29(a). Average F over ages 4–7 from the main assessment model (XSA, black line) and four formulations of ASAP (coloured lines) for Irish Sea sole.

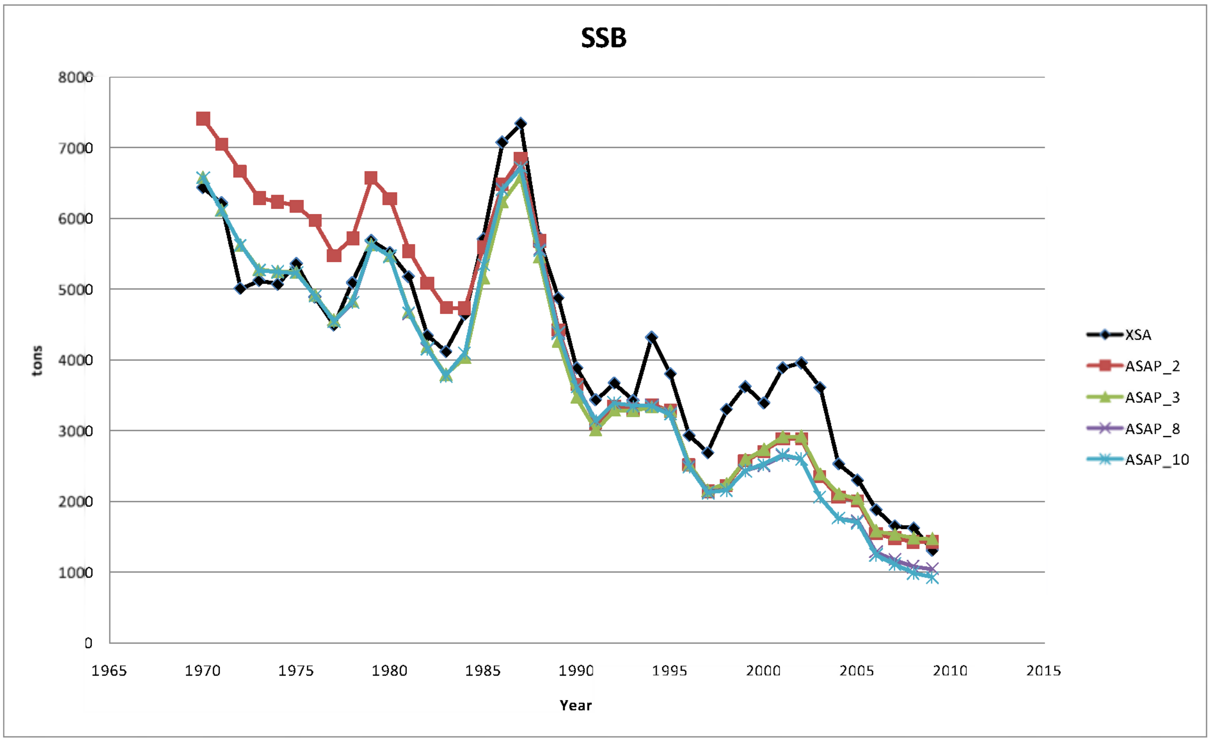

Figure 5.29(b). Spawning–stock biomass (tons) from the main assessment model (XSA, black line) and four formulations of ASAP (coloured lines) for Irish Sea sole.

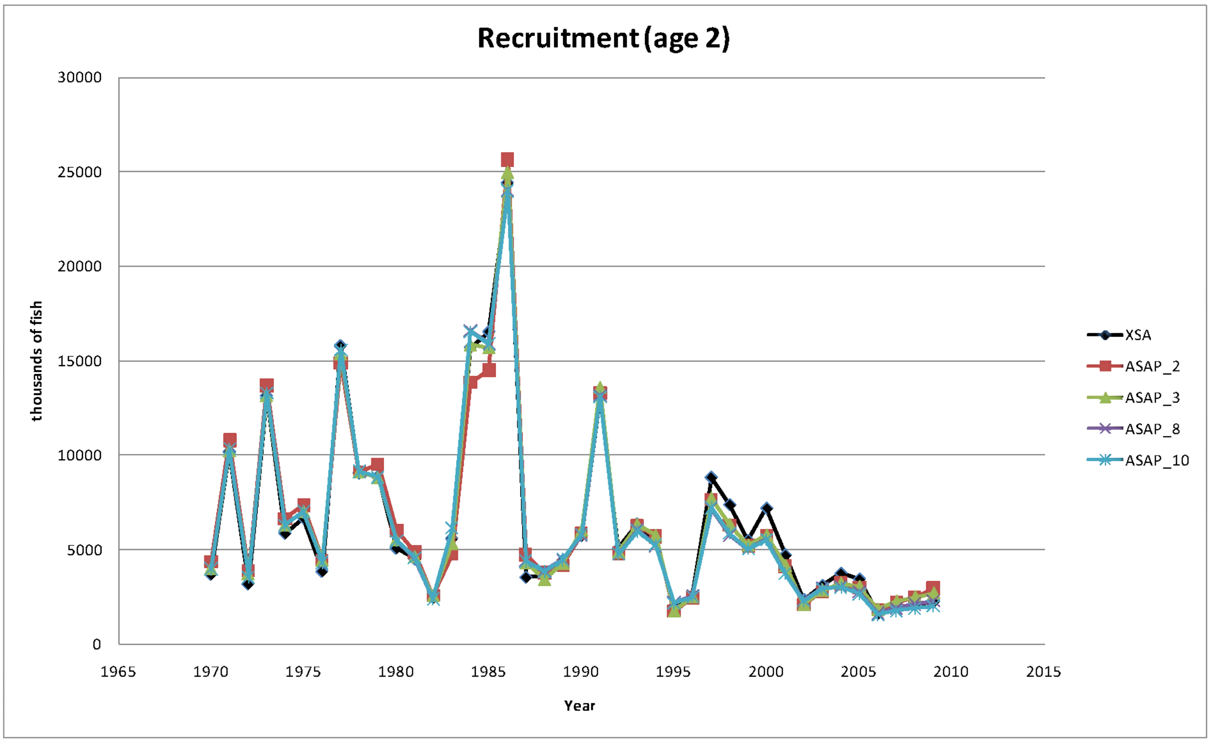

Figure 5.29(c). Recruitment-at-age 2 (thousands of fish) from the main assessment model (XSA, black line) and four formulations of ASAP (coloured lines) for Irish Sea sole.

6 Bay of Biscay sole

6.1 Current assessment and issues with data and assessment

The comparison of historical results of the Bay of Biscay stock assessments displays some difficulties in the estimates of fishing mortalities in some years but no inconstancies in the successive estimated trends of biomass in recent years (Figure 7.4.13.2 in ICES, 2010 a).

The assessment of this stock has been carried out using XSA-model since 1998 with the IFAP/Lowestoft VPA suite. Since 2006, the XSA-settings as well as the tuning fleets have remained unchanged (see Stock Annex).

Since the beginning of the use of XSA, the tuning of the assessment is largely driven by the two commercial fleets of the tuning dataset. These fleets are trawler fleets based in two harbours of the southern part of the Bay of Biscay: La Rochelle and Les Sables (Table 6.1). The cpue series of these two fleets were revised in 2005 to limit the effect of the change in fleet composition and in target species. The process is documented in the Stock Annex. The residual of these two fleets has always been low, demonstrating no trend, and consecutively the tuning of the assessment is considered to perform reasonably well. However, there is a strong concern on the ability to continue to tune the assessment with these two historical tuning fleets because the number of boats of each of them has declined dramatically in recent years.

A new beam trawl survey should provide a new tuning-series in the near future. This ORHAGO survey was launched in 2007 and should provide a tuning-series long enough to be included in the tuning files in 2012. This new series is particularly necessary to improve the recruitment estimates in the last year of the assessment. This latter is poorly estimated by XSA and it has been replaced for years by a geometric mean. Consequently, the catch forecast relies largely on this assumed value.

6.2 Compilation of available data

6.2.1 Catch and landings data

The last best estimates of landings and catches were those which were provided at the 2010 WGHMM (Table 6.1a in ICES, 2010 b). The French catches are predominant (about 90% of the total official international landings over the historical series). The French WG landing estimates are obtained by cross-checking auction sales and available logbooks. Because the French fishing boats land nearly exclusively in Bay of Biscay harbours, the total landing is fairly well estimated throughout the time-series.

Discards are not included in the assessment. However, some of them have been included for some years before 2005. A survey aiming at the estimates of discards of the hake fishery in the Bay of Biscay (RESSGASC survey) provides sole discards estimates for the French offshore trawler fleet from 1984 to 2002. Because these estimates depend largely on some questionable hypothesis (see Stock Annex), this survey was stopped in 2004 and the discards have no longer been used in the assessment since then. However, this survey allowed affirmation that the discards of offshore trawlers are low at age 2 and above. This low level has been confirmed by observations at sea in recent years. These observations have also revealed that discards of beam trawlers and gillnetters are generally low but that the inshore trawlers fleet may have occasionally high discards of sole (Figure 6.1). Unfortunately, they are difficult to estimate because the effort data of inshore trawlers are not precise enough to allow estimating them by relevant areas. However, if one considers the discards have probably been high in 2009 because the 2007 year class seems to have been above the mean according to the ORHAGO survey, and if on uses the observed ratio of discards on landings of the inshore trawler fleet in 2009, which is likely to be an overestimate because the observed trips were mainly in nursery areas, the discards of the inshore trawlers are no more than 5% of the landings in number. Consequently, the lack of discards data does not appear to be a major problem for the quality of the assessment, notwithstanding that their estimates will increase the quality of the recruitment-series.

6.2.2 Biological data

Length and age sampling of catches are carried out as described in the Stock Annex. The level of sampling is considered to be satisfactory. There is however a concern about a discrepancy between French and Belgian mean weight-at-age. It is presumed to be due to a combination of differences in French and Belgian age readings (though this latter is good, being about 80% for a reading comparison carried out in 2006 on a set of otoliths) and of the weight-at-age samples process (weight–length relationship for French mean weights and straight estimate for Belgian ones).

A maturity ogive has been estimated in 2000 (Stock Annex). Because the maturity of the sole is below the commercial length size (24 cm), the estimation of the maturity ogive needs data collected at sea during the first term, which is the spawning season. The available data were examined but the sampling was considered to be insufficient to provide a fair estimate of the maturity ogive. Consequently, the WKFLAT decided to keep unchanged the maturity ogive used since 2001.

6.2.3 Survey tuning data

A new survey was launch in 2007 to get the abundance index series which is lacking in the assessment of the Bay of Biscay sole, as it has been pointed out for many years by successive ICES WG. This survey, named ORHAGO, is a beam trawl survey. It is coordinated by the WGBEAM to which the results are reported each year since its beginning. The series was presented to the WKFLAT which considered that this series should be used to tune the assessment in the near future but that its length is still too short to be inserted in the tuning process in 2011.

Two other survey-series have been used in the recent assessments. They were provided by the quarterly RESSGASC survey which was stopped in 2002. The second and the last quarter series were estimated to provide the more reliable cpue for an abundance index of Bay of Biscay sole stock. However, this survey aimed to estimate discards (mainly of hake) and the sampling plan was not very relevant to a sole abundance index. It provides cpue series which are consequently noisier than the commercial cpue series. Furthermore, being terminated for several years, these series have no effect on recent year trends. However, the WGHMM preferred to keep them in the assessment in order to limit the change in historical trends. Indeed, these two series increase the fishing mortalities before 1992 and, inversely, lower the SSB. The management plan in force for this stock reinforced particularly this need to have some coherence with preceding assessments because its first step was to reach an SSB target which was B_{pa}, itself based on the SSB trend.

The first step of the management plan has now been achieved. Since 2002 the trend in SSB has evolved and the lowest values of SSB are no longer at the beginning of the series. The WKFLAT concluded not to include the RESSGASC series in the revised tuning process because the survey terminated in 2002 and no longer contributes to the estimates of terminal population numbers in the assessment.

6.2.4 Commercial tuning data

The adding of new commercial tuning-series was the main point investigated during the WKFLAT for the Bay of Biscay sole stock. As for the former tuning fleets, the bottom trawl was the unique gear which was retained for this investigation because the catches of gillnetters are highly dependent on sea conditions, specifically the swell. Within the trawlers fleets, the French fleets were solely considered because the Belgian beam trawler fleet has a limited fishing period in the Bay of Biscay.

Furthermore, the investigation had to be limited to the period after 1999 because of inconstancies in effort data over the period 1984 to 1999. This problem was thought to be due to the recent transfer of old data into a new database. The two historical series of La Rochelle and Les Sables trawler fleets remain, consequently, the only available commercial tuning-series for the period before 2000.

The work was carried out by quarter. During the first quarter, the offshore fishery is located mainly on the spawning grounds and inshore fishery is usually less active because of the weather. Also, the swell may have an important effect on catches in the first quarter. During the other quarters, the changes in spatial distribution of fishing effort can affect the relation between cpue and abundance. Consequently, the cpue may not provide abundance indices of the same reliability in each quarter and doing investigations by quarter was thought a choice that could help to get a reliable abundance index.

In order to limit 1) the effect of change in the composition of the fleet from year to year and 2) the effect of change in target species, the same kind of work has been carried out than formerly in 2005 when the cpue of the two tuning fleets of La Rochelle and Les Sables were revised. Furthermore, an investigation was carried out on the effect of the spatial distribution of effort in cpue calculation.

Fleet composition

To limit the effect of changes in the composition of the fleet, two ranges of boat lengths were selected to maximize the homogeneity of the fleets but also the number of boats in each. The first length group is the 10 to 12 meters long vessels and the second is the 14 to 18 meters long vessels (Figure 6.2). The vessel length of 12 meters is the usual criterion to separate inshore and offshore fishing boats. Below 10 meters, the fishing is spatially and temporally different and it is thus considered not to be a relevant group to provide a sole abundance index. Consequently, an **inshore fleet** was formed by the boats with a length from 10 to 12 meters. Above a vessel length of 12 meters, there are few boats less than 14 meters long and also above 18 meters, and furthermore large engine power variations in this latter case. Consequently, an **offshore fleet** was formed by the boats with a length from 14 to 18 meters.

As was the case for the construction of the La Rochelle and Les Sables tuning fleets, a threshold of a minimum of years with cpue data over the ten last years of the cpue series was set to limit the effect of year-to-year changes in the fleet composition. This threshold was set to five years, lower than in the past (seven years) to account for the selection on boat length which was more restrictive than for the former two fleets (which includes 12–23 meters long boats). As long as a boat will meet this criterion, it will be included in the tuning fleets. Through this process we derived eight new cpue series: one by quarter for the inshore and the offshore fleets (Table 6.2).

Percentage of sole in the total catch

To limit the effect of the change in target species, a threshold on the percentage of sole in the total catch was fixed as also previously for the La Rochelle and Les Sables tuning fleets. The aim of such a threshold is to avoid altering the quality of the cpue as sole abundance index by the inclusion of hauls during which the vessel is targeting other species outside the sole fishing grounds. Because the information is available for a variable time period (few hours to several days), the percentage of sole catch in the total catch is considered to provide a better way to select fishing period on sole grounds than a threshold on a quantity of sole. A 10% threshold has been set for selecting relevant fishing periods for the commercial tuning fleet used in past assessments. It resulted from the advice of fishermen given at a meeting. For the present investigation, it was necessary to reduce this percentage to 6% for increasing the number of available data. This requirement is due to the choice to carry out the work on a more reduced time period than previously (quarter instead of year) and to look at the spatial distribution of effort. This latter choice arises from having new fleets which are made up by boats from several harbours. The change in fleet composition may affect the spatial distribution of effort more largely than considering boats from only one harbour. The comparison of the trends in cpue reveals a limited effect of the change in sole percentage threshold from 6 to 10% (Figure 6.3).

Effect of the spatial distribution of effort on cpue

The effect of spatial distribution of the effort was investigated by the comparison of an unweighted cpue (ratio of total catch to total effort) to a weighted mean of cpue by area. To calculate this latter cpue, the habitat of the sole was considered to be the sandy and muddy ground between the coast and the 100 meters depth sounding line. The surface of this area was calculated for each statistical rectangle. However, because the high variability of effort from year to year in a statistical rectangle (even missing values some years and low fishing effort associated to extremely high or low cpue), it was preferred to split the sole habitat in the Bay of Biscay in only two areas to avoid having not enough data by area. The effort distribution and the location of the spawning and the nursery areas give some support to a division of the Bay of Biscay in a northern and a southern part at latitude 46°30 N. This unweighted as well as the weighted cpue were calculated by selecting the statistical rectangles which have provided a cpue for more than five years from 2000 onwards. This selection was thought to give more interannual reliability to the cpue, but the comparison to the cpue calculated without a selection of rectangles demonstrates that its effect is limited (Figure 6.4). Between the unweighted and the weighted cpue, the difference is more important. However, the split of the Bay of Biscay in two areas and the weighting by habitat area change only slightly the trend in cpue. The trends are different only in the first quarter for the inshore fleet, and it seems mainly due to the lack of data in the southern area before 2005. The use of a weighted cpue seems more to reveal deficiencies in data than to improve the quality of the relationship between the cpue and the abundance. Consequently, the use of an unweighted cpue was preferred to build the new tuning-series.

GLM analysis by age group

The check of the effect of the selection of boats and of spatial distribution of effort has been carried out by doing GLM analysis by age group (applying catch-at-age distributions of less than 12 meters long trawlers to the inshore fleet catch and the one of more than 12 m long trawlers for the offshore fleet catch). It reveals that the relationship between the exponential of GLM year factor and observed cpue is linear (Figure 6.5). That relationship demonstrates that different selections which were made to build up the tuning fleets allow to get observed cpue which are lightly affected by the changes in contribution of boats and of fishing areas that may occur from year to year.

Consistency of cpue series regarding year-class strength in following years

The quality of the eight new cpue series (Table 6.3) was analysed by comparing the trends of the log mean standardized cpue at different ages of each cohort (Figure 6.6 a and b). The overall ability of the tuning indices to identify year-class strengths consistently across all ages was generally poor although this is likely to be a consequence of reduced variability in recruitment in recent years giving rise to successive cohorts of similar year-class strength. The offshore fleet cpue in the second quarter appears to be the series which is the more consistent all along the time-series regarding the tracking of cohort strengths. The inshore fleet in the second quarter is also rather consistent. The fourth quarter of this fleet provides also a rather coherent pattern in the second part of the time-series.

The pairwise plots of age by log cohort (Figure 6.7) confirm the better ability of offshore tuning-series in the second quarter to pick up abundance signals, but not at ages 7 and 8. The first quarter of this fleet provides more consistent pairwise plots at these older ages but not at younger ages. The plots of third and the fourth quarter have lower consistency with some negative slopes near the diagonal for some ages. For the inshore fleet, the second and the fourth quarter show better consistency between ages, but again only up to age 6 in the second quarter. The fourth quarter reveals a more consistent pattern at older ages.

6.2.5 Industry/stakeholder data inputs

No data input.

6.2.6 Environmental data

No new information.

6.3 Stock identity, distribution and migration issues

Not an issue for this stock which is geographically isolated from other stocks (see Stock Annex).

6.4 Influence of the fishery on the stock dynamic

No information on other influence than the catches on stock abundance.

6.5 Influence of environmental drivers on the stock dynamic

The environment is likely to have a major effect on recruitment strength according to a study carried out on a limited area (Vilaine Bay, see Stock Annex) but the effect on the wider stock area is unclear.

6.6 Role of multispecies interactions

6.6.1 Trophic interactions

No analysis on trophic interactions was carried out.

6.6.2 Fishery interactions

No analysis on fishery interactions was carried out.

6.7 Impacts of the fishery on the ecosystem

No analysis on impacts of the fishery on the ecosystem was carried out.

6.8 Stock assessment methods

6.8.1 Models

The model used for the assessment of sole in the Bay of Biscay is XSA. An exploration of the dynamic of the stock was also carried out using the ASAP model during the meeting.

6.8.2 Data screening with XSA

XSA tuning runs (low F shrinkage s.e. = 2.5, other settings as in 2010 WGHMM tuning) were carried out on data from each available commercial tuning-series individually. No trend was noticed in XSA Log-catchability residuals which are small except in the third quarter series of the two new fleets (Figure 6.8). These series were not retained in further analysis because they are, furthermore, less consistent regarding the tracking of the year-class strength.

6.8.3 Sensitivity analysis

A sensitivity analysis was carried out to investigate the effect of some combinations of the new fleets in XSA outputs (Table 6.4). In all the runs, the two old commercial fleets were kept, considering that future assessments should continue to include them in the tuning process because they are the only ones to provide information on abundance trend before 2000 and also because their use will guarantee some consistency between past and future assessments. The RESSGASC series were excluded because of the reasons given in Section 6.2.3 but ORHAGO included in all the runs to compare their year-class estimates to those of other fleets.

For each set of fleets, a run was carried out with the settings which have been adopted in the assessments since 2004 (see Stock Annex: no taper, catchability independent of stock size for all ages, q plateau at age 6, F shrinkage s.e. = 1.5, Fleet s.e. threshold = 0.2). A second one was also carried out with a higher minimum standard error allowed for population estimates derived from each fleet. The standard errors of two older fleets being much lower. New investigations on sensitivity of the assessment to changes in other settings were not considered to be necessary.

Six sets of fleets were compared and consequently twelve runs were carried out to compare the effect of the two different values considered for minimum s.e. threshold for each set of fleets. The first run included the two commercial tuning fleets' cpue series of the second quarter, because of their good consistency regarding the year-class strength from age 3 to 6 in following years. In following runs, series of first or fourth quarter were added to get information for the older ages. The offshore fleet series of the second quarter was retained in all the runs because its better ability in picking up abundance signals from age 3 to 6. The inshore fleet series of the first quarter was tried once for comparison in the second run but not kept thereafter because the sampling of the landing of this fleet might be poor in the first term due to lower fishing effort of this fleet in winter. This series was replaced by the inshore fleet series of the fourth quarter in the following runs which aimed at comparing XSA outputs when the number of inshore and offshore series is the same (2 or 1) or when one fleet has two quarterly series and the other has one.

Whatever the sets of tuning fleets in the XSA inputs were, the trends in fishing effort and in SSB of the runs are rather close (Figure 6.9).

6.8.4 Final XSA

Because the sensibility of the assessment to the addition of new fleets is limited, it appears better to limit the number of new fleets to two: an inshore and an offshore series to limit the risk to duplicate information. The ORHAGO survey was not retained because its series is still too short. The fleet s.e. threshold was kept to 0.2. Increasing this value to 0.3 did not change greatly the outputs of the assessment and does not appear justify as long as the old commercial fleets may be considered to bring relevant information on abundance trend.

The offshore fleet in the second quarter was retained because of its consistency in cohort tracking at ages 2 to 6. For the inshore fleet, the fourth quarter series was retained to provide tuning information for the older age groups, given its relatively good consistency in cohort tracking and relatively small standard errors of mean log-catchability at ages 3 and above. The addition of the inshore fleet in the second quarter or/and that of the offshore fleet in the first quarter were also considered to be of potential use as tuning-series and may be considered for inclusion in the assessment in future. This may be considered at the next benchmark analysis of this stock at which the inclusion of the ORHAGO survey should also be investigated.

The results are given in Table 6.5. The log-catchability residuals are shown in Figure 6.10. The two old commercial fleets drive largely the estimates of survivors, their total weight being 70–80% throughout the ages, each receiving about the same weight (32 to 45%). The inshore commercial fleet has weights comprised between 10 and 15%, increasing with the ages and, on the contrary, the offshore commercial fleet has weights which decrease with the ages, from 6% to 14–17%. The F shrinkage receives less than 2% throughout. Commercial fleet estimates are close at ages 3 to 7 but at age 2 the Les Sables estimate is largely above La Rochelle and offshore fleet estimates.

Fishing mortalities and stock numbers-at-age are given in Tables 6.6 and 6.7 respectively. The results are summarized in Table 6.8. Trends in yield, F, SSB and recruitments are plotted in Figure 6.11. Fishing mortality in 2009 is estimated by XSA to have been at 0.35, a bit higher than by the 2010 WGHMM (0.33). However the trends in fishing mortality and in SSB of the 2011 WKFLAT and of 2010 WGHMM are very close (Figure 6.12), except in the earlier part of the series because of the exclusion of the RESSGASC surveys from the tuning-series, as it has already been pointed out in past WGHMM and WGSSD assessments.

6.8.5 Retrospective patterns

The retrospective pattern of the final XSA retained by the WKFLAT is similar to one of the 2010 WHHMM in recent years (Figure 6.13). The main difference is the large reduction of the diverging trends observed prior to 1991 due to the removal of the RESSGASC survey-series.

6.8.6 Evaluation of the models

The ASAP model (see Section 5.8.1.1) was applied to Bay of Biscay sole to check for consistency in population estimates between the two model approaches. The Bay of Biscay sole landings data were treated as a single fleet in ASAP with selectivity either constant over the time period 1984–2009 or else separated into three blocks (1984–1990, 1991–2000, and 2001–2009). The selectivity pattern was assumed to be flat-topped through either the use of a logistic curve or by estimating ages 2–4 and fixing selectivity for ages 5+ at one. The four indices (Sables, Rochelle, inshore Q4, and offshore Q2) were treated as a set of numbers-at-age indices. A number of combinations of these settings were explored for this stock but there was insufficient time to fully explore a sufficient number of possibilities to arrive at a final model setting. Instead, a range of possible model results are shown to demonstrate the robustness of the estimated F (Figure 6.14), SSB (Figure 6.15), and recruitment-at-age 2 (Figure 6.16) time-series to these model settings.

6.8.7 Conclusion

The consistency of the estimates to the ASAP model settings and with the XSA model demonstrates that there is no indication of any problems with the XSA assessment.

The low sensitivity of the XSA outputs to the set of fleets used in the tuning process demonstrates a good robustness of XSA outputs. The agreement between all commercial tuning fleets for terminal estimates at age 3 and above demonstrates that the two new commercial fleets added in the WKFLAT tuning process may provide consistent assessment in future if the number of trawlers continues to decrease in the La Rochelle and Les Sables fleets. It is also expected that the ORHAGO survey contributes to improve the reliability of the assessment in the near future. If there is some need to consider other tuning fleet inclusion before this survey-series becomes long enough, it will be possible to consider the adding of the inshore fleet in the second quarter or of the offshore fleet in the first quarter to replace some of the new fleets or to complete their information, both of them having a quality rather near of the two new fleets retained for the WKFLAT assessment.

6.9 Short-term and medium-term forecasts

6.9.1 Input data

The input data for the short-term projection will continue to be computed as in recent years:

- Recruitment: geometric mean of past recruitment values XSA.
- Age group above recruitment: derived from the GM.
- Fishing mortality at recruiting age: arithmetic mean over the two years before the terminal year to be consistent with the overwriting of the XSA recruitment estimate by a GM.
- Fishing mortalities above recruiting age: arithmetic mean over the three last years of the assessment (scaled if observed trend).
- Weight-at-age: Catch and stock weights-at-age are taken as the mean of the last three years. The stock weights are set to the catch weights but always using the old fresh/gutted transformation coefficient for the French landing (1.11) in order to have comparable spawning biomass.
- Natural mortality: Set to 0.1 for all ages in all years.

- Maturity: Same ogive used for all years (see Stock Annex).

6.9.2 Model and software

Model used: Age structured deterministic projection

Software used: MFDP

6.9.3 Conclusion

No work was done by 2011 WKFLAT in relation to short-term and medium-term forecasts for Bay of Biscay sole. Past methodology should continue to be in use (see Stock Annex).

6.10 Biological reference points

The outputs of the WKFLAT assessment are very close to the ones of the 2010 WGHMM. Consequently F_{max} remains unchanged as well as F_{MSY} which is set to F_{max}.

The change in SSB trends in the earlier part of this series (due to the removal of the RESSGASC survey-series from the tuning-series) has slightly modified the Recruits–SSB plots (Figure 6.17). There is still little evidence of any relationship between SSB and recruits than previously and the basis for setting B_{pa} at 13 000 t remains valid: "The probability of reduced recruitment increases when SSB is below 13 000 t, based on the historical development of the stock."

The basis for setting F_{lim} was kept (historical response of the stock) and its value remains coherent with the historical SSB trend. Consequently, F_{pa} is unchanged.

6.11 Recommendations on the procedure for assessment updates and further work

WKFLAT 2011 recommends that future assessments are carried out following the methodology that was define during this meeting and described in the Stock Annex. A particular attention must be paid to the tuning-series which evolve by the adding 1) of the ORHAGO survey as soon as its series is five years long and 2) of the two commercial series which were considered to have some interest if the agreement between the four retained fleets decreases.

Further work should include investigation on 1) the monitoring of the inshore trawlers discards, 2) the origin of the discrepancy between French and Belgian mean weights-at-age and 3) the possibility to expend the length of the new tuning-series backwards before 2000.

6.12 Implications for management (plans)

A management plan is agreed for the Bay of Biscay sole but long-term target is not yet set. The WKFLAT has confirmed the robustness of WGHMM assessment and indicated the absence of need to change the biological reference points.

6.13 References

ICES. 2010 a. Sole in Divisions VIIIa, b (Bay of Biscay) *in* ICES advice 2010, Book 7 : 73–79.

ICES. 2010 b. Bay of Biscay sole *in* ICES WGHMM report 2010, ICES CM 2010/ACOM: 11, 94–138.

Table 6.1. Bay of Biscay sole lpue and indices of fishing effort for French offshore trawlers and Belgian beam trawlers.

Year	CPUE RESSGASC survey (kg/H) term 2	CPUE RESSGASC survey (kg/H) term 4	LPUE La Rochelle offshore trawlers of French sole fishery (kg/h)	LPUE Les Sables offshore trawlers of French sole fishery (kg/h)	LPUE Belgian beam trawlers (kg/h)	Landing Belgian beam trawlers (t)	Effort Belgian beam trawlers (1000 h)
1976					15.5	26.3	1.7
1977					18.7	64.4	3.4
1978					17.7	29.8	1.7
1979							
1980					17.9	33.1	1.9
1981					16.4	4.1	0.3
1982					18.6	20.5	1.1
1983					17.3	10.2	0.6
1984	-	-	6.0	6.9			
1985	-	-	5.6	6.5	17.2	26.7	1.6
1986	-	-	7.2	7.2	18.4	52.0	2.8
1987	0.7	1.1	6.6	5.9	16.1	124.0	7.7
1988	1.6	0.7	6.4	6.7	24.1	134.7	5.6
1989	1.2	0.9	5.5	6.1	18.6	311.0	16.7
1990	1.0	1.6	7.1	6.3	34.3	309.4	9.0
1991	1.1	2.2	6.5	6.5	41.0	400.5	9.8
1992	0.8	2.1	5.4	5.6	30.6	452.9	14.8
1993	1.0	1.5	4.6	6.4	37.5	399.7	10.7
1994	1.0	1.8	5.0	6.6	34.6	467.6	13.5
1995	1.0	1.8	4.6	5.4	33.0	446.7	13.5
1996	1.8	2.1	4.9	6.0	33.9	459.8	13.6
1997	1.2	1.4	4.1	5.3	26.9	435.4	16.2
1998	1.9	2.2	4.2	5.3	26.1	463.1	17.8
1999	1.1	0.9	3.7	5.9	24.0	498.7	20.8
2000	0.9	0.7	4.0	5.7	23.9	459.2	19.2
2001	1.0	1.0	3.4	4.0	21.1	368.2	17.5
2002	0.8	1.2	4.4	5.0	18.8	310.6	16.5
2003	-	-	4.1	3.9	23.6	295.8	12.5
2004	-	-	4.0	4.1	26.2	318.7	12.2
2005	-	-	3.9	5.2	24.3	365.1	15.0
2006	-	-	3.4	5.4	23.5	392.9	16.7
2007	-	-	3.5	5.3	24.8	404.2	16.3
2008	-	-	4.1	5.6	23.6	305.1	12.9
2009	-	-	3.3	5.2	22.5	363.3	16.2

Table 6.2. Bay of Biscay sole lpue for Inshore (10–12m) and offshore (14–18m) trawlers.

		Inshore trawlers	Offshore trawlers
Quarter	Year	LPUE	LPUE
1	2000	4.14	4.60
	2001	3.95	3.87
	2002	2.61	3.97
	2003	3.30	4.08
	2004	3.35	3.62
	2005	3.19	4.15
	2006	2.71	3.33
	2007	3.78	4.22
	2008	3.47	4.20
	2009	5.24	4.54

		Inshore trawlers	Offshore trawlers
Quarter	Year	LPUE	LPUE
2	2000	3.50	3.62
	2001	3.31	3.41
	2002	3.72	4.25
	2003	3.77	4.05
	2004	3.62	3.59
	2005	3.36	3.32
	2006	2.60	2.17
	2007	2.93	3.72
	2008	3.70	3.22
	2009	3.47	3.77

		Inshore trawlers	Offshore trawlers
Quarter	Year	LPUE	LPUE
3	2000	4.33	3.34
	2001	3.64	2.77
	2002	3.75	4.49
	2003	4.56	3.68
	2004	4.52	3.32
	2005	4.24	3.55
	2006	3.98	3.45
	2007	3.99	3.62
	2008	3.91	3.90
	2009	3.86	5.73

		Inshore trawlers	Offshore trawlers
Quarter	Year	LPUE	LPUE
4	2000	6.34	4.58
	2001	5.76	3.40
	2002	4.83	4.88
	2003	5.90	3.66
	2004	5.54	3.57
	2005	5.28	3.95
	2006	6.43	4.31
	2007	5.42	3.98
	2008	4.44	3.72
	2009	6.79	5.30

Table 6.3. Sole 8ab, available tuning data (landings) Sole VIIIa,b (commercial landing numbers in thousand, commercial fishing efforts in hour, survey catch in number per 100 nautical miles; Series, year and age range used in tuning are shown in bold type).

FR - SABLES

Year	Fishing effort	2	3	4	5	6	7	8
1991	33763	**242.1**	**332.8**	**194.7**	**73.8**	**32.4**	**23.6**	19.5
1992	30445	**236.8**	**285.8**	**130.2**	**59.5**	**32.1**	**15.0**	11.9
1993	34273	**152.0**	**441.3**	**224.0**	**75.7**	**27.0**	**8.0**	10.9
1994	20997	**94.1**	**157.4**	**184.3**	**77.3**	**24.2**	**13.4**	10.8
1995	31759	**173.4**	**228.1**	**177.1**	**69.1**	**34.1**	**15.9**	19.5
1996	31518	**193.0**	**222.6**	**169.8**	**55.6**	**37.8**	**29.4**	23.2
1997	27040	**140.9**	**290.9**	**114.2**	**49.0**	**26.7**	**10.6**	11.4
1998	16260	**86.9**	**112.1**	**113.6**	**31.4**	**13.8**	**8.1**	7.7
1999	12528	**64.9**	**53.2**	**39.7**	**26.8**	**15.0**	**15.2**	17.6
2000	11271	**81.3**	**121.3**	**45.0**	**15.7**	**8.4**	**4.7**	4.7
2001	9459	**35.2**	**67.8**	**35.8**	**8.7**	**5.1**	**2.9**	2.0
2002	10344	**76.9**	**60.5**	**37.7**	**19.4**	**8.3**	**3.8**	1.7
2003	7354	**39.1**	**49.3**	**14.3**	**7.8**	**4.0**	**1.7**	0.6
2004	6909	**38.7**	**36.4**	**23.0**	**5.7**	**3.9**	**1.7**	1.8
2005	6571	**46.3**	**26.0**	**24.8**	**15.4**	**6.5**	**3.3**	3.3
2006	6223	**62.5**	**29.6**	**11.9**	**6.6**	**3.7**	**2.4**	6.3
2007	5954	**31.5**	**28.4**	**18.2**	**12.5**	**10.7**	**6.6**	8.2
2008	4321	**22.8**	**23.0**	**16.7**	**8.1**	**5.3**	**4.9**	7.7
2009	3577	**23.0**	**22.6**	**9.9**	**7.1**	**4.2**	**2.4**	5.6

FR - ROCHEL

Year	Fishing effort	2	3	4	5	6	7	8
1991	15250	**134.8**	**157.4**	**88.9**	**30.3**	**11.6**	**6.7**	5.5
1992	12491	**99.4**	**130.1**	**58.7**	**21.2**	**9.1**	**4.5**	2.8
1993	12146	**53.3**	**126.5**	**51.8**	**17.2**	**6.4**	**2.1**	2.0
1994	8745	**42.4**	**56.5**	**52.9**	**19.4**	**6.4**	**2.7**	1.5
1995	4260	**25.9**	**31.3**	**20.7**	**7.2**	**2.4**	**1.1**	1.1
1996	10124	**113.1**	**74.6**	**34.3**	**8.8**	**5.0**	**3.1**	2.8
1997	12491	**74.1**	**117.6**	**35.8**	**12.6**	**7.3**	**2.6**	2.6
1998	10841	**77.7**	**65.4**	**57.9**	**11.3**	**4.7**	**2.9**	2.8
1999	8311	**53.7**	**31.6**	**19.0**	**10.1**	**6.4**	**4.3**	2.1
2000	8334	**63.3**	**45.1**	**19.3**	**6.5**	**2.7**	**1.4**	2.6
2001	7074	**22.4**	**38.1**	**23.9**	**6.2**	**3.8**	**2.0**	1.9
2002	6957	**90.1**	**36.2**	**11.8**	**5.4**	**2.3**	**1.2**	0.4
2003	5028	**37.4**	**40.0**	**9.1**	**3.7**	**1.8**	**0.5**	0.2
2004	1899	**12.1**	**11.8**	**4.4**	**1.0**	**0.7**	**0.3**	0.4
2005	3292	**17.5**	**10.6**	**8.8**	**5.3**	**2.4**	**1.1**	1.3
2006	2304	**10.8**	**8.2**	**3.8**	**2.4**	**1.3**	**0.6**	1.9
2007	2553	**12.3**	**21.4**	**4.5**	**1.9**	**1.6**	**0.7**	1.0
2008	1887	**11.3**	**14.6**	**5.4**	**2.1**	**1.1**	**1.1**	1.5
2009	1176	**4.9**	**7.1**	**2.3**	**1.3**	**0.7**	**0.4**	0.6

FR - RESSGASC 2

Year	Fishing effort	2	3	4	5	6	7	8
1987	80	84.9	67.7	40.9	14.1	11.8	2.0	11.7
1988	85	473.2	193.6	81.1	39.9	14.5	3.8	2.0
1989	82	228.9	163.6	52.8	26.6	11.3	9.5	5.0
1990	85	375.2	110.0	61.7	29.0	3.8	5.0	2.0
1991	87	164.2	157.1	111.7	39.3	16.5	6.2	11.0
1992	85	66.5	118.1	98.6	35.6	16.5	2.7	11.0
1993	76	32.7	113.6	111.3	73.9	21.4	11.5	9.5
1994	79	172.4	130.9	104.7	30.3	8.0	6.0	4.0
1995	82	126.8	135.3	65.7	35.8	22.7	19.0	8.4
1996	74	265.9	372.7	196.6	39.0	22.4	8.9	8.5
1997	98	176.4	377.7	127.7	40.4	15.6	8.8	13.0
1998	85	318.5	287.2	264.4	69.8	26.3	15.6	3.6
1999	82	180.3	185.5	77.4	33.2	24.3	7.2	2.0
2000	78	119.4	121.4	98.3	37.7	10.3	5.4	5.0
2001	84	150.2	152.2	89.4	28.5	21.1	11.0	4.2
2002	47	61.9	66.0	29.2	16.4	4.8	3.2	1.5

FR - RESSGASC 4

Year	Fishing effort	2	3	4	5	6	7	8
1987	79	126.7	86.1	42.4	18.8	7.8	2.5	2.0
1988	93	141.2	73.7	23.3	13.4	10.0	5.6	1.2
1989	65	89.1	60.2	31.5	22.5	18.8	5.5	3.0
1990	72	280.9	146.1	55.6	35.5	7.5	7.5	7.5
1991	74	409.1	220.2	64.8	14.6	6.6	2.7	2.5
1992	72	619.4	203.8	46.5	17.9	6.2	2.5	3.0
1993	71	155.1	166.2	79.1	32.5	17.0	1.0	0.0
1994	60	199.9	162.9	76.8	26.4	3.8	3.0	7.0
1995	90	416.7	206.9	94.3	42.0	11.2	3.9	3.3
1996	61	312.8	135.1	58.6	16.6	5.0	6.5	6.5
1997	67	118.7	182.5	69.3	29.7	13.0	8.1	8.8
1998	73	270.7	288.7	163.7	24.1	12.9	6.3	4.6
1999	78	135.8	88.6	68.3	16.5	10.9	6.3	1.5
2000	38	28.0	30.2	25.2	13.6	2.8	1.6	1.0
2001	77	101.3	109.8	70.6	25.3	8.4	1.7	1.8
2002	68	111.7	99.4	34.5	24.6	12.9	3.6	1.7

Table 6.3. (cont'd).

BEL-BT

Year	Fishing effort	2	3	4	5	6	7	8
1997	10740	179.5	390.3	192.1	148.7	61.5	49.0	83.3
1998	11162	48.3	176.1	216.1	99.1	91.6	59.8	196.8
1999	14668	19.0	367.4	420.6	293.2	159.0	118.2	316.0
2000	11566	433.3	656.7	208.8	68.8	25.2	15.3	21.2
2001	13278	144.7	313.3	298.6	184.8	77.7	57.7	81.7
2002	12851	0.0	85.8	309.0	272.0	131.3	56.9	137.4
2003	11198	113.3	599.1	183.0	78.3	44.0	29.7	106.8
2004	12175	393.1	801.0	190.5	67.4	46.9	17.3	42.6
2005	15017	336.5	565.7	318.2	145.3	90.3	31.3	70.0
2006	16699	141.0	605.6	385.0	255.4	127.3	71.4	69.0
2007	16270	554.1	691.6	335.6	151.9	71.6	37.5	113.6
2008	12946	402.8	794.0	140.9	61.8	50.7	20.3	28.2
2009	16159	99.7	692.5	357.8	187.0	99.6	86.9	123.3

FR-BB-IN-Q1

Year	Fishing effort	2	3	4	5	6	7	8
2000	1770	4.2	**17.73**	**5.02**	**2.62**	**1.17**	**0.65**	**0.65**
2001	1475	11.08	**10.59**	**5.25**	**1.92**	**0.91**	**0.38**	**0.18**
2002	2350	9.09	**18.47**	**5.66**	**2.09**	**0.54**	**0.16**	**0.03**
2003	2489	15.9	**14.13**	**4.92**	**3.53**	**1.86**	**0.57**	**0.15**
2004	2993	6.79	**21.11**	**12.8**	**2.17**	**1.48**	**0.71**	**0.84**
2005	2948	14.04	**10.62**	**8.14**	**5.35**	**2.38**	**1.1**	**0.96**
2006	2369	2.58	**7.26**	**5.4**	**3.69**	**1.76**	**0.68**	**2.82**
2007	2876	4.78	**18.57**	**11.61**	**7.2**	**5.45**	**3.26**	**2.98**
2008	2075	1.52	**23.86**	**8.99**	**3.43**	**1.13**	**0.98**	**1.48**
2009	1911	0.17	**15.72**	**7.52**	**4.69**	**2.47**	**1.14**	**3**

FR-BB-IN-Q2

Year	Fishing effort	2	3	4	5	6	7	8
2000	3677	**23.09**	**23.12**	**11.53**	**4.1**	**1.05**	0.34	0.74
2001	4625	**27.22**	**32.43**	**12.94**	**2.98**	**1.58**	0.98	1.51
2002	4448	**57.45**	**29.25**	**4.85**	**2.89**	**1.41**	0.84	0.6
2003	5815	**49.31**	**41.37**	**10.57**	**2.88**	**1.53**	0.3	0.26
2004	5750	**21.16**	**50.58**	**15.2**	**1.74**	**1.24**	0.52	0.93
2005	5698	**27.65**	**31.06**	**15.68**	**5.49**	**0.47**	0.31	0.42
2006	6284	**17.52**	**32.6**	**9.63**	**4**	**3.1**	0.84	1
2007	6935	**16.95**	**55.41**	**10.81**	**1.89**	**2.77**	0.33	0.48
2008	5395	**23.89**	**36.5**	**14.46**	**5.38**	**1.13**	2.09	1.75
2009	2966	**4.74**	**30.42**	**5**	**1**	**0.2**	0.09	0.37

FR-BB-IN-Q3

Year	Fishing effort	2	3	4	5	6	7	8
2000	3931	67.79	7.68	2.3	1.25	0.51	0.38	0.32
2001	5899	44.71	45.83	12.31	2.25	0.52	0.14	0.06
2002	6765	110.27	13.34	3.95	0.72	0.67	0.34	0.27
2003	5647	89.56	30.63	3.06	1.2	0.17	0.21	0.18
2004	6185	65.01	21.08	4.66	1.97	1.5	1.74	1.67
2005	6852	74.22	25.02	8.15	4.58	3.57	1.88	2.01
2006	8093	79.4	21.67	9.7	5.39	2.54	2.31	7.7
2007	7541	55.02	29.9	14.57	6.3	4.23	2.23	3.37
2008	5723	53.8	14.72	5.66	3.88	1.07	0.91	1.34
2009	2980	49.92	5.68	0.46	0.19	0.14	0.04	0.02

FR-BB-IN-Q4

Year	Fishing effort	2	3	4	5	6	7	8
2000	1336	21.85	**11.66**	**3.47**	**1.04**	**0.35**	**0.24**	**0.09**
2001	2451	49.95	**8.82**	**2.73**	**1.04**	**0.88**	**0.42**	**0.69**
2002	2942	31.21	**14.52**	**2.13**	**1.3**	**1.3**	**0.84**	**0.66**
2003	3423	35.5	**38.68**	**5.46**	**1.04**	**0.63**	**0.46**	**0.6**
2004	2725	22.03	**21.65**	**7.9**	**3.14**	**2.67**	**0.5**	**1.25**
2005	4432	42.24	**14.57**	**11.7**	**4.75**	**1.89**	**0.99**	**2.42**
2006	5212	67.59	**22**	**5.47**	**3.76**	**3.17**	**2.12**	**4.93**
2007	3139	29.16	**13.62**	**6.15**	**3.15**	**2.61**	**0.58**	**1.86**
2008	3082	12.32	**14.05**	**7.62**	**2.64**	**1.48**	**1.09**	**1.1**
2009	1271	19.22	**5.91**	**1.35**	**0.73**	**0.62**	**0.26**	**0.55**

Table 6.3. (cont'd).

FR-BB-OFF-Q1

Year	Fishing effort	2	3	4	5	6	7	8
2000	10901	16.94	**117.99**	**43.4**	**15.01**	**9.47**	**5.54**	**5.76**
2001	13471	27.44	**76.4**	**57.39**	**16.95**	**11.24**	**7.27**	**5.35**
2002	10708	14.55	**57.36**	**48.66**	**25.82**	**10.59**	**5.46**	**2.45**
2003	10643	21.94	**92.5**	**33.77**	**20.64**	**10.32**	**4.05**	**1.07**
2004	10252	10.77	**62.98**	**54.12**	**10.08**	**6.36**	**3.01**	**3**
2005	12819	18.35	**36.91**	**50.12**	**37.34**	**17.47**	**8.69**	**7.95**
2006	8356	7.23	**28.95**	**22.97**	**16.78**	**8.14**	**2.99**	**13.47**
2007	8679	13.41	**45.99**	**29.12**	**20.12**	**17.25**	**10.48**	**13.33**
2008	11391	2.27	**52.91**	**40.95**	**20.88**	**15.47**	**14.21**	**23.49**
2009	6734	1.86	**46.63**	**22.54**	**15.78**	**9.35**	**5.43**	**11.9**

FR-BB-OFF-Q2

Year	Fishing effort	2	3	4	5	6	7	8
2000	4940	**20.77**	**25.67**	**21**	**8.64**	**2.47**	0.82	1.5
2001	4538	**13.5**	**27.47**	**18.9**	**5.17**	**3.31**	1.29	0.98
2002	4639	**31.89**	**29.4**	**14.88**	**7.87**	**3.55**	1.84	0.46
2003	3252	**23.23**	**28.04**	**7.1**	**1.88**	**0.82**	0.08	0.03
2004	4810	**14.05**	**44.18**	**14.6**	**1.38**	**0.7**	0.27	0.41
2005	4468	**12.79**	**19.09**	**15.79**	**5.63**	**0.54**	0.42	0.56
2006	2111	**3.29**	**8.97**	**2.73**	**1.41**	**0.91**	0.31	0.29
2007	3972	**13.33**	**45.84**	**6.38**	**1.17**	**1.68**	0.24	0.54
2008	3005	**15.28**	**21.67**	**6.78**	**2.15**	**0.36**	0.77	0.45
2009	1184	**1.51**	**10.88**	**3.64**	**1.14**	**0.35**	0.22	0.48

FR-BB-OFF-Q3

Year	Fishing effort	2	3	4	5	6	7	8
2000	5446	66.2	10.98	2.35	0.93	0.27	0.17	0.88
2001	6741	18.44	46.58	14.16	2.16	0.47	0.17	0.07
2002	6814	120.34	21.65	7.12	1.23	0.79	0.13	0.07
2003	4704	51.79	24.3	2.41	0.59	0.26	0.05	0.05
2004	5821	55.74	13.31	2.5	1.23	0.7	0.82	0.49
2005	6307	64.3	18.52	5.89	3.36	2.68	0.9	1.17
2006	4924	39.17	13.7	6.06	2.95	1.63	1.27	3.82
2007	6331	65.93	29.31	11.54	3.09	1.85	1.08	0.89
2008	5688	80.11	16.32	4.47	2.4	0.67	0.35	0.47
2009	2629	40.31	12.79	3.16	2.19	1.16	0.8	0.45

FR-BB-OFF-Q4

Year	Fishing effort	2	3	4	5	6	7	8
2000	4778	43.36	32.85	12.13	3.9	1.1	0.49	0.12
2001	6819	41.56	32.51	14.44	3.33	1.34	0.51	0.6
2002	4012	45.5	28.14	4.66	1.68	0.8	0.23	0.14
2003	6849	55.17	41.91	6.04	1.24	0.45	0.34	0.39
2004	6460	20.93	28.24	13.46	6.39	4.99	1.14	2.14
2005	6613	53.9	18.84	13.24	5.03	1.59	0.68	1.94
2006	6059	56.04	21.01	5.17	2.79	1.81	1.56	2.81
2007	5609	60.1	24.57	6.53	4.23	1.93	0.48	0.89
2008	4616	29.77	26.49	9.91	2.27	1.21	1.03	0.45
2009	2442	38.55	16.12	3.11	1.1	0.65	0.28	0.36

FR-ORHAGO

Year	Fishing effort	2	3	4	5	6	7	8
2007	100	214	95	30	17	7	1	1
2008	100	205	134	38	8	4	6	2
2009	100	686	160	31	7	3	1	5

Table 6.4. Settings of the runs chosen for the sensitivity analysis.

WKFLAT Run XSA	Run 00_02	Run 00_05	Run 01_02	Run 01_05	Run 02_02	Run 02_05	Run 03_02	Run 03_05	Run 04_02	Run 04_05	Run 05_02	Run 05_05
Catch data range	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009	1984-2009
Age range in catch data	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+
Fleet : FR-SABLES	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7
Fleet : FR-ROCHELLE	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7	91-09 2-7
Fleet : FR-BB-IN-Q1			00-09 3-7	00-09 3-7								
Fleet : FR-BB-IN-Q2	00-09 2-6	00-09 2-6	00-09 2-6	00-09 2-6	00-09 2-6	00-09 2-6	00-09 2-6	00-09 2-6				
Fleet : FR-BB-IN-Q4					00-09 3-7	00-09 3-7	00-09 3-7	00-09 3-7	00-09 3-7	00-09 3-7	00-09 3-7	00-09 3-7
Fleet : FR-BB-OFF-Q1			99-09 3-7	99-09 3-7	99-09 3-7	99-09 3-7			99-09 3-7	99-09 3-7		
Fleet : FR-BB-OFF-Q2	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6	99-09 2-6
Fleet : FR-ORHAGO	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7	07-09 2-7
Taper	No	No	No	No	No	No	No	No	No	No	No	No
Q plateau	6	6	6	6	6	6	6	6	6	6	6	6
F shrinkage se	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Year range	5	5	5	5	5	5	5	5	5	5	5	5
age range	3	3	3	3	3	3	3	3	3	3	3	3
Fleet se threshold	0.2	0.5	0.2	0.5	0.2	0.5	0.2	0.5	0.2	0.5	0.2	0.5
F bar range	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6

Table 6.5.

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

SOLE VIIIa,b

CPUE data from file tunfilt.dat

Catch data for 26 years. 1984 to 2009. Ages 2 to 8.

```
    Fleet,          First, Last, First, Last, Alpha,  Beta
               ,    year, year,  age ,  age
FR-SABLES         ,  1991, 2009,   2,     7,   .000,  1.000
FR-ROCHELLE       ,  1991, 2009,   2,     7,   .000,  1.000
FR-BB-IN-Q4       ,  2000, 2009,   3,     7,   .750,  1.000
FR-BB-OFF-Q2      ,  2000, 2009,   2,     6,   .250,   .500
```

Time-series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 6

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1.500

Minimum standard error for population
estimates derived from each fleet = .200

Prior weighting not applied

Tuning had not converged after 30 iterations

Total absolute residual between iterations
29 and 30 = .00051

Final year F values

```
Age         ,     2,      3,      4,      5,      6,      7
Iteration 29,  .1626,  .2905,  .3508,  .3354,  .4232,  .4758
Iteration 30,  .1626,  .2905,  .3508,  .3353,  .4231,  .4756
```

1

Regression weights

```
     , 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000
```

Fishing mortalities

```
  Age,  2000,  2001,  2002,  2003,  2004,  2005,  2006,  2007,  2008,  2009
```

2, .274, .209, .247, .200, .232, .248, .195, .232, .170, .163
3, .479, .503, .523, .472, .376, .350, .426, .424, .449, .290
4, .762, .650, .809, .442, .428, .432, .457, .425, .393, .351
5, .719, .587, 1.004, .417, .290, .533, .386, .403, .360, .335
6, .530, .553, .957, .600, .369, .510, .426, .397, .449, .423
7, .483, .548, .774, .754, .413, .420, .500, .497, .479, .476

1
XSA population numbers (Thousands)

AGE
YEAR , 2, 3, 4, 5, 6, 7,

2000 , 2.49E+04, 1.94E+04, 1.01E+04, 5.21E+03, 2.44E+03, 1.15E+03,
2001 , 1.68E+04, 1.71E+04, 1.09E+04, 4.28E+03, 2.30E+03, 1.30E+03,
2002 , 2.50E+04, 1.23E+04, 9.38E+03, 5.13E+03, 2.15E+03, 1.20E+03,
2003 , 2.44E+04, 1.76E+04, 6.61E+03, 3.78E+03, 1.70E+03, 7.48E+02,
2004 , 1.72E+04, 1.81E+04, 9.96E+03, 3.84E+03, 2.25E+03, 8.45E+02,
2005 , 1.90E+04, 1.23E+04, 1.12E+04, 5.87E+03, 2.60E+03, 1.41E+03,
2006 , 2.12E+04, 1.35E+04, 7.87E+03, 6.59E+03, 3.12E+03, 1.41E+03,
2007 , 1.94E+04, 1.58E+04, 7.95E+03, 4.51E+03, 4.06E+03, 1.84E+03,
2008 , 2.13E+04, 1.39E+04, 9.33E+03, 4.70E+03, 2.73E+03, 2.47E+03,
2009 , 1.70E+04, 1.62E+04, 8.03E+03, 5.70E+03, 2.97E+03, 1.57E+03,

Estimated population abundance at 1st Jan 2010

, 0.00E+00, 1.31E+04, 1.10E+04, 5.12E+03, 3.69E+03, 1.76E+03,

Taper weighted geometric mean of the VPA populations:

, 2.44E+04, 1.82E+04, 1.11E+04, 6.14E+03, 3.33E+03, 1.80E+03,

Standard error of the weighted Log(VPA populations) :

, .2045, .2104, .2365, .2461, .2842, .4077,
1

Log-catchability residuals.

Fleet : FR-SABLES

Age , 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999
2 , -.25, -.15, -.40, -.42, -.10, -.23, -.14, -.05, -.20
3 , .13, -.16, .19, -.08, -.15, .00, .23, .02, -.39
4 , .16, -.24, -.06, .40, .17, .05, .05, .47, -.19
5 , .12, -.12, -.07, .26, .03, -.08, -.20, .20, .31
6 , -.18, .18, -.38, .04, -.23, .25, -.01, -.38, .45
7 , -.05, -.14, -.27, .18, .06, .48, -.01, .12, .55

Age , 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009
2 , .18, -.12, .20, -.14, .28, .41, .64, .10, -.02, .39
3 , .42, .15, .28, .04, -.27, -.19, -.05, -.21, .04, -.02
4 , .16, -.01, .17, -.27, -.15, -.14, -.45, -.01, .05, -.15
5 , -.05, -.33, .38, -.14, -.46, .27, -.71, .36, .19, .04
6 , -.02, -.28, .36, .05, -.30, .19, -.54, .29, .33, .19
7 , .12, -.27, .09, .09, -.12, .08, -.15, .64, .36, .28

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

Age , 2, 3, 4, 5, 6, 7

Mean Log q, -15.0554, -14.5499, -14.5104, -14.7031, -14.6791, -14.6791,
S.E(Log q), .2859, .2045, .2287, .2903, .2915, .2840,

Regression statistics :

Ages with q independent of year-class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2,	3.94,	-2.809,	29.75,	.05,	19,	.96,	-15.06,
3,	.89,	.578,	14.05,	.64,	19,	.19,	-14.55,
4,	.71,	2.296,	13.01,	.79,	19,	.15,	-14.51,
5,	.92,	.341,	14.19,	.49,	19,	.27,	-14.70,
6,	1.29,	-.828,	16.62,	.32,	19,	.38,	-14.68,
7,	.73,	2.285,	12.61,	.81,	19,	.17,	-14.57,

1

Fleet : FR-ROCHELLE

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999
2	-.10	-.19	-.47	-.40	-.05	.32	-.07	.18	-.04
3	.23	-.01	.02	-.18	-.08	.09	.15	-.07	-.46
4	.48	.16	-.18	.33	.34	-.11	-.03	.51	-.21
5	.48	.20	-.06	.22	.24	-.33	-.33	.04	.21
6	.12	.34	-.26	.11	-.35	-.11	.00	-.53	.54
7	.01	.07	-.05	-.02	-.07	-.11	-.12	.02	.23

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	.17	-.34	.69	.14	.35	.07	-.18	-.05	.05	-.10
3	-.22	-.09	.21	.26	-.06	-.35	-.30	.40	.46	-.02
4	-.07	.18	-.29	-.03	-.20	-.18	-.30	-.25	.06	-.19
5	-.17	.09	-.04	-.04	-.45	.35	-.26	-.21	.13	-.08
6	-.33	.25	.00	.16	-.19	.41	-.07	-.24	.11	.03
7	-.26	.17	-.14	-.23	-.04	.20	-.02	-.23	.22	.13

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

Age ,	2,	3,	4,	5,	6,	7
Mean Log q,	-14.9965,	-14.5963,	-14.8170,	-15.1651,	-15.2070,	-15.2070,
S.E(Log q),	.2775,	.2452,	.2604,	.2519,	.2773,	.1535,

Regression statistics :

Ages with q independent of year-class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2,	1.03,	-.101,	15.16,	.36,	19,	.29,	-15.00,
3,	.96,	.181,	14.39,	.51,	19,	.24,	-14.60,
4,	.68,	2.283,	13.08,	.75,	19,	.16,	-14.82,
5,	.79,	1.163,	13.81,	.65,	19,	.20,	-15.17,

```
 6,   1.67,  -1.627,    20.01,    .26,    19,    .44, -15.21,
 7,    .84,   1.994,    13.93,    .90,    19,    .12, -15.22,
1


Fleet : FR-BB-IN-Q4

 Age  , 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009
   2 , No data for this fleet at this age
   3 ,  .31, -.43,  .23,  .66,  .20, -.32, -.09, -.23, -.03, -.30
   4 ,  .56, -.45, -.60,  .22,  .40,  .19, -.36,  .23,  .27, -.46
   5 ,  .27, -.26, -.04, -.62,  .59,  .30, -.33,  .39,  .15, -.46
   6 , -.49, -.10,  .53, -.43,  .76, -.09,  .01,  .04, -.07, -.16
   7 , -.16, -.27,  .52,  .22,  .11, -.20,  .47, -.59, -.25, -.35


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


  Age ,        3,        4,        5,        6,        7
Mean Log q,  -14.4209,  -14.9855,  -15.2691,  -15.0029,  -15.0029,
S.E(Log q),     .3447,     .4197,     .4026,     .3852,     .3682,


Regression statistics :

Ages with q independent of year-class strength and constant w.r.t. time.

Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e,  Mean Q

 3,    .60,    .954,    12.50,    .41,    10,    .21, -14.42,
 4,    .83,    .231,    13.99,    .19,    10,    .37, -14.99,
 5,   1.40,   -.370,    17.97,    .10,    10,    .59, -15.27,
 6,    .98,    .032,    14.87,    .28,    10,    .40, -15.00,
 7,   2.19,  -1.718,    24.39,    .21,    10,    .72, -15.06,
1


Fleet : FR-BB-OFF-Q2

 Age  , 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009
   2 ,  .05,  .08,  .53,  .57,  .04, -.08, -.81,  .06,  .36, -.80
   3 , -.48, -.20,  .19,  .12,  .12, -.27, -.34,  .50,  .17,  .20
   4 ,  .44,  .30,  .25,  .08, -.01,  .03, -.61, -.42, -.25,  .19
   5 ,  .81,  .53,  .90, -.09, -.85,  .29, -.51, -.94, -.11, -.02
   6 ,  .53,  .98, 1.24,  .24, -.68, -.96,  .10, -.19,-1.04, -.23
   7 , No data for this fleet at this age


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


  Age ,        2,        3,        4,        5,        6
Mean Log q,  -15.5050,  -14.4343,  -14.7996,  -15.4117,  -15.6994,
S.E(Log q),     .4782,     .3059,     .3343,     .6440,     .7744,


Regression statistics :
```

```
Ages with q independent of year-class strength and constant w.r.t. time.

Age, Slope , t-value , Intercept, RSquare, No Pts, Reg s.e,  Mean Q

 2,    .40,   1.580,     12.17,     .47,     10,     .18,  -15.50,
 3,   1.13,   -.177,     15.07,     .18,     10,     .37,  -14.43,
 4,    .55,   1.246,     12.26,     .49,     10,     .18,  -14.80,
 5,    .57,    .632,     12.42,     .21,     10,     .38,  -15.41,
 6, -14.60,   -.977,    ******,     .00,     10,   11.34,  -15.70,
1


Terminal year survivor and F summaries :

Age  2   Catchability constant w.r.t. time and dependent on age

Year class = 2007

Fleet,               Estimated,    Int,      Ext,    Var,    N, Scaled,  Estimated
    ,               Survivors,    s.e,      s.e,   Ratio,    , Weights,    F
FR-SABLES          ,    19427.,  .293,     .000,    .00,  1,  .408,     .113
FR-ROCHELLE        ,    11869.,  .285,     .000,    .00,  1,  .434,     .178
FR-BB-IN-Q4        ,       1.,  .000,     .000,    .00,  0,  .000,     .000
FR-BB-OFF-Q2       ,     5861.,  .502,     .000,    .00,  1,  .140,     .333

 F shrinkage mean  ,     9592.,   1.50,,,,                     .018,     .216

Weighted prediction :

Survivors,       Int,      Ext,    N,    Var,     F
at end of year,   s.e,      s.e,     ,   Ratio,
   13102.,       .19,      .23,    4,   1.229,   .163


Age  3   Catchability constant w.r.t. time and dependent on age

Year class = 2006

Fleet,               Estimated,    Int,      Ext,    Var,    N, Scaled,  Estimated
    ,               Survivors,    s.e,      s.e,   Ratio,    , Weights,    F
FR-SABLES          ,    10759.,  .171,     .001,    .00,  2,  .406,     .296
FR-ROCHELLE        ,    11056.,  .189,     .032,    .17,  2,  .327,     .289
FR-BB-IN-Q4        ,     8110.,  .362,     .000,    .00,  1,  .096,     .376
FR-BB-OFF-Q2       ,    13934.,  .271,     .071,    .26,  2,  .163,     .236

 F shrinkage mean  ,     7389.,   1.50,,,,                     .007,     .406

Weighted prediction :

Survivors,       Int,      Ext,    N,    Var,     F
at end of year,   s.e,      s.e,     ,   Ratio,
   10991.,       .11,      .05,    8,    .496,   .290


1
Age  4   Catchability constant w.r.t. time and dependent on age

Year class = 2005

Fleet,               Estimated,    Int,      Ext,    Var,    N, Scaled,  Estimated
    ,               Survivors,    s.e,      s.e,   Ratio,    , Weights,    F
FR-SABLES          ,     4901.,  .143,     .075,    .53,  3,  .402,     .364
FR-ROCHELLE        ,     5389.,  .160,     .206,   1.28,  3,  .316,     .336
FR-BB-IN-Q4        ,     3982.,  .286,     .214,    .75,  2,  .105,     .432
FR-BB-OFF-Q2       ,     6044.,  .221,     .029,    .13,  3,  .170,     .304

 F shrinkage mean  ,     4020.,   1.50,,,,                     .007,     .428

Weighted prediction :
```

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
5115., .09, .07, 12, .738, .351

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2004

Fleet,	Estimated,	Int,	Ext,	Var,	N,	Scaled,	Estimated
,	Survivors,	s.e,	s.e,	Ratio,	,	Weights,	F
FR-SABLES ,	3856.,	.134,	.137,	1.03,	4,	.377,	.323
FR-ROCHELLE ,	3824.,	.142,	.112,	.79,	4,	.358,	.325
FR-BB-IN-Q4 ,	3043.,	.247,	.216,	.88,	3,	.124,	.394
FR-BB-OFF-Q2 ,	3572.,	.215,	.242,	1.13,	4,	.134,	.345

F shrinkage mean , 3030., 1.50,,,, .006, .395

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
3689., .08, .07, 16, .853, .335

1
Age 6 Catchability constant w.r.t. time and dependent on age

Year class = 2003

Fleet,	Estimated,	Int,	Ext,	Var,	N,	Scaled,	Estimated
,	Survivors,	s.e,	s.e,	Ratio,	,	Weights,	F
FR-SABLES ,	1974.,	.131,	.067,	.51,	5,	.370,	.385
FR-ROCHELLE ,	1711.,	.135,	.083,	.61,	5,	.370,	.433
FR-BB-IN-Q4 ,	1751.,	.222,	.095,	.43,	4,	.147,	.425
FR-BB-OFF-Q2 ,	1310.,	.219,	.062,	.28,	5,	.106,	.535

F shrinkage mean , 1717., 1.50,,,, .007, .432

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
1760., .08, .04, 20, .545, .423

Age 7 Catchability constant w.r.t. time and age (fixed at the value for age) 6

Year class = 2002

Fleet,	Estimated,	Int,	Ext,	Var,	N,	Scaled,	Estimated
,	Survivors,	s.e,	s.e,	Ratio,	,	Weights,	F
FR-SABLES ,	1019.,	.131,	.131,	.99,	6,	.328,	.425
FR-ROCHELLE ,	911.,	.123,	.084,	.69,	6,	.453,	.465
FR-BB-IN-Q4 ,	749.,	.208,	.131,	.63,	5,	.150,	.543
FR-BB-OFF-Q2 ,	502.,	.219,	.167,	.76,	5,	.062,	.730

F shrinkage mean , 1201., 1.50,,,, .007, .371

Weighted prediction :

Survivors, Int, Ext, N, Var, F
at end of year, s.e, s.e, , Ratio,
886., .08, .07, 23, .825, .476

1
1

Table 6.6. Bay of Biscay Sole, Fishing mortality-(F)at-age.

Terminal Fs derived using XSA (With F shrinkage)

YEAR		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
AGE															
	2	0.2966	0.3598	0.2573	0.1742	0.2167	0.2024	0.2651	0.1439	0.1483	0.0834	0.1101	0.1565	0.1144	0.1844
	3	0.2429	0.3535	0.2707	0.3543	0.3983	0.4355	0.3831	0.3522	0.3186	0.3533	0.3268	0.3282	0.3545	0.5135
	4	0.3356	0.272	0.3175	0.3455	0.43	0.4259	0.5229	0.4602	0.4531	0.4974	0.7497	0.6803	0.5278	0.6702
	5	0.3477	0.3717	0.3866	0.3707	0.3457	0.5904	0.5748	0.4424	0.5588	0.6374	0.7378	0.7148	0.5058	0.5711
	6	0.3194	0.229	0.4835	0.4093	0.4205	0.5231	0.3211	0.4114	1.079	0.5968	0.7543	0.5614	0.7705	0.6734
	7	0.3351	0.2916	0.3971	0.3763	0.4	0.515	0.4746	0.6119	0.8394	0.7835	0.7734	0.7616	1.0035	0.7405
+gp		0.3351	0.2916	0.3971	0.3763	0.4	0.515	0.4746	0.6119	0.8394	0.7835	0.7734	0.7616	1.0035	0.7405
0 FBAR 3- 6		0.3114	0.3065	0.3646	0.3699	0.3986	0.4937	0.4505	0.4165	0.6024	0.5212	0.6422	0.5712	0.5397	0.607

YEAR		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	FBAR **-**
AGE														
	2	0.2111	0.1309	0.2739	0.2086	0.2467	0.2003	0.2325	0.2476	0.1954	0.2323	0.1704	0.1626	0.1885
	3	0.3955	0.3919	0.4787	0.5033	0.5228	0.4719	0.3763	0.35	0.4265	0.4237	0.449	0.2905	0.3877
	4	0.7315	0.6359	0.7624	0.6501	0.8086	0.4422	0.4281	0.4318	0.457	0.4249	0.3926	0.3508	0.3895
	5	0.6018	0.731	0.7187	0.5869	1.0044	0.4167	0.29	0.5325	0.3861	0.4027	0.36	0.3353	0.366
	6	0.4213	0.7337	0.5299	0.5531	0.9566	0.5998	0.3692	0.5096	0.4256	0.397	0.4493	0.4231	0.4231
	7	0.7513	0.5485	0.4835	0.5483	0.7736	0.7541	0.413	0.42	0.4998	0.4967	0.4789	0.4756	0.4837
+gp		0.7513	0.5485	0.4835	0.5483	0.7736	0.7541	0.413	0.42	0.4998	0.4967	0.4789	0.4756	
0 FBAR 3- 6		0.5375	0.6231	0.6224	0.5733	0.8231	0.4826	0.3659	0.456	0.4238	0.4121	0.4127	0.3499	

Table 6.7. Bay of Biscay Sole, Stock number-at-age (start of year) Numbers*10**-3

Terminal Fs derived using XSA (With F shrinkage)

YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
AGE														
2	24173	29544	28383	24953	26775	28212	32149	35791	35387	24923	26251	23578	29449	23734
3	15422	16260	18654	19855	18970	19507	20849	22315	28045	27606	20747	21277	18244	23767
4	10272	10944	10331	12876	12606	11526	11420	12861	14197	18452	17544	13539	13865	11581
5	7281	6644	7545	6805	8247	7420	6812	6126	7345	8166	10153	7501	6205	7400
6	4476	4654	4146	4638	4250	5281	3720	3469	3561	3801	3906	4393	3321	3385
7	3249	2943	3349	2313	2787	2526	2832	2442	2080	1095	1893	1662	2267	1391
+gp	4346	3021	3947	2385	2433	1297	2410	2241	1747	1361	1349	1932	2170	1751
0 TOTAL	69219	74010	76355	73825	76069	75769	80192	85244	92363	85405	81844	73882	75521	73009

YEAR	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	GMST 84-**	AMST 84-**
AGE															
2	22626	24423	24909	16770	24962	24399	17211	19045	21166	19377	21282	17035	0	24882	25341
3	17860	16577	19387	17139	12317	17648	18070	12343	13454	15752	13898	16239	13102	18442	18836
4	12869	10881	10135	10869	9375	6607	9961	11222	7870	7947	9330	8027	10991	11359	11656
5	5361	5603	5213	4279	5134	3779	3842	5874	6594	4509	4701	5701	5115	6228	6410
6	3783	2657	2441	2299	2153	1701	2254	2601	3121	4055	2728	2968	3689	3371	3503
7	1562	2246	1154	1300	1196	748	845	1410	1414	1845	2467	1575	1760	1792	1940
+gp	2349	2421	1212	1212	847	495	1031	1554	4073	2537	3287	2741	2427		
0 TOTAL	66409	64808	64452	53868	55984	55378	53214	54050	57692	56022	57694	54286	37084		

( ) age 2 replaced by GM 93-2007 = 22591

( ) age 3 replaced by GM e-(F07-08+M) = 16714

Table 6.8. Bay of Biscay Sole, Summary (without SOP correction).

Terminal Fs derived using XSA (With F shrinkage)

	RECRUITS Age 2	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 6
1984	24173	14821	12326	4038	0.3276	0.3114
1985	29544	16067	13374	4251	0.3179	0.3065
1986	28383	17085	14491	4805	0.3316	0.3646
1987	24953	18680	15499	5086	0.3282	0.3699
1988	26775	18541	15385	5382	0.3498	0.3986
1989	28212	17820	14498	5845	0.4031	0.4937
1990	32149	18449	14868	5916	0.3979	0.4505
1991	35791	19162	14853	5569	0.3749	0.4165
1992	35387	20595	16036	6550	0.4085	0.6024
1993	24923	19977	16447	6420	0.3903	0.5212
1994	26251	19364	15920	7229	0.4541	0.6422
1995	23578	17723	14311	6205	0.4336	0.5712
1996	29449	17808	13880	5854	0.4218	0.5397
1997	23734	16542	13382	6259	0.4677	0.607
1998	22626	16510	13290	6027	0.4535	0.5375
1999	24423	16018	12381	5249	0.4239	0.6231
2000	24909	15538	11875	5760	0.485	0.6224
2001	16770	13113	10641	4836	0.4545	0.5733
2002	24962	13236	9822	5486	0.5585	0.8231
2003	24399	13415	9690	4108	0.4239	0.4826
2004	17211	14281	11269	4002	0.3551	0.3659
2005	19045	14690	11668	4539	0.389	0.456
2006	21166	15986	12574	4793	0.3812	0.4238
2007	19377	15335	12169	4363	0.3585	0.4121
2008	21282	15912	12591	4299	0.3414	0.4127
2009	(17035)	14796	11962	3600	0.301	0.3499
Arith. Mean	24866	16595	13277	5249	0.3974	0.4876
0 Units	(Thousands	(Tonnes)	(Tonnes)	(Tonnes)		

GM 93-2007 = 22591

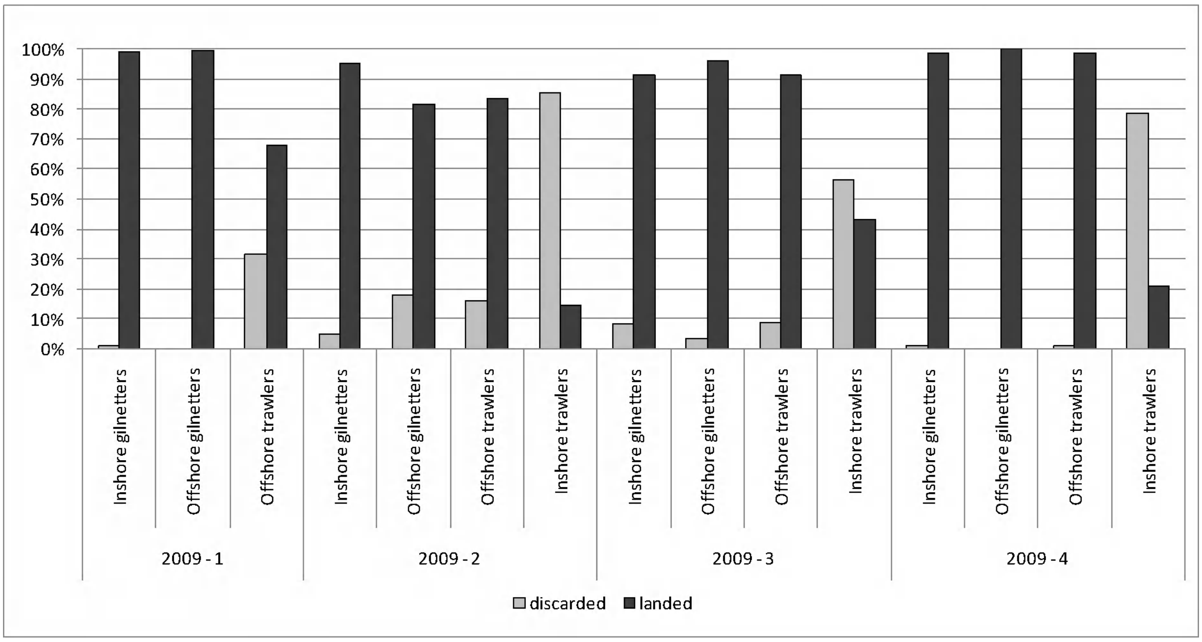


Figure 6.1. Bay of Biscay sole (Division VIIIa,b). Discards rates in number by quarter for the four French fleets.

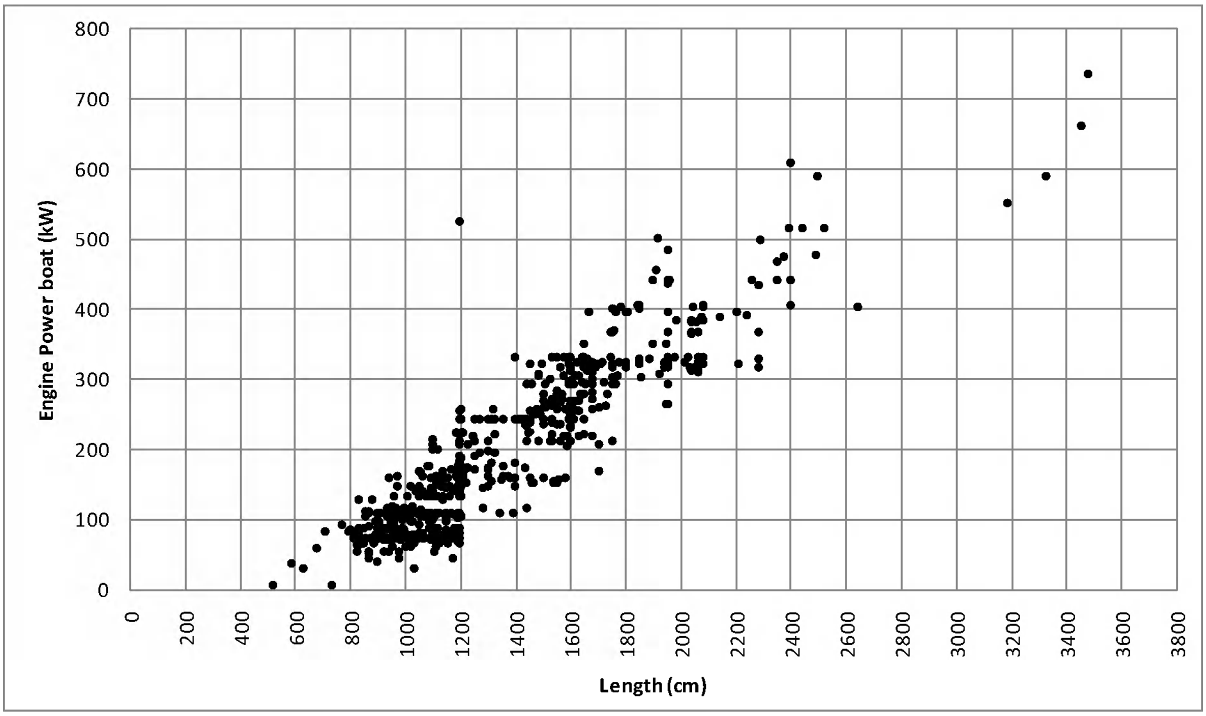


Figure 6.2. Bay of Biscay sole (Division VIIIa,b). Selection of vessel length groups to form the new tuning fleets (black rectangle on the engine power – vessel length plot).

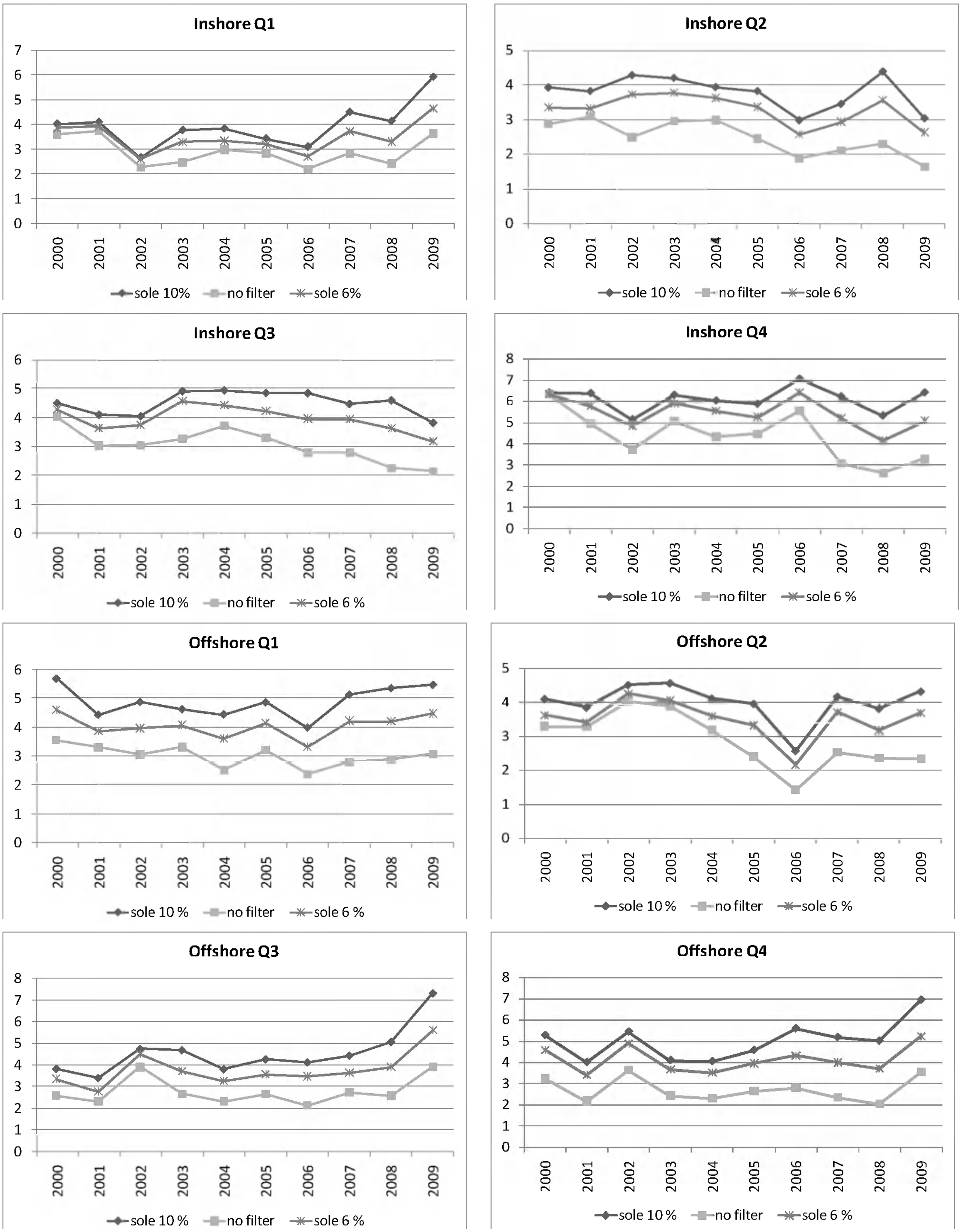


Figure 6.3. Bay of Biscay sole (Division VIIIa,b). Trends in quarterly cpue of the inshore and of the offshore fleet for 3 sole percentage thresholds in catches (>0 %, ≥6% and ≥10%).

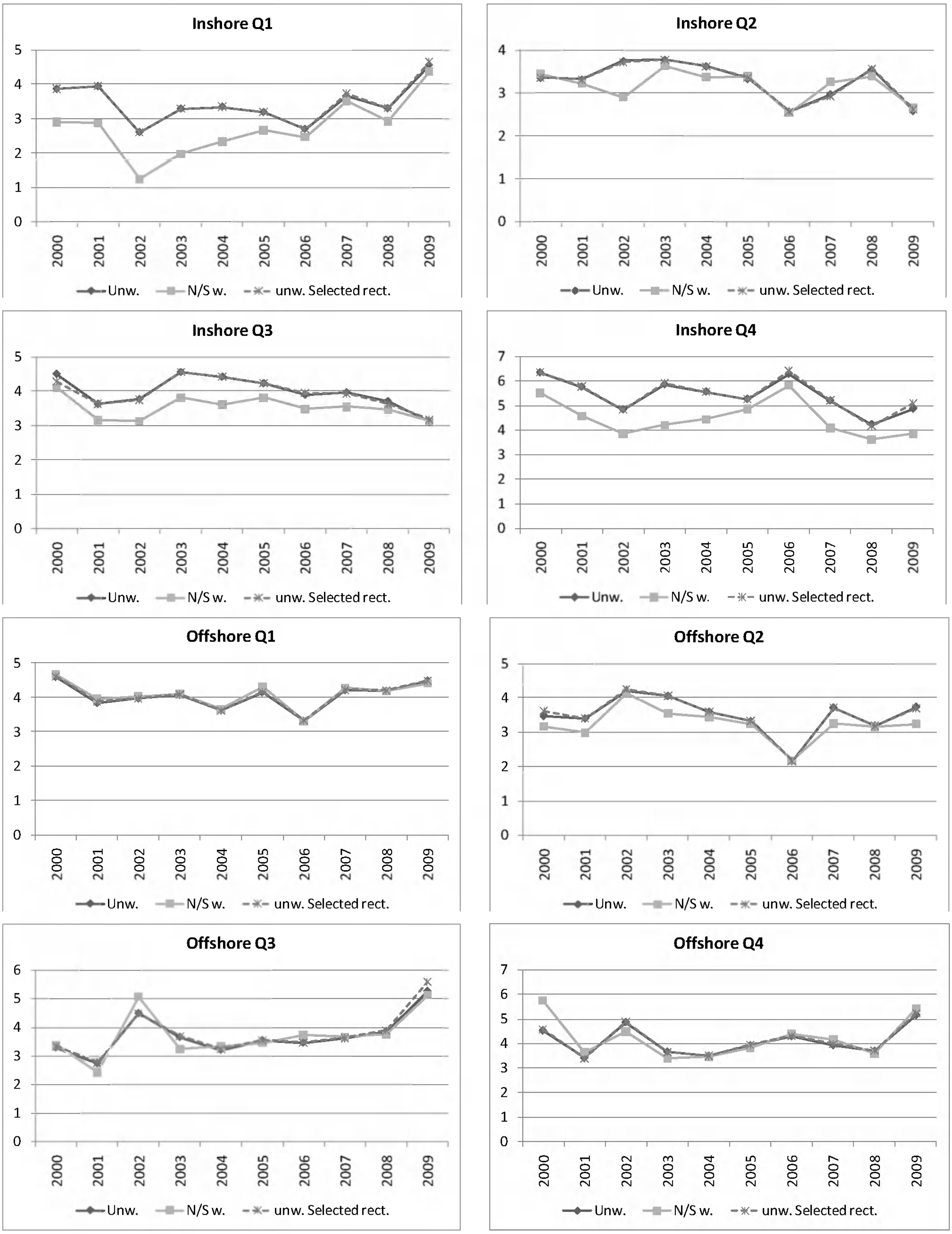


Figure 6.4. Bay of Biscay sole (Division VIIIa,b). Trends in quarterly cpue of the inshore and of the offshore fleet using all available data (Unw.), with a selection of rectangles and an area weighting (N/S w.) or without area weighting (unw. Selected rect.).

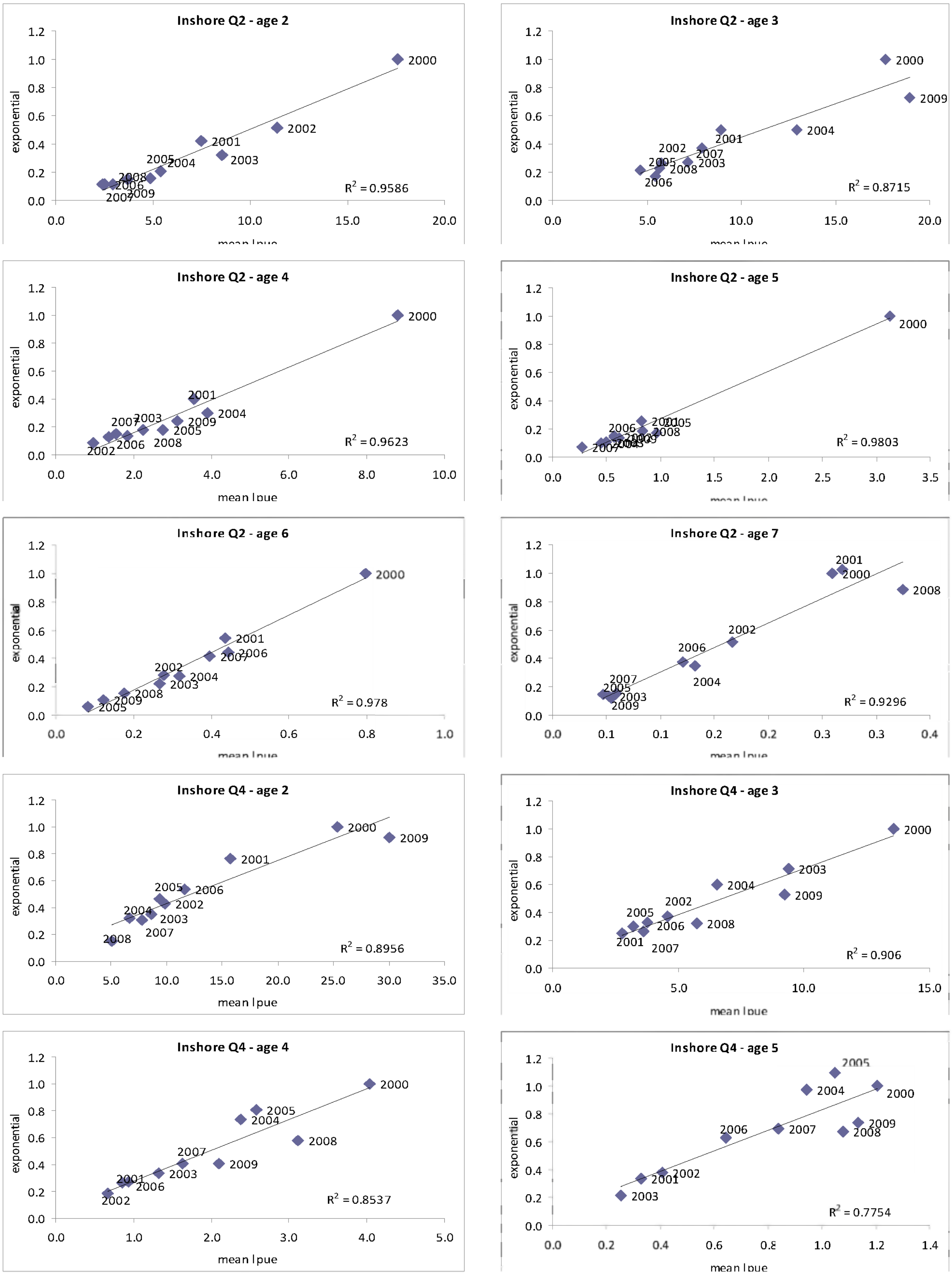


Figure 6.5. Bay of Biscay sole (Division VIIIa,b). Relationships between the exponential of GLM year factor and observed lpue for the four series (at age 2 to 7) which were considered the most interesting to be added in the tuning process.

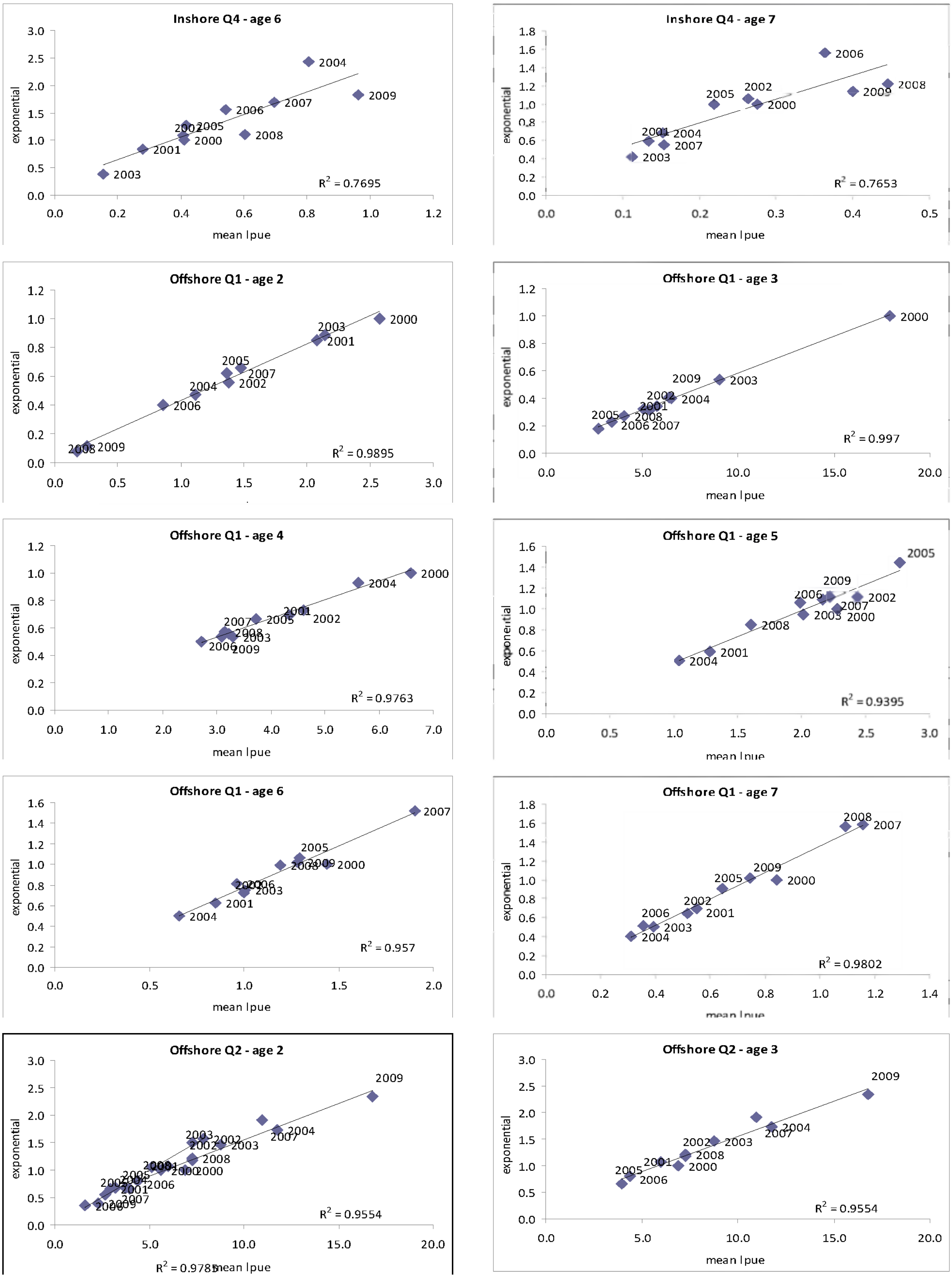


Figure 6.5. (continued). Bay of Biscay sole (Division VIIIa,b). Relationships between the exponential of GLM year factor and observed lpue for the four series (at age 2 to 7) which were considered the most interesting to be added in the tuning process.

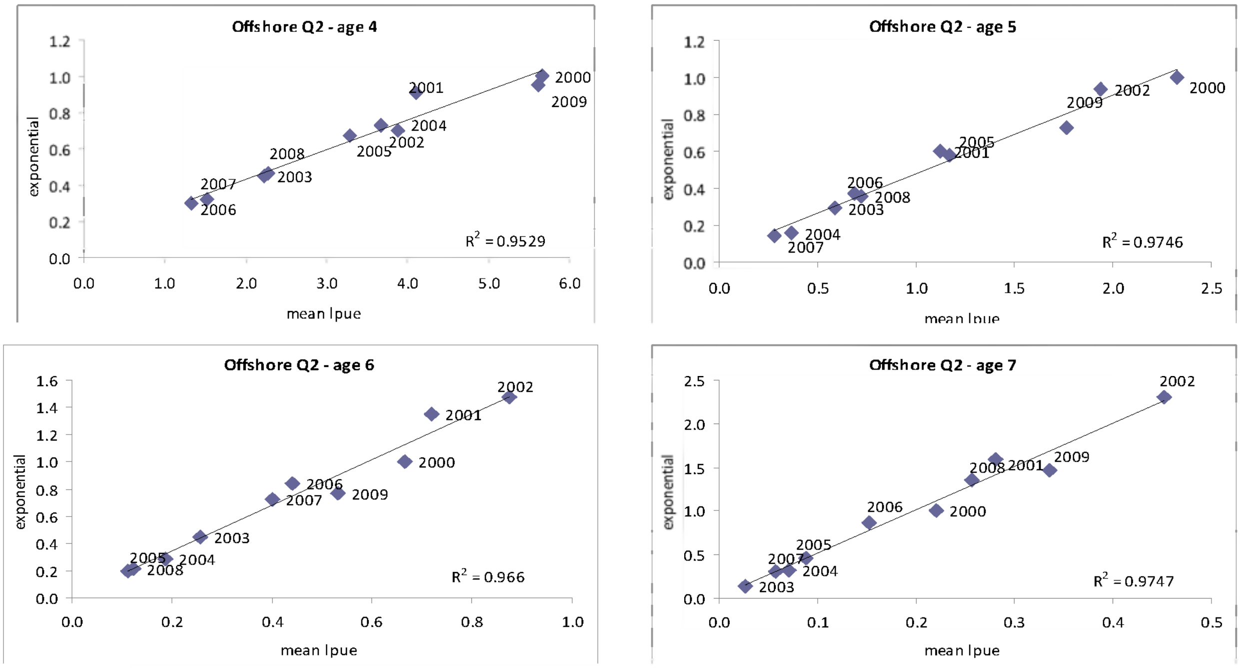


Figure 6.5. (continued). Bay of Biscay sole (Division VIIIa,b). Relationships between the exponential of GLM year factor and observed lpue for the four series (at age 2 to 7) which were considered the most interesting to be added in the tuning process.

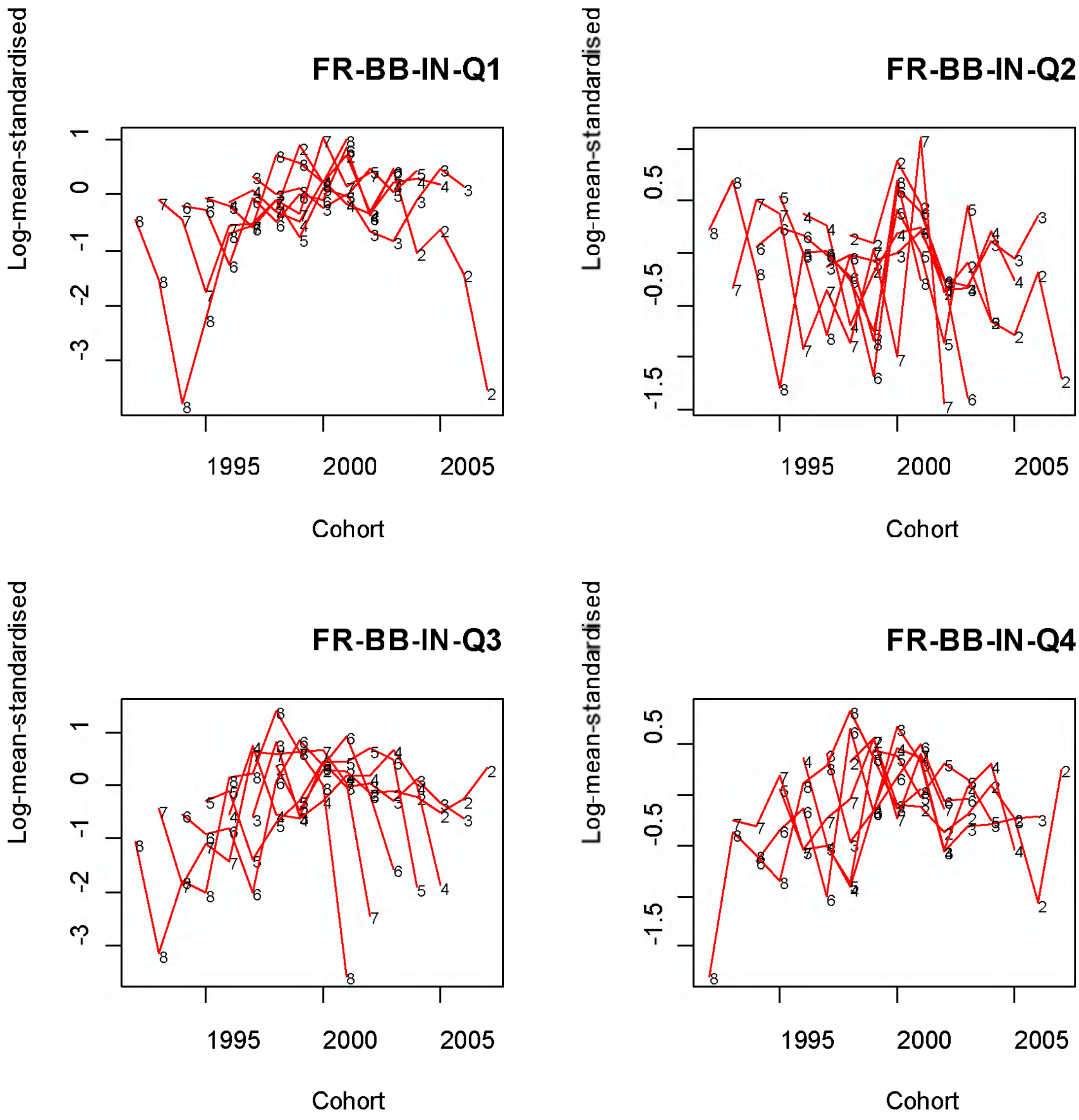


Figure 6.6 a. Bay of Biscay sole (Division VIIIa,b). Log mean standardized cpue at ages by cohort of the inshore fleet in each quarter.

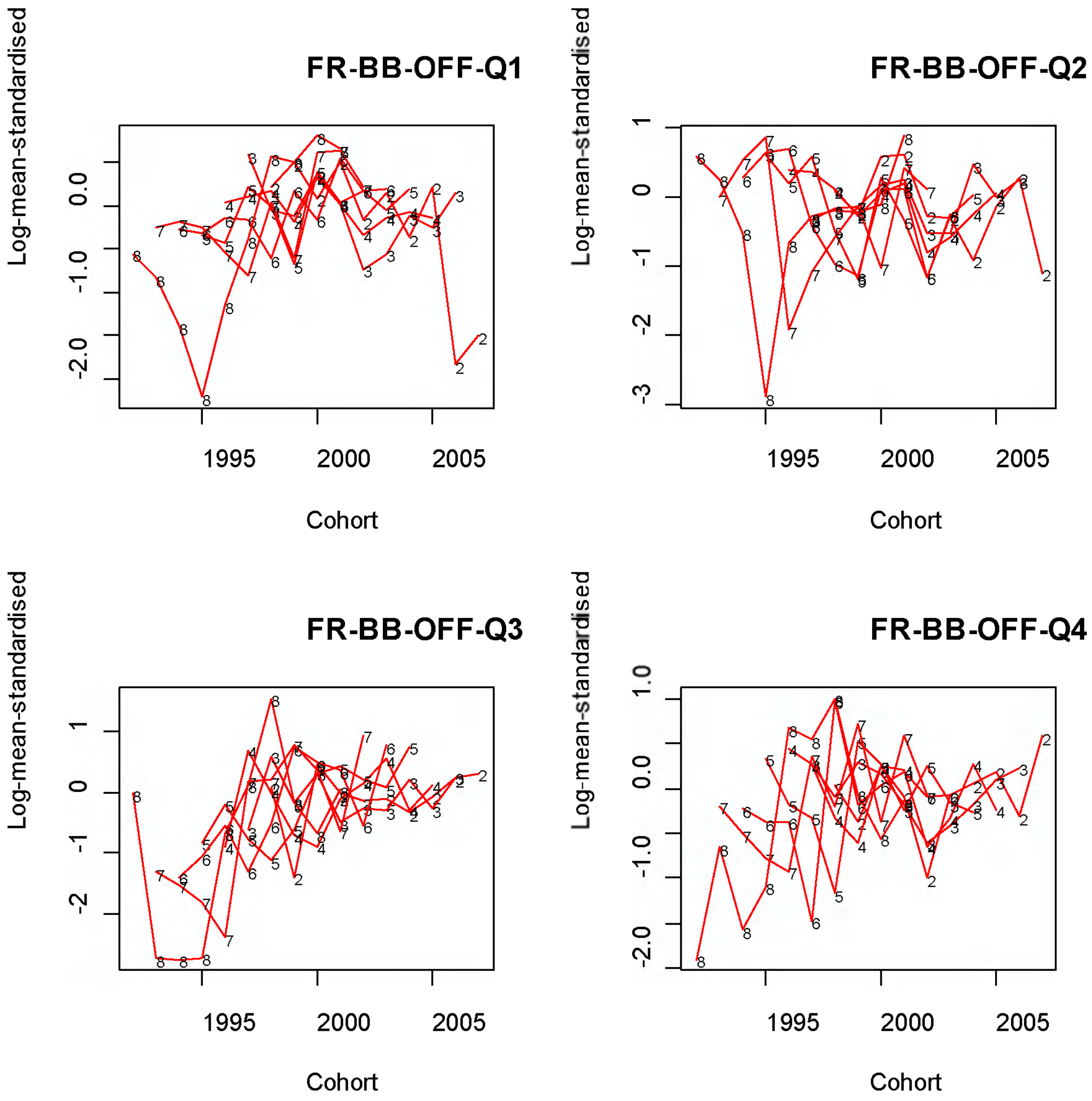


Figure 6.6 b. Bay of Biscay sole (Division VIIIa,b). Log mean standardized cpue at ages by cohort of the offshore fleet in each quarter.

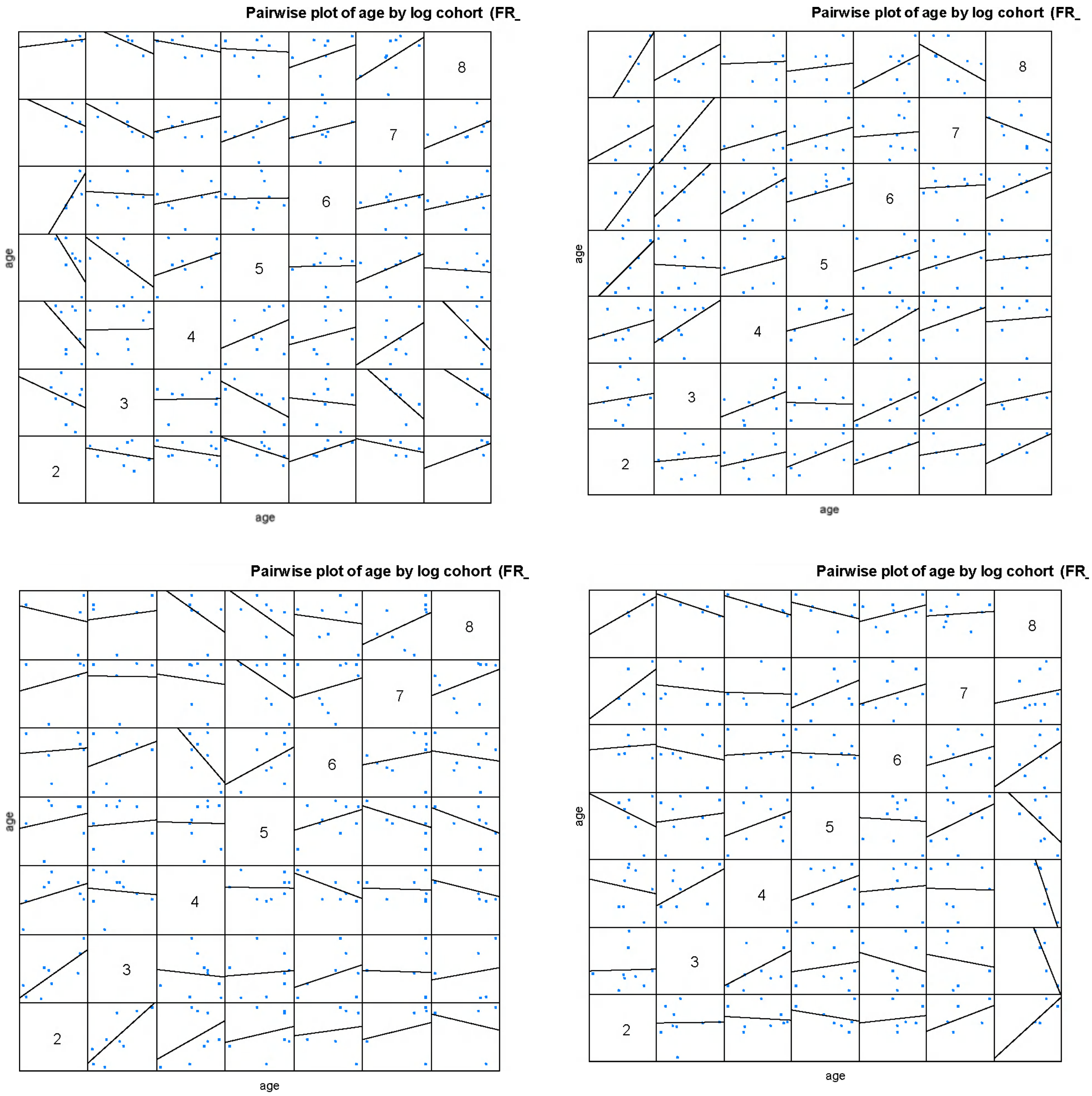


Figure 6.7 a. Bay of Biscay sole (Division VIIIa,b). Pairwise plot of Log mean cpue at ages of the inshore fleet in each quarter.

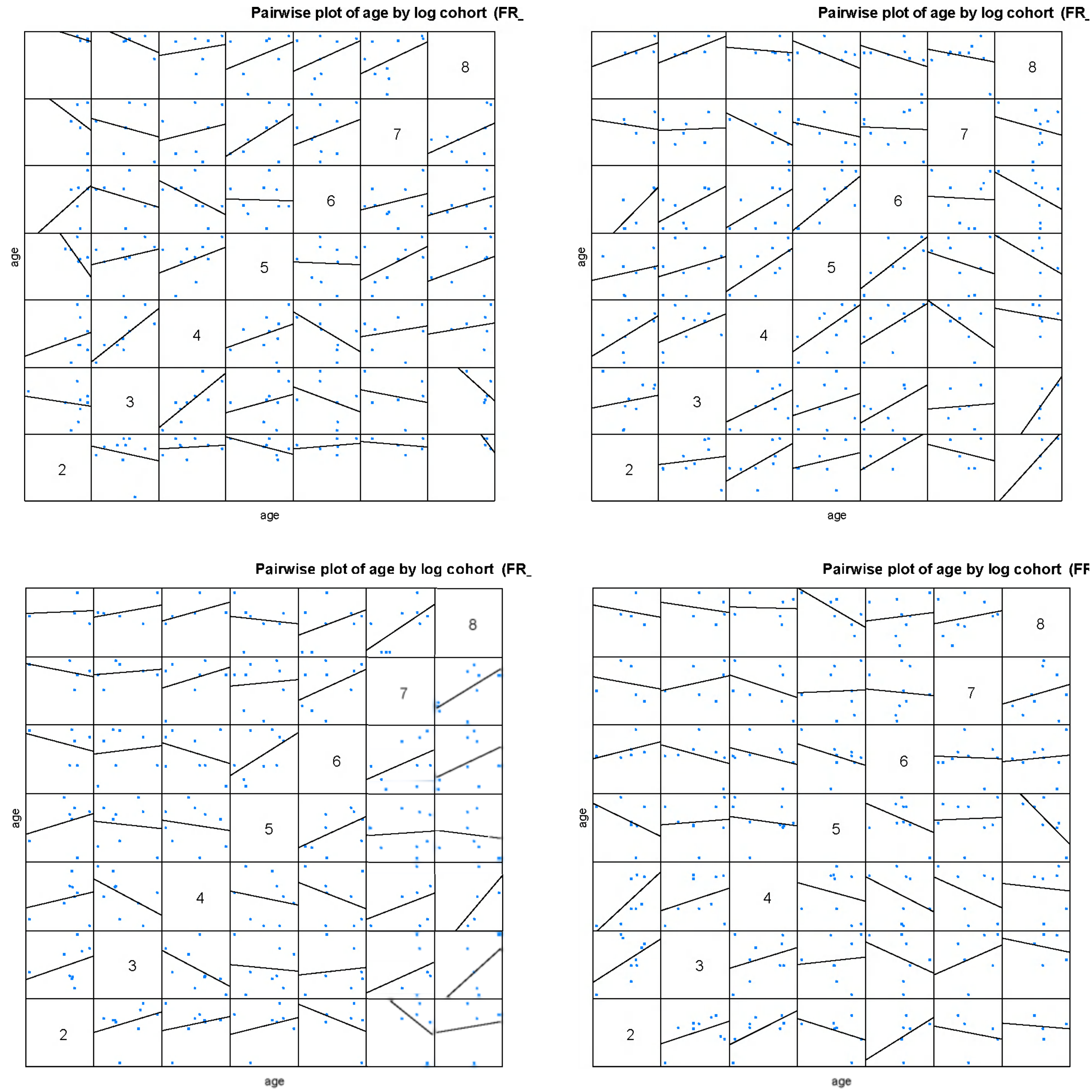


Figure 6.7 b. Bay of Biscay sole (Division VIIIa,b). Pairwise plot of Log mean cpue at ages of the offshore fleet in each quarter.

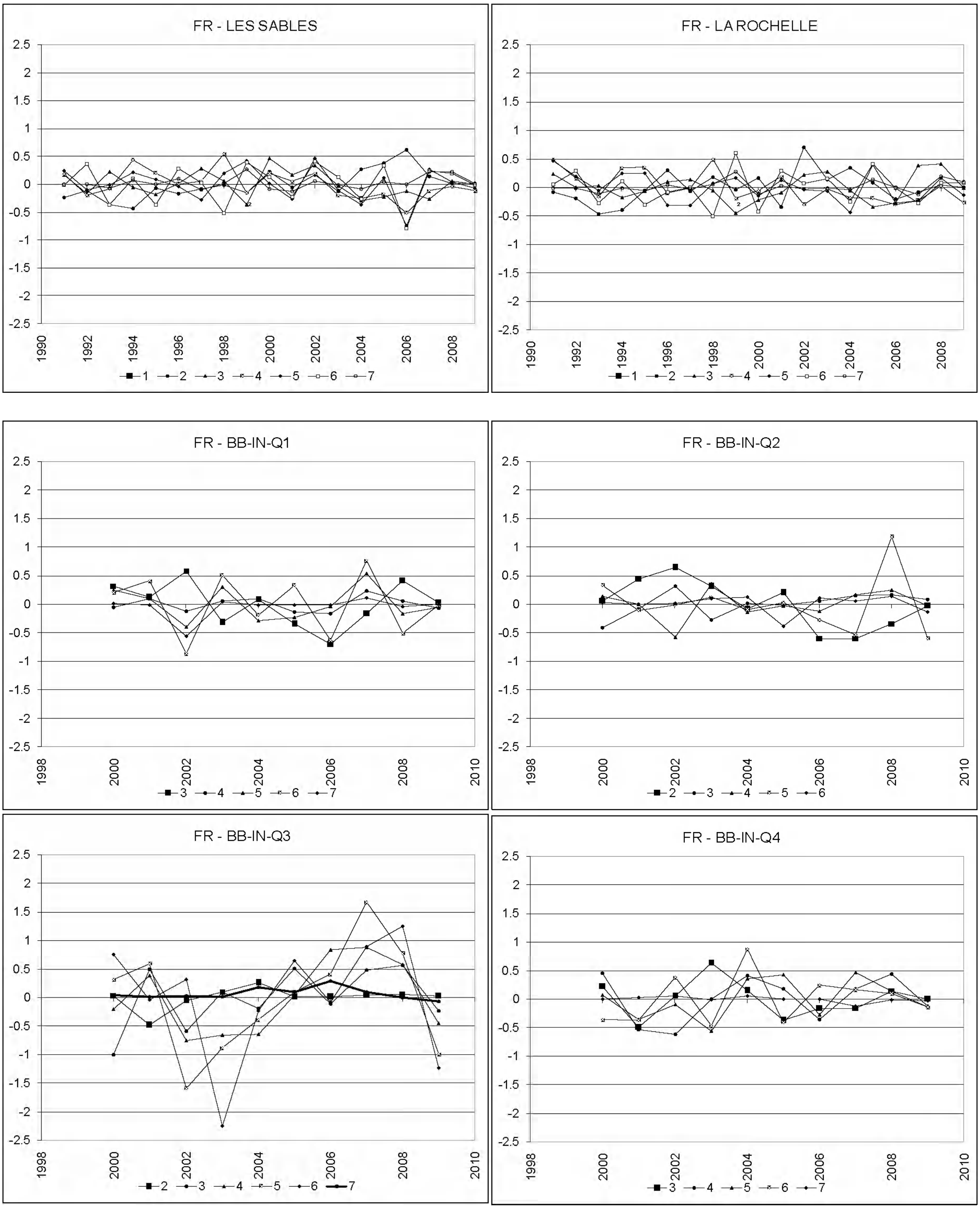


Figure 6.8. Bay of Biscay sole (Division VIIIa,b). Trend in XSA Log-catchability residual plots (No Taper, mean q, s.e. shrink = 2.5, s.e. min = .2) for individual runs.

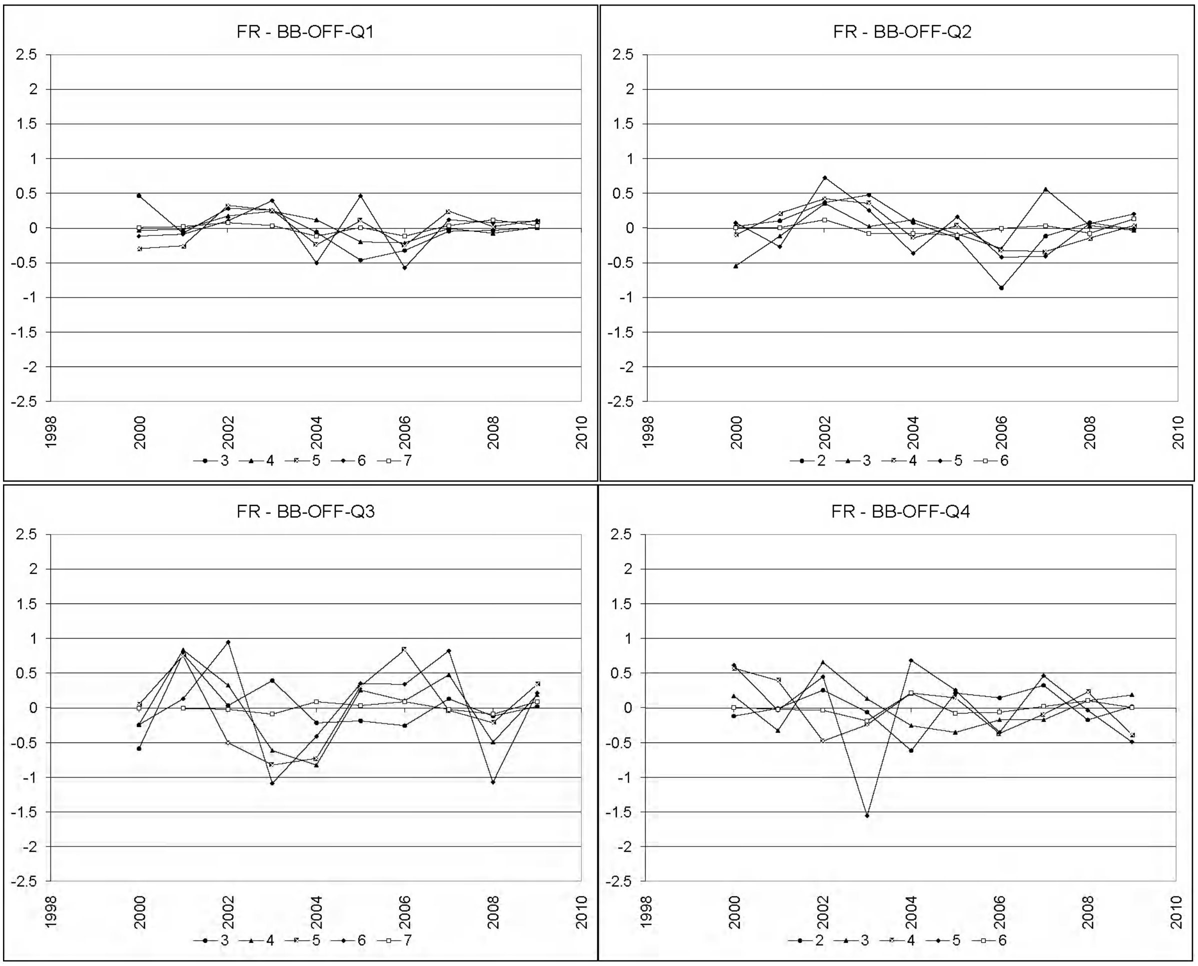
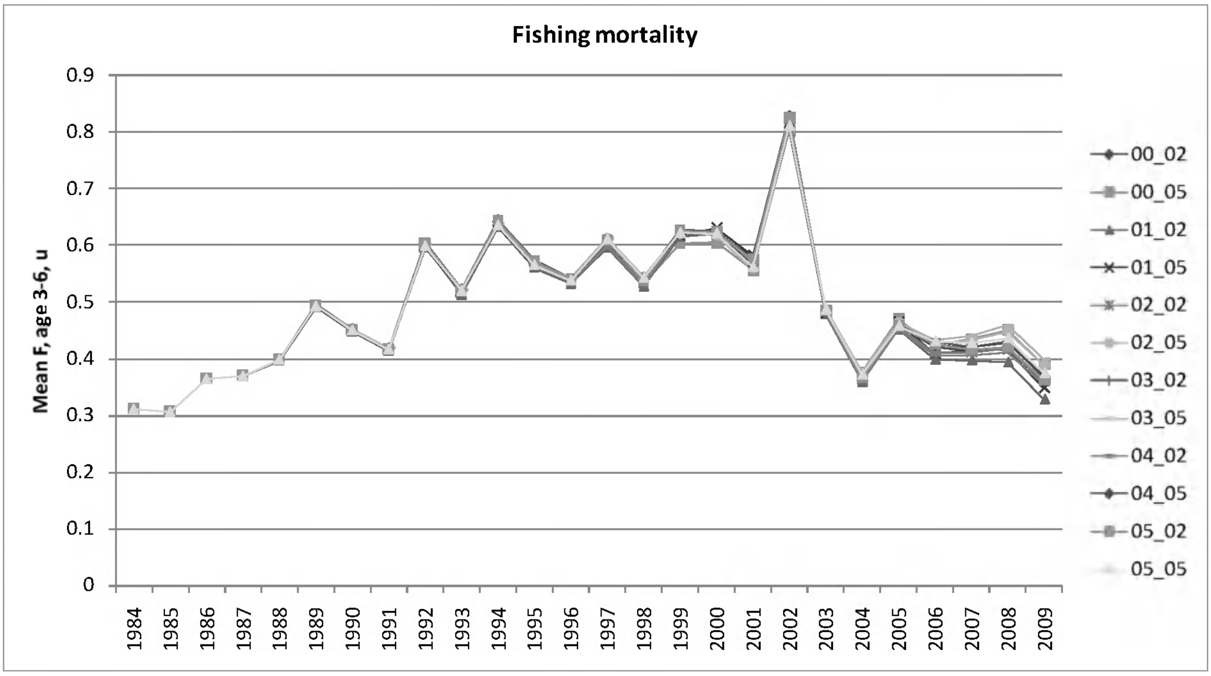


Figure 6.8 (continued). Bay of Biscay sole (Division VIIIa,b). Trend in XSA Log-catchability residual plots (No Taper, mean q, s.e. shrink = 2.5, s.e. min = .2) for individual runs.



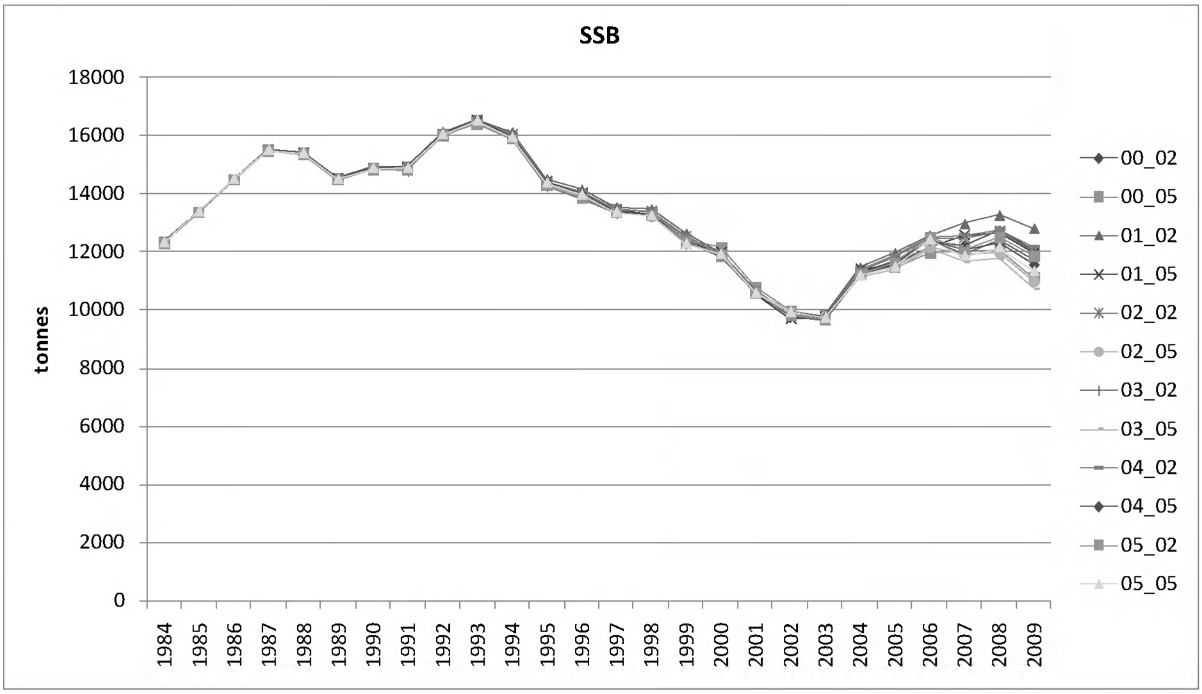


Figure 6.9. Bay of Biscay sole (Division VIIIa,b). Comparative trends in XSA outputs for the different settings adopted in the sensitivity analysis (details of setting are in Table 6.4).

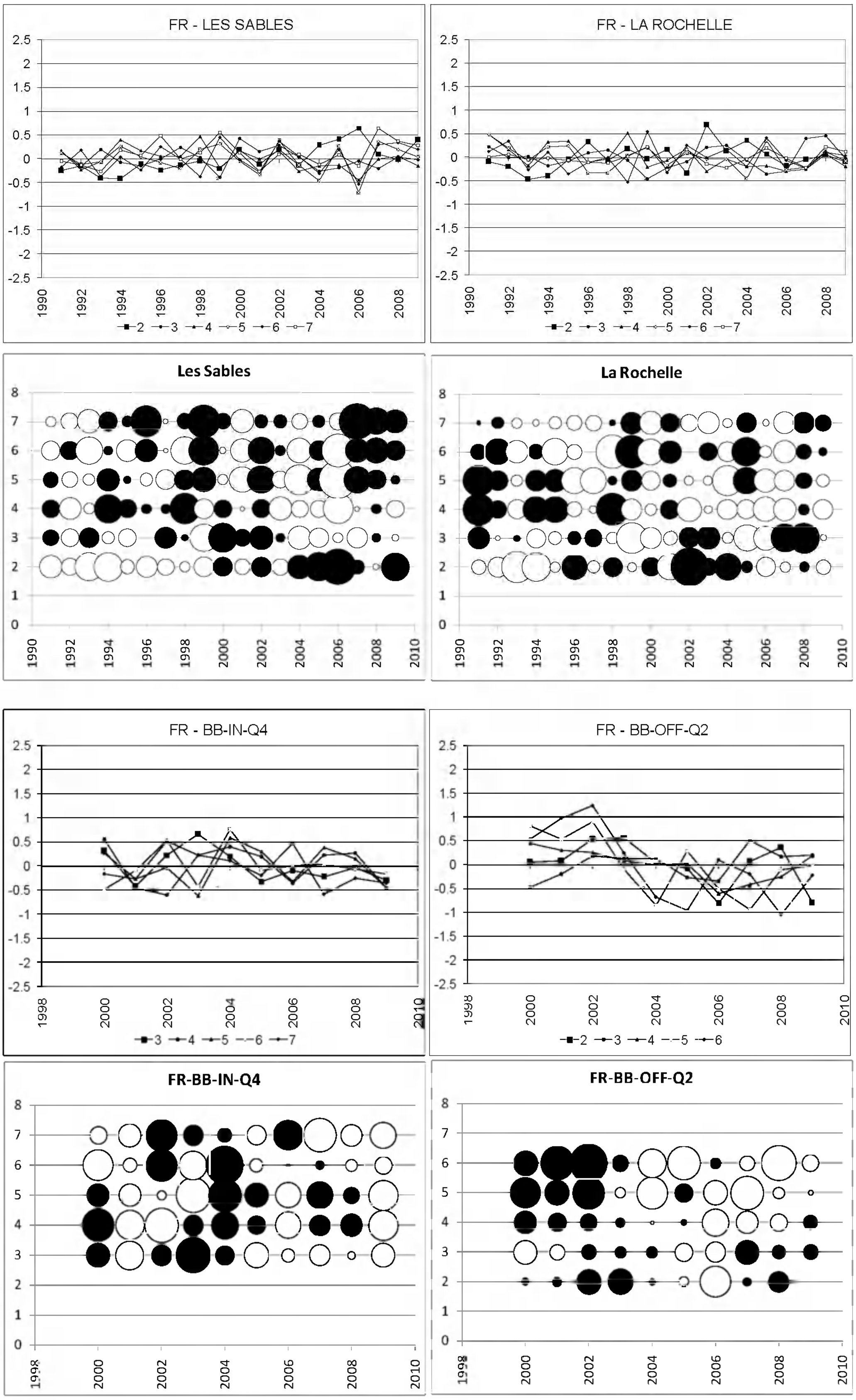


Figure 6.10. Bay of Biscay sole (Division VIIIa,b). XSA Log-catchability residual plots (No Taper, mean q, s.e. shrink = 1.5, s.e. min = .2) (positive in black).

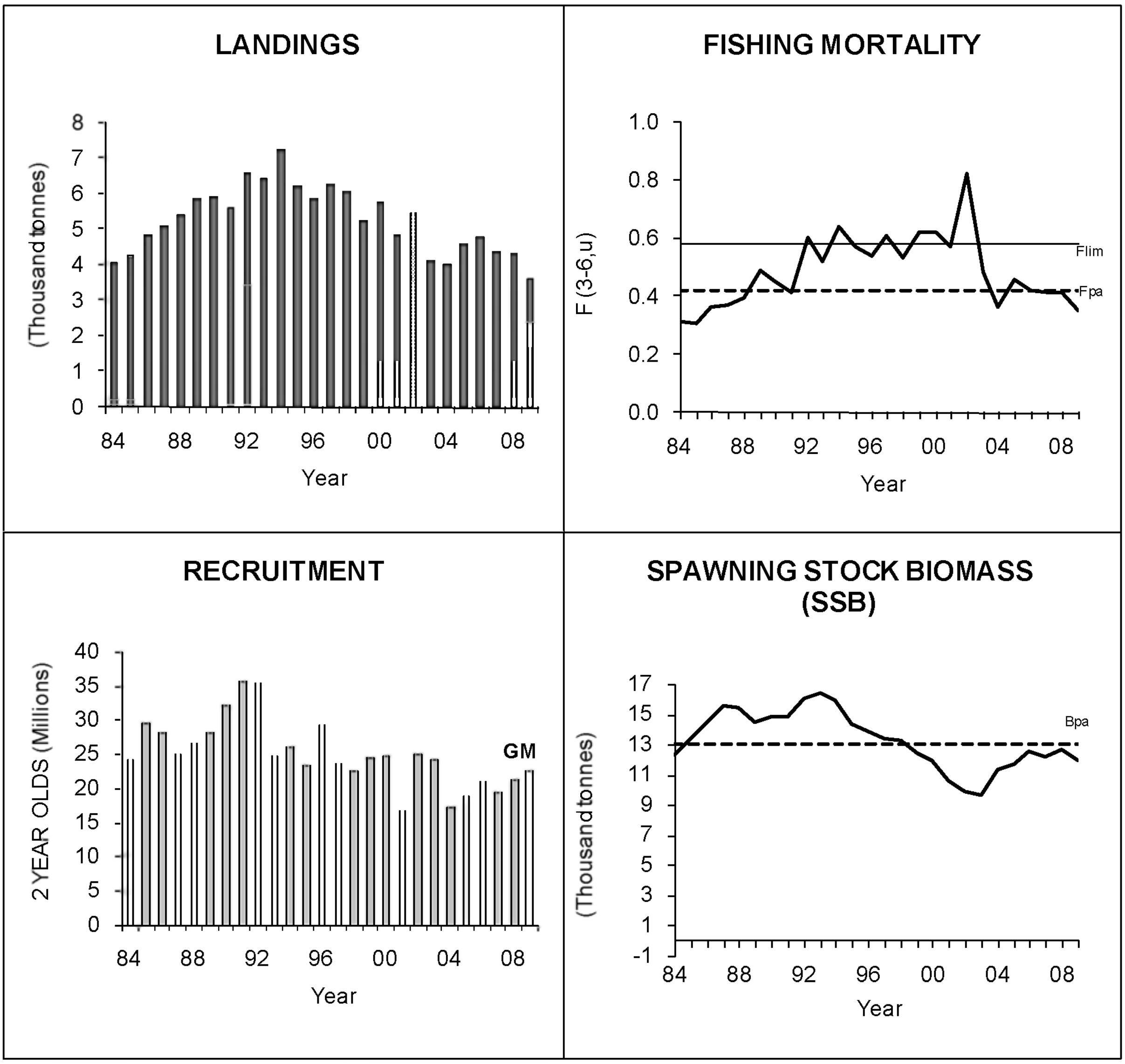


Figure 6.11. Sole in Division VIIIa,b (Bay of Biscay). XSA outputs.

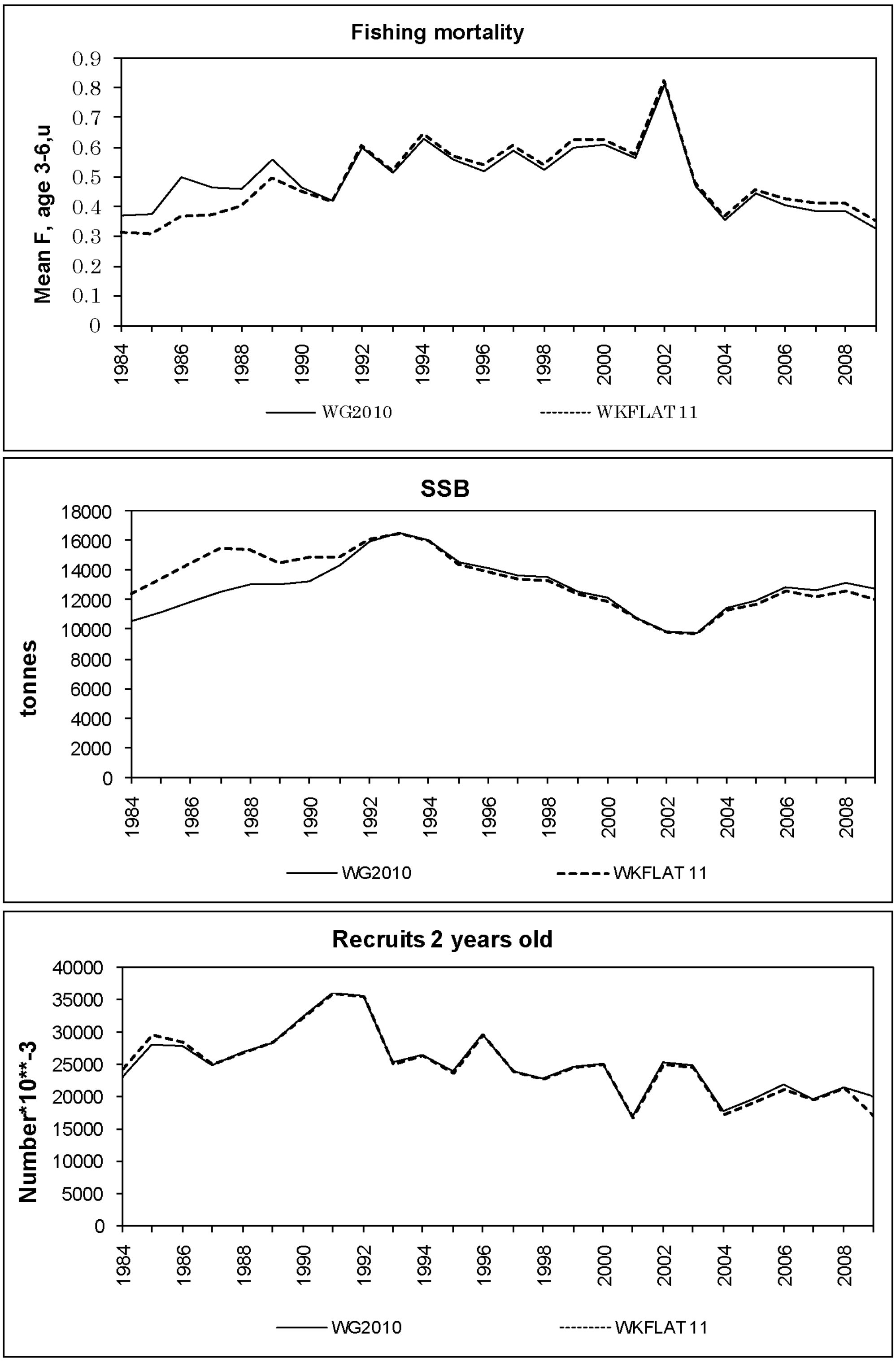


Figure 6.12. Bay of Biscay sole (Division VIIIa,b). WGHMM10/WKFLAT 11 comparison.

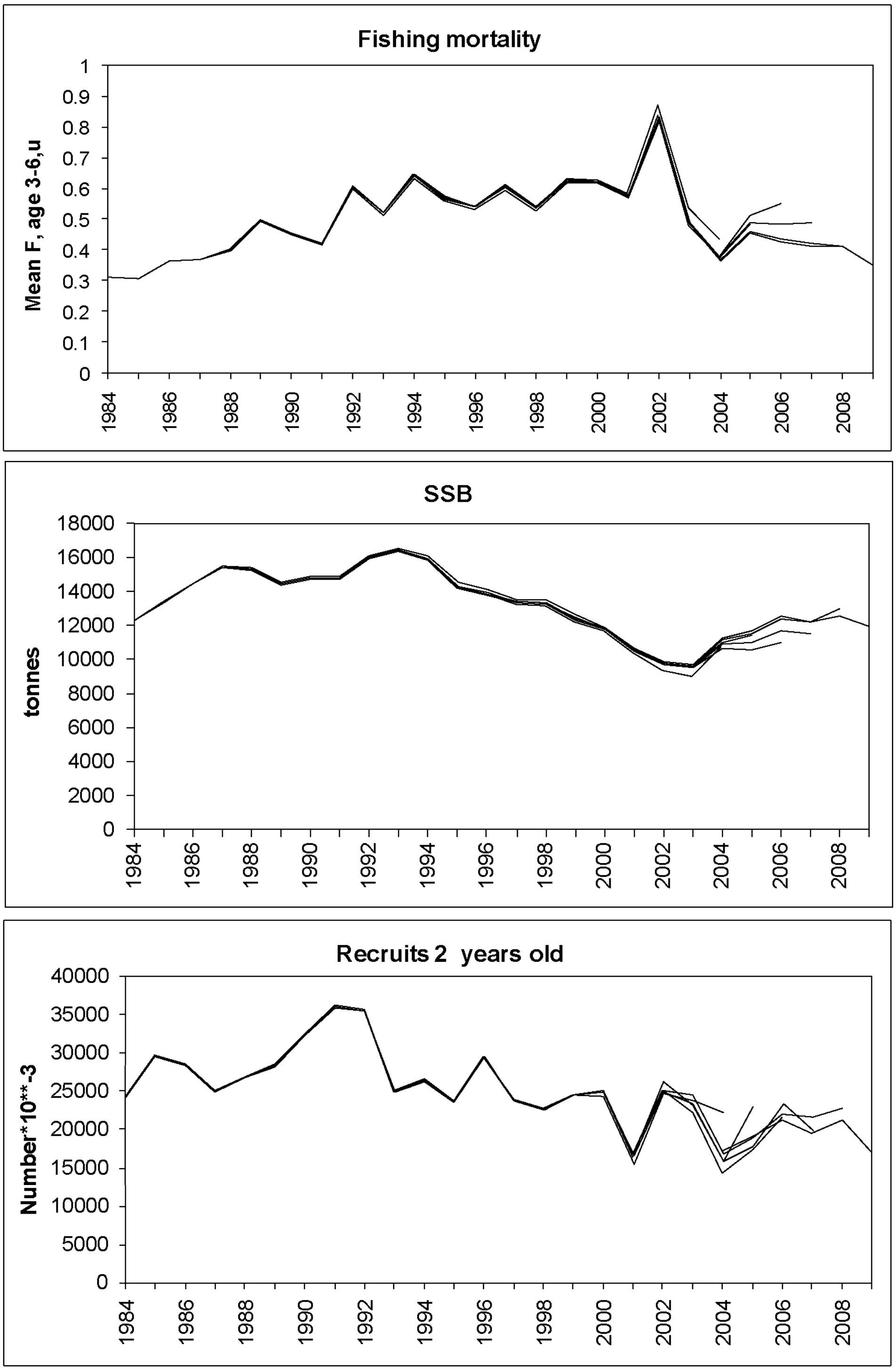


Figure 6.13. Bay of Biscay sole (Division VIIIa,b). Retrospective results (No taper, q indep. stock size all ages, q indep. of age>=6, shr.=1.5).

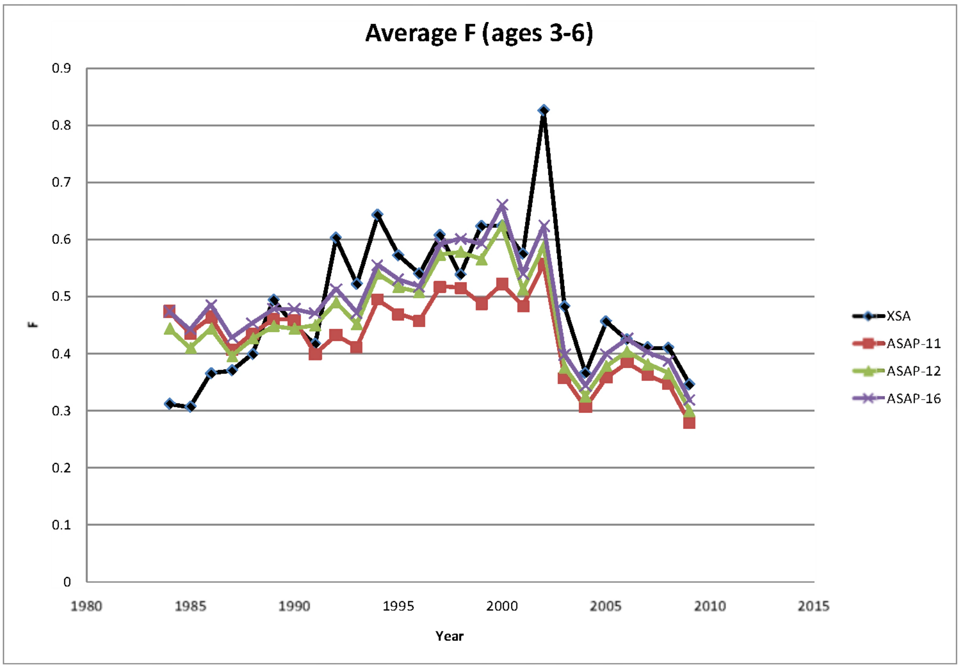


Figure 6.14. Bay of Biscay sole (Division VIIIa,b). Average F over ages 4–7 from the main assessment model (XSA, black line) and four formulations of ASAP (coloured lines).

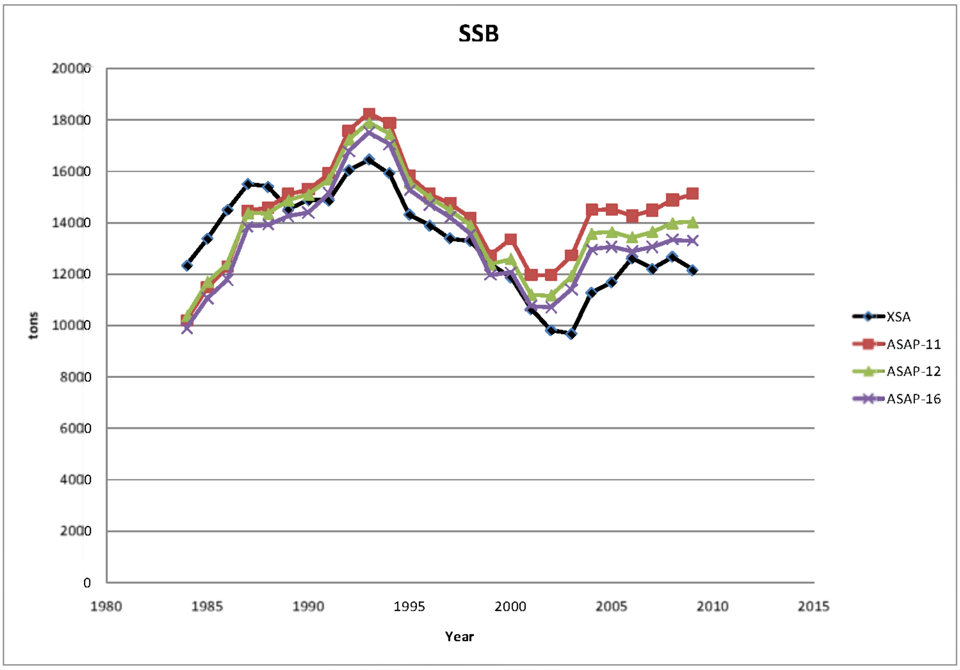


Figure 6.15. Bay of Biscay sole (Division VIIIa,b). Spawning–stock biomass (tons) from the main assessment model (XSA, black line) and four formulations of ASAP (coloured lines).

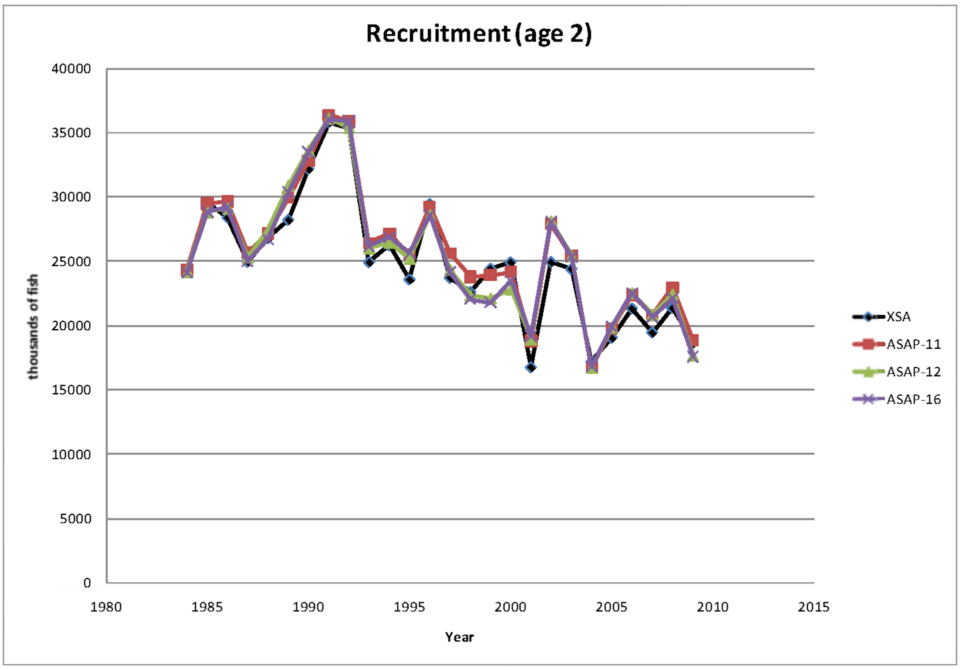


Figure 6.16. Bay of Biscay sole (Division VIIIa,b). Recruitment-at-age 2 (thousands of fish) from the main assessment model (XSA, black line) and four formulations of ASAP (coloured lines).

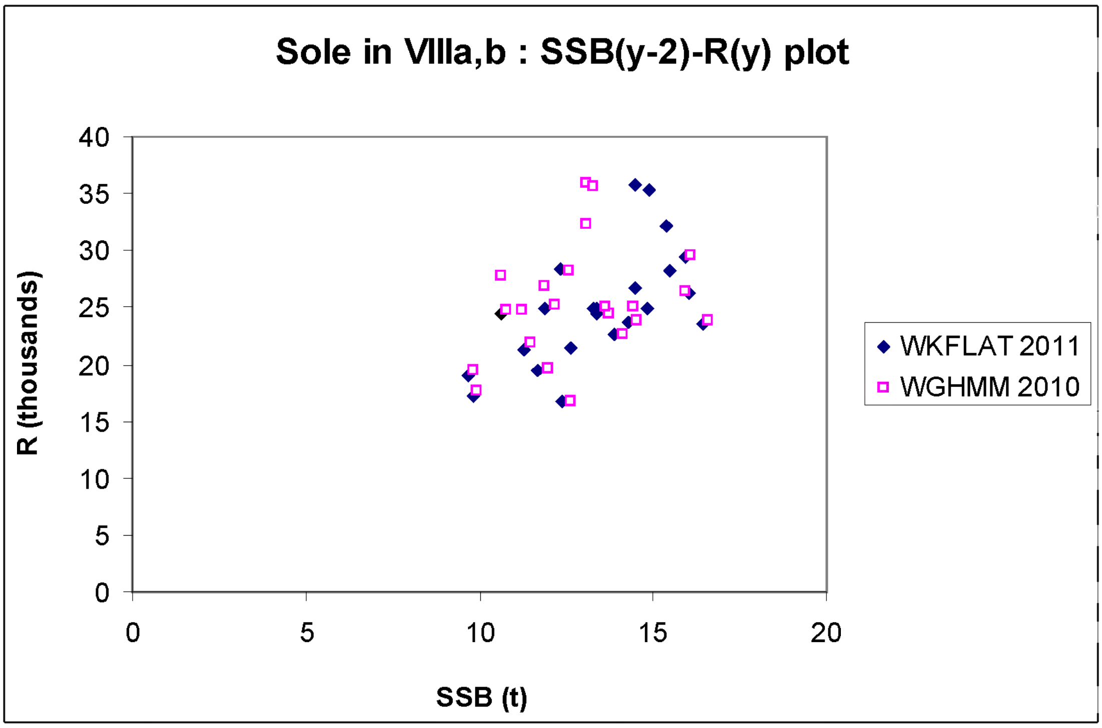


Figure 6.17. Bay of Biscay sole (Division VIIIa,b). Comparison of the SSB-R plots of the WKFLAT with the one of the 2010 WGHMM.

7 Megrim

7.1 Stock structure

As noted by WGNSDS (2008), megrim in IVa has historically not been considered by ICES. Only megrim in VIa was assessed (last agreed assessment [XSA} 1999). Megrim 'stock' structure in VI is uncertain and historically the Working Group has considered megrim populations in VIa and VIb as separate stocks. Data collected during an EC study contract (98/096) on the 'Distribution and biology of anglerfish and megrim in the waters to the West of Scotland' demonstrated significantly different growth parameters and significant population structure differences between megrim sampled in VIa and VIb (Anon, 2001). Spawning fish occur in both areas but whether these populations are reproductively isolated is not clear. Megrim in IVa has historically not been considered by ICES, but since 2009 data from IV and IIa are now considered by the ICES Working Group on the Celtic Seas Ecoregion (WGCSE, 2008). However, advice is provided on the basis of two separate 'stocks' in VI and IV. While there is some population structure evidence and physical separation to suggest that VIb is separate from VIa, there is little evidence to suggest that megrim in VIa and IVa are separate. Here we consider whether megrim in VIa and IVa belong to two separate stocks.

Analysis of spatially explicit commercial catch data indicates little evidence of a discrete break in catches between the northern part of VIa and IVa. (Figure 7.1). While there is a clear separation in the catches between VIa and VIb due to the presence of the deep-water Rockall trough, catches along the northern part of VIa and western part of IVa appear continuous.

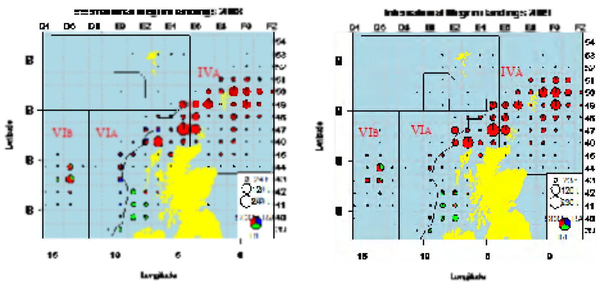


Figure 7.1. Catches (landings) by statistical rectangle in ICES Subdivisions VIb, VIa and IVa longitudinal boundary between VIa and IVa is at 4 degrees.

Analysis of cpue rates from both the IBTS Q1 and Q4 fishery-independent surveys (Figure 7.2), a dedicated anglerfish/megrim survey conducted in 1999 (Figure 7.3) and the Industry Science Partnership Anglerfish survey (Figure 7.4) all indicate continuous catches of megrim along the shelf break (200 m) and on the shelf area.

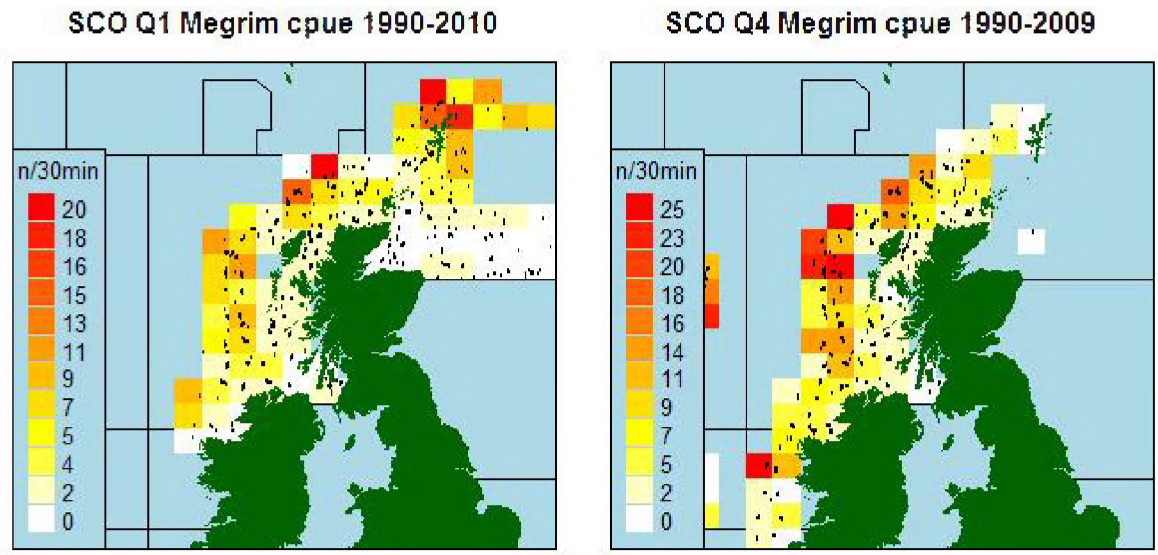


Figure 7.2. Catch rates of megrim in VIa and IVa from the Scottish ALT_IBTS data (source DATRAS).

Earlier work by Anon (2001) from dedicated megrim and Anglerfish surveys, demonstrate continuous catches of megrim along the shelf break in VIa and IVa (figure 7.3).

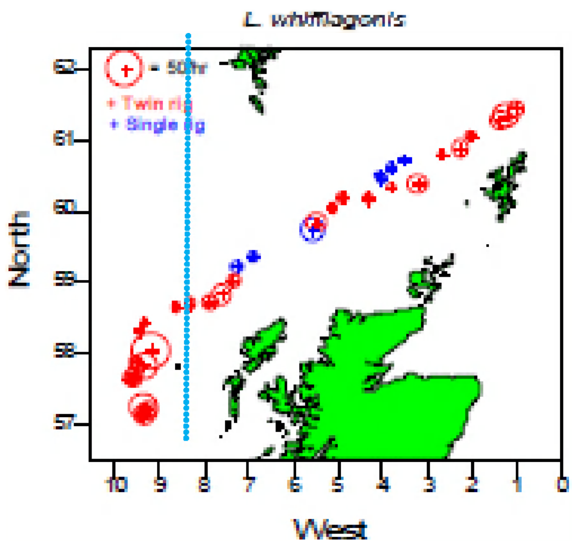


Figure 7.3. Catch rates of *L. wiffiagonis* (numbers per hour) along the shelf break in VIa and IVa. The longtitudinal split between VIa and VIa is 4 degrees shown by the vertical dashed line. From Anon (2001).

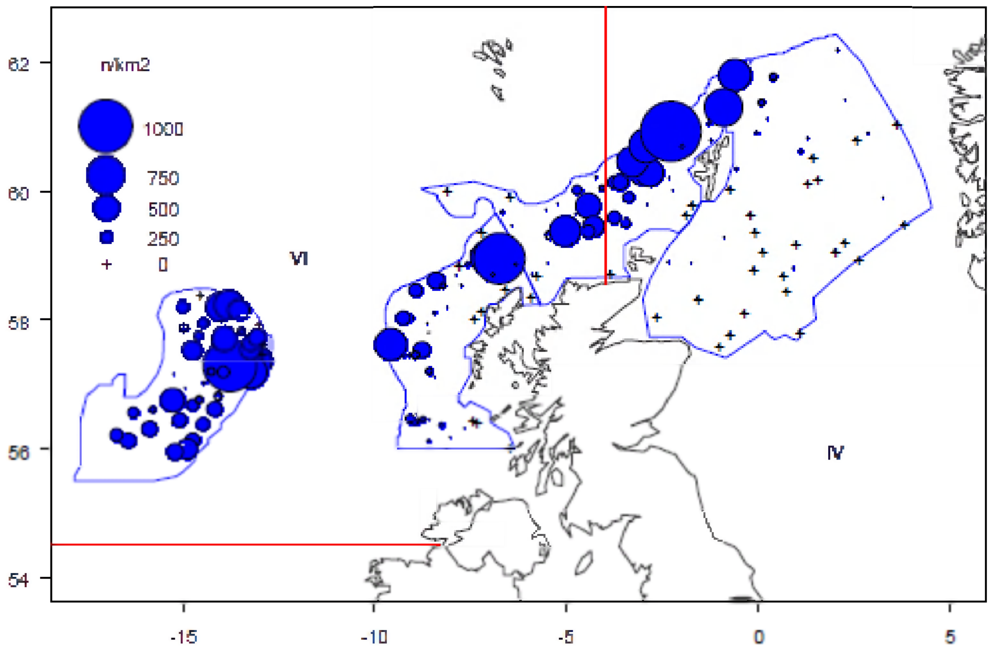


Figure 7.4. Catch rates (n.Km²) from the Scottish and Irish Anglerfish Survey (WCCSE, 2009).

While there may be no discernible split between VIa and IVa based on a visual inspection of the above figures, unfortunately there is no known genetic analysis available to ascertain whether the stocks are biologically separate. However, mapping of the location of spawning megrim conducted during 1999 and 2002 presented by Anon (2001) indicates continuous catches of spawning females across both VIa and IVa.

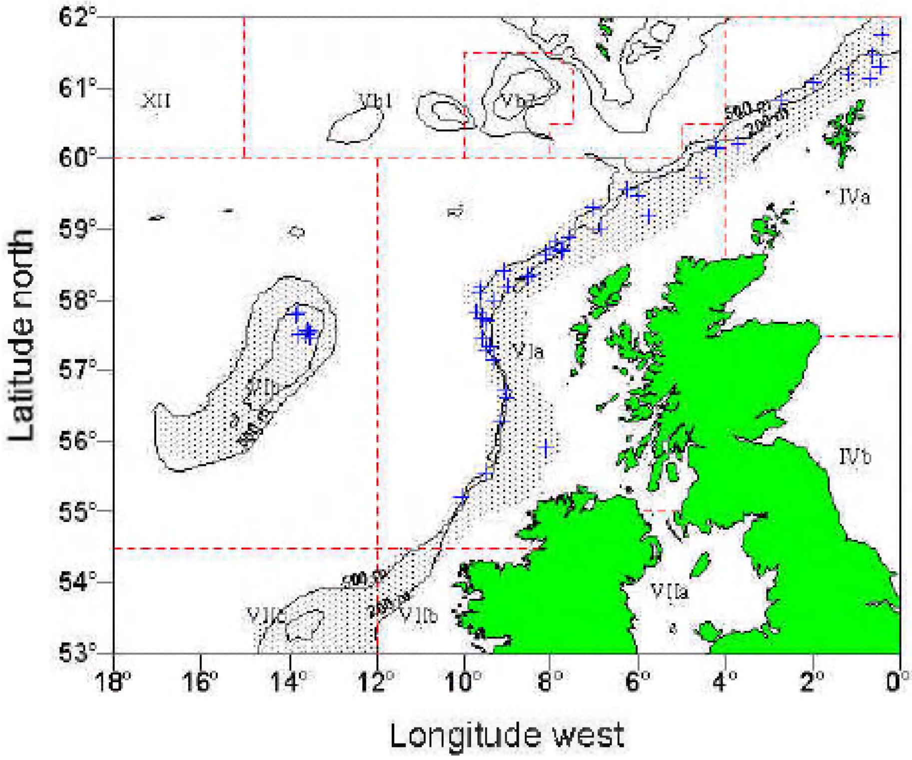


Figure 7.5. The hypothetical spawning grounds (shaded area) for female megrim that were caught in Subarea VI. (Capture locations of spawning fish during 1999 and 2000 as indicated by +.) From Anon (2001).

Analysis of the length and age compositions between VIa and IVa may provide some information, but it is important to remember that there is depth-dependent differences in growth as well as and therefore if differences exist between areas this may simply be due to these depth-dependent differences.

Analysis of the weighted mean length of megrim retained in the Scottish IBTS surveys conducted in VIa, VIb and IVa reveals no indication of differences in mean length.

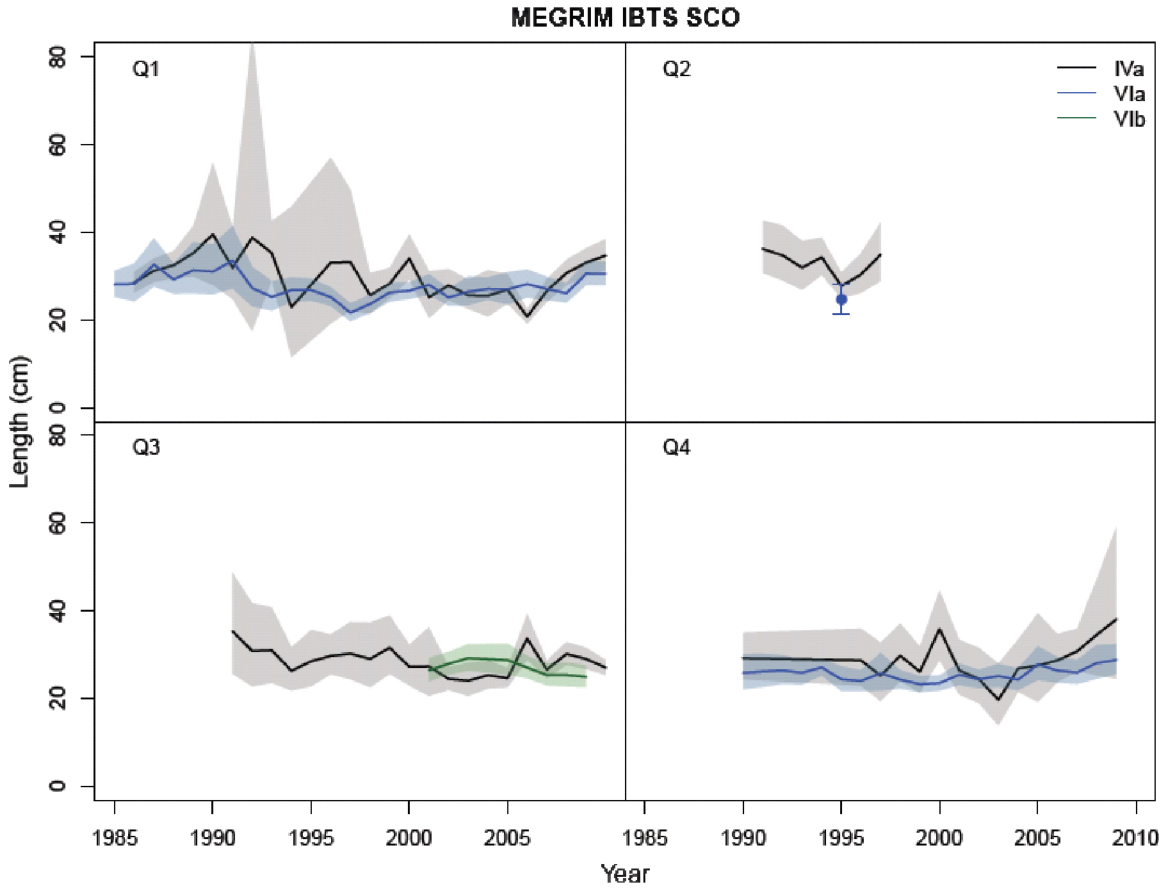


Figure 7.6. Comparison of weighted mean length between Scottish quarter 1 and 2 surveys and quarter 3 and 4 surveys in VIa, VIb and IVa.

A similar analysis contrasting the weighted mean length of megrim caught in the Scottish/Irish Anglerfish survey reveals no significant difference (with the exception of 2006) in mean lengths of megrim caught in VIa or IVa.

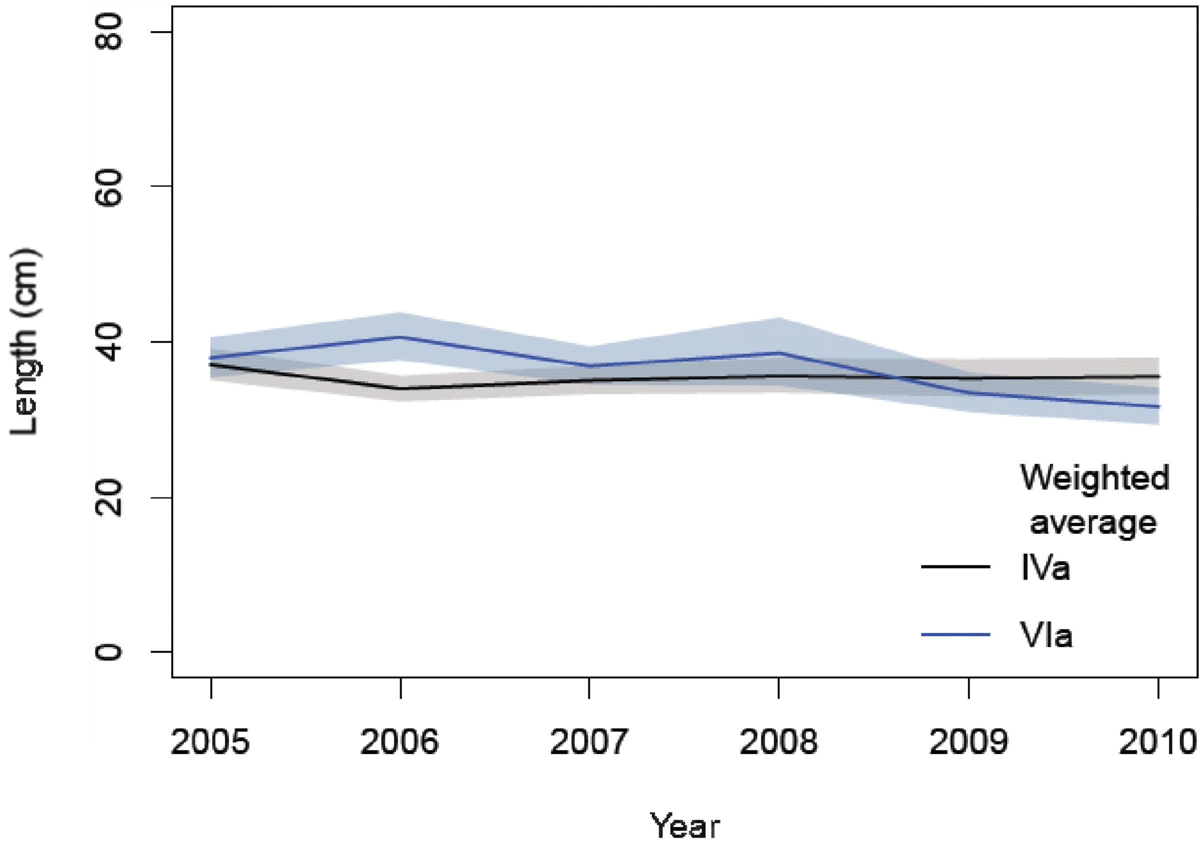


Figure 7.7. Comparison of weighted mean length between megrim caught in IVa and VIa from the Anglerfish survey.

Based on the above, there is no clear evidence to suggest that megrim in VIa and IVa constitute separate stocks and WGFLAT considers that any future assessments should be undertaken on the basis that megrim in VIa and IVa be considered as a single stock. Due to the significantly different growth parameters, population structure and the geographical separation, megrim in VIb should continue to be treated as a separate stock.

Anon (2002) observed differences in growth within ICES areas and Gerritsen *et al.* (2010) observe depth-dependent differences in growth within ages. It is therefore important that countries continue sampling for ages across the full distribution of the fishery in VIa and IVa.

Contrast of commercial length and age distributions in VIa and IVa

Raised landings number-at-age for VIa were available from Ireland and the UK for the period 1990 to 2009, with the exception of 2005 data from the UK. The earlier component of the time-series (pre 2000) aggregated landings-at-age across VIa and VIb using a combined ALK, unless raw sampling data with associated subdivision data, it is not possible to re-split the earlier part of the time-series into separate VIa and IVa components. Landings-at-age data from VIb is only available from certain years.

For IVa, raised catch numbers-at-age were made available for 2006–2009, but no data prior to 2006 was made available. Figures 7.6–7.7 contrast the commercial length and age distributions from VI and IVa obtained from UK market sampling. With the exception of the most recent data (2009) there is no data available to assess the variability in the sampling data between areas. Sampling levels from VIa during 2006 are very low and the landings numbers-at-age were not provided. The data presented from the other years displays no clear pattern between VIa and IVa. Contrasting the length and age distributions between areas, with the exception of 2007 where more smaller fish are retained in IV, there is no difference in cumulative length between years. The cumulative age plots indicate no difference in age selectivity in 2008, more younger fish retained in IV in 2007, with the converse being true in 2009, where younger fish were caught in 2009.

However, given the wide confidence intervals in the 2009 data neither the age or length selectivity data should be over interpreted; it is not possible to say with any degree of certainty whether there are any significant differences in length and age selectivity between the two areas. Further analysis is required based on the raw age sampling data. Until such analysis is completed based on data from the UK being made available, applying ALKs derived from VIa to derive a time-series of landings numbers-at-age in IVa will be subject to question. Any further work to generate commercial catch numbers-at-age combined across VIa and IVa depends on the data being made available.

Comparison of survey and fishery length and age selectivity

Figure 7.8 shows a comparison of the cumulative length frequency from the Anglerfish survey length data and from the megrim length distribution from the commercial fishery based on market sampling data.

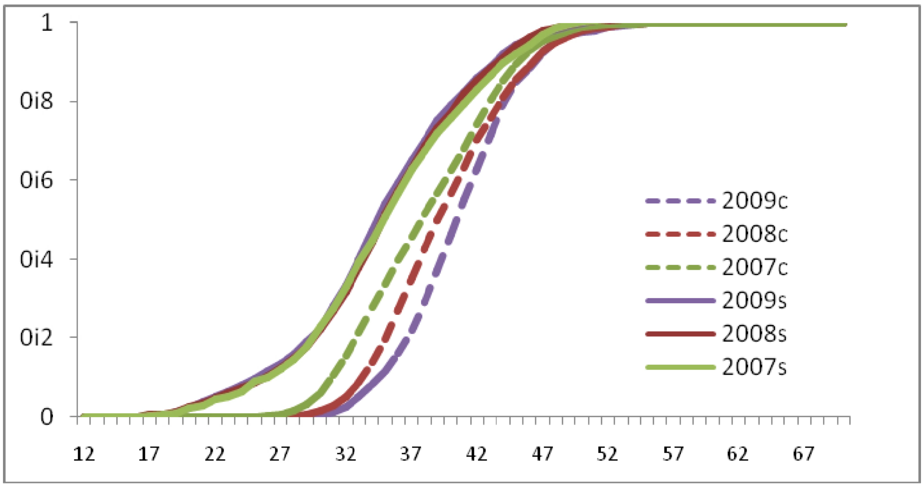


Figure7.8. Comparison of cumulative length frequency between the Anglerfish survey and commercial catch data for 2007 to 2009. Commercial catch data are denoted by 'c' while the survey data are denoted by 's'.

There is no apparent shift in the length distribution of megrim caught over the period 2007 to 2008 indicating that the length distribution is very stable over the time period. However, there is an apparent shift in the selectivity of the fleet over the same time period. Given that there were no changes in technical regulations governing mesh size during the period, and the survey data suggests a stable length distribution, this suggest that there may have been a change in targeting behaviour over the period., although this could also be an artefact of market sampling. What is also evident from the figure is that the survey catches more smaller fish than revealed in the commercial landings. This could be due to the smaller codend mesh size (100 mm) compared with the current MMS (120 mm) and length based discarding in the commercial fishery.

In order to understand whether the apparent sequential change in selectivity is associated with a change in spatial activity and how this can be considered in any future age or surplus production assessments, it would be important to understand and factor these changes. A time-series of spatially explicit catch and effort for the main fleets is required. This has been an ongoing recommendation from the former ICES Working Group on Northern Shelf Demersal Stocks (2002; 2003; 2004; 2005; 2006; 2007) and the Working Group on the Celtic Seas Ecoregion (2008; 2009).

Analysis of VIa landings numbers-at-age

Exploration of catch numbers-at-age for use in age based models was undertaken. A full catch-at-age matrix has not been available for VIa megrim since 2002 and there in matrix available for IVa or VIb. Landings-at-age are available for IVa since 2006. Given the lack of historical age sampling from IVa, an initial analysis of the commercial landings numbers-at-age from VIa only was undertaken. Analysis using FLEDA for both Scottish and Irish landings numbers separately.

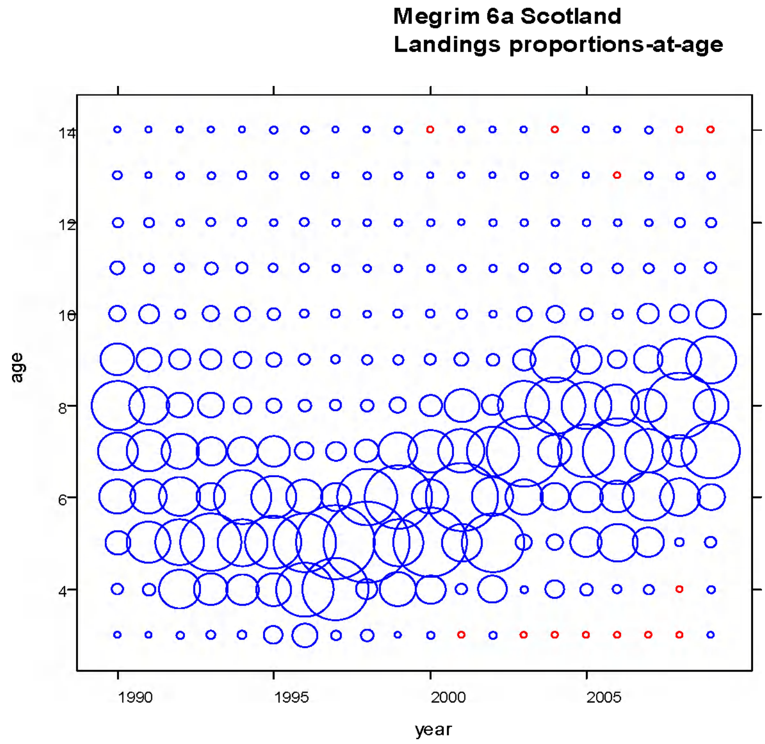


Figure 7.9. Landings proportion at age for Megrim in VIa

Figure 7.9 Shows that in the most recent year There has been an increase in the most recent years in the mean age in the landings since about 2003 onwards (Figure 7.9). This may be due to changes in selectivity associated with changes in fleet dynamics and changes in mesh selectivity which occurred during this period.

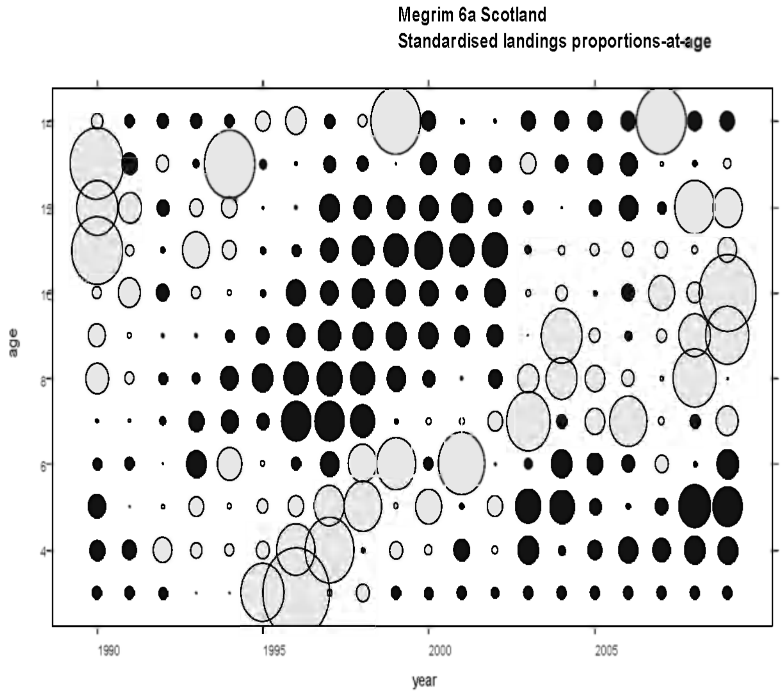


Figure 7.10. Standardized landings proportion at age for Megrim in VIa

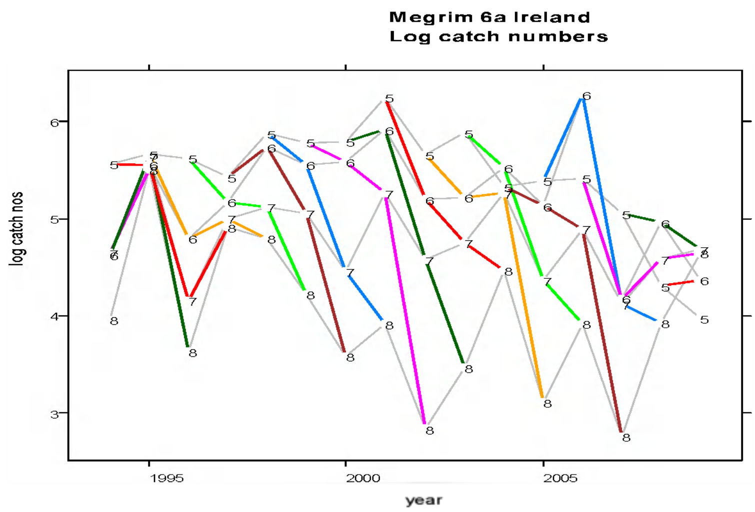


Figure 7.11. Megrim in Via: log catch numbers by cohort

Exploratory model testing

Given the poor cohort tracking evident in recent years, two non-equilibrium surplus-Production methods were investigated.

1) ASPIC (Prager, 2005); NOAA Toolbox.

2) Bayesian state-space implementations of the Schaefer surplus production (Meyer and Miller, 1999; Davies and Jonsen, 2008).

Initial runs focused on VIa megrim only using four survey time-series (Q1 [1985–2010] and Q4 ATL_IBTS [1990–2009) and the VIa anglerfish survey [2005–2010] and using the available landings data. From 1990 to 2008, WGNSDS/WGCSE corrected officially reported landings data for area misreporting. In the analysis presented here, the corrected data as used by the WG is used.

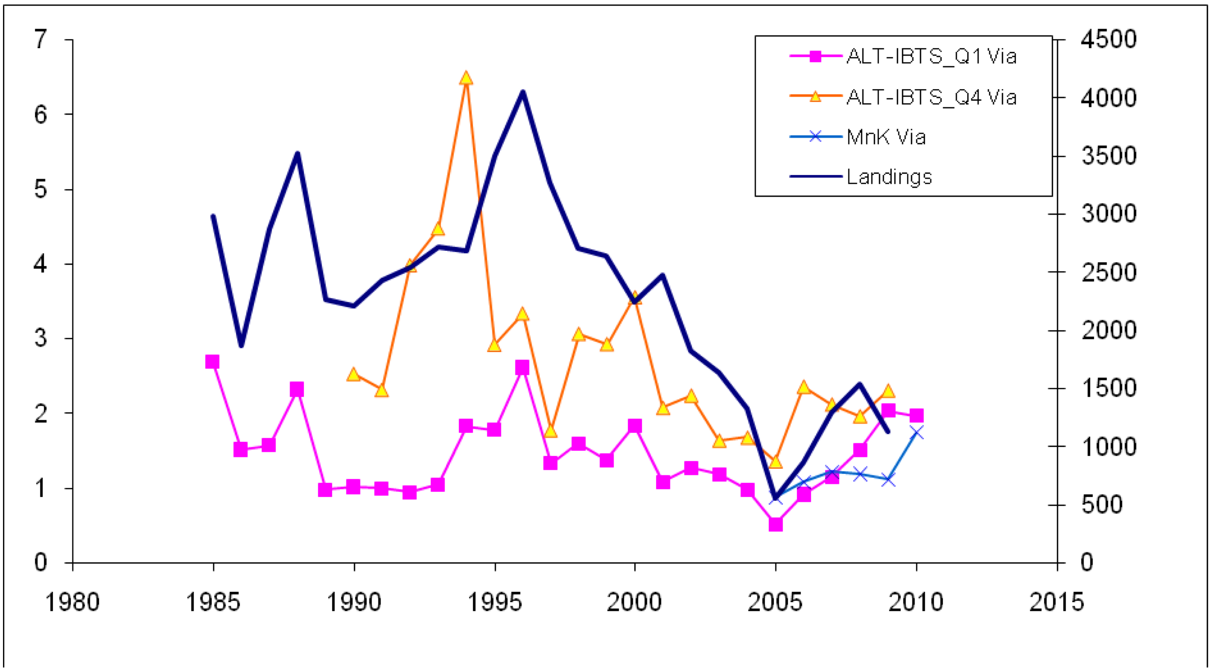


Figure 7.12. Survey time-series for Megrim in VIa.

Runs with ASPIC demonstrated that the outputs were highly sensitive to starting guesses for K, MSY and min/max ranges. Large differences between runs with same time-series data with different starting estimates were found and the model predicted K converged at the initial starting guess max (both) and the predicted MSY converged at initial starting guess MSY max (run 1) (Figure 7.13 and Table 7.1). For both runs, unrealistically low F/F_{msy} and B/B_{msy} ratio estimates were returned.

Table 7.1. Starting estimates (in italics) for two ASPIC runs with associated model output estimates.

Run	1	2
Kinit	*10 000*	*22 896*
Kmin	*5000*	*2290*
Kmax	*40 000*	*457 912*
MSYinit	*2500*	*2290*
MSYmin	*1000*	*229*
MSYmax	*4000*	*45 791*
B1/K	*0.40000*	*0.50000*
q1init	*0.00012*	*0.00012*
q2init	*0.00023*	*0.00023*
q3init	*0.00092*	*0.00092*
K	40 000	457 900
MSY	4000	29 170
MSE	0.11550	0.13450
contrast	0.15010	0.33050
nearness	0.74220	0.51990
q1	0.00020	0.000003
q2	0.00040	0.000006
q3	0.00191	0.000024
B1/K	0.21180	1.31100
B2010/Bmsy	0.40760	1.97600
F(2009)/Fmsy	0.7549	0.0196
Fmsy	0.20000	0.12740

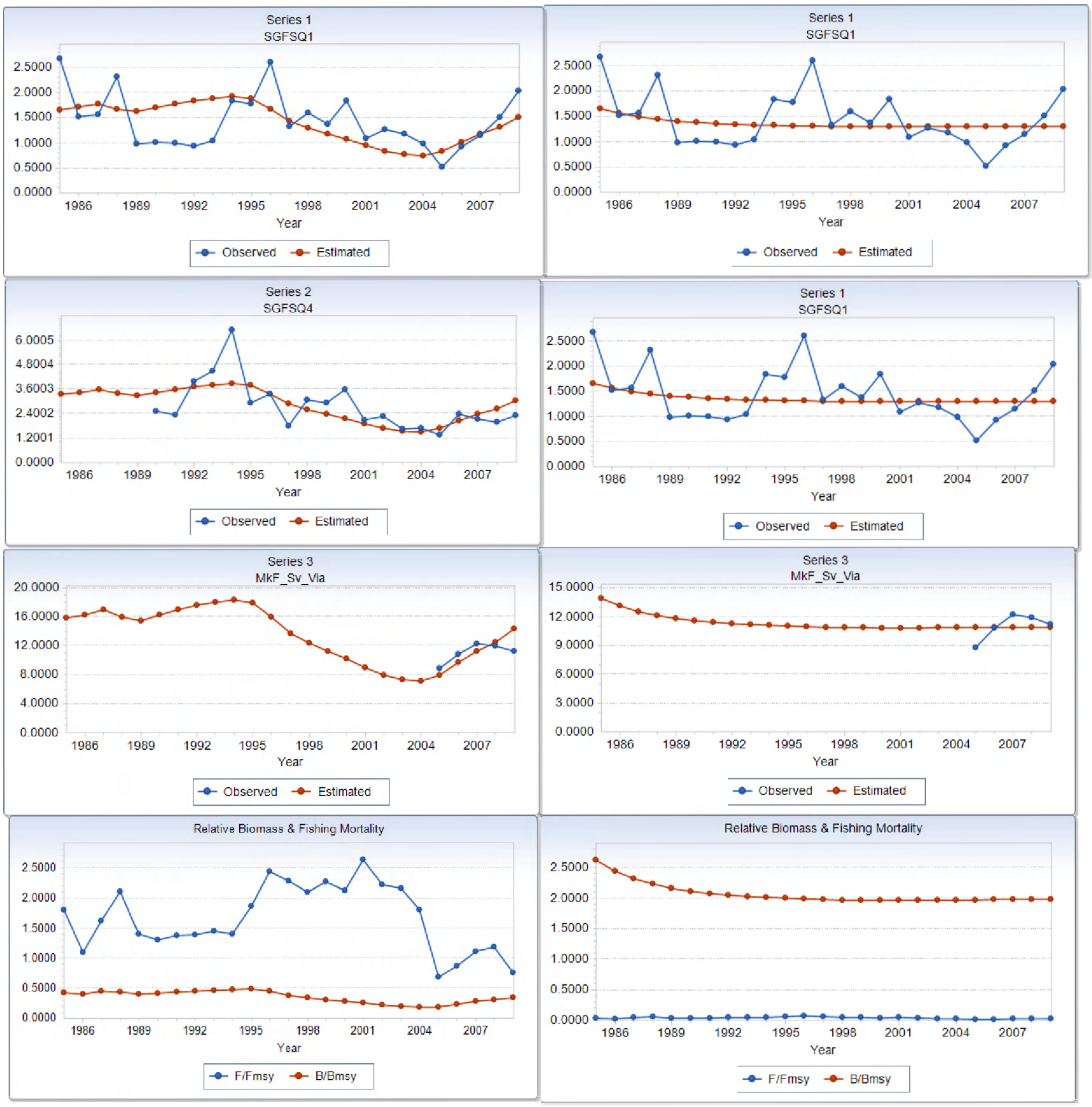


Figure 7.13. Model outputs for two runs of ASPIC with different starting estimates. The top six plots show the estimated and observed biomass based on three survey indices. The bottom two plots show the estimated ratio of F(2009)/Fmsy and B(2009)/Bmsy.

The model estimates are highly sensitive to the starting estimates and the two runs give widely different estimates. It is thought that this is due to the yield and the survey cpue estimates being autocorrelated with little contrast between cpue and yield.

Bayesian state-space models, implemented in WinBUGS , to investigate trends in exploitable biomass. State-space models differ from the 'traditional' surplus production model in that they can separately describe both observation and process errors. The model consists of two coupled components, a state process model and an observation model. By considering these two error structures in a state-space framework, the errors in the observation process can be separated from inherent variabilty in the population processes.

Prior etimates of K set to uninformative uniform over 0–100 000 tonnes and prior estimate of *r* set to uninformative uniform over 0 to 2.0. While the biomass outputs from this approach tracks the cpue in the fishery well (Figure 7.14) , the K estimate is improbably low (mean B> mean K in some years) (Figure 7.15). Further work with this approach will be presented to WGCSE (2011) and include:

1) A full investigation of prior sensitivity, including uninformative and biologically informed priors (Punt and Hilborn, 1997).

2) A comparison between fits using different combinations of data sources, particularly the combination or separation of data from Areas IVa and VIa.

3) Plots of the relationship between estimated biomass and surplus production to further understand the values of the estimated parameters, e.g. is there noticeable hump or only one limb available from which to estimate r and K.

4) An investigation of asymmetric surplus production using the Pella-Tomlinson implementation of the Schaefer model. This may account for the present overlap between biomass and K.

References

Punt, A.E., and Hilborn, R. 1997. Fisheries stock assessment and decision analysis: the Bayesian approach. *Reviews in Fish Biology and Fisheries*, **7**: 35–63.

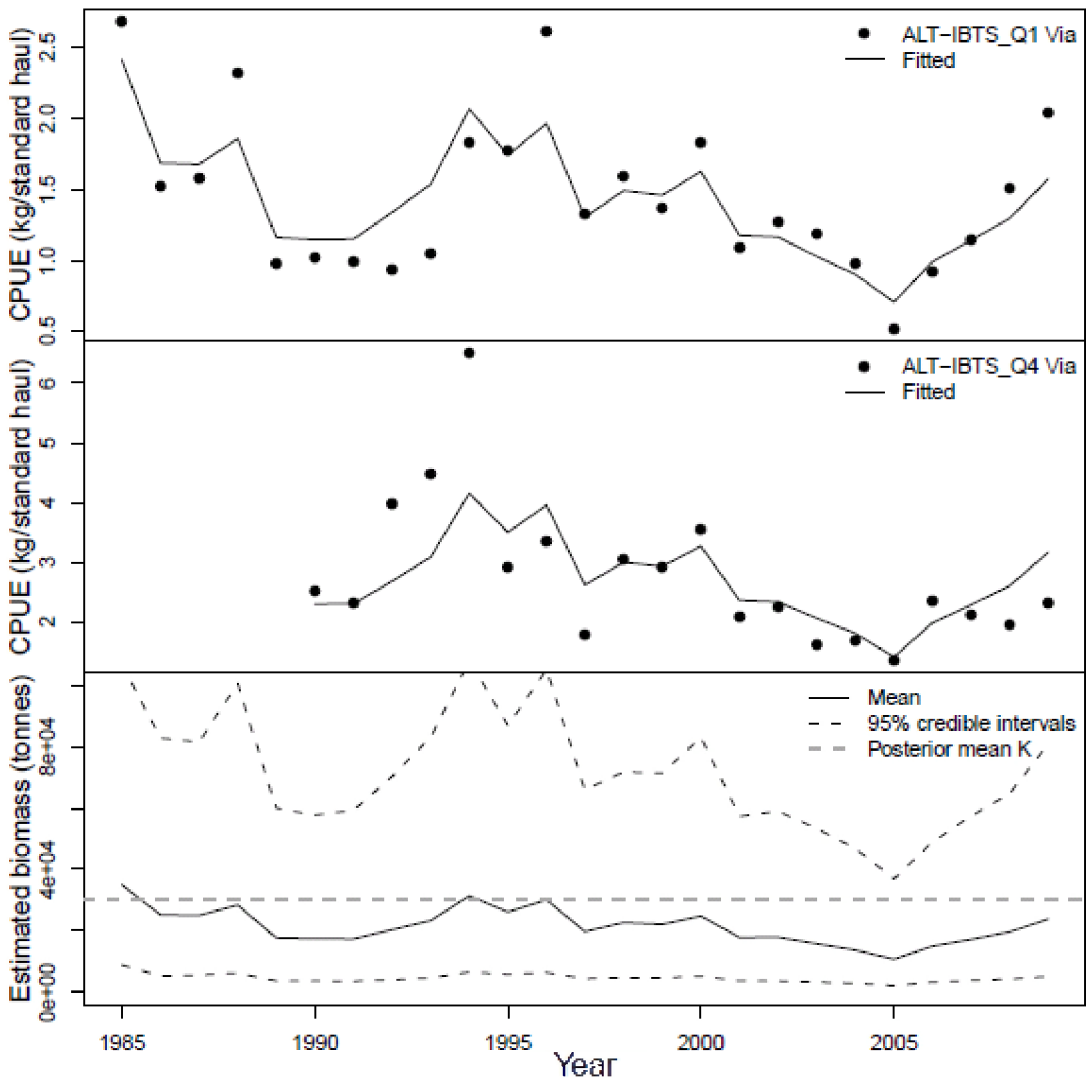


Figure 7.14. Model fits from the Bayesian state-space implementations of the Schaefer surplus production.

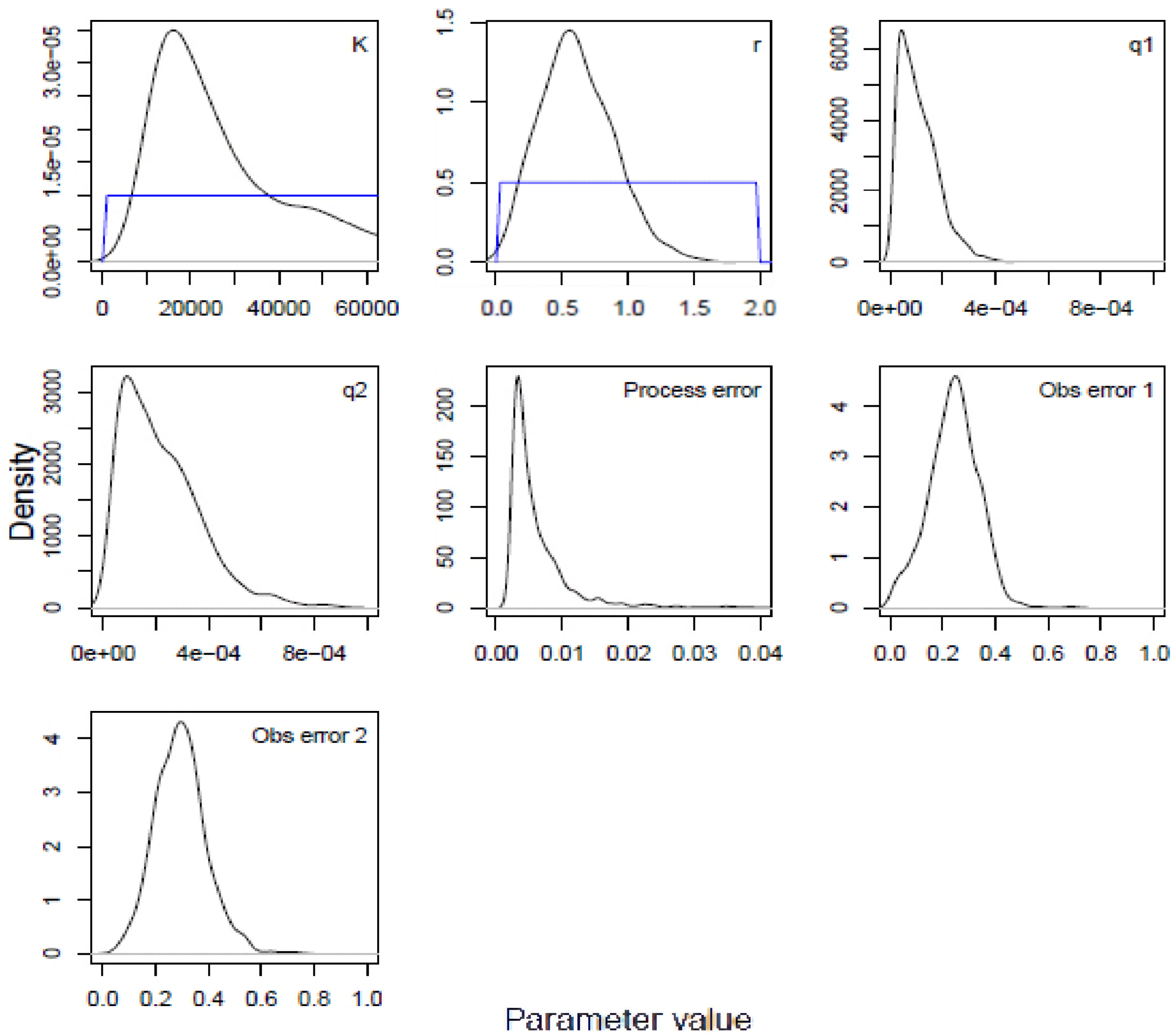


Figure 7.15. Posterior parameter estimates from model run with Bayesian state-space implementations of the Schaefer surplus production with uninformative prior estimates for carrying capacity (K) and intrinsic rate of growth (*r*).

Conclusions and recommendations for further work

Based on the distribution of survey and commercial catches in VIa and IVa, there is no firm evidence to conclude that megrim in VIa and IVa belong to a separate stock. WKFLAT recommends that megrim in VIa and IVa should be assessed as a unit stock.

The survey time-series appear autocorrelated with landings. Further analysis using a GLM approach should be undertaken to determine if survey indices are able to predict landings in the following year.

While the biomass and F/F_{msy} ratios form the surplus production models appear unrealistic and inconclusive, the biomass estimate over time does appear to track the yield from the fishery. Further work on prior inputs of intrinsic rate of growth (*r*) and maximum carrying capacity (K) needs to be undertaken.

Analysis of the available log catch numbers-at-age, indicate credible cohort tracking during the middle part of the time-series. However, in later years the signal has become noisy and no pattern can be seen. It is unclear at this stage whether this is due to a spatial shift in exploitation, resulting in a change in selection, or due to a reduction in the quality (quantity) of aged samples. However, due to the lack of data on age sampling levels and spatially refined landings and effort data, it has not been possible for WKFLAT to explore the reasons behind the deterioration in signal in recent years.

WKFLAT considers that current sampling levels for age from the main fleets contributing to catches may be too low and therefore insufficient to undertake any form of age-based assessment. WKFLAT recommends that minimum sampling levels estimated by Gerritsen (2010) be used as a target for all countries with reported catches of megrim in VIa, VIb and IV. This equates to the collection of approximately 600 age samples per year from each subdivision.

WKFLAT reiterates recommendations of IBTSWG (2001) that age sampling of megrim for abundance indices-at-age should be carried out by sex for all IBTS VIa, IVa and VIb surveys and that age samples should be obtained from other surveys.

WKFLAT reiterate the ongoing recommendations and statements from the WGNSDS (2004–2008) and WGCSE (2008+) that spatially disaggregated catch and effort data be made available and that annual ALK data are provided in order to undertake analysis on variability in ALK estimation and to investigate the potential to combine ALKs where data are sparse.

Until the ageing issues identified above are resolved and age or biomass based models are further developed, WKFLAT concludes that survey trends in biomass are continued to be used as the basis of scientific advice.

8 Recommendations from the Workshop

RECOMMENDATION	FOR FOLLOW UP BY
Benchmark preparation: Several of the assessments considered during this benchmark were not sufficiently developed in advance of the workshop. In some cases data were not made available in sufficient time prior to the meeting and in one instance data were not available even at the end of the meeting. Data availability was not always the reason for a lack of preparation. This resulted in a much greater proportion of the meeting being devoted to preliminary analyses but also to a lack of information in the form of working documents being made available prior to the meeting. The lack of such information prior to the meeting restricted initial discussions and particularly disadvantaged those external experts who were less familiar with the stocks under consideration. The use of preliminary workshops (as recommended by WKROUND) to first establish a sound model formulation which could then be considered in a full benchmark process may help to facilitate the benchmark system but will still depend on work being carried out prior to the meetings.	ACOM
Comparison of ALKs: The issues list for several of the assessments considered during this benchmark highlighted problems with the underlying data used for the assessment. Particular issues related to methods for aggregating catch-at-age information to provide an international catch-at-age matrix. No standard methodology exists for determining the quality of an age length key (ALK) or for statistically comparing one ALK with another. Such issues are of particular importance especially when raising discard samples for which sampling levels are often much lower than those of commercial landings. WKFLAT was aware of a small number of recent studies that have investigated this issue and recommends that PGCCDBS considers this issue for a broader range of stocks to provide appropriate guidance.	PGCCDBS
Inclusion of discards in stock assessments: The non inclusion of discards in the stock assessment is considered to be a significant deficiency for those stocks that may be subject to high discard rates. Very often discards information are only available for a short and recent time period which makes the inclusion of this information into existing assessment methods very difficult. WKFLAT trialed several different approaches for incorporating discards into the assessment when historical discard information were not available. Although some of these approaches showed promise, none were found to be entirely satisfactory. Further work will be conducted before the next benchmark (and indeed the next assessment) of these stocks. However, the problem remains and any guidance or assistance that other ICES groups can provide (specifically WGMethods) would be greatly appreciated.	WGMethods

Annex 1: WKFLAT–Benchmark Workshop on Flatfish Species ToRs 2011

2010/2/ACOM40 The **Benchmark Workshop on Flatfish Species** (WKFLAT), chaired by External Chair Robert Scott (JRC), ICES coordinator Jean-Claude Mahé, France, and two invited external experts Chris Legault (USA) and Chris Francis (New Zealand) will be established and will meet at ICES Headquarters, 1–8 February 2011 to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term outlook taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of fishery-dependent, fishery-independent, environmental, multispecies and life-history data.

b) Agree and document the preferred method for evaluating stock status and (where applicable) short-term forecast and update the stock annex as appropriate.

If no new analytical assessment method can be agreed, then an alternative method (the former method, or a trends based assessment) should be put forward.

c) Evaluate the possible implications for biological reference points, when new standard analyses methods are proposed. Propose new MSY reference points taking into account the WKFRAME and ADGMSY results.

d) Develop recommendations for future improving of the assessment methodology and data collection.

e) As part of the evaluation:

i) Conduct a one-day data compilation workshop. Stakeholders shall be invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. As part of the data compilation workshop consider the quality of data including discard and estimates of misreporting of landings.

ii) Consider the possible inclusion of environmental drivers for stock dynamics in the assessments and outlook.

iii) Evaluate the role of stock identity and migration.

iv) Evaluate the role of multispecies interactions on the assessments.

Stock	Assessment Lead
Sole Bay of Biscay	Gerard Biais
Sole VIIa	Sofie Nimmegeers
Megrim IV, VI	Norman Graham
Plaice VIIa	Chris Lynam
Plaice VIIf,g	Chris Darby

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Annex 3: List of Working documents

WD 1. Using annual, international ALKs to obtain catch numbers-at-age. Hans Gerritson

WD 2. Horse Power correction Belgian Beam trawl tuning fleet. Mauricio Ortiz

WD 3. Review of ICES sole stock MSY and reference points. John Simmonds

WD 4. Plaice Discards in the Irish and Celtic Sea by Ireland. Colm Lordan, Sara-Jane Moore and Hans Gerritsen

WD 5. Method for calculating International weight and number-at-age data, Ian Holmes

WD 6. Overview of recent Irish Groundfish Survey plaice catches in the Celtic Sea (VIIg). David Stokes

WD 7. Plaice VIIfg and VIIa: Belgian discard data from the observer programme. Chris Lynam

WD 8. A reanalysis of the UK Beam Trawl Survey Index for Irish Sea plaice (VIIa) including an extension of the spatial coverage of the survey. Chris Lynam

Annex 4: Stock Annexes

Stock Annex: Irish Sea Plaice

Stock	Plaice (Division VIIa)
Working Group	Celtic Seas Ecoregion
Date	08th Feb 2011
By	Christopher Lynam

A. General

A.1. Stock definition

There are considered to be three principle spawning areas of plaice in the Irish Sea: one off the Irish coast, another northeast of the Isle of Man towards the Cumbrian coast, and the third off the north Wales coast (Nichols *et al.*, 1993; Fox *et al.*, 1997; Figure A1). Cardigan Bay has also been identified as a spawning ground for plaice in the Irish Sea (Simpson, 1959).

The level of mixing between the east and west components of the Irish Sea stock appears small. (Dunn and Pawson, 2002). Length-at-age measurements from research surveys as well as anecdotal information from the fishing industry suggests that plaice in the western Irish Sea grow at a much slower rate than those in the eastern Irish Sea. Earlier studies have suggested that the east and west components of the stock are distinct (Brander, 1975; Sideek, 1989). Morphometric differences have been observed between the east and west components of the stock; the 2004 WG indicated that the UK(E&W) beam trawl survey in September (from 1989) catches plaice off the Irish coast that are smaller-at-age than those caught in the eastern Irish Sea. In 2009, however, the raw catch weight data from UK(E&W) and Irish fleets (all gears) indicates that plaice landed by the Irish fleets are approximately 50 g heavier than those caught by the UK(E&W) fleet (Figure A2) suggesting that fish from the Irish coastal area are not landed.

Although considered separate stocks, the stocks of plaice in the Irish Sea and the Celtic Sea do mix during spawning. Tagging studies have indicated a southerly movement of mature fish (or fish maturing for the first time) from the southeast Irish Sea, off North Wales, into the Bristol Channel and Celtic Sea during the spawning season, such that 43% of the new recruits are likely to recruit outside the Irish Sea (Figure A1). While some of these migrant spawning fish will remain in the Bristol Channel and Celtic Sea, the majority ($\geq$ 70%) are expected to return to summer feeding grounds in the Irish Sea (Dunn and Pawson, 2002).

Very little mixing is considered to occur between the Irish Sea and Channel stocks or between the Irish Sea and North Sea (Pawson, 1995). Nevertheless, time-series of recruitment estimates for all stocks in waters around the UK (Irish Sea, Celtic Sea, western and eastern Channel, North Sea) demonstrate a significant level of synchrony (Fox *et al.*, 2000). This could indicate that the stocks are subject to similar large-scale environmental forces and respond similarly to them, or alternatively that there are subpopulations that share a common spawning.

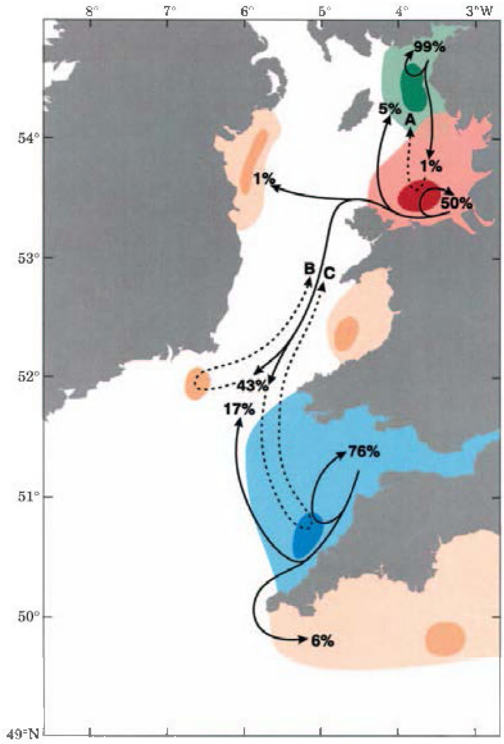


Figure A1. Principal substock areas and movements of plaice on the west coast of England and Wales. Percentages are the recaptures rates of tagged plaice <25 cm total length when released, and >26 cm when recaptured in English and Welsh commercial fisheries. Tagging exercises in 1979–1980 and 1993–1996 were combined based on the assumption that the dispersal patterns of plaice were consistent over time. For each substock, the main feeding area (derived from tag recaptures during April–December; light shading), and the main spawning area (derived from tag recaptures during January–March, and ichthyoplankton surveys; dark shading) are indicated. The substocks tagged have been coloured green, red and blue. The substocks coloured orange are less well determined, with the feeding area around southeast Ireland unknown. Letters represent return migrations, where A ≈ 6%, and B+C ≈ 46%. Reproduced from Dunn and Pawson (2002).

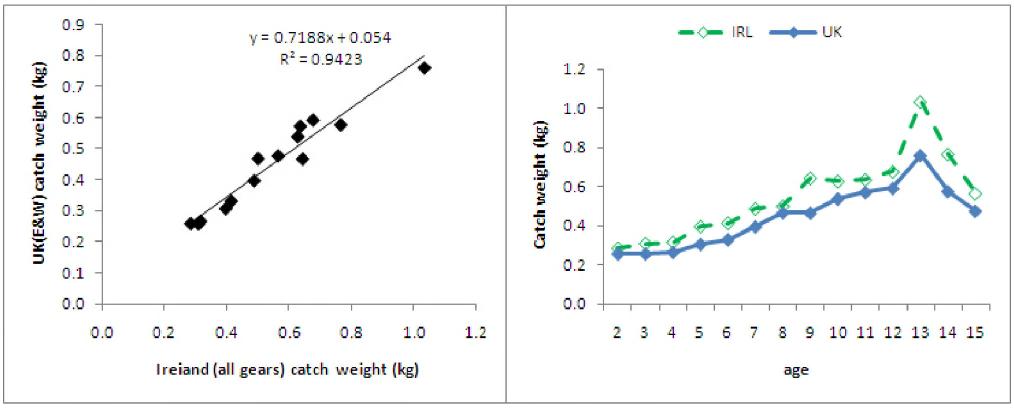


Figure A2. Observed weight-at-age of plaice from landed catches by the UK (E&W) and Irish fleets (all gears) in 2009.

A.2. Fishery

The status and activities of the fishing fleets operating in ICES Subdivision VIIa are described by Pawson *et al.*, 2002 and also by Anon, 2002. Following the massive decline in effort (hours fished) by otter trawlers targeting demersal fish in the early1990s, the majority of fisheries effort in the Irish Sea is now exerted by otter trawlers fishing for *Nephrops* in the western Irish Sea followed by beam trawlers targeting sole in the eastern Irish Sea. A small proportion of otter trawlers still target cod, haddock, whiting and plaice with bycatch of angler-fish, hake and sole. Since 2001, trawlers for demersal fish have adopted mesh sizes of 100–120 mm and other gear modifications depending on the requirements of recent EU technical conservation regulations and national legislation. In 2004 the effort exerted by UK trawlers with mesh 100–120 mm declined to low levels and in 2006 the effort by UK trawlers targeting demersal fish with mesh 80–99 mm also declined to low levels. Concomitantly, the effort by UK trawlers targeting *Nephrops* with mesh 80–99 mm increased to record highs. Square mesh panels have been mandatory for UK otter trawlers since 1993 and for Irish trawlers since 1994. The number of Irish vessels operating in this area has declined in recent years. Fishing effort in 2009 effort by the Irish and UK (E&W) otter fleets targeting demersal fish reached historical lows.

Beam trawlering increased in the Irish Sea during the late 1980s, with vessels from England and Belgium exploiting sole. This fishery has important bycatch of plaice, rays, brill, turbot and angler-fish. The fishing effort of the Belgium beam trawl fleet varies according to the catch rates of sole in the Irish Sea relative to the other areas in which the fleet operates. In 2009, effort (hours fished) by the UK (E&W) beam trawl fleet fell to the lowest observed level.

A fleet of vessels primarily from Ireland and Northern Ireland take part in a targeted *Nephrops* fishery using 70 mm mesh nets with 75 mm square mesh panels. This fishery takes a substantial bycatch of whiting, most of which is discarded. Some inshore shrimp beam trawlers occasionally switch to flatfish when shrimp become temporarily unavailable. Other gear types employed in the Irish Sea to catch demersal species are gillnets and tanglenets, notably by inshore boats targeting cod, bass, grey mullet, sole and plaice.

The minimum landing size for plaice in the Irish Sea was set in 1980 to 25 cm (Council Regulation (EEC) No 2527/80). This was increased in 1998 to 27 cm (Annex XII of Council Regulation 850/98).

Since 2000 a recovery programme has been implemented to reduce exploitation of the cod spawning stock in the Irish Sea. In 2002 the European Commission regulations included a prohibition on the use of demersal trawl, enmeshing nets or lines within the main cod spawning area in the northwest Irish Sea between the 14th February and 30th April. Some derogations were permitted for *Nephrops* trawls and beam trawlers targeting flatfish.

A.3. Ecosystem aspects

Plaice are preyed upon and consume a variety of species through their life history. However, plaice have not as yet been included in an interactive role in multispecies assessment methods (e.g. ICES WGSAM 2008). Among other prey items, plaice typically consume large proportions of polychaetes and molluscs.

Other than statistical correlations between recruitment and temperature (Fox *et al.*, 2000), little is known about the effects of the environment on the stock dynamics of plaice in the Irish Sea. Negative correlations between year-class strength of plaice (in either the Irish Sea, Celtic Sea, Channel or North Sea) and sea surface temperature (SST) are generally strongest for the period February–June. However, western (North Sea and Channel) and eastern (Irish Sea and Celtic Sea) stocks have been found to respond to different time-scales of temperature variability, which might imply that different mechanisms are operating in these stocks and/or that the Irish Sea and Celtic Sea share common spawning (Fox *et al.*, 2000).

B. Data

B.1. Commercial catch

Landings

International landings-at-age data based on quarterly market sampling and annual landings figures are available from 1964. Throughout the period 1978 to 2003 quarterly age compositions have typically represented around 80–90% of the total international landings. Table B1 details the derivation of international landings for the period 1978 to 2003.

Prior to 1983 the stock was assessed on a separate sex basis: the catch numbers of males and females were worked up separately and the numbers of males and females in the stock as estimated from each assessment combined to give a total biomass estimate. Since 1983 a combined sex assessment of the stock has been conducted and the numbers of males and females in the catch have been combined at the international data aggregation level prior to running a single assessment.

Data exploration

Data exploration for commercial landings data for Irish Sea plaice has involved:

1. expressing the total landings-at-age matrix as proportions-at-age, normalized over time, so that year classes making above-average contributions to the landings are demonstrated as large positive residuals (and vice-versa for below-average contributions);
2. applying a separable VPA model in order to examine the structure of the landed numbers-at-age before they are used in catch-at-age analyses, in particular whether there are large and irregular residuals patterns that would lead to concerns about the way the recorded catch has been processed.

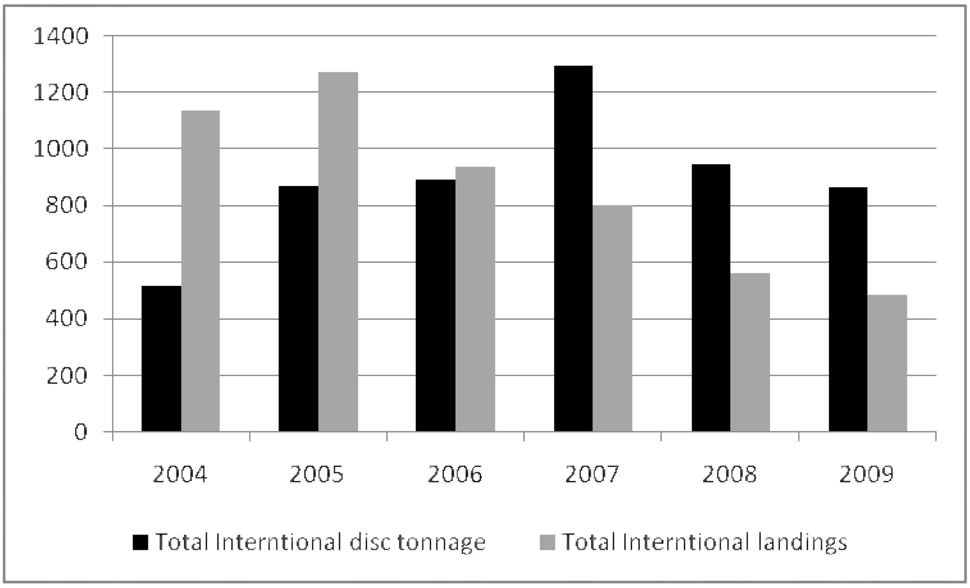
Given that discards now represent a larger proportion of the catch than the landings method 1 should be applied to the discard-at-age matrix in addition to the discard-at-age matrix and method 2 is unnecessary.

Discards

In 1986, the UK fleet was restricted to a 10% bycatch of plaice for almost the entire year. Estimates were made of the increased quantity of plaice that would have been discarded based on comparisons of lpue values for 1985–1986 with those for 1984–1985. The estimated quantity of 250 tonnes was added to the catch. A similar situation arose the following year and 250 tonnes was added to the catch for 1987.

The 10% plaice bycatch restriction was enforced again in 1988 to all UK (E&W) vessels in the 1st quarter and to beam trawlers in the 2nd and 3rd quarters. However, this time the landings were not corrected for discard estimates.

Discard information was not routinely incorporated into the assessment prior to 2011.



B.2. Biological

Weights-at-age

A number of different methodologies have been employed to determine weights-at-age for this stock. Stock weights and catch weights-at-age were determined on a separate sex basis and remained unchanged from 1978 until 1983. Catch weights were derived from a von Bertalanffy length-at-age fit to Belgian (70–74), UK (E&W) (64–74) and Irish (62–66) catch samples. The estimated lengths-at-age were converted to weights-at-age using a Belgian length–weight dataset (ages 2–15 females; 3–9 males). Stock weights were calculated as the mean of adjacent ages from the catch weights, where catch weights represented 1st July values and stock weights 1st January.

From 1983 weights-at-age have been calculated on a combined sex basis. Catch weights were taken from market sampling measurements combined on a sex weighted basis and smoothed. For the period 1983 to 1987 catch weights were smoothed by eye, from 1988 onwards a smooth curve was fitted using a numerical minimization routine. Stock weights were derived from the smoothed international catch weights-at-age curve with values representing 1st January. In 1985 the stock weights-at-age were adjusted for ages 1 to 4. The difference between the smoothed catch weights and survey (F.V. *Silver Star*) observations were adjusted using the maturity ogive to give "best estimate" stock weights "for ages where growth and maturity differences can bias sampling procedures". The same procedure was adopted in 1986 (when stock weights in 1982 and 1983 were also revised so as to be consistent with this methodology) and 1987. In 1988 however, the *Silver Star* survey was discontinued and stock weights-at-ages 1 to 3 were calculated as means of the three previous years. Correction of the estimated stock weights of the younger age groups did not occur in 1989 or in subsequent years which explains the sudden increase in weight of the younger age groups for this stock from 1988 onwards.

Catch weights at the younger ages also demonstrate a similar increase coincident with the start of the smoothing process. This apparent increase in the estimated catch weights is not believed to have affected the derivation of catch numbers because smoothing of the catch weights occurs after having determined the catch numbers-at-age. SOP checks are generally very close to 100%.

The 1982 WG report notes a study by R. Cross, unpublished stating that there was no evidence of a change in growth rates for the stock nor was there any evidence of density-dependent effects on growth.

WKFLAT 2011 rejected the use of the polynomial smoother for weights-at-age and suggested that raw catch weights are used in future. Raw data back to 1995 was obtained by WKFLAT and used to update the catch weights and stock weights files.

Discard weight-at-age were also calculated back to 2004 from UK (E&W) and Belgian data. However, given that the discard weight prior to 2004 were unknown the stock weights file was not updated to include the discard component. This requires further work.

Natural mortality and maturity ogives

As for the weights-at-age, natural mortality and maturity was initially determined on a separate sex basis. Natural mortality was taken as 0.15 for males and 0.1 for females. In 1983 when a combined sex assessment was undertaken a sex weighted average value of 0.12 was used as an estimate of natural mortality. This estimate of natural mortality has remained unchanged since 1983.

The maturity estimates used prior to 1982 are not specified. A new separate sex maturity ogive (Sideek, 1981) was implemented in 1982. This ogive was recalculated as sex weighted mean values in 1983 when the assessment was conducted on a combined sex basis. The maturity ogive was revised again in 1992 based on the results of an EU project. Maturity ogives are applied as vectors to all years in the assessment.

WKFLAT 2011 was unable to update the maturity ogive due to time restraints. However, preliminary analysis indicated that the ogive may have changed over time, in each sector of the Irish Sea, such that plaice mature at a smaller size and age than previously.

Table A1. Maturity ogives for Irish Sea plaice used in ICES WGs.

Age	WG 1978-1982		WG 1983-1992	WG 1992-2010
	M	F		
1	0	0	0	0
2	0.3	0.04	0.15	0.24
3	0.8	0.4	0.53	0.57
4	1.0	0.94	0.96	0.74
5	1.0	1.0	1.0	0.93
6	1.0	1.0	1.0	1.0

The proportion of fishing mortality and natural mortality before spawning was originally set to 0. It was changed in 1983 to a value of 0.2 on the grounds that approximately 20% of the catch was taken prior to March (considered to be the time of peak spawning activity). As for Celtic Sea plaice the proportion of F and M before spawning was reset to 0, as it was considered that these settings were more robust to changes in the fishing pattern, especially with respect to the medium-term projections.

B.3. Surveys

In 1993, the UK (E&W) beam trawl survey series that began in 1988 was considered to be of sufficient length for inclusion in the assessment. Since 1991, tow duration has been 30 minutes but prior to this it was 15 minutes. In 1997, values for 1988 to 1990 were raised to 30 minute tows. However, data for 1988 and 1989 were of poor quality and gave spurious results: thus, the series was truncated to 1990. A similar March beam trawl survey began in 1993 and was made available to the WG in 1998. The March beam trawl survey ended in 1999 but continued to be used as a tuning index in the assessment until 2003.

In 2011, the UK (E&W) beam trawl survey was re-examined and additional stations sampled in the western Irish Sea and St Georges Channel (Cardigan and Caernarfon Bays) since 1993 were included in the index. The extended index replaced the earlier 'prime stations' index because it was considered more representative of the entire stock (see WD 5 WKFLAT 2011).

An Irish juvenile plaice survey index was presented to the WG in 2002 (1976–2001, ages 2–8). Between 1976 and 1990 this survey had used an average ALK for that period. Serious concerns were expressed regarding the quality of the data for this period and the series was truncated to 1991. The stations for this survey are located along the coast of southeast Ireland between Dundalk Bay and Carnsore Point and there was some concern that this localized survey series would not be representative of the plaice population over the whole of the Irish Sea. Numerous tests were conducted at the 2002 WG to determine the validity of this and other tuning indices and it was concluded that this survey could be used as an index of the plaice population over the whole of the Irish Sea.

The SSB of plaice can be estimated using the Annual Egg Production Method (AEPM) (Armstrong *et al*., 2002 and WD 11, WGCSE 2010). This method uses a series of ichthyoplankton surveys to quantify the spatial extent and seasonal pattern of egg production, from which the total annual egg production can be derived. The average fecundity (number of eggs spawned per unit body weight) of mature fish is estimated by sampling adult females immediately prior to the spawning season. Dividing the annual egg production by average fecundity gives an estimate of the biomass of mature females. Total SSB can be estimated if the sex ratio is known. Although substantial discrepancies between absolute estimates of SSB from the Annual Egg Production method (AEPM) and ICES catch-based assessments were observed, they do confirm that SSB of plaice in the Irish Sea is currently at high levels.

AEPM estimates of SSB for plaice (RSE = relative standard error, as %), based on production of Stage 1 eggs) are indicated below (note 1995–2006 estimates were revised in 2010, see WD11, WGCSE 2010):

Table A3. AEPM estimates of SSB for Irish Sea plaice.

	total		west		east	
Year	SSB(t)	RSE	SSB(t)	RSE	SSB(t)	RSE
1995	9081	21	3411	42	5670	22
2000	13 303	19	5654	36	7649	19
2006	11 487	16	3655	29	7833	19
2008	12 729	19	4309	43	8420	18

Splitting the SSB estimate by substrata (Figure below) suggests that the perceived increase in plaice SSB is limited to the eastern Irish Sea. This finding agrees with an analysis of UK (NI) GFS data by substrata, which also indicates an increase in biomass limited to the eastern Irish Sea.

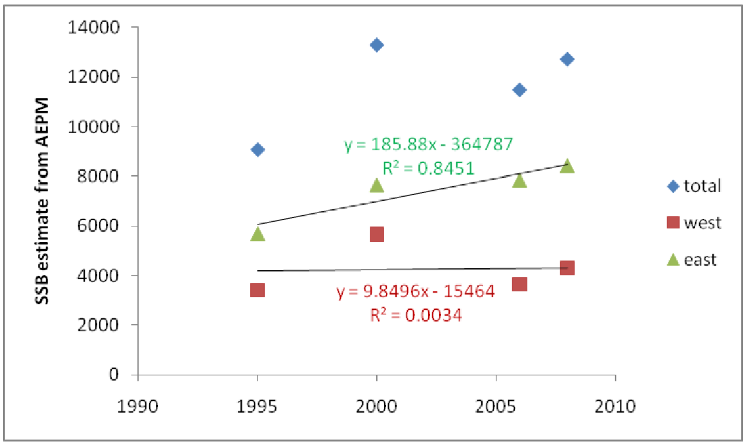


Figure A3. AEPM estimates by year and substrata.

B.4. Commercial lpue

Prior to 1981 tuning data were not used in the assessment of this stock. A separable assessment method was used and estimates of terminal S and F were derived iteratively based on an understanding of the recent dynamics of the fishery.

In 1981 the choice of terminal F was determined from a regression of exploited stock biomass on cpue. Catch and effort series were available for the UK (E&W) trawl fleet and the Belgian beam trawl fleet for the period 1964 to 1980. In 1994 the Belgian and UK cpue series were combined to provide one mean standardized international index. The UK (E&W) trawl series was revised in 1986 (not known how) and in 1987 was recalculated as an age based cpue index enabling the use of the hybrid method of tuning an *ad hoc* VPA.

The UK (E&W) trawl tuning-series was revised in 1999 and separate otter trawl and beam trawl tuning-series were produced using length samples from each gear type and an all gears ALK. Because the data could only be separated for 1988 onwards the two new tuning-series were slightly reduced in length. In 1996 UK(E&W) commercial effort data were re-scaled to thousands of hours so as to avoid numerical problems associated with low cpue values and in 2000 the UK(E&W) otter trawl series was recalculated using otter trawl age compositions only rather than combined fleet age compositions as previously.

Two newly revised survey indices for the *Lough Beltra* were presented to the WG in 1996 though they were considered too noisy for inclusion in the assessment. They were revised again for the following year and found to be much improved but were again not included because they ended in 1996 and the WG felt that they would add little to the assessment. An Irish otter trawl tuning index was made available in 2001 (1995–2000, age 0 to 15). Whereas this fleet mainly targets *Nephrops*, vessels do on occasion move into areas where plaice are abundant. Landings of plaice by this fleet were approximately 15% of total international landings in 2000 and the WG considered that this fleet could provide a useful index of abundance for plaice.

The effects of vessel characteristics on lpue for UK(E&W) commercial tuning-series was investigated in 2001 to investigate the requirement for fishing power corrections due to MAGP IV re-measurement requirements. It was found that vessel characteristics had less effect on lpue than geographic factors and unexplained noise and concluded that corrections were not necessary. However, vessels of certain size tended to fish in certain rectangles. This confounding may have resulted in the underestimation of vessel effects.

Currently, age based tuning data available for this assessment comprise three commercial fleets; the UK (E&W) otter trawl fleet (UK (E&W) OTB, from 1987), the UK (E&W) beam trawl fleet (UK (E&W) BT, from 1989) and the Irish otter trawl fleet (IR-OTB, from 1995). However, as a consequence of inconsistencies in these commercial tuning fleets and surveys in the Irish Sea no commercial tuning information is used in the assessment. The area and HP-correction employed to calculate the UK (E&W) commercial effort indices may require re-evaluation because vessels have changed greatly since the relationship was modelled. The UK (E&W) *Nephrops* fleet has increased since 2006 and effort and lpue should be included in the report.

B.5. Other relevant data

Model used: Aarts and Poos (AP)

Software used: R version 2.10.1

Model Options chosen:

Input data types and characteristics.

ASSESSMENT YEAR		2011 WKFLAT
Assessment model		AP
Tuning fleets	UK-BTS Sept	Series omitted
	Extended UK-BTS Sept	1993–2009, ages 1–6
	UK(E&W) BTS Mar	Survey omitted
	UK(E&W) OTB	Series omitted
	UK(E&W) BT	Series omitted
	IR-OTB	Series omitted
	UK(NI) GFS Mar	1993–2009
	UK(NI) GFS Oct	1993–2009
Selectivity model		Linear Time Varying Spline at age (TVS)
Discard fraction		Polynomial Time Varying Spline at age (PTVS)
Landings number-at-age, range:		1–9+
Discards number-at-age, year range, age range	2004–2009, ages 1–5	

C. Historical stock development

The stock of plaice in the Irish Sea has been assessed by ICES since 1977.

Assessment methods and settings

In 1987 the stock was assessed using a Laurec-Shepherd (hybrid) tuned VPA. Concerns about deteriorating data quality prompted the use in 1994 of XSA. A subsequent divergence in commercial cpue and survey data, and the wish to include biomass indices, prompted the use of ICA. The settings for each of the assessments between 1991 and 2009 are detailed in Table B.2. Since 2006, the assessment has been an update ICA assessment with the separable period increased by one year at each assessment working group. In 2009 and 2010, FLICA was used to run the assessment: the R and FLR packages have been documented within the WG report. In 2011, WKFLAT estimated discards-at-age and proposed that the AP model is used to model the stock.

Over the years, trial runs have explored many of the options with regards XSA settings, including:

- The applicability of the power model on the younger ages was explored in: 1994; 1996; 1998; 1999; 2000 and 2001.
- Different levels of F shrinkage were explored in 1994; 1995; 1997.
- The effect of different time tapers was investigated in 1996.
- The S.E. threshold on fleets was examined in 1996.
- The level of the catchability plateau was investigated in 1994.

ICA settings explored since 2005 have included:

- The length of the separable period.
- The reference age
- The age range of the landings data
- The effect of including hypothetical discard reconstructions in the catch

AP model settings were trialled in 2011:

- The various combinations of time-variance for selectivity and discard fraction
- The suitable age range of the discards was investigated

The suitable starting year of the model was investigated with values from 1990 to 1993 trialled.

D. Short-term projection

Short-term projections are not made for Irish Sea plaice at present. However, the methodology last employed follows for reference by future working groups.

Software: Multi Fleet Deterministic Projection (MFDP)

Age based short-term projections were conducted for a three year period using initial stock numbers derived from ICA analyses. Numbers-at-age 2 were considered poorly estimated and generally overwritten using a geometric mean (GM) of past recruitment values. Population numbers-at-age 3 in the intermediate year (terminal year +1) were also overwritten with the GM estimate depreciated for Fsq and natural mortality. Recruitments since 1990 have been estimated to be at a lower level and to be less variable than those earlier in the time-series. Consequently a short-term geometric mean (from 1990 to two years before the terminal year) was used.

Previously, the exploitation pattern is an un-scaled three year arithmetic mean. However, alternative options may be used depending on recent F trajectories and the working group's perception of the fishery. Catch and stock weights-at-age were generally taken as the mean of the last three years and the maturity ogive and natural mortality estimates are those used in the assessment method.

E. Medium-term projections

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

Previous Software: *MLA miscellany*

Input values to the medium-term forecast were the same as those used in the short-term forecast. Although a Beverton–Holt stock–recruit relationship has been assumed previously, a simple geometric mean may now be more appropriate.

F. Yield and biomass-per-recruit/long-term projections

Software: *Multi Fleet Yield-per-Recruit (MFYPR)*

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts. Currently the YPR calculations are used as a basis for determining the catch option for advice.

G. Biological reference points

WKFLAT have rejected the use of reference points given the current trends only assessment and indicated that these will need to be revised. Biological reference points, last used by WGCSE in 2010, were proposed for this stock by the 1998 working group as below.

	Type	Value	Technical basis
Precautionary approach	B_{lim}	Not defined.	There is no biological basis for defining B_{lim} as the stock–recruitment data are uninformative.
	B_{pa}	3100 t	Bpa = Bloss.
	F_{lim}	Not defined.	There is no biological basis for defining F_{lim} as F_{loss} is poorly defined.
	F_{pa}	0.45	$F_{pa} = F_{med}$ in a previous assessment, and in long-term considerations. This is considered to provide a high probability of maintaining SSB above B_{loss} in the long term.
Targets	F_y	Not defined.	

Yield and spawning biomass per Recruit

F-reference points:

	Fish Mort	Yield/R	SSB/R
	Ages 3–6		
Average last 3 years	0.10	0.17	1.64
$F_{0.1}$	0.14	0.19	1.31
F_{med}	0.43	0.21	0.53

Estimated by the WG in 2010.

MSY reference points were explored by WGCSE 2010 using the Cefas ADMB code presented to WKFRAME (ICES 2010). However, due to the high level of discards in the stock and unreliable estimates of recruitment, MSY reference points were rejected by the working group.

H. Other issues

None.

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Table B1. Data sources and derivation of international landings, where % sampled indicates the percentage of the total landings represented by sampling.

Year of WG	Data	Source UK	Belgium	Ireland	Netherlands	Derivation of international landings	% sampled
1978	Len. comp.	quarterly[1]	quarterly[1]	quarterly[1]		Irish raised to Irish and N.Irish; UK raised to UK (E&W) and Scotland	85
	ALK	quarterly[1]	quarterly[1]	quarterly[1]		Belgian raised to Belgian, Dutch and French	
	Age comp.	quarterly[1]	quarterly[1]	quarterly[1]		UK + Bel + IR combined to total int. separate sex	
1979							
1980	Len. comp.	quarterly[1]	quarterly[1]	quarterly[1]		Irish raised to Irish and N.Irish; UK raised to UK (E&W), Sco and IOM.	86
	ALK	quarterly[1]	quarterly[1]	quarterly[1]		Belgian raised to Belgian, Dutch and French	
	Age comp.	quarterly[1]	quarterly[1]	quarterly[1]		UK + Bel + IR combined to total int. separate sex	
1981							
1982		As for 1980	As for 1980	As for 1980		As for 1980, separate sex	92
1983		As for 1980	As for 1980	As for 1980		As for 1980; sexes combined	90
1984	Len. comp.	quarterly	2nd qtr	quarterly		Irish raised to Irish and N.Irish	90
	ALK	quarterly	2nd qtr	quarterly		UK raised to UK (E&W), Scotland, I.O.M., French, Dutch and Belgian	
	Age comp.	quarterly	2nd qtr	quarterly		UK + IR combined to total int. sexes combined	
1985	Len. comp.	quarterly	quarterly	quarterly		Irish raised to Irish and N.Irish; UK raised to UK (E&W), Sco and IOM	92
	ALK	quarterly	quarterly	quarterly		Belgian raised to Belgian, Dutch and French	
	Age comp.	quarterly	quarterly	quarterly		UK + Bel + IR combined to total int. sexes combined	
1986	Len. comp.	quarterly	quarterly	quarterly		Irish raised to Irish.,N.Irish and French	91
	ALK	quarterly	quarterly	quarterly		UK raised to UK (E&W), Scotland and I.O.M.; Belgian used alone	
	Age comp.	quarterly	quarterly	quarterly		UK + Bel + IR combined to total int.	
1987		As for 1986	As for 1986	As for 1986		As for 1986	84
1988		As for 1986	As for 1986	As for 1986		As for 1986 except Irish beam trawl raised using UK age comps	75

Year of WG	Data	Source UK	Belgium	Ireland	Netherlands	Derivation of international landings	% sampled
1989		As for 1986	As for 1986	As for 1986		As for 1986 (Irish beam trawl now sampled)	86
1990							
1991		As for 1986	As for 1986	As for 1986		As for 1986	83
1992		As for 1986	As for 1986	As for 1986		As for 1986	83
1993		As for 1986	As for 1986	As for 1986		As for 1986	91
1994		As for 1986	As for 1986	As for 1986		As for 1986 (Belgian samples supplemented with UK data)	90
1995							
1996		As for 1986	As for 1986	As for 1986		As for 1986	89
1997		As for 1998	As for 1998	As for 1998	As for 1998	As for 1998	83
1998	Len. comp.	quarterly	quarterly	quarterly	quarterly	Irish raised to Irish., N.Irish and French; Belgian and Dutch used alone	87
	ALK	quarterly	quarterly	quarterly	quarterly	UK raised to UK (E&W), Scotland and I.O.M.	
	Age comp.	quarterly	quarterly	quarterly	quarterly	UK + Bel + IR + NL combined to total int.	
1999		As for 1986	As for 1986	As for 1986		As for 1986 (except UK raised to include NL landings)	89
2000		As for 1999	As for 1999	As for 1999		As for 1999	88
2001		As for 1998	As for 1998	As for 1998	As for 1998	As for 1998	87
2002		As for 1986	As for 1986	As for 1986		As for 1986	88
2003	Len. comp.	quarterly	1st qtr	quarterly		Belgium raised using 1st qtr values	70
	ALK	quarterly	1st qtr	quarterly		UK raised to Sco and France; Irish raised to Irish and N.Irish	
	Age comp.	quarterly	1st qtr	quarterly		UK + Bel + IR combined to total int.	
2004	Len. comp.	quarterly	quarterly	quarterly			52
	ALK	quarterly	-	quarterly		UK raised to Sco and France; Irish raised to Irish, N.Irish and Bel	
	Age comp.	quarterly	-	quarterly		UK + IR combined to total int.	
2005	Len. comp.	quarterly	quarterly	quarterly			81

Year of WG	Data	Source UK	Belgium	Ireland	Netherlands	Derivation of international landings	% sampled
	ALK	quarterly	qrts 1,2	quarterly		UK raised to Sco and France; Irish raised to Irish, N.Irish and Bel	
	Age comp.	quarterly	qrts 1,2	quarterly		UK + IR combined to total int.	
2006	Len. comp.	quarterly	quarterly	quarterly			92[3]
	ALK	quarterly	quarterly	quarterly		UK raised to Sco and France; Irish raised to Irish, N.Irish and Bel	
	Age comp.	quarterly	quarterly	quarterly		UK + IR combined to total int.	
2007	Len. comp.	quarterly	quarterly	quarterly			90[3]
	ALK	quarterly	quarterly	quarterly		UK raised to Sco and France; Irish raised to Irish and N.Irish	
	Age comp.	quarterly	quarterly	quarterly		UK + Bel + IR combined to total int.	
2008	Len. comp.	quarterly	annual	quarterly			94
	ALK	quarterly	annual	quarterly		UK raised to Sco and France; Irish raised to Irish and N.Irish	
	Age comp.	quarterly	annual	quarterly		UK + Bel + IR combined to total int.	
2009	Len. comp.	quarterly	quarterly	quarterly			89
	ALK	quarterly	quarterly	quarterly		UK raised to Sco and France; Irish raised to Irish and N.Irish	
	Age comp.	quarterly	quarterly	quarterly		UK + Bel + IR combined to total int.	
2010	Len. comp.	quarterly	quarterly	quarterly			94
	ALK	quarterly	quarterly	quarterly		UK raised to Sco and France; Irish raised to Irish and N.Irish	
	Age comp.	quarterly	quarterly	quarterly		UK + Bel + IR combined to total int.	

1 Assumed – (not explicitly stated in report)

2 Revised 2007

3 Revised 2008.

Table B.2. Assessment model settings since 1991.

Assessment Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Assessment Age Range	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+	1–9+
Fbar Age Range	3–8	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6
Assessment Method	L.S.	L.S.	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets														
UK trawl, years:	81–90	82–91	76–92	76–93	76–94	-	-	-	-	-	-	-	-	-
ages:	1–8	1–8	1–8	1–8	1–8									
UK otter, years:	-	-	-	-	-	86–95	87–96	88–97	89–98	90–99	91–00	87–01	87–02	87–03
ages:						2–8	2–8	2–8	2–8	2–8	2–8	2–8	2–8	2–8
UK beam, years:			-	-	-	-	-	-	89–98	90–99	91–00	89–01	89–02	89–03
ages:									2–8	2–8	2–8	2–8	2–8	2–8
Bel Beam, years:	-	-	-	-	85–94	86–95	87–96	88–97	-	-	-	-	-	-
ages:					2–8	3–8	3–8	3–8						
IR otter, years:					-	-	-	-	-	-	-	95–01	95–02	95–03
ages:												2–8	2–8	2–8
UKBTS Sept, years:			88–92	88–93	88–94	88–95	89–96	89–97	89–98	90–99	91–00	89–01	89–02	89–03
ages:			1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–4	1–7
UKBTS Mar, years:								93–97	93–98	93–99	93–99	93–99	93–99	-
ages:								1–4	1–4	1–4	1–4	1–4	1–4	
IR-JPS, years:						-	-	-	-	-	-	91–01	91–02	-
ages:												1–6	1–6	
Time taper			20yr tri	20yr tri	20yr tri	No	No	No	No	No	No	No	No	No
Power model ages			1	0	1	1	1	1	1	0	0	0	0	0
P shrinkage			True	False	True	True	True	True	True	False	False	False	False	False
Q plateau age			5	5	5	5	5	5	5	5	5	5	5	5
F shrinkage S.E			0.3	0.3	0.5	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Number of years			5	5	5	5	5	5	5	5	5	5	5	5
Number of ages			5	5	4	4	4	4	4	4	4	4	4	4
Fleet S.E.			0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Assessment year		2005	2006	2007	2008	2009	2010
Assessment model		ICA	ICA	ICA	ICA	ICA	ICA
Tuning fleets	UK(E&W)OTB	-	-	-	-	-	-
	UK(E&W)BTS Sept	1989 – 2004	1989 – 2005	1989 – 2006	1989 – 2007	1989 – 2008	1989 – 2009
	ages:	1 – 7	2 – 7	2 – 7	2 – 7	2 – 7	2 – 7
	UK(E&W)BTS March	-	-	-	-	-	-
	UK(E&W)BT	-	-	-	-	-	-
	IR-OTB	-	-	-	-	-	-
	UK(NI) GFS Mar	1992–2004	1992–2005	1992–2006	1992–2007	1992–2008	1992–2009
	Biomass index						
	UK(NI) GFS Oct	1992–2004	1992–2005	1992–2006	1992–2007	1992–2008	1992–2009
	Biomass index						
Time-series weights		Full time-series - unweighted	Full time-series - unweighted	Full time-series - unweighted	Full time-series - unweighted	Full time-series - unweighted	Full time-series - unweighted
Num years for separable		5	5	6	7	8	9
Reference age		4	5	5	5	5	5
Terminal S		1	1	1	1	1	1
Catchability model fitted		linear	linear	linear	Linear	linear	linear
SRR fitted		No	No	No	No	No	No
Landings number-at-age, range:		1 – 9+	2 – 9+	2 – 9+	2 – 9+	2 – 9+	2 – 9+

Stock Annex: Plaice VIIfg

Stock	Plaice (Division VIIf&g)
Working Group	Celtic Seas Ecoregion
Date	March 2011
By	Chris Darby

A. General

A.1 Stock definition

The degree of separation between the stocks of plaice in the Celtic Sea and the Irish Sea is unclear. Historical tagging studies indicate a southerly movement of mature fish (or fish maturing for the first time) from the southeast Irish Sea, off North Wales, into the Bristol Channel and Celtic Sea during the spawning season (Figure A1). While some of these migrant spawning fish will remain in the Bristol Channel and Celtic Sea, the majority are expected to return to summer feeding grounds in the Irish Sea (Dunn and Pawson, 2002).

Very little mixing is considered to occur between the stocks (Pawson 1995). Nevertheless, time-series of recruitment estimates for all stocks in waters around the UK (Irish Sea, Celtic Sea, western and eastern Channel, North Sea) demonstrate a significant level of synchrony (Fox et al. 2000). This could indicate that the stocks are subject to similar large-scale environmental forces and respond similarly to them.

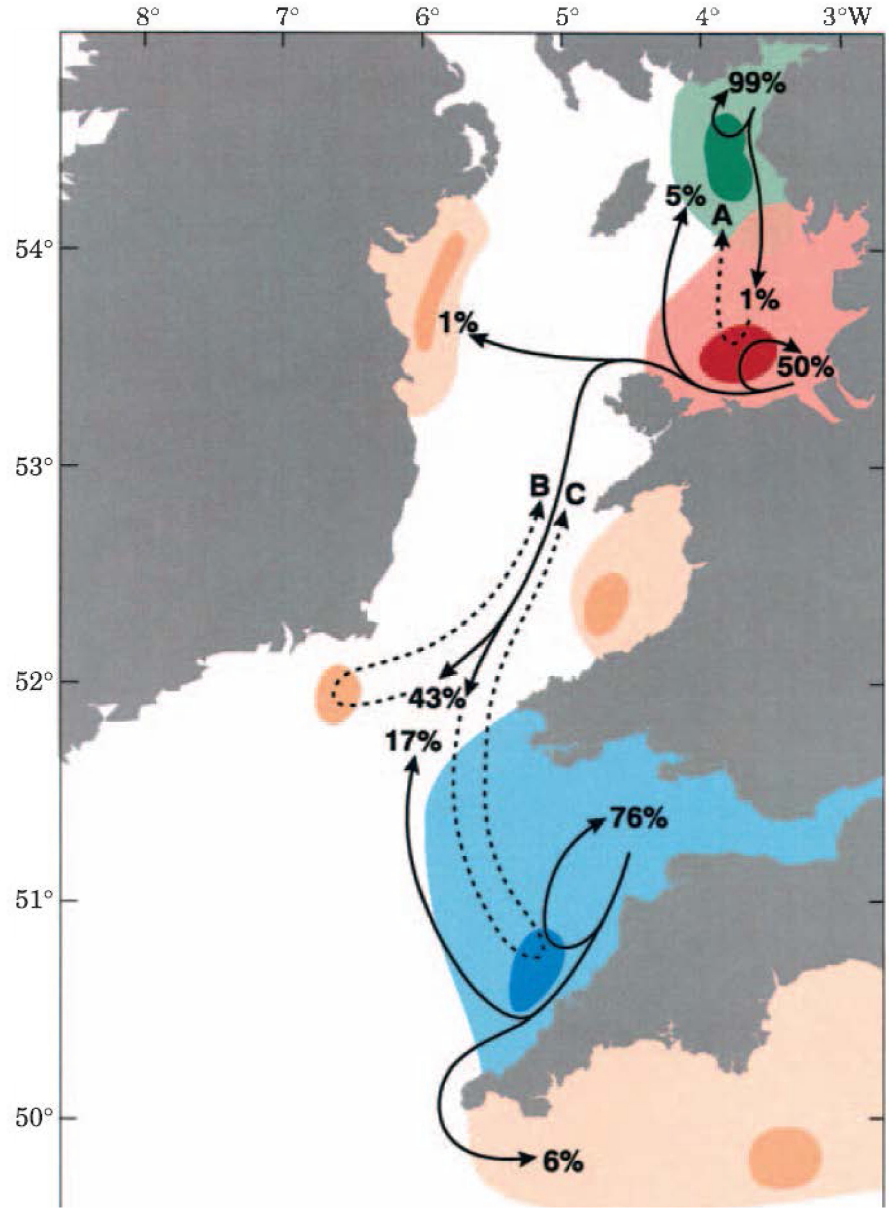

Figure A1. Principal substock areas and movements of plaice on the west coast of England and Wales. Percentages are the recaptures rates of tagged plaice <25 cm total length when released, and >26 cm when recaptured in English and Welsh commercial fisheries. Tagging exercises in 1979–1980 and 1993–1996 were combined based on the assumption that the dispersal patterns of plaice were consistent over time. For each substock, the main feeding area (derived from tag recaptures during April–December; light shading), and the main spawning area (derived from tag recaptures during January–March, and ichthyoplankton surveys; dark shading) are indicated. The substocks tagged have been coloured green, red and blue. The substocks coloured orange are less well determined, with the feeding area around southeast Ireland unknown. Letters represent return migrations, where A ≈ 6%, and B+C ≈ 46%. Reproduced from Dunn and Pawson (2002).

A.2. Fishery

The main fishery is concentrated on the Trevose Head ground off the north Cornwall coast and around Land's End. Although plaice are taken throughout the year, heaviest landings are in March, after the peak of spawning, with a second peak in September. The fisheries taking plaice in the Celtic Sea mainly involve vessels from Belgium, France, England and Wales.

A.3. Ecosystem aspects

Plaice are preyed upon and consume a variety of species through their life history. However, plaice have not as yet been included in an interactive role in multispecies assessment methods (e.g. ICES WGSAM 2008). Among other prey items, plaice typically consume large proportions of polychaetes and molluscs.

Other than statistical correlations between recruitment and temperature (Fox *et al*., 2000), little is known about the effects of the environment on the stock dynamics of plaice in the Irish Sea. Negative correlations between year-class strength of plaice (in either the Irish Sea, Celtic Sea, Channel or North Sea) and sea surface temperature are generally strongest for the period February–June. However, western (North Sea and Channel) and eastern (Irish Sea and Celtic Sea) stocks have been found to respond to different time-scales of temperature variability, which might imply that different mechanisms are operating in these stocks and/or that the Irish Sea and Celtic Sea share common spawning (Fox *et al*., 2000).

B. Data

B.1. Commercial catch

Landings

International landings-at-age data based on quarterly market sampling and annual landings figures are available from 1977. Landings rose to a maximum in the late 1980s, declined during the early 1990s, then fluctuated around 1000 t. The decline reach a low at 390 t in 2005 following which there has been a gradual increase. Estimates of the level of discarding have been collected since 2004 and have demonstrated a consistent increase, apart from 2007 when a substantial increase occurred by all fleets, followed by a return to the previously lower levels.

For the period 1991 to 2005 quarterly age compositions have typically represented around 70% of the total international landings, though in 2002 this fell to around 25% when age compositions were not available for the Belgian fleet. Belgian age sampling in 1993 was at a reduced level and was augmented with UK data. There was no UK sampling in the 4th quarter of 1994 and landings of 1 year olds by the UK otter trawl fleet may be underestimated in this year. Sampling levels during the earlier years in the time-series are considered to be low for all fleets and the quality of the catch data, particularly for older ages, up until around 1992 is believed to be poor. In 1995 UK age compositions for the period 1984–1988 were revised using new ALKs which used data from adjacent time periods where necessary. In the 2005 benchmark assessment, it was noted that numbers-at-age 1 in the landings data were very sparse and variable, reflecting the selection on this age (and especially considering the probable substantial discarding), so the values were replaced by zero to avoid fitting to noise. Keeping age 1 in the assessment allows the survey data at age 1 to contribute.

Discards

Discard information was not routinely incorporated into the assessment prior to 2011. WG estimates of the combined, raised, level of discards are available from 2004, they have demonstrated a consistent increase apart from 2007 when a substantial increase occurred in the discarding by all fleets followed by a return to the previously lower levels. Recent discard rates, although variable, are substantial in some fleets/periods. Total raised discard information is available for some fleets, and data raised to sampled vessels for others.

B.2. Biological

Weights-at-age

Landings

Historically, landings weights-at-age were constructed by fitting a quadratic smoother through the aggregated catch weights for each year. In 2011 WKFLAT decided not to continue with this approach, following concerns raised by WGCSE that the quadratic smoothing was resulting in the youngest ages having heavier weights than older ages. WKFLAT 2011 rejected the use of the polynomial smoother for weights-at-age and suggested that raw catch weights are used in future. Raw data back to 1995 was obtained by WKFLAT and used to update the catch weights and stock weights files.

Discards

Discard weight-at-age data were available for Belgium and UK(E+W). The UK weight-at-age data were derived from data collected by Cefas for each year (2002–2009). The Belgian weight-at-age data were derived using estimates of total catch biomass and total numbers-at-age for years 2004–2009. These values were used to derive a weight-at-age matrix in grammes for an individual fish. The two national weight-at-age matrices were 'combined' to a total international matrix by weighting the individual weights-at-age for each year, by the total discard tonnages from the two countries for that year. Where only one estimate of weight was available for an age/year, then that estimate was used.

The above processes also produced estimates of discard numbers-at-age for the two countries. The UK estimates were raised to incorporate equivalent levels of discards for the 'un-sampled' countries of France, Ireland and N Ireland (on the basis of similar gear types). A raising factor based on tonnages 'landed' for these countries was calculated and applied to the UK(E+W) estimates of discard numbers. Finally, these estimates were added to those calculated for Belgium to give total international discard numbers-at-age estimates.

Stock weights

For the years 2004–2009 where discard estimates were available, a revised set of stock weights-at-age were calculated. The stock weights-at-age based on landings, with SOP correction but no 'fitting', were combined with the international discard weights-at-age data. These were weighted by the relative landed or discarded international annual tonnages. The international annual discard tonnage was not readily available, as the 'unsampled' countries did not have estimates. These were derived using the ratio of UK(E+W) tonnages of landings and discards and this ratio was applied to these un-sampled nations landings to produce an estimate of total discard biomass for each of these countries. For the years prior to 2004, a revised set of stock weights-at-age data based on the international landings only was produced. These new values were based on the 'observed' weight data, but were SOP corrected. For this series of data, the 'smoothing' of the data by fitting a curve through the observed data were removed.

Natural mortality and maturity ogives

Initial estimates of natural mortality (0.12 yr all years and all ages, from tagging studies) and maturity were based on values estimated for Irish Sea plaice. A new maturity ogive based on UK(E&W) VIIfg survey data for March 1993 and March 1994 (Pawson and Harley, 1997) was produced in 1997 and is applied to all years in the assessment.

AGE	1	2	3	4	5+
Historical maturity	0	0.15	0.53	0.96	1.00
Revised maturity	0	0.26	0.52	0.86	1.00

The proportion of mortality before spawning was originally set at 0.2 because approximately 20% of the total catch was taken prior to late February–early March, considered to be the time of peak spawning activity. The proportion of F and M before spawning was changed to zero at the request of ACFM in 1996 as it was considered that these settings were more robust to seasonal changes in fishing patterns, especially with respect to the medium-term projections. No updated information was provided to WKFLAT and the estimates were retained.

B.3. Surveys

Indices of abundance are available from the UK (BTS-Q3) beam trawl survey in VIIf and the Irish Celtic Explorer IBTS survey (IBTS-EA-4Q).

The UK (E&W) beam trawl survey-series that began in 1988; since 1991, tow duration has been 30 minutes but prior to this it was 15 minutes. In 1997, values for 1988 to 1990 were raised to 30 minute tows. However, data for 1988 and 1989 were of poor quality and gave spurious results: thus, the series was truncated to 1990. A similar March beam trawl survey began in 1993 and was made available to the WG in 1998. The March beam trawl survey ended in 1999 but continued to be used as a tuning index in the assessment until 2003.

Recent data have revealed less correlation between ages than the historical time-series which should be monitored in case it is a developing problem. The log catch curves demonstrate good consistency over time and the reduction through time of the negative slope indicates that mortality rates have been declining.

The IGFS is a demersal trawl survey which started in 2003. It is coordinated through the ICES International Bottom Trawl (IBTS) working group, providing annual indices of abundance for commercially exploited groundfish stocks on the Irish continental shelf (ICES VIa, VIIb,g&j) for Q3–4. Plaice are caught by the survey off the SE coast up to, and just over, the border of VIIg with VIIa (ICES rectangles (32E2, 32E3).

Year effects in the survey catch rates dominate the abundance indices. The year-class and catch-curve plots illustrates that the consistency of plaice year-class abundance estimates at each age is relatively poor. The survey was not fitted within the assessment model, but will be monitored as the time-series progresses.

B.4. Commercial lpue

Commercial tuning indices of abundance from the UK(E&W) beam trawl and otter trawl data are used in the assessment to provide information on the oldest ages in the population. Historically, only ages 4–8 have been used to calibrate the assessment because of concerns about the level of discarding at the youngest ages. The data reveal good historical consistency of year-class estimates throughout the time-series, especially for the beam trawls, with more noise resulting from two major year effects in the otter trawl data.

C. Stock assessment

Historically the stock was assessed using XSA, under the assumption that discarding had a minimal effect on the estimates. Recent increases in the level of discarding led to this assumption being untenable and so at the 2011 WKFLAT discard estimates were introduced to the assessment fitted using the AP model. The settings and data for the model fits are set out in the table below:

Assessment year		2011 WKFLAT
Assessment model		AP
Catch data		Including discards 1990–2009
Tuning fleets	UK(E&W)-BTSurvey	1990–2009 ages 1–5
	UK commercial beam trawl	1990–2009 ages 4–8
	UK commercial otter trawl	1990–2009 ages 4–8
	Ire GFS Q3/4	Series omitted
Selectivity model		Linear Time Varying Spline at age (TVS)
Discard fraction		Polynomial Time Varying Spline at age (PTVS)
Landings num-at-age, range:		1–9+
Discards num-at-age, year range, age range		2004–2009, ages 1–8+

Three AP models which could not be distinguished in terms of the AIC, similar residual patterns and fits to the dataseries; the TI_PTVS, TI_TVS and TV_PTVS models. WKFLAT 2011 concluded that the TV_PTVS model, which allows for variation in time in the selection patterns of both landings and discards, was the most plausible model; given the known changes in gear types and discarding. However, it was not statistically distinguishable from the models which maintain the landings selection pattern as constant throughout the time-series.

Comparison of the management and stock metrics from the three model fits demonstrated very similar time-series trends in the estimates of fishing mortality, SSB and total estimated discards. WKFLAT therefore concluded that:

1. Due to the change in estimated fishing mortality when discards are included within the model fit, that discards should be retained within the assessment model structure.
2. Given that the time-series of discard data to which the models are fitted is short and that, consequently, there are likely to be changes in the manage-

ment estimates as discard data are added in subsequent years, no definitive model structure can be recommended at this stage in the development process.

3. The most flexible of the models TVS_PTVS should be used as the basis for advice; in terms of relative changes in estimated total fishing mortality and biomass.
4. The other two models which provide similar structures should continue to be fitted at the WG to provide sensitivity comparisons.
5. As the dataseries are extended a final model selection can be then determined.

D. Short-term projection

For short-term forecasts based on the revised assessment it is recommended that the current methods be applied to the populations and fishing mortalities (separated into discard and landings mortalities) derived from the PV_TVS model (assuming that the previously discussed sensitivity analyses do not indicate a change of model); in order to provide indications of the expected trends in discards, landings and spawning biomass.

E. Medium-term projections

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

F. Yield and biomass per recruit/long-term projections

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts. Currently the YPR calculations are used as a basis for determining the catch option for advice.

G. Biological reference points

The addition of discards increases the estimates of spawning biomass in the most recent years following the increased estimates of discards in time. Similarly fishing mortality averaged across ages 3–6, which include ages that are discarded also increases. Previous BRPs may therefore not be consistent with new assessment methodology and should not be used until the assessment methodology is considered sufficiently stable (a longer time-series of discard data) to evaluate new reference levels.

H. References

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Stock Annex: Irish Sea sole VIIa

Stock	Irish Sea Sole (Division VIIa)
Working Group	WGCSE
Date	6 Feb 2011
Revised by	WKFLAT 2011/Sofie Nimmegeers, Willy Vanhee, Kelle Moreau

A. General

A.1. Stock definition

Sole occur throughout the Irish Sea, but are found more abundant in depth less than 60 m. Recent information on stock identity, distribution and migration issues is included in the report of WKFLAT 2011. Cuveliers *et al.* (2011) combined the results obtained from ten microsatellite markers (long-term estimate of population structure) with results from otolith microchemistry analyses (short-term estimate of connectivity) on adult sole populations in the Northeast Atlantic area. Major large-scale differentiation was detected between three distinct regions (Baltic transition area, North Sea, Irish/Celtic Seas) with both types of markers. The assignment success of individuals to their collection location was much higher based on otolith edge microchemistry compared to the genetic assignments at all sampling locations, except for the Irish Sea. Only 28.6% of individuals (n = 30) caught in the Irish Sea could be assigned to their catch location based on otolith edge microchemistry, whereas this region demonstrated high genetic self-assignment scores (ca 60% of 91 individuals) suggesting a spawning population that is genetically distinct. 32% of the misclassifications based on otolith microchemistry were allocated to the neighbouring Celtic Sea. These results are consistent with tagging studies of sole in the Irish Sea and Bristol Channel, demonstrating mainly local recruitment and limited movement of sole outside the management areas (Horwood *et al.*, 1993). Therefore, the management unit is considered to correspond to the stock unit for Irish Sea sole.

A.2. Fishery

There are three main countries fishing for sole in the Irish Sea; Belgium, taking the bulk of the landings (60–80% in recent years). UK and Ireland taking about 20% and 10% respectively of the sole landings. The Netherlands and France take the remainder. Approximately 25 Belgian beam trawlers are operating in the Irish Sea, targeting sole. The UK trawl fleet and the Belgian beam trawls operate predominantly in the eastern part of the Irish Sea (Liverpool Bay and Morecambe Bay). Sole catches from Ireland are mainly coming from bycatches in the *Nephrops* fishery (operation in the Northwest of the Irish Sea).

When fishing in VIIa it is prohibited to use any beam trawl of mesh size range 70–90 mm unless the entire upper half of the anterior part of such a net consists of a panel of netting material attached directly to the headline of the net, extending towards the posterior of the net for at least 30 meshes and constructed of diamond-meshed netting material of which no individual mesh is of mesh size less than 180 mm. The Irish otter trawl fleet employs either a 70 mm mesh with square mesh panels or more commonly an 80 mm mesh. Similarly the Belgian and UK(E&W) beam trawls use 80 mm mesh gear. Otter trawlers targeting roundfish have, since 2000, used 100 mm mesh gear.

It was concluded at the 2000 working group and confirmed in 2001 that the cod recovery measures first enacted (EU Regulations 304/2000 and 2549/2000 + revisions in 2001–2003) in 2000 would have had little impact on the sole fishery. The closed area in 2001 covered a reduced area confined to the west of the Irish Sea and therefore is also expected to have had little effect on the level of fishing effort for sole The spawning closure for cod in 2002 is also unlikely to have had an impact on the sole fishery. The effort regulations and maximum daily uptake, implemented in 2003 will delay the uptake of the quota but is also unlikely to be restrictive for the total uptake. It is unlikely that any measures concerning the cod management plan in the Irish Sea had restrictions on the sole fishery after 2003.

Discard are estimated to be minor. Preliminary data indicate ranges from 0 to 2% by weight discarded.

Although no data are available on the extent of misreporting of landings from this stock, it is not considered to be a problem for this stock.

A.3. Ecosystem aspects

No information.

B. Data

B.1. Commercial catch

Quarterly age compositions are available from UK(E&W), Belgium and Ireland, as well as quarterly landings from France and Northern Ireland. The total international age composition is obtained using a combined ALK from UK(E&W), Belgium and Ireland raw data, responsible for 99% of the total international sole landings. The combined ALK is applied to the length distributions of the separate countries to obtain an aggregated age composition.

Catch weights were obtained from the combined AWK (UK(E&W), Belgium and Ireland raw data).

Stock weights were obtained using the Rivard weight calculator (http://nft.nefsc.noaa.gov./) that conducts a cohort interpolation of the catch weights.

B.2. Biological

Currently there are no direct (from tagging) or independent (from survey information) estimates of natural mortality. Therefore, annual natural mortality (M) is assumed to be constant over ages and years, at 0.1 yr^{-1}.

The maturity ogive used in this and previous assessments is based on survey information for this stock:

Age	1	2	3	4	5	6 and older
Mat.	0.00	0.38	0.71	0.97	0.98	1.00

Proportions of M and F before spawning were set to zero, as in previous years.

Males and females of this stock are strongly dimorphic, with males displaying much reduced rates of growth after reaching maturity, whereas females continue to grow.

Given the minimum landing size of 24 cm the majority of landings represent mature females.

B.3. Surveys

One survey is used in the assessment of VIIa sole: the UK beam trawl survey (UK (BTS-3Q)).

Area covered

Irish Sea; 52° N to 55° N; 3° W to 6° 30′ W.

Target species

Flatfish species, particularly juvenile plaice and sole. Length data recorded for all finfish species caught; samples for age analysis taken from selected species.

Time period

1988–2009: September (continuing)

Gear used

Commercially rigged 4 m steel beam trawl; chain matrix; 40 mm codend liner.

Mean towing speed: 4 knots over the ground. Tow duration: 30 minutes. Tow duration for trips in 1988–1991 was 15 minutes; in 1992 comparative tows of 15 and 30 minutes length were carried out, and subsequent cruises used a standard 30 minute tow. The data from earlier years were converted to 30 minutes tow equivalent using relationships for each species derived from the comparative work in 1992.

Vessel used: R.V. *Endeavour* (Cefas).

Survey design

Survey design is stratified by depth band and sector (Depth bands are 0–20, 20–40, 40+). Station positions are fixed. Number of stations = 35 in the eastern Irish Sea, 15 in the western Irish Sea, and 16 in St George's Channel (primary stations). Sampling intensity highest in the eastern Irish Sea, in the main flatfish nursery and fishery areas.

Method of analysis

Raised, standardized length frequencies for each station combined to give total length distribution for a stratum (depth band/sector). Sector age–length keys applied to stratum length distributions 1988–1994; stratum age–length keys applied 1995 onwards. Mean stratum cpue (kg per 100 km and numbers-at-age per 100 km) are calculated. Overall mean cpue values are simple totals divided by distance in metres (or hours fished). Population number estimates derived using stratum areas as weighting factors.

The September beam trawl survey has proven to estimate year-class strength well, and providing 50% to over 90% of the weighting to the total estimates of the incoming years classes.

B.4. Commercial cpue

Cpue and effort-series were available from the Belgium beam trawlers, UK(E&W) beam and otter trawlers, and the Irish otter trawlers and from two UK beam trawl surveys (September and March).

Cpue for both UK and Belgian beam trawlers has declined since the beginning of the time-series, but has remained relatively constant over the last decade, with a renewed increase over the last few years (2008–2009 for Belgium and 2007–2009 for UK).

Effort from both commercial beam trawl fleets increased from the early seventies until the late eighties. Since then Belgian beam trawl effort has declined over the nineties, increased again in the period 2000–2005 and subsequently dropped to much lower values in 2008–2009 (the lowest values since 1984). In the nineties, the UK beam trawl effort fluctuated around a lower level than the late eighties, and dropped during the 21st century to the lowest value of the time-series in 2009.

Indices of abundance derived from the UK September survey (UK (BTS-3Q)) (data from 1988 onwards) are demonstrated in WGNSDS 2002 (Table 12.2.2). High abundance indices for the UK September survey (UK (BTS-3Q)) can be seen for year classes 1989, 1995 and 1996. The dataseries from the UK March beam trawl survey (UK (BTS-1Q)) is rather short (from 1993 to 1999), and therefore difficult to interpret.

B.5. Other relevant data

No information.

C. Assessment: data and method

Model used: XSA

Software used: IFAP/Lowestoft VPA suite

Model Options chosen since 2004:

ASSESSMENT YEAR	2004	2005	2006	2007-2010	WKFLAT 2011
Assessment Model	XSA	SURBA	XSA	XSA	XSA
Fleets					
BEL-CBT	1975–2003 4–9		omitted	omitted	omitted
UK-CBT	1991–2003 2–9		omitted	omitted	omitted
UK (BTS-3Q)	1988–2003 2–9	1988–2004 1–9	1988–rec yr 2–7	1988–rec yr 2–7	1988–rec yr 2–7
UK (BTS-1Q)	1993–1999 2–9		1993–1999 2–7	1993–1999 2–7	omitted
Time Ser. Wts	tricubic 20yrs		linear 20 yrs	linear 20 yrs	uniform
Power Model	none		none	none	none
Q plateau	5		5	7	4
Shk se	0.8		1.5	1.5	1.5
Shk Age-yr	5 yrs 5 ages		5 yrs 3 ages	5 yrs 3 ages	5 yrs 3 ages
Pop Shk se	0.3		0.3	0.3	0.3
Prior Wting	none		none	none	None
Plusgroup	10		8	8	8
Fbar	4–7		4–7	4–7	4–7

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1970–last data year	2–8+	Yes
Canum	Catch-at-age in numbers	1970–last data year	2–8+	Yes
Weca	Weight-at-age in the commercial catch	1970–last data year	2–8+	Yes
West	Weight-at-age of the spawning stock at spawning time	1970–last data year	2–8+	Yes-but based on back calculated catch weights
Mprop	Proportion of natural mortality before spawning	1970–last data year	2–8+	No-set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1970–last data year	2–8+	No-set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1970–last data year	2–8+	No-the same ogive for all years
Natmor	Natural mortality	1970–last data year	2–8+	No-set to 0.1 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	UK (BTS-3Q)	1988–last data year	2–7

Note : several other commercial tuning fleets – BEL-CBT (Belgian beam trawl fleet), UK-CBT (UK beam trawl fleet), UK-COT (UK otter trawl fleet), IRL-COT (Irish otter trawl fleet) – and two other surveys (UK (BTS-1Q) and Irish Juvenile Plaice Survey) have been used or made available in the past. A thorough investigation of the utility of these tuning indices was conducted at the 2002 working group. The results are summarized in the Stock Annexes of the reports of WGNSDS 2002–2008 and WGCSE 2009.

D. Short-term projection

Model used: Age structured deterministic projection

Software used: MFDP

Initial stock size: Taken from the XSA for ages 3 and older. The recruitment-at-age 2 in the last data year is estimated using RCT3. The long-term geometric mean recruitment (1970–penultimate estimate) is used for age 2 in all projection years.

Maturity: the same ogive as in the assessment is used for all years (see table above)

F and M before spawning: set to 0 for all ages in all years

Weight-at-age in the stock: average weight of the last three years

Weight-at-age in the catch: average weight of the three last years

Exploitation pattern: average of the three last years, scaled to the last year's Fbar (4–7) if a trend in F was detected (not scaled to the last year's Fbar (4–7) if no trend in F was detected)

Intermediate year assumptions: *status quo* F

Stock–recruitment model used: none

Procedures used for splitting projected catches: not relevant

E. Medium-term projections

Medium-term projections were not conducted at WKFLAT 2011. The last medium-term projections were carried out in 2008. The settings used are described below.

Model used: Age structured

Software used: IFAP single option prediction

Initial stock size: Same as in the short-term projections.

Natural mortality: Set to 0.2 for all ages in all years

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages in all years

Weight-at-age in the stock: Assumed to be the same as weight-at-age in the catch

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern: Average of the three last years, scaled by the Fbar (3–6) to the level of the last year

Intermediate year assumptions: F-factor from the management option table corresponding to the TAC

Stock–recruitment model used: None, the long-term geometric mean recruitment-at-age 2 is used

Uncertainty models used: @RISK for excel, Latin Hypercubed, 500 iterations, fixed random number generator

- Initial stock size: Lognormal distribution, LOGNORM(mean, standard deviation), with mean as in the short-term projections and standard deviation calculated by multiplying the mean by the external standard error from the XSA diagnostics (except for age 2, see recruitment below)
- Natural mortality: Set to 0.2 for all ages in all years
- Maturity: The same ogive as in the assessment is used for all years
- F and M before spawning: Set to 0.2 for all ages in all years
- Weight-at-age in the stock: Assumed to be the same as weight-at-age in the catch
- Weight-at-age in the catch: Average weight of the three last years
- Exploitation pattern: Average of the three last years, scaled by the Fbar (3–6) to the level of the last year
- Intermediate year assumptions: F-factor from the management option table corresponding to the TAC
- Stock–recruitment model used: Truncated lognormal distribution, TLOGNORM(mean, standard deviation, minimum, maximum), is used for re-

cruitment age 2, also in the initial year. The long-term geometric mean, standard deviation, minimum, maximum are taken from the XSA for the period 1960–4th last year.

F. Long-term projections

Model used: age structured deterministic projection

Software used: MFYPR

Inputs as for short-term projection.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	3100 t	Default to value of B_{pa}.
Approach	F_{MSY}	0.16	Provisional proxy based on stochastic simulations assuming a Ricker S–R relationship (range 0.1–0.25).
	B_{lim}	2200 t	$B_{lim} = B_{loss}$. The lowest observed spawning stock (ACFM 1999), followed by an increase in SSB.
Precautionary	B_{pa}	3100 t	B_{pa} . B_{lim} * 1.4. The minimum SSB required ensuring a high probability of maintaining SSB above its lowest observed value, taking into account the uncertainty of assessments.
Approach	F_{lim}	0.4	$F_{lim} = F_{loss}$. Although poorly defined, there is evidence that fishing mortality in excess of 0.4 has led to a general stock decline and is only sustainable during periods of above-average recruitment.
	F_{pa}	0.3	This F is considered to have a high probability of avoiding F_{lim}.

Precautionary approach reference points have not been changed during 1999–2006. In this period, F_{pa} was set at 0.45 on the technical basis of high probabilities of avoiding F_{lim} and of SSB remaining above B_{pa}. In 2007, F_{pa} was changed to 0.3 due to the re-scaling of SSB estimates. In 2010, MSY reference points were added by WGCSE.

H. Other issues

A management plan for Irish Sea sole could be developed, also taking into account the dynamics of the plaice stock in that area.

I. References

ICES. 2002. Report of the Working Group on the Assessment of Northern Shelf Demersal Stocks (WGNSDS). ICES CM 2002/ACFM:02. 448 pp.

ICES. 2010. Report of the Working Group on the Celtic Seas Ecoregion (WGCSE), 13–19 May 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:09. 1430 pp.

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Stock Annex: Bay of Biscay Sole

Stock	Sole (Division VIIIab)
Working Group	Assessment of Hake, Monk and Megrim Stocks
Date	WGHMM 2010 (G. Biais and M. Lissardy)
Last updated	WKFLAT 2011 (G. Biais and M. Lissardy)

A General

A.1 Stock definition

The Bay of Biscay sole stock extends on shelf that lies along Atlantic French coast from the Spanish border to the west point of Brittany. This shelf forms a geographical unit, being narrow at its two extreme parts, particularly in the south. As sole is chiefly present at less than 150 m, this geography of the living area gives some supports to the absence or only limited exchanges with other southern or northern stocks. However, a tagging experiment carried out in 1992 on two nursery areas has revealed that fish may move from south coast of Brittany to the Iroise sea, in the west of Brittany (KoutsiKopoulos et *al*., 1993).

Several spawning grounds are known at depth from 30 to 100 m, from south to north (Arbault *et al*., 1986):

- in the north of Cape Breton, off the Landes coast;
- Between Arcachon and the Gironde estuary;
- in front of La Rochelle;
- in front of the Loire Estuary;
- in several but limited areas off the south coast of Brittany.

Nursery grounds are located in the coastal waters, in bays (Pertuis d'Antioche, Pertuis Breton, Baie de Bourgneuf) and estuaries (Gironde, Loire, Vilaine) (Le Pape *et al*., 2003a).

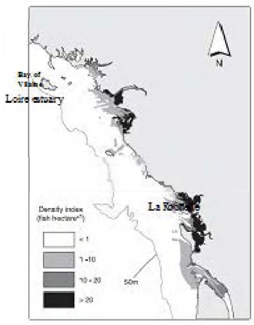


Figure 1. Fitted 0-group sole density (number of fish per hectare) in the Bay of Biscay (Le Pape *et al*., 2003a).

A.2 Fishery

The French fleet is the major participant in the Bay of Biscay sole fishery with landings being about 90% of the total official international landings over the historical series. Most of the remaining part is usually landed by the Belgian fleet.

The fishery is largely a fixed net fishery directed on sole, particularly in the first term on the year. The other component is a French and Belgian trawl fishery. The French trawlers are otter trawlers with mixed species catches (sole, cuttlefish, squid, hake, pout, whiting….). The Belgium trawlers are beam trawlers directed at sole, but monk is an important part of its catch. The French coastal boats of these two fisheries have a larger proportion of young fish in their catch than offshore boats. These boats less than 12 m long contribute to the landings by about one third from 2000 onwards. Sole is a major resource for all these boats, given the price of this species on the market. Although the species is taken throughout the year, the catch of coastal netters is less important in autumn, those of coastal trawlers in winter and those of offshore French boats are heaviest in the first quarter.

Otter trawling predominated until the late 1980s, including a small-mesh shrimp fishery which decreased markedly at the beginning of the 1990s. The fixed fishery begun in the 1980s and it have expanded in the 1990 to account for two third to three quarters of the French landings at the beginning of 2000s. The beam trawl effort increased also rapidly and continuously in the 1990s. It has decreased after 1999 until 2004 but it has returned to its previous 2001–2002 level in 2006–2007. On the opposite, the otter trawl effort demonstrates a decreasing trend until 1999 but it is stable since then.

Catches have increased continuously since the beginning of the 1980s, until a maximum was reached in 1994 (7400 t). They have decreased afterwards to 3600–4800 t in 2003–2009; the last year is the lower.

A.3 Ecosystem aspects

The quality and the extent of the nursery grounds have likely a major effect in the dynamic of sole recruitment. Studies in Villaine Bay revealed a significant positive relationship between the fluvial discharges in winter-spring and the size of the nursery (Le Pape *et al.*, 2003b). The extent of the river plume influences both the larval supply and the size and biotic capacity of habitats in estuarine nursery grounds and determines the number of juveniles produced.

The WGSSDS looked at the possibility of such effect for the whole Bay of Biscay stock at it 2006 meeting. The relationship between recruitment and river flows was investigated using the Loire river flow in the first half of the year which is considered to be a representative index of the water discharge influences on nursery areas in the Bay of Biscay. Unfortunately, no relationship can be seen between this index and the recruitment-at-age 2 (Figure 2). The environmental effect is likely to be more complex at the Bay of Biscay scale.

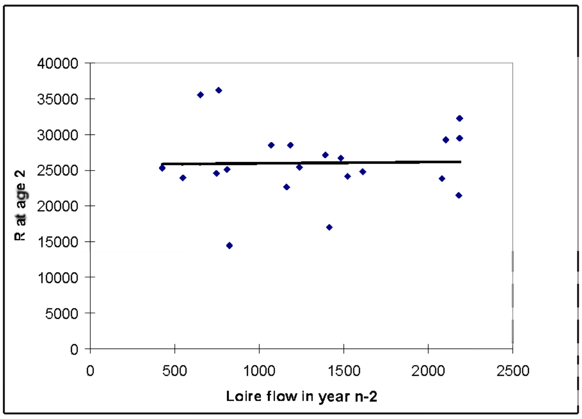


Figure 2. Relationship between recruitment-at-age 2 (as estimated by WGSSDS in 2006) and mean Loire flow in first half year.

B. Data

B.1. Commercial Catch

B.1.1. Discards estimates

Discard data are not included in the assessment because the available discards estimates are limited and, furthermore, may be biased (see thereafter).

Discards data collected within the DCF regulation framework

These observations have demonstrated that discards of beam trawlers and gillnetters are generally low but that the inshore trawlers fleet may have occasionally high discards of sole. Unfortunately, they are difficult to estimate because the effort data of inshore trawlers are not precise enough to allow estimating them by relevant areas. However, if one considers the discards have probably been high in 2009 because the 2007 year class seems to have been above the mean according to the ORHAGO survey, and if on uses the observed ratio of discards on landings of the inshore trawler fleet in 2009, which is likely to be an overestimate because the observed trips were mainly in nursery areas, the discards of the inshore trawlers are no more than 5% of the landings in number. Consequently, the lack of discards data does not appear to be a major problem for the quality of the assessment, notwithstanding that their estimates will increase the quality of the recruitment-series.

Discards estimates of the French offshore trawlers provided by the RESSGASC surveys from 1987 to 2003

Discards estimates of the French offshore trawlers were provided by the French trawl surveys FR-RESSGASC-S from 1987 to 2002. These surveys were carried out each quarter until 1997 and in the second and last quarter from 1998 to 2002.

In 2002, this survey was discontinued because the discards estimates that it provides were estimated to depend on the following questionable assumptions:

1. Trawls of the Gwen Drez R/S and the offshore trawlers have the same selectivity.
2. Gwen Drez R/S operate in the same area and in the same conditions than the offshore trawlers during the quarter (up to 1997) or the semester of the sur-

vey (quarter 4 year n + quarter 1 year n+1 for November survey year n; quarter 2 and 3 for may survey).

These discards estimates are been included several years in the assessments. They have represented about 1 to 3 % of the total catches from 1991 to 2003 and less than 0.5% since in 2002 and 2003. Given their low contribution to the total catch and the uncertainty due to the assumptions on which they are based, they have been no longer used in the assessment, as recommended by ACFM, since 2005.

Their estimation method may be found in the annexes appended to the 2005 and 2006 WGSSDS reports or in the WGHMM stock annexes from 2007 to 2010 (Bay of Biscay sole stock was moved from WGSSDS to WGHMM in 2007).

B.1.2. Landing numbers-at-length

The quarterly French sampling for length compositions is by gear (trawl or fixed net) and boat length (below or over 12 m long). The contributions of each of these components of the French fleet to the landings are estimated by quarter from logbook data, assuming that the landings associated with logbooks are representative of the whole landings. In 2000–2002, surveys on fishing activities by month have provided a likely less biased estimate of landing split by gear than logbooks, which are filled in only by a part of the fleet (50–60% of the landings in 2000–2002). As logbooks are often recorded in the file with delay, the percentage of landings associated with logbook may be well below preceding years, particularly in the last quarter. In that case, the process is to use logbooks to get a landing split in the last year if it is close to the mean over the three preceding years otherwise the quarterly mean over the three preceding years is used.

B.1.3. Catch number-at-age

Age reading method

From 1984 to 2008, the ages in the French landings have been determined by reading otoliths which have been burnt and manually cut. From 1996 onwards, the ages in Belgian landings begun to be determined by reading the age on thin slices of otolith.

In 2005, the ages in French landings begun to be also determined by using this latter method which is the more commonly used for sole age reading. However, in order to estimate the effect of the change in age reading method, from 2005 to 2008 the age reading of French sampled fishes were carried out using the two methods. One otolith was burnt and the second was collected to get thin slices.

Two catch and weight-at-age 1984–2008 time-series can thus be used to carry out two assessments, the set of data differing one from the other in the four terminal years. A comparison of these two assessments was presented to the 2010 WGHMM. It reveals only limited differences in the outputs. Consequently, the French catch and weight-at-age were revised from 2005 onwards at the 2010 WGHMM to use the 2005–2009 dataset provided by age reading on otolith slices, which is now the unique age reading method for the Bay of Biscay sole stock.

ALKs use to get catch-at-age estimates

Age compositions of the French landings and discards (up to 2003) are estimated using quarterly ALKs. Up to 1998, it is only FR-RESSGASC-S surveys ALKs. From the second half of the 1998 year and up to 2002, the first and third quarter ALKs are obtained from commercial landings samples. In 2003, commercial landing samples are completed by fish caught during a survey which was planned to design gear and methodology for the future survey ORHAGO aiming at a sole abundance index-series in the Bay of Biscay. In 2004 and 2005, only market samples are used. From 2006 onwards, market samples are mainly used but the ORHAGO survey-series provides age estimates at length for a large part of the landing length distribution in the last quarter of the year. Another survey (Langolf) provides also some fish in the second quarter. Market samples are used to complete these ALKs for the upper part of the distribution.

Prior to 1994, the age composition of French offshore trawler catches is raised to include Belgian landings. In 1994 and 1995, FR-RESSGASC-S ALKs are applied to Belgian length distributions. From 1996 ahead, catch numbers-at-age of the Belgian fleet are estimated with Belgian ALKs. French and Belgian age composition are added before being raised to the total international catch except in 2001 where the Belgian age compositions were raised to the total of Belgian and Dutch landings.

B.2. Biological

Weights-at-age

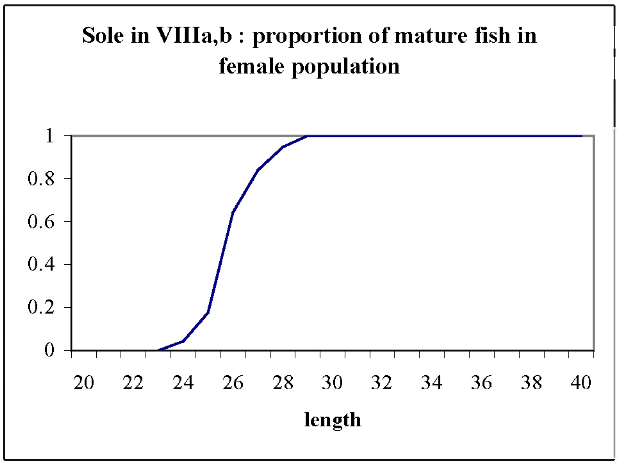
French mean weights-at-age are estimated using quarterly length–weight relationships in which weight are gutted weight multiplicated by the fresh/gutted transformation coefficient of French landing. This latter was changed from 1.11 to 1.04 in 2007. The French mean weights-at-age in catches are consequently estimated with a fresh/gutted transformation coefficient which is 1.11 up to 2006 and 1.04 from 2007 onwards.

Belgian mean weights-at-age are straight estimates. International mean weights-at-age are French-Belgian quarterly weighted mean weights.

Stock weights are set to the catch weights but always using the old fresh/gutted transformation coefficient of French landing (1.11) to have the predicted spawning biomass comparable to the biomass reference point of the management plan (B_{pa} as estimated in 2006 using mean weights in the stock which were mean weights in the catches).

Maturity ogive

In assessments up to the 2000 Working Group, a knife-edge maturity was used, assuming a full maturity-at-age 3.



During the 4 first months in 2000, the maturity-at-length and at-age was observed on 296 female fish, 112 being between 24 cm and 28 cm long, which is the observed length range for maturity occurrence of sole in Bay of Biscay. The sampling was assumed to be at random within a length class of 1 cm. The maturity ogive was then estimated applying a maturity/age/length key thus obtained to the length distribution of the first quarter in 2000.

The maturity-at-age was so estimated to be:

Age	≤ 1	2	3	4	≥ 5
Mature	0	0.32	0.83	0.97	1

Natural mortality

Natural mortality is assumed to be 0.1 for all age groups and all years.

B.3. Surveys

RESSGASC surveys

Quarterly RESSGASC survey-series are available from 1987 to 2002 but it worth noting that these surveys were carried out to provide hake discard estimates and consequently not well designed for providing sole abundance indices. Each quarter from 1987 to 1998, and thereafter each second and fourth quarter of the year, the survey aimed to catch as commercial fishing boats in the same areas. These series were disrupted in 2003. They have been withdrawn from the assessment by the 2011 WKFLAT because they no longer contribute to the estimates of the terminal population numbers.

ORHAGO survey

The ORHAGO survey was launch in 2007. The fishing gear is a beam trawl with 40 mm codend. This survey is carried out in November–December in order to have a good catchability of sole at the age 1. The sampling plan is systematic. 50 hauls are distributed in 10' latitude by 10' longitude rectangles all over the sole habitat in the Bay of Biscay. The haul positions are kept unchanged from year to year. This beam trawl survey is coordinated by the WGBEAM to which the results are reported each year since its beginning. The inclusion of this survey in the assessment was examined by the 2011 WKFLAT who concluded that this series is not long enough to be included in the assessment in 2011 but that possibility should be examined by the WGHMM when the series is more than five years long.

B.4. Commercial cpue

Four commercial cpue series are used in the assessment: La Rochelle offshore trawlers (FR-ROCHEL), Les Sables d'Olonne offshore trawlers (FR-SABLES), the Bay of Biscay offshore trawlers in the second quarter (FR-BB-OFF-Q2) and the Bay of Biscay inshore trawlers in the last quarter (FR-BB-IN-Q4).

These series are provided by boats which are selected to form homogeneous groups and to limit year-to-year changes in fleet compositions. The following methods were adopted:

- The La Rochelle and the Les Sables d'Olonne offshore trawler fleets are two fixed groups of fishing boats. These fleets were first included in the tuning fleets at the 2005 WGSSDS. They were formed by boats which have landed sole either in La Rochelle (or near La Rochelle) or in Les Sables and for which cpue data (with sole and *Nephrops* percentage in catches thresholds indicated thereafter) are available for a minimum number of years (10 from 1984 or 7 from 1995 to 2004). The criterion of skippers having declared to have looked for sole in 2003–2004 (Ifremer annual activities survey) was added to avoid inclusion of boats fishing sole sporadically. The La Rochelle vessels are 14 to 20 meters long and the Les Sables vessels are 12 to 23 meters long.
- The Bay of Biscay offshore trawler fleet in the second quarter and the Bay of Biscay inshore trawler fleet in the fourth quarter are formed by fishing boats which have caught sole in Bay of Biscay and for which cpue data (with sole and *nephrops* percentage in catches thresholds indicated thereafter) are available for five years over the ten last years. Furthermore, to limit effect of changes in fishing area, the cpue were calculated by selecting the statistical rectangles which have provided a cpue for more than five years from 2000 onwards. These tuning-series were first included in the tuning process at the 2011 WKFLAT. They were added to the tuning-series because the decrease in number of trawlers in La Rochelle or Les Sables fleets due to the decommissioning measures or the change in gear. The inshore vessels are 10 to 12 meters long and the offshore vessels are 14 to 18 meters long.

To take into account changes in fishing areas due to change in targeting species, a minimum percentage of sole in total landing of a trip (data from 1984 to 1998) or of a day (from 1999 onwards) was selected to avoid effects of a shift in target species from sole to cephalopods in recent years. This percentage has been set to 10% in 2005 for selecting relevant fishing periods for the La Rochelle and Les Sables tuning fleets. It resulted from the advice of fishermen given at a meeting. For defining new tuning fleets in 2011, it was necessary to reduce this percentage to 6% for increasing the number of available data. This requirement is due to the choice to carry out the work on a more reduced time period than previously (quarter instead of year) and to pay attention to the spatial distribution of effort.

A second threshold was fixed on the percentage of *nephrops* in total landing (below or equal to 10%) to avoid the inclusion of trips or days during which a large part of effort is devoted to this species.

The effort is in hours. It is not corrected for horse power (H x 100 kW) because this correction is considered introducing more noise, because of the quality of the measurement of horse power, than any improvement in fleets which are constructed to be homogeneous and with limited change in composition over the time period.

C. Assessment: data and method

Model used: XSA

Software used: Lowestoft VPA program

The XSA settings to be used were set by the WKFLAT 2011 are given in the following text table.

	WKFLAT 2011
Catch data range	84–last year
Catch age range	2–8+
Sables d'Olonne offshore trawlers fleets tuning fleet (FR – SABLES)	1991–last year 2–7
La Rochelle offshore trawlers fleets tuning fleet (FR – ROCHELLE)	1991–last year 2–7
Bay of Biscay offshore trawlers in the second quarter tuning fleet (FR-BB-OFF-Q2)	2000–last year 2–6
Bay of Biscay inshore trawlers in the fourth quarter tuning fleet (FR-BB-IN-Q4)	2000–last year 3–7
Taper	No
Ages catch dep. Stock size	No
Q plateau	6
F shrinkage se	1.5
Year range	5
age range	3
Fleet se threshold	0.2
F bar range	3–6

Historical review of changes in XSA settings (see text table thereafter):

Age range in the assessment was changed from 0–8+ to 1–8+ in 1998, and to 2–8+ in 2004. In both cases, this change is largely due to the uncertainties in discards estimates.

Because French 1999 catches were not available at the 2000 WG, the 2000 XSA was identical with the 1999 XSA.

The age range of F bar was change from 2–6 to 3–6 at the 2004 WG because the age 2 is not fully recruited. This age range was turned back to 2–6 by ACFM because its implication on reference points. The Review Group asked nevertheless to investigate changing it again to 3–6 in 2005 and ACFM accepted the change to 3–6 in 2006.

WG year XSA	1998 XSA	1999 & 2000 XSA	2001 XSA	2002 XSA	2003 XSA	2004 XSA	2005 XSA	2006 XSA	2007 XSA	2008 XSA	2009 XSA	2010 XSA
Catch data range	1984-1997	1984-1998	1984-2000	1984-2001	1984-2002	1984-2003	1984-2004	1984-2005	1984-2006	1984-2007	1984-2008	1984-2009
Age range in catch data	1-8+	1-8+	1-8+	1-8+	1-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+	2-8+
FR – SABLES	88-97 1-7	89-98 1-7	84-00 2-7	84-01 2-7	84-02 2-7	84-03 2-7	91-04 revised 2-7	91-05 2-7	91-06 corrected 2-7	91-07 2-7	91-08 2-7	91-09 2-7
FR – ROCHEL	88-97 1-7	89-98 1-7	84-00 2-7	84-01 2-7	84-02 2-7	removed	95-04 revised 2-7	91-05 corrected 2-7	91-06 corrected 2-7	91-07 2-7	91-08 2-7	91-09 2-7
FR – ROCHEL1	Not used	Not used	Not used	Not used	Not used	84-92 2-7	Removed	Removed	Removed	Removed	Removed	Removed
FR – ROCHEL2	Not used	Not used	Not used	Not used	Not used	93-03 2-7	Removed	Removed	Removed	Removed	Removed	Removed
FR – OTHER	Not used	Not used	Not used	Not used	Not used	Not used	95-04 2-7	Removed	Removed	Removed	Removed	Removed
FR – RESSGASC-S	88-97 1-7	89-98 1-7	removed	removed	removed	removed	Removed	Removed	Removed	Removed	Removed	Removed
FR – RESSGASC-S 2	Not used	Not used	87-00 2-6	87-01 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6
FR – RESSGASC-S 3	Not used	Not used	87-97 2-6	removed	removed	removed	Removed	Removed	Removed	Removed	Removed	Removed
FR – RESSGASC-S 4	Not used	Not used	87-00 1-6	87-01 1-6	87-02 1-6	87-02 2-6	87-02	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6	87-02 2-6
Taper	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No

WG year XSA	1998 XSA	1999 & 2000 XSA	2001 XSA	2002 XSA	2003 XSA	2004 XSA	2005 XSA	2006 XSA	2007 XSA	2008 XSA	2009 XSA	2010 XSA
Tuning range	10	10	17	18	19	20	14	15	16	17	18	19
Ages catch dep. Stock size	No	No	No	No	No	No	No	No	No	No	No	No
Q plateau	6	6	6	6	6	6	6	6	6	6	6	6
F shrinkage se	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Year range	5	5	5	5	5	5	5	5	5	5	5	5
age range	3	3	3	3	3	3	3	3	3	3	3	3
Fleet se threshold	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
F bar range	2-6	2-6	2-6	2-6	2-6	3-6	2-6	3-6	3-6	3-6	3-6	3-6

D. Short-term projection

Model used: Age structured deterministic projection

Software used: MFDP

Inputs

Initial stock size

- Recruitment is the geometric mean of recruitment values XSA over 1993 to three years before the assessment year (short mean because recruitment values are lower since 1993) if the XSA last year recruitment is considered poorly estimated according to the retrospective pattern.
- Recruitment is XSA last year recruitment if this latter one is considered to be accurately estimated according to the retrospective pattern.
- Age group above recruitment is derived from the GM.

Natural mortality: Set to 0.1 for all ages in all years.

Maturity: Same ogive used for all years (given in Section B.2).

F and M before spawning: None.

Weight-at-age:

- Weights-at-age in the landings are the unweighted means over the last three years using the new fresh/gutted transformation coefficient of French landing which was changed from 1.11 to 1.04 in 2007.
- Weights-at-age in the stock are the unweighted means over the last three years using the old fresh/gutted transformation coefficient of French landing (1.11). The predicted spawning biomass is consequently comparable to the precautionary biomass reference point (B_{pa}) set before the change in fresh/gutted transformation coefficient of the French landing.

Exploitation pattern:

- Fishing mortality at recruiting age is the arithmetic mean over the two years before the terminal year if the XSA recruitment estimate is overwritten by a GM.
- Fishing mortalities above recruiting age is the arithmetic mean over the three last years of the assessment.
- Unscaled if no trend is detected.
- Scaled to the last year's F_{bar} if a trend is detected.

Intermediate year assumptions:

Status quo F except if there is some information about the possibility that the TAC may be limiting.

F. Yield and biomass per recruit/long-term projections

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	13 000 t	B_{pa} (provisional estimate. MSY $B_{trigger}$ to be re-evaluated).
Approach	F_{MSY}	0.26	F_{max} because no stock–recruitment relationship, limited variations of recruitment, Fishing mortality pattern known with low uncertainty
	B_{lim}	Not defined	
Precautionary Approach	B_{pa}	13 000 t	The probability of reduced recruitment increases when SSB is below 13 000 t, based on the historical development of the stock.
	F_{lim}	0.58	Based on the historical response of the stock.
	F_{pa}	0.42	F_{lim} * 0.72

(unchanged since: 2010).

H. Other issues

None.

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Stock Annex: Megrim

Stock	Megrim in VI and IV
Working Group	WGCSE
Date:	(February 2011)
Revised by	(WKFLAT 2011)

A. General

A.1. Stock definition

Since the end of the 1970s ICES has assumed three different stocks for assessment and management purposes: megrim in ICES Subarea VI, megrim in Divisions VIIb–k and VIIIa,b,d and megrim in Divisions VIIIc and IXa. Megrim stock structure is uncertain and historically the Working Group has considered megrim populations in VIa and VIb as separate stocks. The Review Group questioned the basis for this in 2004. Data collected during an EC study contract (98/096) on the 'Distribution and biology of anglerfish and megrim in the waters to the West of Scotland' demonstrated significantly different growth parameters and significant population structure difference between megrim sampled in VIa and VIb (Anon, 2001). Spawning fish occur in both areas but whether these populations are reproductively isolated is not clear.

As noted by WGNSDS 2008, megrim in IVa has historically not been considered by ICES and WGNSDS 2008 recommended that VIa megrim should be considered by WGCSE. Landings data from IV and IIa are now included in this Report and work is underway to collect international catch and weight-at-age data for IV as well as VI. However, the availability of these data is sporadic. Spatial data from both the commercial fishery (using VMS and catches by statistical rectangle) and from fishery-independent surveys provide little evidence to support the view that megrim in VIa and IVa are indeed separate stocks. Based on the recommendations from WKFLAT (2011), megrim in VIa and IVa are considered a single unit stock and assessed accordingly. Megrim in VIb is considered a separate stock unit for assessment purposes.

A.2. Fishery

Megrim are predominately taken in otter trawl and to a lesser extent by Scottish seine. Analysis of VMS data indicates that megrim is taken in spatially discrete shelf fisheries and also in trawl fisheries conducted along the 200 m shelf break. Historically, ICES has assumed that megrim catches are closely linked to those of monkfish. Area misreporting of monkfish from VIa into IVa as a result of restrictive TACs in VIa is known to have occurred historically and catches have been redistributed into VIa using an algorithm developed by the Marine Laboratory, Aberdeen (see stock annex for Monkfish) Due to the assumed linkage between megrim and monkfish, megrim caught in VIa are also considered to have been area misreported and therefore the Working Group has historically applied the same redistribution method as used for monkfish. It remains unclear whether this pattern has continued in recent years, in 2009 the Working Group did not redistribute megrim catches in VIa as the historical pattern, higher catches in the statistical rectangles immediately east of the 4^0 line, was not observed in 2009, indeed the 2009 pattern may indicate a reversal of the process due to a more restrictive TAC in IVa. However, treating megrim in VIa and IVa as a single unit stock will mitigate this problem.

The introduction of the Cod Long-Term Management Plan (EC Regulation 1342/2008) and additional emergency measures applicable to VIa in 2009 (EC Regulation 43/2009, annex III 6) has impacted on the amount of effort deployed and increased the gear selectivity pattern of the main otter trawl fleets. Additionally, EC regulation 43/2009 has effectively prohibited the use of mesh sizes <120 mm for vessels targeting fish, which had been used particularly by the Irish fleet up to that point, the resultant rapid decline in effort for this category can be seen in Figure 5.3.1. Effort associated with the French fleet has continued to decline while the decline in both the Irish and Scottish TR1 fleets (120 mm mesh) appears to have stabilized. Note that 2009 data are only available for the Irish fleets. The increase in mesh size (from 100 to 120 mm) has also impacted on the retention length of megrim, increasing L50 from 28 cm to 42 cm, an increase of almost 50%.

Fishing effort in IV for the main Scottish otter fleet (TR1) have stabilized since the large effort reductions observed in previous years, effort levels associated with this mesh band have fallen by 64% since 2000. Following the increases in Irish effort in subdivision VIb from 2004–2008, effort in 2009 has declined significantly. These reductions in effort in Scotland and Ireland are considered to have contributed to the decline of landings in Subarea VI. Landings in VI are well below the TAC. Uptake by France, who account for 44% of the TAC, is very low (~11%). Official landings in Subarea IV and Division IIa in recent years are close to the TAC.

There is anecdotal information from the Scottish industry that since the introduction of the Conservation Credits Scheme in Area IV, those vessels have responded with increasing focus on anglerfish and megrim in both IVa and VIa. Based on landings data presented to the Working Group, only 53% of the overall TAC for VI, EC waters of Vb and international waters of XII and XIV was used. The TAC in IV was fully utilized.

Commercial catches are dominated by female megrim, typically 90% of the total catch. Analysis of Irish logbook data by Anon (2002) revealed that cpue trends varied throughout the year, demonstrating a maximum in late spring/early summer following the spawning period and at their lowest in late autumn.

A.3. Ecosystem aspects

None considered.

B. Data

B.1. Commercial catch

Commercial landings by country are available since 1990. The UK accounts for ~80% of the total landings. Over 50% of the landings are taken in the North Sea (IVa) with the remainder taken in VIa (~40%) and VIb, there are also landing reported from other areas (IVb and IVc), but these are negligible. International landings-at-age data based on quarterly market sampling and annual landings figures are available from 1990 for VIa, only partial landings-at-age are available for VIb and IVa, depending on year and country. This has prevented the construction of a full-time and spatial series for megrim separately in VIa, VIb and IVa. The available data are not separated by sex. Females make up approximately 90% of the landings, but survey data demonstrates that the relative proportion of males increases with depth. Discard data are only routinely supplied by Ireland, which represents only a small component of the stock area (southern part of VIa). The quality of the available landings data (specifically the area misreporting), discard information, lack of effort data and cpue data for the main fleet in the fishery, severely hampers the ability of ICES to carry out an assessment for this stock. For stocks like megrim and anglerfish on the northern shelf, there is a general need for improved spatio-temporal resolution of commercial catch and effort data through integration of VMS and logbook data from countries engaged in the fishery.

Discard data are only routinely made available by Ireland. Given the limited spatial coverage of the Irish fleet (southern component of VIa), it is uncertain how these compare with the other fleets and areas. Discarding is variable, Laurenson and MacDonald (2008) note that while discarding of megrim below minimum landing size is low (<1%), discarding of legal sized fish was much higher at 22% over the six observed trips. This is attributed to low market price for small grades and bruised fish, resulting in highgrading of catches on length/quality reasons to maximize the value of a restrictive quota.

B.2. Biological

Megrim exhibit a strong negative growth relationship with increasing depth. Fish found in deep water (>200 m) are commonly the same size as fish one year younger found in shallower areas (Gerritsen *et al.*, 2010). Analysis of age-at-length data reveals a wide length distribution within ages and that age precision deteriorates when sampling levels fall below ~500 per annum. Poor age precision in recent years prevents the development of an age based assessment.

B.3. Surveys

There are currently five survey indices available in VIa (ALT_IBTS Q1 [1995+]; ALT_IBTS Q4 [1990+]; Rockall_IBTS [2001+]; IRE_IBTS Q4 [2003+]; ISP-Anglerfish [2005+], two in IVa (NS-IBTS Q1 [1965+]; NS-IBTS Q3 [1991+] and the ISP-Anglerfish [2005+]). With the exception of IRE_IBTS and some low levels of ageing data from the NS_IBTS, ageing of megrim is not routinely undertaken. Combined with the poor precision of ageing data from the commercial fishery, severely limits the utility of the survey data beyond the provision of relative trends in abundance-at-length.

B.4. Commercial cpue

Commercial cpue indices are available for several fleets which are standardized for vessel power (kw.days). The Irish OTB series corrected for fishing power extends back to 1995 and terminates in 2002. From 2003 the Irish OTB index is split between two mesh size categories (TR2 70–99 mm and TR2>100 mm). Cpue estimates for the French and Scottish TR1 fleets operating in VIa are available and for the Scottish TR1 and TR2 fleets in IVa. The only available time-series for VIb is from the Irish otter trawl fleet which is corrected for fishing power.

C. Assessment: data and method

The last accepted assessment for megrim (VIa only) was in 1999.

There are a number of ageing issues that currently prevent the development of an age-based assessment. Analysis of the log catch numbers in the middle part of the time-series for VIa megrim indicates credible cohort tracking, however, this signal has been lost in recent years. It is likely that this deterioration is due to either a reduction in sampling levels and possible changes in fleet selectivity (spatial and gear). However, due to a lack of data on sampling levels and spatial data from the main component of the fishery, a more detailed analysis of ageing issues is currently not possible.

There are several survey time-series available for megrim; however with limited exception (IRE_IBTS) aging of megrim is not routinely undertaken despite a recommendation by IBTSWG (2001) to collect age data disaggregated by age.

ICES advice since 2009 has been based on survey trends in biomass and TAC setting based on the application of the EC rule for stocks.

Model used:

The current assessment is based on survey trends in relative biomass from the ISP-Anglerfish survey conducted annually in VIa, IVa and VIb. This is a targeted anglerfish survey undertaken by Marine Scotland with a scientific design using commercial gear. Megrim are caught in sufficient numbers to provide signals in the relative trends in megrim abundance and biomass. In 2006, 2007 and 2009 Ireland extended the anglerfish survey to cover the remaining part of VIa (from 54°30′ to 56°39′). Further details of the survey including information on design, sampling protocol and gear and vessel are given in Fernandes *et al.*, 2007 and in annual working documents which describe the survey results.

D. Short-term projection

Given that the stock status is based on survey trends only, no short-term projections can be provided.

E. Medium-term projections

Given that the stock status is based on survey trends only, no short-term projections can be provided.

F. Long-term projections

Given that the stock status is based on survey trends only, no short-term projections can be provided.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	Not defined	
Approach	F_{MSY}	Not defined	
	B_{lim}	Not defined	
Precautionary	B_{pa}	Not defined	
Approach	F_{lim}	Not defined	
	F_{pa}	Not defined	

H. Other issues

H.1. Historical overview of previous assessment methods

The last analytical assessment for this stock (VIa component only) was in 1999 using XSA.

I. References