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Report of the Benchmark Workshop on Flatfish (WKFLAT)

25 February–4 March 2010

Copenhagen, Denmark

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CIEM Conseil International pour l'Exploration de la Mer

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Contents

1 Executive summary

The Benchmark Workshop on Flatfish (WKFLAT) met from February 25 to March 4 2010 at ICES Headquarters in Copenhagen. The meeting was chaired by Bill Brodie (Canada) and the ICES Coordinator was David Miller (Netherlands), who also served as a subgroup chair. Bill Clark (USA) and Darren Gillies (Canada) participated in the meeting as invited external experts. A total of 22 participants from 8 countries were in attendance.

The main goals and objectives of the meeting were to evaluate the appropriateness of stock assessment data and methods for four flatfish stocks: sole in IIIa, sole in IV, plaice in VIId and plaice in VIIe. WKFLAT was to agree and document the preferred stock assessment method for each stock and update the relevant stock annexes with current best practice assessment inputs and methods.

Much of the first two days of the Workshop were devoted to reviewing data in the context of current assessments (as part of a data workshop), including invited input from stakeholders, and to identifying assessment issues and a work plan. The remainder of the Workshop then concentrated on resolving the assessment issues and revising the Stock Annexes.

The Report is structured along the lines of a pre-agreed template. The detailed descriptions of data and assessment methods are contained in the individual stock by stock sections. A key output was the updated stock annex for each stock.

The key findings of WKFLAT include:

- for sole in IIIa, the recommended use of a new assessment method (stochastic state-space assessment model - SAM);
- for sole in IV, the continued use of an XSA-based approach with consideration of moving to a SAM approach;
- for plaice in VIId, the use of an XSA model which accounts for migration to/from the adjacent stocks of plaice in the North Sea and English Channel. However there are limitations on the use of this model in providing forecasts and reference points;
- for plaice in VIIe, the use of an XSA approach which accounts for catches taken in Q1 in the adjacent VIId stock. An alternative model using truncated indices was also explored.
- for sole in IIIa and the two plaice stocks, there was considerable discussion on stock definition/structure and appropriate stock boundaries. For sole in IIIA it was recommended that the assessment include catches from the adjacent Belts area (Subdivision 22 and 23).
- for the plaice stocks, it was recognized that there was considerable catch in Q1 in VIId which came from plaice spawning in that area but otherwise residing in VIIe or IV. WKFLAT recommended revised approaches for both the VIId and VIIe stocks, and recognized that catches for IV plaice would also have to be adjusted in reciprocal fashion.
- for all four stocks, WKFLAT carefully considered all available data, particularly the survey and commercial indices used in tuning the stock assessment models. In several instances, recommendations were made to change the use (discontinue or change the year or age-range) of some of these tuning-series.

2 Introduction

The requirements for benchmark workshops were detailed by ACOM in 2008. This Flatfish Workshop is the second such Benchmark Workshop for flatfish stocks (the first for flatfish was WKFLAT09 in February 2009). The key aspects of the Terms of Reference (see Annex 1 for full ToRs) are:

i) Evaluate the appropriateness of stock assessment data and methods;

ii) Agree and document preferred stock assessment method for each stock;

iii) Update the relevant Stock Annexes to include what WS participants identify as current best practice assessment inputs and methods, providing sufficient detail to ensure that assessments can be readily replicated.

Much of the first two days of the Workshop were devoted to reviewing data in the context of current assessments, including invited input from stakeholders, and to identifying assessment issues and a work plan. The remainder of the Workshop then focused on resolving the assessment issues to the extent possible, with a view to revising the Stock Annexes.

The meeting was chaired by Bill Brodie (Canada) and the ICES Coordinator was David Miller (Netherlands), who also served as a subgroup chair. Bill Clark (USA) and Darren Gillies (Canada) participated in the meeting as invited external experts. Other participants included members of the WGNSSK and WGCSE ICES assessment groups, other scientists, industry representatives, and members of the ICES Secretariat and ACOM. A full list of participants is provided in Annex 2.

2.1 Plaice mixing issue and recommendation to investigate a combined assessment of plaice in Areas IV and VII.

Tagging data show substantial mixing of plaice between the western and eastern English Channel (Areas VIIe and VIId) and between the eastern English Channel and the North Sea (Area IV) and possibly IIIa. At present a separate assessment is done for each of these three areas, but the abundance estimates obtained from these assessments for the smaller stocks may be questionable because they assume a closed population in each area. When there is mixing among areas, standard stock assessments that do not account for this are liable to overestimate present abundance in some areas and underestimate it in others. As a result, quotas based on the separate assessments can result in actual fishing mortality rates well above target in some areas and well below in others. The sum of the separate estimates should accurately estimate total historical abundance in all areas, but may or may not be accurate for total abundance in each individual area at a given time.

In this case, the mixing occurs when a portion of the North Sea stock moves into the eastern English Channel in January and February to spawn. The magnitude and timing of this migration is known approximately from archival tagging data. Kell *et al.* (2004) simulated its effect on separate assessments in the North Sea and Area VIId. They found that if the two areas are managed to the same target F, the separate assessments perform well, with negligible bias. But if Area VIId is fished at a much higher rate, the separate Area VIId assessment will grossly underestimate F and overestimate abundance in Area VIId. (The North Sea assessment is little affected.) At present the estimated F in the North Sea is under 0.3 and the estimated F in Area VIId is 0.6, so there is little doubt that the VIId assessment is biased and the true F there is very high. If Area VIId were fished to a target F of 0.3, like the North Sea, this problem would go away and the separate assessments could be relied on. Unless and until that happens, the standalone Area VIId assessment will be unreliable.

There was considerable discussion on the stock structure of plaice in VIId , VIIe, and SA IV, including how the stocks are defined, where spawning and nursery areas occur, likelihood that there are stock components that do not mix completely, etc. There are no genetic studies which give an answer to the stock definition, and there are questions on the extent of mixing on the spawning grounds, where the juveniles settle, etc. which make traditional definition of closed population stocks complex and quite difficult. Given the tagging results and relative sizes of the three stock units, the effect of mixing is likely to have much more impact on the assessment of the smaller components (English Channel) than on the larger one (North Sea).

Bias due to mixing can be avoided by combining the areas and conducting a single assessment, but that approach raises some difficult issues. One is how to choose and combine series of relative abundance data that reflect trends in the combined area as a whole. A more difficult issue is how to apportion the estimated catch opportunities among areas. Although there are examples of how this has been applied elsewhere (Clark and Hare, 2007, herring reference), these issues require careful study for the plaice stocks.

Therefore WKFLAT recommends that ICES set up a Study Group similar to SGHERWAY to explore for all plaice stocks between VIIe and IIIa, 1) stock identity 2) improved management regimes, with the potential for performing a combined assessment of plaice in the North Sea and English Channel, and apportioning catch opportunities between them. Such a SG could also explore the possibility of modeling/assessing the three different "sub-populations" and trying to estimate migration factors between the areas, using tagging studies to ground-truth these results.

WKFLAT explored impacts of various mixing rates on the assessments of the plaice stock components in VIId and VIIe, based on published tagging results and some previous studies (e.g. Burt *et al*., 2006; Hunter *et al*., 2004; Kell *et al*., 2004). For plaice in VIIe, an adjustment to the catch-at-age was carried out by adding 15% of Q1 landings from VIId to the catch in VIIe. For plaice in VIId, the catch-at-age was also adjusted for that change, and a further 50% of Q1 landings and catch-at-age in VIId were assumed to come from North Sea (SA IV). Thus the Q1 catch-at-age for plaice in VIId was reduced by 65%. WKFLAT emphasized the importance of making corresponding adjustments if catch from one area is re-assigned to another.

References

Burt, G., D. Goldsmith, and M. Armstrong. 2006. A summary of demersal fish tagging data maintained and published by Cefas. Sci. Ser. Tech Rep., Cefas Lowestoft, 135: 40pp.

Clark, W.G., and S.R. Hare. 2007. Assessment of the Pacific halibut stock at the end of 2006. Report of Assessment and Research Activities 2006: 97–128. International Pacific Halibut Commission, Seattle.

Hunter, E. J. D. Metcalfe, G. P. Arnold and J. D. Reynolds. 2004. Impacts of migratory behaviour on population structure in North Sea plaice. *Journal of Animal Ecology* 73, 377–385.

Kell L.T., R. Scott, and E. Hunter. 2004. Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research 51, 287–299.

3 Plaice Eastern Channel (ICES Division VIId)

3.1 Current stock status and assessment issues

The spawning-stock biomass of plaice in VIId has followed a steady decline in the last ten years, following a peak generated by the strong 1996 year class. The current level of SSB is stable at a low level, below B_{lim}, and this confirms the fishers' impressions as assessed by a survey in France in 2006.

F varies without trend around the long-term average. Year classes 2006 and 2007 suggest a substantially stronger recruitment than in recent years. Based on a status quo fishing value in 2009 and 2010, the short-term projections suggest a stock size between B_{lim} and B_{pa} by 2011 (WGNSSK, 2009).

The evaluation of the status of the stock is based on an XSA assessment using three commercial cpue indices, and three survey indices. The commercial tuning-series are the Belgian Beam Trawlers, the UK Beam Trawlers and the French Otter Trawlers. It is notable that those three commercial tuning-series are the major contributors to the total catches of plaice in the Eastern Channel. The French Otter trawler time-series has been split into two parts, before and after 1997, because of trends in the log-catchability residuals. The survey indices are the UK Beam Trawl Survey (designed for catching plaice and sole), the French Groundfish Survey and the International Young fish Survey. The International Young Fish survey (combination of UK and French YFS survey, on the basis of the carrying capacity of the respective habitats), was stopped in 2006 because of the cessation of the UK YFS, which is a cause of concern for the estimation of recruitment.

The current level of sampling of the commercial fishery is considered to be reasonable.

The assessment has a tendency to overestimate SSB and underestimate F, especially from 2000, when survey and commercial fleet information begins to diverge.

There is uncertainty about the stock structure. Historical tagging information demonstrates migration routes from North Sea and Western Channel into the Eastern Channel during winter for spawning (see Section 3.3).

Lack of discarding information also adds to the uncertainty. Routine discard sampling began in 2003 following the introduction of the EU Data Collection Regulations and indicates percentages of discards up to 50% in number, depending on the trip and on fishing practices. However, the time-series of discards is not yet long enough to be used in an analytical assessment (ICES Advice, 2009).

The assessment settings used in the most recent years were as follows:

Year of assessment		2008	2009
Assessment model		XSA	XSA
Assessment software		FLR library	FLR library
Fleets			
UK Inshore Trawlers	Age range Year range	Excluded	Excluded
UK Beam Trawl	Age range Year range	2–10 1991–2007	2–10 1991–2008
BE Beam Trawlers	Age range Year range	2–10 1981–2007	2–10 1981–2008

FR Otter Trawlers	Age range	2–10	2–10
	Year range	1989–1996	1989–1996
		2–10	2–10
		1997–2007	1989–1996
UK Beam Trawl Survey	Age range	1–6	1–6
	Year range	1988–2007	1988–2008
FR Ground Fish Survey	Age range	1–3	1–3
	Year range	1988–2007	1988–2008
Intern'l Young Fish Survey	Age range	0–1	0–1
	Year range	1987–2007	1987–2008
Catch/Landings			
Age range:		1–10+	1–10+
Landings data:		1980–2007	1980–2008
Discards data		None	None
Model settings			
F_{bar}:		3–6	3–6
Time-series weights:		None	None
Power model for ages:		No	No
Catchability plateau:		Age 7	Age 7
Survivor est. shrunk towards the mean F:		5 years/3 ages	5 years/3 ages
S.e. of mean (F-shrinkage):		1.0	1.0
Min. s.e. of population estimates:		0.3	0.3
Prior weighting:		No	No

The previous Reference Points were as follows:

B_{lim} = 5400 t.

B_{pa} = 8000 t.

F_{lim} = 0.54

F_{pa} = 0.45

3.2 Compilation of available data

3.2.1 Catch and landings data

The landings are taken by three countries France (55% of combined TAC), England (29%) and Belgium (16%). Quarterly catch numbers and weights were available for a range of years depending on country; the availability is presented in the text table below. Levels of sampling prior to 1985 were poor and these data are considered to be less reliable. In 2001 international landings covered by market sampling schemes represented the majority of the total landings. More detailed information on sampling procedures is available in the stock annex document.

Country	Numbers	Weights-at-age
Belgium	1981–present	1986–present
France	1989–present	1989–present
UK	1980–present	1989–present

For investigation by the Benchmark Working Group, a time-series of discards has been estimated using all discards samples available from the three countries involved in the plaice VIId fisheries (Belgium, UK and France). The stratification used and the number of samples per strata is given in Table 3.2.1. The details of the estimation procedure were reviewed by WKFLAT. The results are presented in Figure 3.2.1 and Table 3.2.2 for length distribution and Figure 3.2.2 and Table 3.2.3 for age distribution. The final annual estimates of discards for inclusion in the assessment are presented in Table 3.2.4.

3.2.2 Biological data

Natural mortality: assumed constant over ages and years at 0.1, as for plaice in the North Sea.

Maturity ogive: assumes that 15% of age 2, 53% of age 3 and 96% of age 4 are mature and 100% for ages 5 and older.

Weights-at-age: prior to 2001, stock weights were calculated from a smoothed curve of the catch weights interpolated to the 1st January. From 2001, second quarter catch weights were used as stock weights in order to be consistent with North Sea plaice. The database was revised back to 1990.

Both the proportion of natural mortality before spawning (M_{prop}) and the proportion of fishing mortality before spawning (F_{prop}) are set to 0.

3.2.3 Survey tuning data

A dedicated 4 m beam trawl survey for plaice and sole has been carried out by England using the RV Corystes since 1988. The survey covers the whole of VIId and is a depth stratified survey with most samples allocated to the shallower inshore stations where the abundance of sole is highest. In addition, inshore small boat surveys using 2 m beam trawls were undertaken along the English coast and in a restricted area of the Baie de Somme on the French coast. In 2002, The English and French Young Fish Surveys were combined into an International Young Fish Survey. The dataset was revised for the period back to 1987. The two surveys operate with the same gear (beam trawl) during the same period (September) in two different nursery areas. Previous analysis (Riou *et al*., 2001) has demonstrated that asynchronous spawning occurs for flatfish in Division VIId. Therefore both surveys were combined based on weighting of the individual index with the area nursery surface sampled (Cf. Annex 1). Taking into account the low, medium, and high potential area of recruitment, the French YFS got a weight index of 55% and the English YFS of 45%. The UK Young Fish Survey ceased in 2006, disrupting the ability to derive an International YFS.

A third survey is the French otter trawl groundfish survey (FR GFS) in October. Prior to 2002, the abundance indices were calculated by splitting the survey area into five zones, calculating a separate index for each zone, and then averaging to obtain the final GFS index. This procedure was not thought to be entirely satisfactory, as the level of sampling was inconsistent across geographical strata. A new procedure was developed based on raising abundance indices to the level of ICES rectangles, then by averaging those to calculate the final abundance index. Although there are only minor differences between the two indices, the revised method was used in 2002 and subsequently.

3.2.4 Commercial tuning data

Three commercial fleets have been used in tuning. UK and Belgian Beam Trawlers and French Otter Trawlers.

The effort of the French otter trawlers is obtained from the logbook information on the duration of the fishing time weighted by the engine power (in KW) of the vessel.

Only trips where sole and/or plaice have been caught are accounted for. The effort of the Belgian Beam Trawlers is corrected for engine power.

3.2.5 Industry/stakeholder data inputs

No industry/stakeholder data inputs were available to the Benchmark.

3.3 Stock identity and migration issues

The management area for this stock is strictly ICES Area VIId, called the Eastern English Channel, although the TAC area includes area VIIe (Western English Channel).

Major spawning centres were found in the eastern English Channel, the Southern Bight, the central North Sea and the German Bight. Other less important local spawning centres were found in the western English Channel and off the UK coast from Flamborough Head northwards to Moray Firth (Houghton and Harding, 1976; Harding and Nichols, 1987 *in* ICES PGEGGS, 2003). The regions of plaice spawning are generally confined within the 50 meter depth contour (Harding *et al*., 1978, *in* ICES PGEGGS, 2003).

The stocks of plaice in the Channel and North Sea are known to mix greatly during the spawning season (January–February). At this time many western Channel and North Sea plaice may be found in the eastern Channel. The comparable lack of spawning habitat in the western Channel alone suggests that this migration from VIIe to VIId during the first quarter may be of considerable importance. More details on plaice migration and related figures may be found in Section 4.3.

From tagging experiments, it was possible to derive estimates of the proportion of fish in quarter 1 in VIId that would return, if not caught by the fishery, to VIIe and IV (complete details, tables and figures may be found in Section 4.3.2). In summary, 14% of males and 9% of females would migrate to VIIe, while 52% of males and 58% of females would migrate to IV. To the nearest 5%, this suggests that 10 to 15% of the catch in Q1 in VIId should be allocated to VIIe, while between 50 and 60% of the catch in Q1 in VIId should be allocated to IV. These estimates are in agreement with previous analyses (based on the same data) reported by Pawson (1995), which suggest that 20% of the plaice spawning in VIIe and VIId spend summer in VIIe, while 56% migrate to the North Sea. Given the assumptions involved in these calculations and the relatively small numbers of adult tags returned the estimates of movement rates are subject to great variability. The limitations of the data do not permit an estimate of annual movement probabilities. Recent studies based on data storage tags suggest that the retention rate of spawning plaice tagged in the eastern English Channel is 28%, while 62% of spawning fish tagged were recaptured in the North Sea (Kell *et al*., 2004).

3.4 Spatial changes in the fishery and stock distribution

The international dataset used for the discarding estimates (see Section 3.2.1) was used to investigate spatial changes in the position of the catches (Figure 3.4.1) and/or the effort spatial distribution (Figure 3.4.2) over the period 2002–2008. The yearly landings distribution of plaice displays a relative stability, with the two northeastern ICES rectangles being the most productive, although the area around Boulogne sur Mer (North coast of France) tends to demonstrate a decline over time. The distribution of days-at-sea for the otter trawlers, beam trawlers and gillnetters from Belgium, UK and France demonstrates a strong north/south dichotomy. The most fished ICES rectangles are those along the UK coast and Northern France. Like the spatial distribution of landings, no significant change can be demonstrated in the distribution of effort over such a short period of time.

3.5 Environmental drivers of stock dynamics

Not investigated during the Benchmark Workshop. Information in the Stock Annex given to be up to date.

3.6 Role of multispecies interactions

3.6.1 Trophic interactions

Not investigated during the Benchmark Workshop.

3.6.2 Fishery interactions

Not investigated during the Benchmark Workshop.

3.7 Impacts on the ecosystem

Not investigated during the Benchmark Workshop.

3.8 Stock assessment methods

3.8.1 Models

The flexible Statistical Catch-at-Age model developed by Aarts and Poos (2009) for reconstructing discards in the North Sea plaice stock has been tested, using the provisional 2004–2008 discard estimates provided to the WKFLAT (see Section 3.2.1). To reduce the number of parameters, only the configuration with time-invariant discard spline was tested, though allowing for time-variant selectivity spline. This choice was supported by evidence that discarding ogives were stable over the years in the sample dataset (Figure 3.8.1). However, the model did not succeed in providing reasonable and robust fit. The convergence was poor and the results did not fit well to the observations. The current discard time-series was considered too short and too variable to support proper model fitting. In particular, observed discard rates at age 1 varied between 30 to 80% in number (Figure 3.8.2), and this lead to very large uncertainty estimates in the statistical model.

Further work on the data and method used for estimating the 2004–2008 series of discards is necessary before further inclusion in the statistical model. For example, the Group suggested the use of the ratio of plaice discarding over the landings of sole (the targeted species) or over the landings of plaice and sole (the targeted assemblage). Following this review, and including the year 2009 in the estimates, a new trial should be made to reconstruct the historical time-series, then perform new trial runs including discards.

As regards the uncertainty in the assessment, exploratory analyses were carried out using the FLR packages, with the objectives of improving the retrospective pattern.

3.8.2 Sensitivity analysis

3.8.3 Retrospective patterns

Given our knowledge of the spawning migrations of plaice in the Channel and the opposite retrospective patterns in F and SSB in the western Channel (VIIe) assessment, WKFLAT attempted a simple combined assessment for Channel VIId,e plaice. Because the VIId stock and landings are about five times greater than those in VIIe, it is perhaps unsurprising that the combined VIId,e assessment model resembles the current VIId assessment and suffers the same retrospective problem in F and SSB.

The persistent retrospective pattern in F and SSB has been scrutinised during the Benchmark Workshop, with the objectives of improving the consistency of the assessment. In the preliminary stage, single fleet runs were carried out (Figure 3.8.3) and the results indicate clearly the difference of perception between the UK BTS, and to a lesser degree the International YFS, and the remaining tuning-series. The second run was done with exactly the same settings as in the 2009 Assessment Working Group. The retrospective analysis split by age (Figure 3.8.4) highlights that the final retrospective pattern in F and SSB is due to the persistent underestimating fishing mortality-at-ages 2 to 4.

The perception of historical stock trends from UK BTS differs from that of the commercial tuning-series. This is interpreted as if the survey would have a full view of the age structure of the stock, whereas the information coming from the commercial series is truncated due to the discarding behaviour. A similar response would be expected from the French GFS, but it is not the case, probably due to a lesser internal consistency than the UK BTS (Figure 3.8.5), and thus a lesser weight in the assessment.

A run was carried out with ages 1, 2 and 3 removed from the UK BTS, to see if the final assessment would indicate no distortion between commercial and survey perception of adult stock size. The resulting retrospective analysis is given in Figure 3.8.6, and shows a net improvement from the original assessment. This demonstrates the potential large effect of discards in the assessment of plaice in VIId. It was therefore agreed that, for consistency reasons, the final assessment should either i) include discards in the assessment and keep the full age range of the UK BTS or ii) perform the assessment on landings only (no discards) then remove the young ages in the UK BTS.

The second aspect scrutinised during the Benchmark Workshop was the effect of migration on the results of the assessment (see Sections 3.3 and 4.3 for the details of the migration behaviour affecting the Eastern Channel). It has been demonstrated that plaice from the southern North Sea and from Western Channel migrate into the Eastern Channel for spawning in January and February, and return back to their home ground relatively quickly after spawning. From the Eastern Channel perspective, accounting for such behaviour would imply removing a proportion of catches from quarter 1 in the input files. However, while the existence of these important migrations is an acknowledged fact, their extent and year-to-year variability are more difficult to quantify precisely. The tagging data suggest that on average 15% of the Eastern Channel plaice stock in quarter 1 are individuals from Western Channel, and 50% of individuals are from the Southern North Sea (see Sections 3.3 and 4.3.2 for the details). The analysis uses a proportion of individuals from VIIe and a proportion of individuals from IV which move into VIId, rather than the proportion of plaice in VIId which come from neighbouring sectors, but the tagging results do not permit such calculation. WKFLAT recommends that tagging studies be carried out in order to assess the proportions of the providing areas (VIIe and IV) migrating into the receptive area (VIId).

The run with 65% of catches removed from VIId quarter 1, for all ages and years, was carried out. The removal of 65% of the catches was done on the true values of quarterly age structure of the catch-at-age matrix from 2000 to 2008 based on the data available during WKFLAT. For the previous years, the catch-at-age values for the first quarter were computed using the average percentage of catches from the first quarter over the period 2000 to 2008 and the annual catch-at-age structure of the landing. The landings values were adjusted accordingly (Table 3.8.1). During the Benchmark Assessment, only the Belgian tuning-series of quarterly age structure was available, so only this tuning-series was modified by removing the same percentage of catches form the series The resulting retrospective analysis (Figure 3.8.7) displays no improvement against an assessment using the same settings as last year, but including only the Belgian tuning-series.

A last run consisted in removing 65% of quarter 1 and ages 1, 2 and 3 from UK BTS. The resulting retrospective patterns (Figure 3.8.8) in F and SSB, are significantly reduced compared with the original assessment, especially in the most recent year. This is confirmed by Mohn's rho indicator (Figure 3.8.9). The log q residuals of this run were plotted (Figure 3.8.10) and hardly any improvement with the original assessment could be seen. The full diagnostics of this run are given Table 3.8.2. It is worth noting that the strong pattern in the log q residuals of the UK BTS is still present. A summary of the assessment results is shown in Table 3.8.3.

3.8.4 Evaluation of the models

3.9 Stock assessment

Waiting for further improvement in the time-series of discard estimates, WKFLAT recommends the use of XSA for assessing plaice VIId stock, with the final settings as follows:

Year of assessment		2009
Assessment model		XSA
Assessment software		FLR library
Fleets		
UK Beam Trawl	Age range Year range	Excluded
BE Beam Trawlers	Age range Year range	2–10 1981–2009 (*)
FR Otter Trawlers	Age range Year range	Excluded
UK Beam Trawl Survey	Age range Year range	4–6 1988–2009
FR Ground Fish Survey	Age range Year range	2–3 1988–2009
Intern'l Young Fish Survey Age range of IYFS should be 1987-2006	Age range Year range	1 1987–2006
Catch/Landings		
Age range:		1–10+
Landings data:		1980–2009 (*)
Discards data		None

Model settings		
Fbar:		3-6
Time series weights:	None	
Power model for ages:	No	
Catchability plateau:	Age 7	
Survivor est. shrunk towards the mean F:	5 years/3 ages	
S.e. of mean (F-shrinkage):		1.0
Min. s.e. of population estimates:		0.3
Prior weighting:	No	

(*) 65% of quarter 1 to be removed.

The proposed final model improves the retrospective pattern, and takes into account the acknowledged mixing between neighbouring areas, but the model is not entirely satisfactory in terms of quality of the assessment. The reasons are that the model still does not account for discards, removes younger ages from an internally consistent survey, and does not provide solutions for some patterns in log-catchability residuals. The assessment is thus useful in determining recent trends in F and SSB, and in providing a short-term forecast and advice on relative changes in F. However, WKFLAT does not recommend this as an analytical assessment, as it will not be useful for calculation of reference points.

Until the further work on including the discard estimates, and sensitivity of the assessment to the 65% adjustment to the Q1 catch-at-age has been examined, an analytical assessment cannot be defined. Further review of this work could be conducted either by correspondence or if a future meeting of WKFLAT was to occur, but in either case an analytical assessment will not be available in time for the next assessment of this stock.

3.10 Recruitment estimation

Not investigated during the Benchmark Workshop.

3.11 Short-term and medium-term forecasts

Not investigated during the Benchmark Workshop.

3.12 Biological reference points

Not investigated during the Benchmark Workshop.

3.13 Recommended modifications to the Stock Annex

All relevant information has been updated to the Stock Annex during the Benchmark Workshop.

3.14 Recommendations on the procedure for assessment updates

See Section 3.9.

3.15 Industry supplied data

No information from the Industry was brought to the Benchmark Workshop.

3.16 References (additional references to be added)

ICES. 2003. Planning Group on North Sea Cod and Plaice Egg Surveys in the North Sea (PGEGGS). IJmuiden, Netherlands. 24–26 June 2003 ICES CM 2003/G:06 Ref. D. 45 p.

Kell, L.T., Scott, R., and Hunter E. 2004. Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research 51: 287–299.

Pawson, M.G. 1995. Biogeographical identification of English Channel fish and shellfish stocks. Fisheries Research Technical Report No. 99. MAFF Directorate of Fisheries Research, Lowestoft. http://www.cefas.co.uk/Publications/techrep/tech99.pdf.

3.17 Recommendations from the Workshop

The recommendation for the settings of the assessment model stands only for the Assessment Working Group 2010. Further work will be carried out on discards during the year 2010 and following the results of this intersessional work, a new recommendation will have to be made.

WKFLAT recommends that ICES set up a study group similar to SGHERWAY to explore the potential for performing a combined assessment of plaice in the North Sea and English Channel, and apportioning quota between them. Such a SG could also explore the possibility of modelling/assessing the three different "subpopulations" and trying to estimate migration factors between the areas, using tagging studies to ground-truth these results.

3.18 Future work to be done on the stocks

In priority, future work should consist of refining the estimation of discards from the international dataset already available. The reconstruction of the time-series of discards prior to 2004 should follow, and different runs of the Aart and Poos model tested. Whether the choice of the model and settings to be used in future could be agreed by correspondence or during another benchmark remains to be seen.

The sensitivity and relevance of all tuning-series should be investigated when discard data have been added. Presently, the three commercial tuning-series correspond to more than 60% of the overall catches, which leads to some circularity in the assessment. Moreover, most of the tuning-series display long-term trends in catchability. During this session, WKFLAT has only used the Belgian Beam Trawl commercial tuning-series for its recommended settings, because only this series could be adjusted for the removal of 65% of Q1 landings.

Investigation on the spatial patterns in length distributions at ages in the age–length keys should be carried out. The methodologies used for raising age structures should be reviewed and an international code of good practice should be developed.

3.19 Data problems relevant to data collection regulation

The scorecard results (see Annex 4) pointed out the difficulty in estimating discards with all confirmed bias positioned on the estimation of discard weight, namely the significant on-board observer refusal rate and the problematic temporal coverage.

The following points were listed as potential bias:

- The difficulty to quantify the landings of vessels not submitting logbooks and not selling their landings under auction;

- The lack of randomness in sampling for length, and the fact that some auctions do not present the entire landings of a vessel to the buyers (pre-sales);
- The lack of randomness in the collection of samples for age.

It was acknowledged that the recent Workshop on maturity for flatfishes (WKMSSPDF, IJmuiden, March 2010) would improve the agreement on assessing maturity stages for plaice, and that there was a need to evaluate the gains in moving to international spatial age–length keys (planned ICES WKDRASS in 2010).

Table 3.2.1. Plaice in VIId. Number of trips sampled per strata, for estimation of discards. All countries combined.

	2002		2003		2004		2005		2006		2007		2008	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
DRB_MOL_[0,+)			2	1		2								
G.._DEF_(0,+)			2	8	4	4	3	3	1	1	13	7	2	7
OT._DEF_(0,12)				2	2	2	2	5	1	2	4	6	2	2
OT._DEF_[12,+)		1	4	8	3	15	3	13	7	6	4	13	2	28
TBB_DEF_(0,24)				4		5	1	2	2					
TBB_DEF_[24,+)				1	5	6	8	4	6	5	7	4	3	9

Table 3.2.2. Plaice in VIId. Length distribution of discards-per-year and semester. Lengths over the minimum landing size are shaded in grey.

length	2004 - 1	2004 - 2	2005 - 1	2005 - 2	2006 - 1	2006 - 2	2007 - 1	2007 - 2	2008 - 1	2008 - 2	2009 - 1	2009 - 2
60	0	0	0	0	0	0	0	0	0	0	0	0
80	26952	0	0	0	0	0	0	0	0	0	0	0
90	17277	0	0	0	0	0	0	0	0	0	0	0
100	9235	0	0	0	0	2207	0	0	0	0	0	0
110	13842	0	0	0	0	6620	0	0	0	0	0	0
120	9235	0	0	0	0	0	0	0	0	0	0	0
130	35147	23556	0	0	0	4413	0	0	0	0	0	0
140	88820	13673	16417	0	27669	4413	0	0	25278	0	0	0
150	368574	50903	61126	30208	158059	0	209648	0	52626	850	0	0
160	396950	67853	18540	0	188495	6620	616605	0	974	6970	0	0
170	732335	196894	26295	76383	451677	37262	143121	2765	173204	19828	0	27864
180	881038	157534	103396	8834	668704	9001	165614	11861	264229	47457	4399	18576
190	871964	200165	205151	70475	520510	48427	141744	24884	787445	83722	0	35797
200	854653	281017	363732	134572	737767	45403	384509	14276	1313348	91425	2466	55728
210	949367	556612	339688	127956	463906	47086	337766	40127	1203243	74616	4399	55728
220	805743	447939	428719	213928	534488	99816	572670	144076	1501888	50037	6910	111456
230	675440	560175	648496	272663	409397	67561	582875	185114	1279515	71286	1256	69660
240	1034942	397201	628772	408441	279803	125036	601455	60289	1558962	125461	13820	0
250	879977	469234	490485	461043	359687	174717	573211	268392	1095951	180583	55299	65016
260	897212	344139	642341	430484	220719	116540	346216	74533	770510	195991	89859	71982
270	1029289	105030	256437	298846	133827	59774	557293	21788	511050	140828	5022	107
280	780840	23012	89941	260224	45068	15326	122507	19539	14157	60096	3767	6966
290	930193	14559	15632	88782	15612	2854	34658	10272	0	29335	1256	0
300	466439	9262	18558	135412	3862	348	2498	3387	0	21640	1256	0
310	293798	569	16803	20408	1394	0	2498	3387	0	15411	0	0
320	71574	4076	8690	16073	1609	174	0	677	0	9341	0	0
330	61774	191	11470	1075	1154	0	1249	0	0	8176	0	0
340	46064	4076	8014	451	134	89	0	0	0	4264	0	0
350	20533	191	0	1335	268	0	0	0	0	1981	0	0
360	5837	191	0	659	322	174	0	892	0	1210	0	0
370	0	0	7122	433	0	0	0	0	0	461	0	0
380	0	191	0	901	107	0	0	0	0	0	0	0
390	0	0	7122	433	0	0	0	0	0	2481	0	0
400	0	382	0	0	0	0	0	0	0	666	0	0
410	0	0	0	0	0	0	0	0	0	256	0	0
420	0	0	0	0	0	0	0	0	0	51	0	0
430	0	191	0	0	0	0	0	0	0	51	0	0
440	0	0	0	0	0	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0	0	0	0
460	0	0	0	0	0	0	0	0	0	0	0	0
470	0	0	0	0	0	89	0	0	0	102	0	0
480	0	191	0	0	0	0	0	0	0	103	0	0
500	0	0	0	0	0	0	0	0	0	102	0	0
520	0	0	0	0	0	0	0	0	0	102	0	0
540	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.2.3. Plaice in VIId. Age distribution of discards-per-year and semester.

age	2004 - 1	2004 - 2	2005 - 1	2005 - 2	2006 - 1	2006 - 2	2007 - 1	2007 - 2	2008 - 1	2008 - 2
1	912389	1237687	95578	299754	35685	205072	109473	341909	1082774	371372
2	6837675	1979167	2473088	1841501	3721722	462600	2572758	457751	7815509	625016
3	3896241	680000	1564657	724465	1040352	121912	1177129	16236	1199499	125421
4	365370	8800	245895	75426	50740	19502	69243	30852	363795	35346
5	71553	0	0	267	1195	3065	0	0	51367	8042
6	0	0	0	0	0	89	0	0	0	3889
7	0	0	0	3182	0	0	0	0	0	589

Table 3.2.4. Plaice in VIId. Final estimates of annual age distribution of discards.

age	2004	2005	2006	2007	2008
1	2150076	395332	240757	451382	1454146
2	8816842	4314589	4184322	3030510	8440525
3	4576241	2289122	1162264	1193366	1324920
4	374170	321320	70242	100096	399141
5	71553	267	4260	0	59409
6	0	0	89	0	3889
7	0	3182	0	0	589

Table 3.8.1. Plaice in VIId. Modification of the annual landings by removing 15% of Q1 catches expectedly coming from VIIe plaice stock, and 50% of Q1 catches expectedly coming from IV plaice stocks.

Year	Total Landings (tonnes)	Total landings Q1 (tonnes)	Landings Q1 from VIIe (tonnes)	Landings Q1 from NS (tonnes)	Modified Total Landings (tonnes)
1980	3756	908	136	454	3166
1981	4735	1635	245	818	3672
1982	4805	1668	250	834	3721
1983	4680	1729	259	865	3556
1984	4431	1770	266	885	3281
1985	5957	2064	310	1032	4615
1986	5762	2343	351	1172	4239
1987	7867	2868	430	1434	6003
1988	9103	3572	536	1786	6781
1989	6667	3002	450	1501	4716
1990	7798	3101	465	1551	5782
1991	7437	2678	402	1339	5696
1992	6232	2173	326	1087	4820
1993	4771	1828	274	914	3583
1994	5633	2099	315	1050	4269
1995	4569	1758	264	879	3426
1996	4598	1849	277	925	3396
1997	5316	2207	331	1104	3881
1998	4830	1993	299	997	3535
1999	5437	2116	317	1058	4062
2000	5233	2647	397	1324	3512
2001	4963	1820	273	910	3780
2002	5499	2340	351	1170	3978
2003	4536	1340	201	670	3665
2004	4007	1268	190	634	3183
2005	3018	1114	167	557	2294
2006	3305	1019	153	510	2643
2007	3674	1207	181	604	2889
2008	3491	1120	168	560	2763

Table 3.8.2. Plaice in VIId. Final run diagnostics.

Lowestoft VPA Version 3.1

3/03/2010 13:02

Extended Survivors Analysis

Plaice in VIId (run: XSAAEDB01/X01)

Cpue data from file D:\Expertise\WKFLAT\xsa\Migration\7d_65percMigration\PLE7DFleet.txt

Catch data for 29 years. 1980 to 2008. Ages 1 to 10.

Fleet,	First, year,	Last, year,	First, age ,	Last, age	Alpha,	Beta
BE CBT ,	1981,	2008,	2,	9,	.000,	1.000
UK BTS ,	1988,	2008,	4,	6,	.500,	.750
FR GFS ,	1988,	2008,	1,	3,	.750,	1.000
IN YFS ,	1987,	2006,	1,	1,	.500,	.750

Time series weights :
Tapered time weighting not applied
Catchability analysis :
Catchability independent of stock size for all ages
Catchability independent of age for ages >= 7

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 = 1.000

Prior weighting not applied

Tuning converged after 37 iterations

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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.045	0.090	0.142	0.046	0.042	0.077	0.028	0.040	0.029	0.027
2	0.151	0.555	0.377	0.603	0.333	0.454	0.329	0.346	0.295	0.170
3	0.672	0.575	0.861	0.998	1.270	0.672	0.685	0.574	0.551	0.402
4	1.196	1.003	0.561	1.071	1.137	0.591	0.583	0.601	0.659	0.579
5	0.886	1.056	0.740	0.937	0.638	0.671	0.615	0.410	0.672	0.456
6	0.657	0.623	0.492	0.780	0.526	0.436	0.754	0.537	0.437	0.427
7	0.669	0.678	0.316	0.755	0.673	0.319	0.554	0.767	0.845	0.340
8	0.619	0.401	0.339	0.346	0.510	0.552	0.321	1.216	1.103	0.325
9	0.327	0.676	0.305	0.707	0.460	0.466	0.538	0.342	0.663	1.657

XSA population numbers (Thousands)

	AGE								
YEAR	1	2	3	4	5	6	7	8	9
1999	17700	13200	26000	9740	1870	373	185	184	143
2000	16800	15300	10300	12000	2660	696	175	86	90
2001	21300	13900	7970	5240	3990	839	338	80	52
2002	21000	16700	8640	3050	2700	1720	464	223	52
2003	16500	18100	8290	2880	945	958	714	197	143
2004	13800	14300	11800	2110	837	452	512	330	107
2005	12400	11600	8220	5430	1050	387	264	337	172
2006	13800	10900	7530	3750	2740	516	165	137	221
2007	29500	12000	6980	3840	1860	1650	273	69	37
2008	14300	26000	8070	3640	1800	859	962	106	21

Estimated population abundance at 1st Jan 2009
, 0.00E+00, 1.26E+04, 1.98E+04, 4.89E+03, 1.85E+03, 1.03E+03, 5.07E+02, 6.20E+02, 6.92E+01,

Taper weighted geometric mean of the VPA populations:
, 2.11E+04, 1.85E+04, 1.21E+04, 5.51E+03, 2.21E+03, 9.79E+02, 5.00E+02, 2.57E+02, 1.23E+02,

Standard error of the weighted Log (VPA populations):
, .3701, .3746, .4570, .5525, .5546, .6560, .7057, .7564, 1.0374,

Log catchability residuals.

Fleet : BE CBT

Age ,	1981,	1982,	1983,	1984,	1985,	1986,	1987,	1988
1 ,	No data for this fleet at this age							
2 ,	.00,	-.18,	.48,	-1.29,	.44,	.57,	.38,	.14
3 ,	.37,	-.29,	.02,	.04,	-.10,	.01,	-.39,	-.12
4 ,	.42,	.04,	.36,	.00,	.04,	-.34,	-.47,	-.45
5 ,	-.46,	.07,	-.31,	.08,	-1.21,	-.30,	-.67,	-.98
6 ,	-.64,	-.13,	-.15,	.18,	.37,	.02,	-.95,	-1.00
7 ,	-.27,	-.40,	-.46,	.38,	-.03,	-.09,	.34,	-.14
8 ,	.03,	.36,	.92,	-.07,	.79,	-1.05,	-.33,	-.29
9 ,	.00,	.00,	.00,	.00,	.00,	.00,	.00,	.00

Age ,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998
1 ,	No data for this fleet at this age									
2 ,	-1.96,	.34,	1.00,	1.28,	.50,	.94,	-1.66,	-.19,	99.99,	-1.07
3 ,	-.32,	.48,	.81,	.54,	-.14,	.15,	.12,	-.07,	-1.50,	-.43
4 ,	-.12,	.08,	.13,	-.27,	-.47,	.62,	.15,	.20,	.49,	.08
5 ,	.37,	-.19,	.61,	-.32,	-.22,	.09,	.24,	.44,	1.18,	.26

Table 3.8.2. Plaice in VIId. Final run diagnostics (continued)

6	-.18	.04	.55	.38	-.25	-.04	-.23	.00	.95	.24
7	-.44	-1.18	.17	-.27	-.19	-.06	.57	-.44	.63	.29
8	.10	-.70	-.91	.56	-.66	.30	.19	.10	-.27	-.22
9	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	No data for this fleet at this age									
2	-1.58	-1.46	.46	.50	.22	.23	.33	.54	.89	.16
3	-.10	-1.04	.86	.73	.68	.16	-.06	-.17	-.15	-.10
4	.36	-1.19	.13	.51	.43	-.13	-.27	-.15	-.27	.10
5	.68	-.37	.15	.57	.04	.21	.40	-.36	.17	-.16
6	.75	-.65	.09	-.21	.44	-.15	.54	-.10	.18	-.03
7	.46	-.50	-.60	.29	.48	-.03	.22	.30	.86	.12
8	-.18	-.65	-.20	-1.08	.06	.25	-.26	.86	.79	-.40
9	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

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	8	9
Mean Log q	-7.9635	-6.1678	-5.6311	-5.7306	-5.9920	-5.9790	-5.9790	-5.9790
S.E(Log q)	.8912	.5123	.3885	.5100	.4586	.4516	.5628	.0007

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	1.21	-.372	7.58	.11	27	1.10	-7.96
3	1.45	-1.432	4.71	.28	28	.73	-6.17
4	1.22	-1.262	4.96	.55	28	.47	-5.63
5	1.14	-.687	5.45	.47	28	.59	-5.73
6	1.04	-.282	5.95	.62	28	.49	-5.99
7	1.12	-.828	5.95	.65	28	.51	-5.98
8	1.29	-1.669	6.19	.56	28	.70	-6.05
9	1.00	-.122	5.98	1.00	28	.00	-5.98

Fleet : UK BTS

Age	1981	1982	1983	1984	1985	1986	1987	1988
1	No data for this fleet at this age							
2	No data for this fleet at this age							
3	No data for this fleet at this age							
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-.13
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	.30
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-.29

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	.32	-.27	-.07	.23	-.60	.24	-.26	-1.32	-1.33	-.15
5	-.12	-.08	.17	.55	-.22	-.01	-.54	-.65	-1.14	-1.01
6	-.23	.23	-.19	.93	-.13	-.54	-.59	-.41	-.97	-.53

Age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	No data for this fleet at this age									
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	-.65	.58	.47	.62	.53	.67	.82	.07	.25	-.01
5	-.43	.57	1.10	-.18	.56	.13	1.03	-.16	-.03	.17
6	-.51	.35	.82	.89	-.15	-.84	1.30	.47	.17	.21

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

Age	4	5	6
Mean Log q	-6.6648	-6.4844	-6.5458
S.E(Log q)	.5954	.5809	.6217

Regression statistics:

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
4	1.04	-.173	6.58	.45	21	.64	-6.66
5	.91	.412	6.59	.55	21	.54	-6.48
6	.97	.131	6.56	.55	21	.62	-6.55

Fleet : FR GFS

Age	1981	1982	1983	1984	1985	1986	1987	1988
1	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-.40
2	99.99	99.99	99.99	99.99	99.99	99.99	99.99	.44
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	.09

Age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	-.70	-.70	-1.30	1.06	1.19	-.38	-.74	-1.08	.73	.63
2	-.30	-1.54	-.84	-.51	.10	-.55	-.52	-1.08	-.27	-.01
3	-.71	-.37	-.90	.12	.41	-1.31	-.35	-1.99	.45	-.39

Table 3.8.2. Plaice in VIId. Final run diagnostics (continued)

```
  Age  ,  1999,  2000,  2001,  2002,  2003,  2004,  2005,  2006,  2007,  2008
     1 ,  -.08,   .33,  -.14,   .34,  -.21,   .52,   .05,   .77,  -.14,   .25
     2 ,  -.29,  1.10,  -.33,   .31,   .36,   .69,  1.08,   .93,   .65,   .57
     3 ,   .30,   .32,  -.21,   .87,   .18,   .55,  1.34,   .75,   .75,   .11


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

    Age ,        1,         2,         3
 Mean Log q,   -7.6165,   -7.5462,   -7.7487,
 S.E(Log q),     .6859,     .7188,     .7757,


 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

  1,    2.29,   -1.164,      4.70,     .04,     21,    1.56,   -7.62,
  2,    1.24,    -.390,      7.02,     .12,     21,     .91,   -7.55,
  3,    1.40,    -.793,      7.10,     .17,     21,    1.10,   -7.75,
1
 Fleet : IN YFS

  Age  ,  1981,  1982,  1983,  1984,  1985,  1986,  1987,  1988
     1 , 99.99, 99.99, 99.99, 99.99, 99.99, 99.99,   .22,   .28

  Age  ,  1989,  1990,  1991,  1992,  1993,  1994,  1995,  1996,  1997,  1998
     1 ,   .02,   .05,  -.25,   .59,   .52,   .27,   .67,  -.45,  -.54,   .38

  Age  ,  1999,  2000,  2001,  2002,  2003,  2004,  2005,  2006,  2007,  2008
     1 ,   .22,  -.21,   .14,   .20, -1.09,   .47,  -.98,  -.51, 99.99, 99.99


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


    Age ,        1
 Mean Log q,  -10.1388,
 S.E(Log q),     .5003,


 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

  1,     .85,     .471,     10.10,     .36,     20,     .44,  -10.14,


 Fleet disaggregated estimates of survivors :


 Age  1   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
 BE CBT             ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 UK BTS             ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 FR GFS             ,     16196.,   .702,       .000,    .00,   1,  .664,     .021
 IN YFS             ,         1.,   .000,       .000,    .00,   0,  .000,     .000

   F shrinkage mean  ,      7735.,   1.00,,,,                       .336,     .043

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
     12634.,       .57,      .43,    2,    .745,   .027


 Age  2   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
 BE CBT             ,     23242.,   .908,       .000,    .00,   1,  .195,     .147
 UK BTS             ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 FR GFS             ,     24331.,   .508,       .356,    .70,   2,  .614,     .141
 IN YFS             ,         1.,   .000,       .000,    .00,   0,  .000,     .000

   F shrinkage mean  ,      8716.,   1.00,,,,                       .191,     .352

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
     19828.,       .41,      .30,    4,    .745,   .170
```

Table 3.8.2. Plaice in VIId. Final run diagnostics (continued)

Age 3 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
 BE CBT             ,      5374.,   .455,       .394,    .87,   2,  .347,     .372
 UK BTS             ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 FR GFS             ,      8004.,   .433,       .207,    .48,   3,  .334,     .264
 IN YFS             ,      2938.,   .513,       .000,    .00,   1,  .206,     .600

   F shrinkage mean  ,      2149.,   1.00,,,,                        .113,     .754

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      4887.,       .26,      .23,    7,    .857,   .402
```

Age 4 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
 BE CBT             ,      1975.,   .310,       .110,    .36,   3,  .516,     .550
 UK BTS             ,      1822.,   .609,       .000,    .00,   1,  .154,     .585
 FR GFS             ,      3281.,   .434,       .266,    .61,   3,  .142,     .365
 IN YFS             ,       695.,   .513,       .000,    .00,   1,  .086,    1.126

   F shrinkage mean  ,      1379.,   1.00,,,,                        .102,     .718

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      1846.,       .22,      .15,    9,    .656,   .579
```

Age 5 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
 BE CBT             ,       853.,   .288,       .061,    .21,   4,  .517,     .529
 UK BTS             ,      1252.,   .446,       .035,    .08,   2,  .262,     .389
 FR GFS             ,      2246.,   .435,       .159,    .36,   3,  .077,     .235
 IN YFS             ,      1646.,   .513,       .000,    .00,   1,  .046,     .309

   F shrinkage mean  ,       718.,   1.00,,,,                        .098,     .604

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
      1030.,       .22,      .10,   11,    .482,   .456
```

Age 6 Catchability constant w.r.t. time and dependent on age
Year class = 2002

```
 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 BE CBT             ,       502.,   .278,       .055,    .20,   5,  .557,     .431
 UK BTS             ,       568.,   .396,       .078,    .20,   3,  .292,     .389
 FR GFS             ,       990.,   .440,       .457,   1.04,   3,  .035,     .241
 IN YFS             ,       170.,   .513,       .000,    .00,   1,  .020,     .951

   F shrinkage mean  ,       377.,   1.00,,,,                        .096,     .540

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       507.,       .22,      .08,   13,    .373,   .427
```

Age 7 Catchability constant w.r.t. time and dependent on age
Year class = 2001

```
 Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 BE CBT             ,       631.,   .245,       .094,    .38,   6,  .666,     .335
 UK BTS             ,       738.,   .378,       .242,    .64,   3,  .202,     .293
 FR GFS             ,       949.,   .434,       .070,    .16,   3,  .031,     .235
 IN YFS             ,       754.,   .513,       .000,    .00,   1,  .019,     .288

   F shrinkage mean  ,       283.,   1.00,,,,                        .082,     .634

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
       620.,       .20,      .10,   14,    .486,   .340
```

Table 3.8.2. Plaice in VIId. Final run diagnostics (continued)

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2000

```
Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
    ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
BE CBT             ,        75.,   .284,       .218,    .77,   7,  .730,     .303
UK BTS             ,       137.,   .391,       .176,    .45,   3,  .120,     .177
FR GFS             ,        79.,   .453,       .121,    .27,   3,  .008,     .291
IN YFS             ,        79.,   .513,       .000,    .00,   1,  .004,     .289

  F shrinkage mean  ,        24.,   1.00,,,,                       .138,     .744

Weighted prediction :

Survivors,       Int,      Ext,    N,    Var,     F
at end of year,  s.e,      s.e,     ,   Ratio,
       69.,       .25,      .18,   15,    .714,   .325
```

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 7
Year class = 1999

```
Fleet,                Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
    ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
BE CBT             ,         4.,   .001,       .000,    .34,   8, 1.000,    1.657
UK BTS             ,         8.,   .416,       .386,    .93,   3,  .000,    1.045
FR GFS             ,         5.,   .437,       .348,    .80,   3,  .000,    1.395
IN YFS             ,         3.,   .513,       .000,    .00,   1,  .000,    1.829

  F shrinkage mean  ,        35.,   1.00,,,,                       .000,     .365

Weighted prediction :

Survivors,       Int,      Ext,    N,    Var,     F
at end of year,  s.e,      s.e,     ,   Ratio,
        4.,       .00,      .00,   16,   1.367,  1.657
```

BE CBT
cpue adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1981	0.0000	7.9448	41.5967	23.3414	2.1029	0.6818	0.2727	0.2562	0.4274
1982	0.0000	3.3866	29.0256	22.1346	5.5695	1.4353	0.5354	0.2871	0.1237
1983	0.0000	12.4777	19.6932	51.7631	5.2653	1.5433	0.6325	1.2367	0.0315
1984	0.0000	1.7641	37.4850	18.8079	12.3160	3.3483	1.6112	0.6426	0.1535
1985	0.0000	12.3761	28.2638	32.2692	2.0237	5.0520	1.2330	0.9442	0.3790
1986	0.0000	16.1941	32.2793	19.2733	7.6394	3.8309	1.5897	0.2633	0.1511
1987	0.0000	27.5920	27.3177	16.0714	5.6318	1.4287	2.9330	0.6888	0.5166
1988	0.0000	11.1992	75.9662	23.5566	3.8692	1.7125	2.0415	0.6109	0.4930
1989	0.0000	1.1744	31.5206	60.5745	21.7430	3.7882	1.9076	1.1735	0.4360
1990	0.0000	6.8917	61.8951	45.8980	22.2753	4.2786	0.8386	0.9845	0.5304
1991	0.0000	14.7501	48.1235	33.3987	29.6789	17.7895	2.1832	0.7601	1.3125
1992	0.0000	22.7387	30.8214	11.0662	7.3271	8.0663	4.0557	1.7252	1.4265
1993	0.0000	13.5236	19.4358	7.7977	5.2499	3.2627	2.0800	1.6235	0.4075
1994	0.0000	10.0910	34.4331	40.0542	6.9552	3.1356	2.5410	2.0075	2.1441
1995	0.0000	0.9605	15.9165	25.7478	10.1467	1.9073	3.5238	2.0411	0.6969
1996	0.0000	5.8441	17.5209	14.5552	14.1297	3.3789	1.0689	1.2566	0.9930
1997	0.0000	0.0000	6.4604	27.4953	16.1302	7.6198	3.5882	0.8129	0.6073
1998	0.0000	3.9901	27.0869	21.9543	4.1040	1.1240	1.1716	0.4968	0.4860
1999	0.0000	0.9482	49.4923	49.8547	11.9274	1.9760	0.7453	0.3887	0.3628
2000	0.0000	1.2430	7.6298	13.1032	5.9602	0.9075	0.2683	0.1134	0.2274
2001	0.0000	7.6469	39.4257	21.3329	15.0105	2.2858	0.4698	0.1660	0.1316
2002	0.0000	9.5978	37.4444	18.1511	15.5076	3.4818	1.5639	0.1915	0.1312
2003	0.0000	7.8358	34.2338	15.8283	3.1829	3.7173	2.9222	0.5310	0.3608
2004	0.0000	6.2775	28.9943	6.6069	3.3623	0.9681	1.2631	1.0686	0.2713
2005	0.0000	5.5931	16.1568	14.8510	5.0969	1.6526	0.8299	0.6571	0.4350
2006	0.0000	6.4815	13.3185	11.5981	6.1815	1.1610	0.5651	0.8217	0.5600
2007	0.0000	10.1496	12.5695	10.5049	7.1879	4.9083	1.6374	0.3843	0.0933
2008	0.0000	10.5950	15.3072	14.4711	4.9854	2.0749	2.7559	0.1802	0.0526

UK BTS
cpue adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1988	0.0000	0.0000	0.0000	11.4961	6.5269	2.0036	0.0000	0.0000	0.0000
1989	0.0000	0.0000	0.0000	33.4431	6.2758	2.0698	0.0000	0.0000	0.0000
1990	0.0000	0.0000	0.0000	11.4514	11.6640	2.9905	0.0000	0.0000	0.0000
1991	0.0000	0.0000	0.0000	9.7009	8.9973	4.8457	0.0000	0.0000	0.0000
1992	0.0000	0.0000	0.0000	6.4751	8.2205	8.0197	0.0000	0.0000	0.0000
1993	0.0000	0.0000	0.0000	2.4367	2.4868	2.1163	0.0000	0.0000	0.0000
1994	0.0000	0.0000	0.0000	9.7447	2.9571	1.0989	0.0000	0.0000	0.0000
1995	0.0000	0.0000	0.0000	6.0497	2.1814	0.7636	0.0000	0.0000	0.0000
1996	0.0000	0.0000	0.0000	1.1341	2.2373	1.2907	0.0000	0.0000	0.0000
1997	0.0000	0.0000	0.0000	1.5891	0.7427	0.6403	0.0000	0.0000	0.0000
1998	0.0000	0.0000	0.0000	6.1808	0.5461	0.3000	0.0000	0.0000	0.0000
1999	0.0000	0.0000	0.0000	6.4906	1.8475	0.3205	0.0000	0.0000	0.0000
2000	0.0000	0.0000	0.0000	27.4050	7.1815	1.4125	0.0000	0.0000	0.0000
2001	0.0000	0.0000	0.0000	10.7223	18.3913	2.7480	0.0000	0.0000	0.0000
2002	0.0000	0.0000	0.0000	7.2516	3.4329	6.0555	0.0000	0.0000	0.0000
2003	0.0000	0.0000	0.0000	6.2598	2.5338	1.1821	0.0000	0.0000	0.0000
2004	0.0000	0.0000	0.0000	5.2309	1.4548	0.2794	0.0000	0.0000	0.0000
2005	0.0000	0.0000	0.0000	15.7645	4.5286	2.0425	0.0000	0.0000	0.0000
2006	0.0000	0.0000	0.0000	5.1069	3.5740	1.1903	0.0000	0.0000	0.0000
2007	0.0000	0.0000	0.0000	6.2592	2.7505	2.7961	0.0000	0.0000	0.0000
2008	0.0000	0.0000	0.0000	4.5797	3.2535	1.5279	0.0000	0.0000	0.0000

Table 3.8.2. Plaice in VIId. Final run diagnostics (continued)

FR GFS

cpue adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1988	8.7362	23.0323	19.2319	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	4.0064	9.4013	4.3991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	4.6248	1.5862	5.4363	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	2.9192	3.5554	1.7921	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	39.7348	5.7743	4.1486	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	21.5192	13.7744	6.9333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1994	5.8444	3.4458	1.6491	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1995	5.9101	4.5570	2.0459	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	5.0842	3.6499	0.5287	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	38.1694	10.6520	9.3702	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	13.9277	17.4082	5.7698	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	8.0594	5.2285	15.1036	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	11.5741	24.2650	6.1320	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2001	9.1432	5.3089	2.7761	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	14.5470	12.0058	8.8560	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	6.5674	13.7174	4.2896	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	11.4363	15.0894	8.8293	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2005	6.3747	18.0338	13.4928	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	14.5755	14.6119	6.8444	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2007	12.6444	12.1438	6.3557	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2008	9.0479	24.3157	3.8763	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

IN YFS

Cpue adjusted to start of year

YEAR	AGE 1	2	3	4	5	6	7	8	9
1987	1.5336	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	1.3844	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.6608	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.7906	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	0.6702	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	1.9952	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.8844	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.8943	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1995	1.9435	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	0.7638	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	0.8599	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	0.8692	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	0.8758	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	0.5406	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2001	0.9653	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	1.0080	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	0.2186	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	0.8709	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2005	0.1841	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	0.3273	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 3.8.3. Plaice in VIId Summary Table of final XSA results.

	RECRUITMENT	SSB	CATCH	LANDINGS	DISCARDS	F_{BAR}3–6	Y/SSB
1980	19 611	3875	2060	2060	0	0.46	0.53
1981	9804	4468	3706	3706	0	0.59	0.83
1982	19 276	5432	3781	3781	0	0.62	0.7
1983	15 638	5648	3919	3919	0	0.61	0.69
1984	20 034	5180	4010	4010	0	0.74	0.77
1985	22 429	5806	4680	4680	0	0.58	0.81
1986	45 527	7315	5311	5311	0	0.66	0.73
1987	23 256	9584	6502	6502	0	0.55	0.68
1988	20 150	9240	8098	8098	0	0.6	0.88
1989	12 509	9757	6807	6807	0	0.65	0.7
1990	15 422	9860	7031	7031	0	0.7	0.71
1991	17 063	7067	6072	6072	0	0.73	0.86
1992	22 409	6088	4925	4925	0	0.66	0.81
1993	10 345	5315	4143	4143	0	0.43	0.78
1994	14 085	5362	4757	4757	0	0.64	0.89
1995	20 791	4779	3987	3987	0	0.53	0.83
1996	23 936	4214	4191	4191	0	0.64	0.99
1997	28 105	4519	4872	4872	0	1.19	1.08
1998	11 162	5227	4467	4467	0	0.8	0.85
1999	14 318	5661	4951	4951	0	0.95	0.87
2000	13 496	3934	4294	4294	0	0.74	1.09
2001	16 563	4010	4083	4083	0	0.57	1.02
2002	16 145	4198	4256	4256	0	1.03	1.01
2003	13 205	2932	3665	3665	0	0.91	1.25
2004	11 117	3049	3183	3183	0	0.58	1.04
2005	9460	3127	2722	2722	0	0.68	0.87
2006	9829	3112	2643	2643	0	0.57	0.85
2007	22 735	3051	2889	2889	0	0.61	0.95
2008	6920	3571	2763	2763	0	0.53	0.77

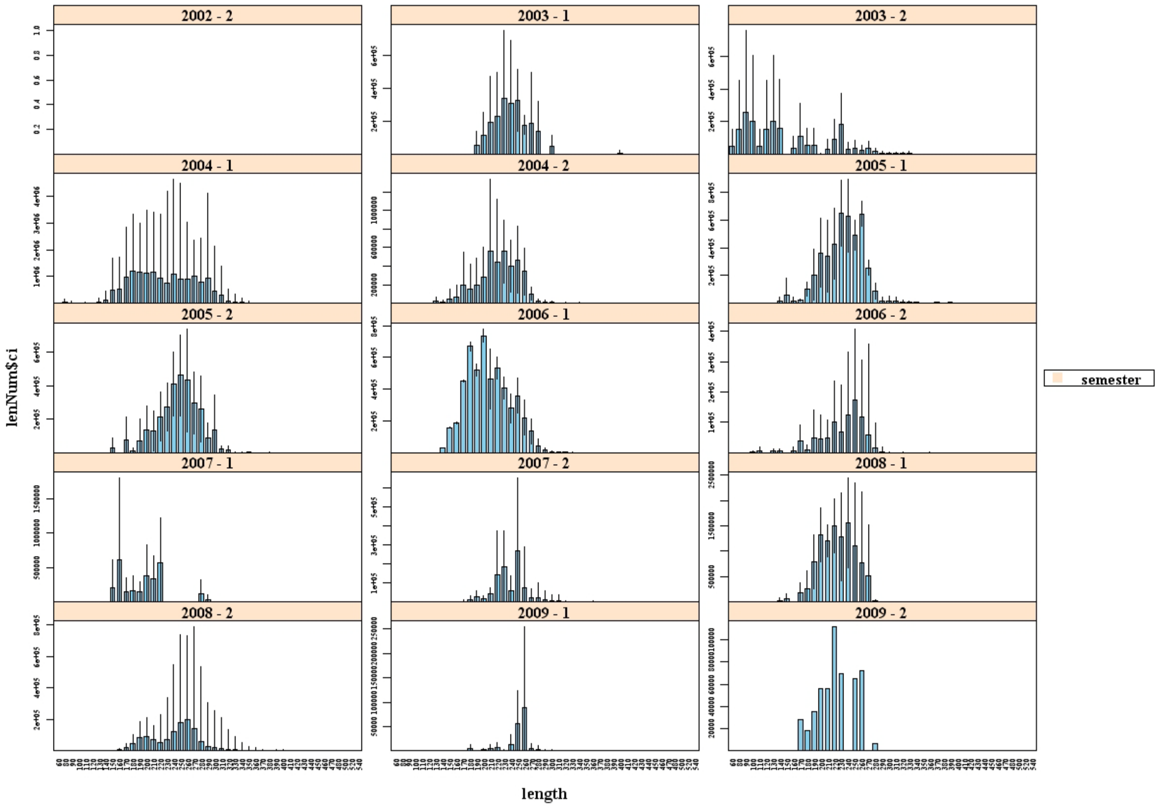


Figure 3.2.1. Plaice in VIId. Length distribution of discards per year and semester. The bars represent the final estimates, and the segments represent the confidence intervals at 95%.

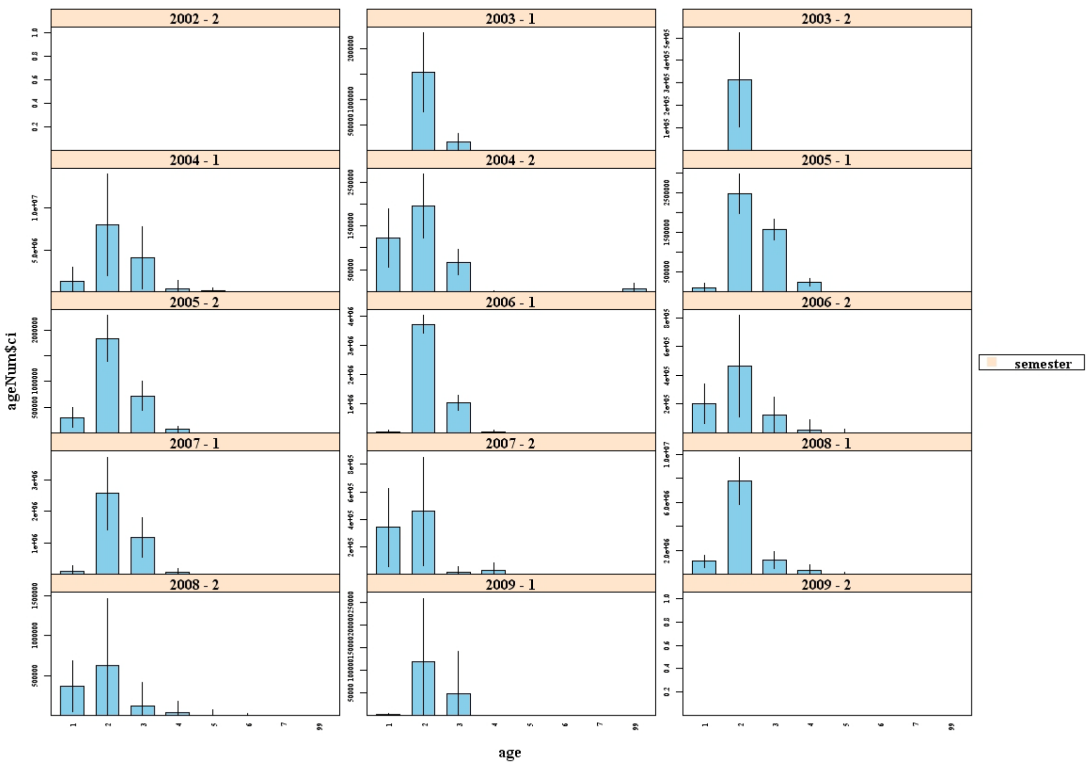
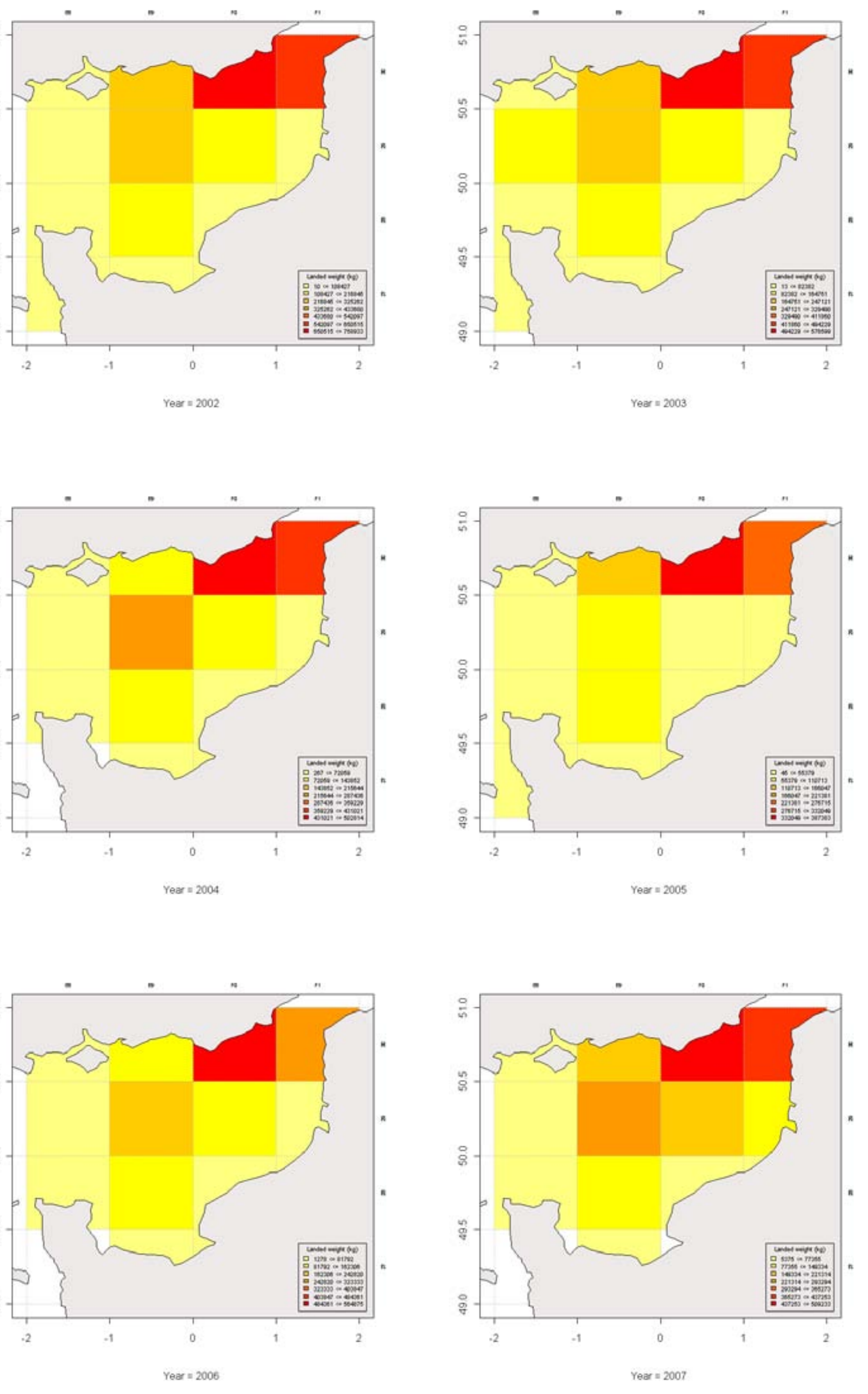


Figure 3.2.2. Plaice in VIId. Age distribution of discards per year and semester. The bars represent the final estimates, and the segments represent the confidence intervals at 95%.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Year = 2003
Year = 2004
Year = 2005
Year = 2006
Year = 2007

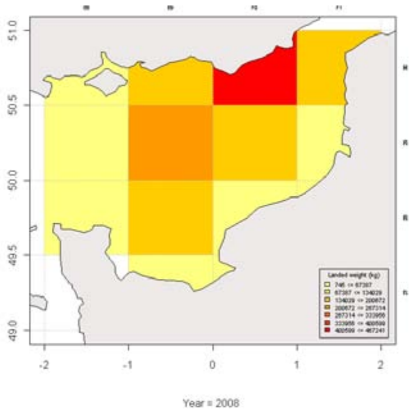
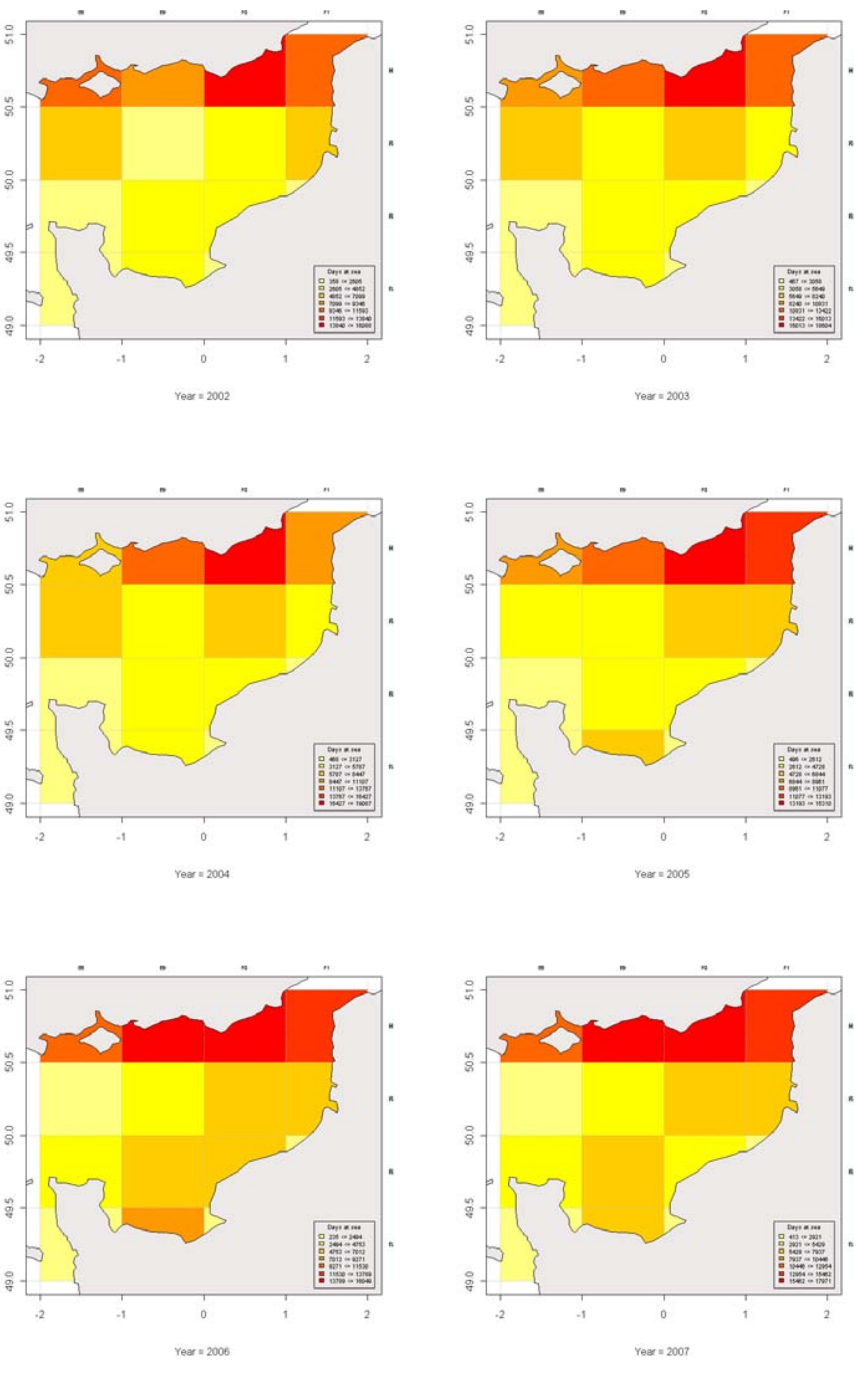


Figure 3.4.1. Plaice in VIId. International landings from 2002 to 2008.


Year = 2002
Year = 2003
Year = 2004
Year = 2005
Year = 2006
Year = 2007

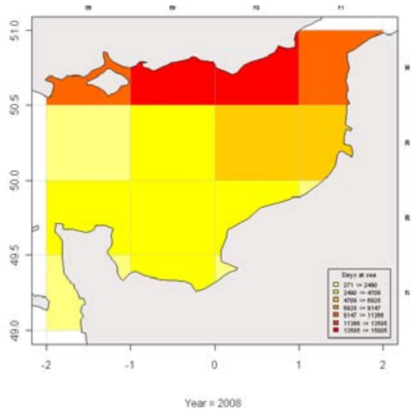


Figure 3.4.2. Plaice in VIId International effort in days at sea from 2002 to 2008.

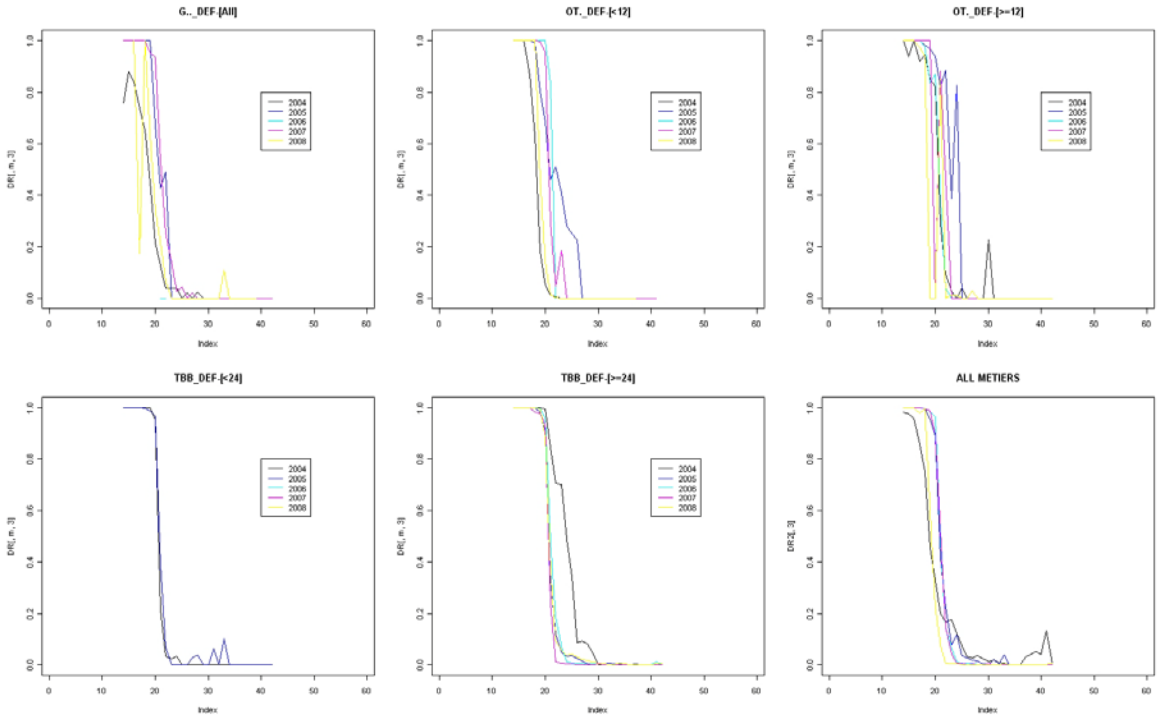


Figure 3.8.1. Plaice in VIId. Discarding ogive by métier and all métiers combined from the dataset used for the Working Document.

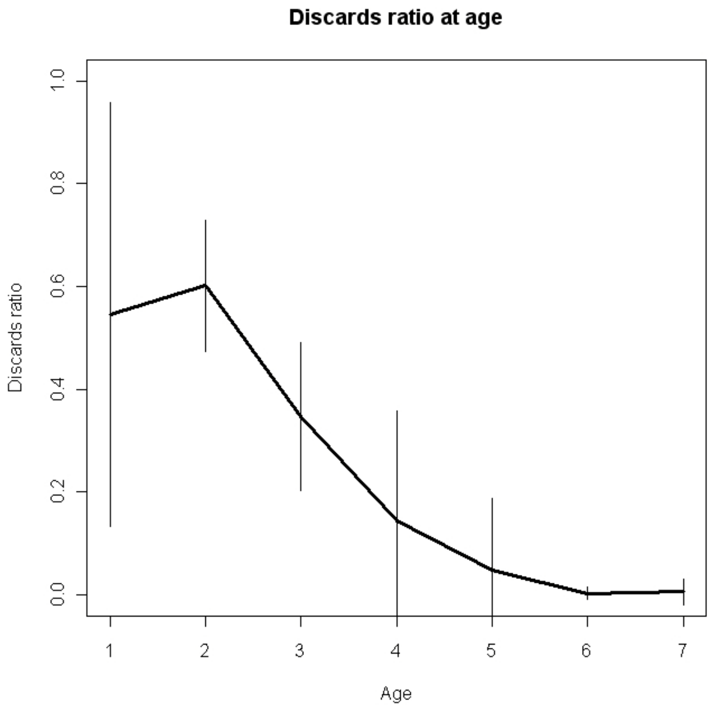


Figure 3.8.2. Plaice in VIId. Discard ratio at age. The segments represent the confidence intervals of the means.

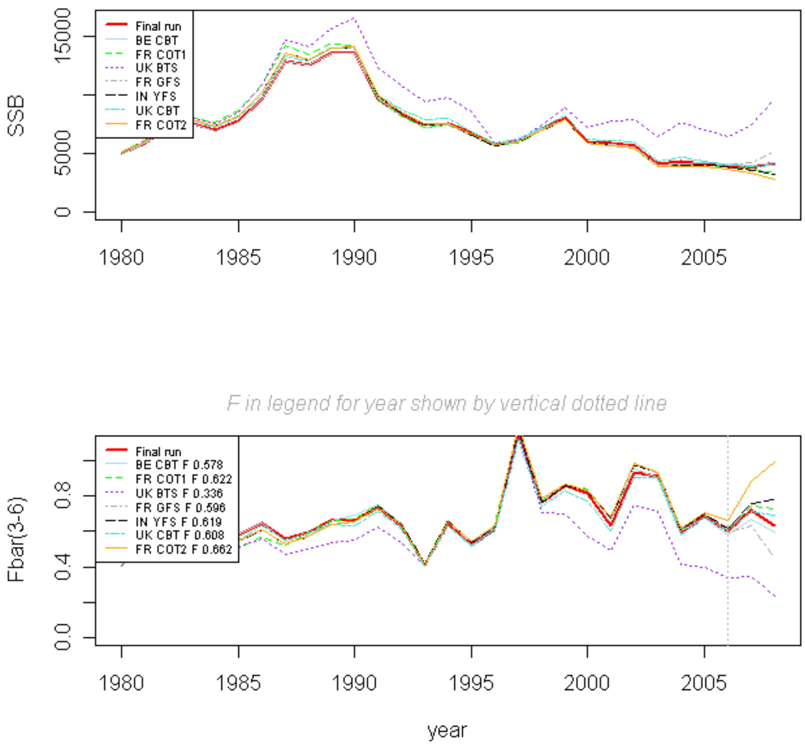


Figure 3.8.3. Plaice in VIId. Retrospective analysis based on single fleet assessment runs.

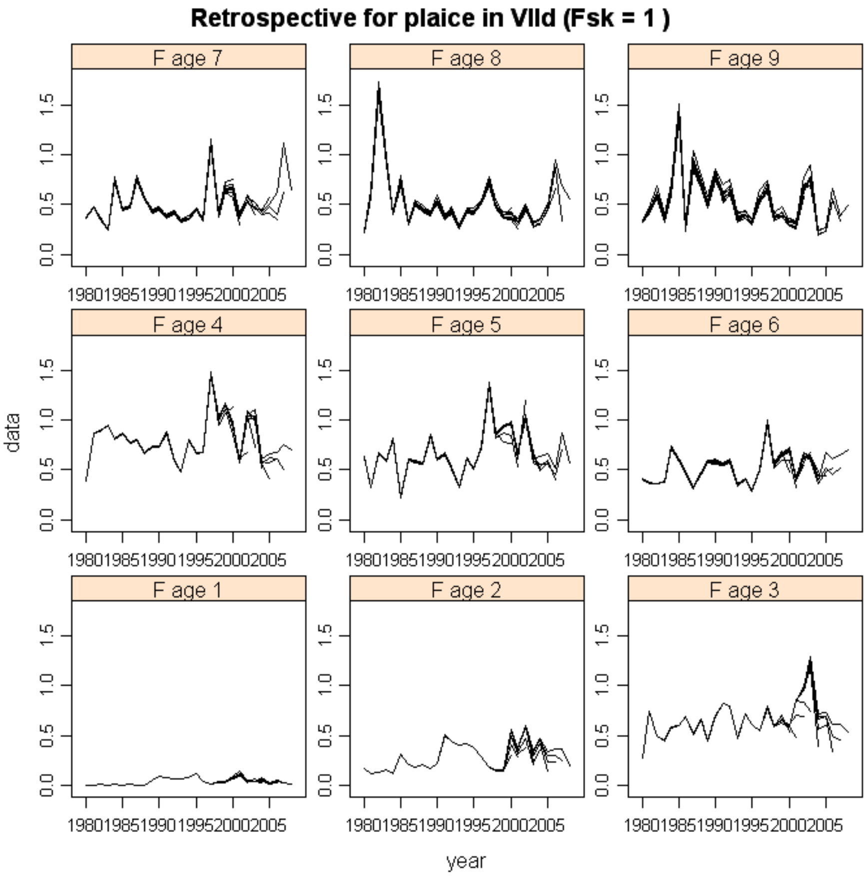


Figure 3.8.4. Plaice in VIId. Retrospective analysis split by age. Model settings are the same as those used in 2009.

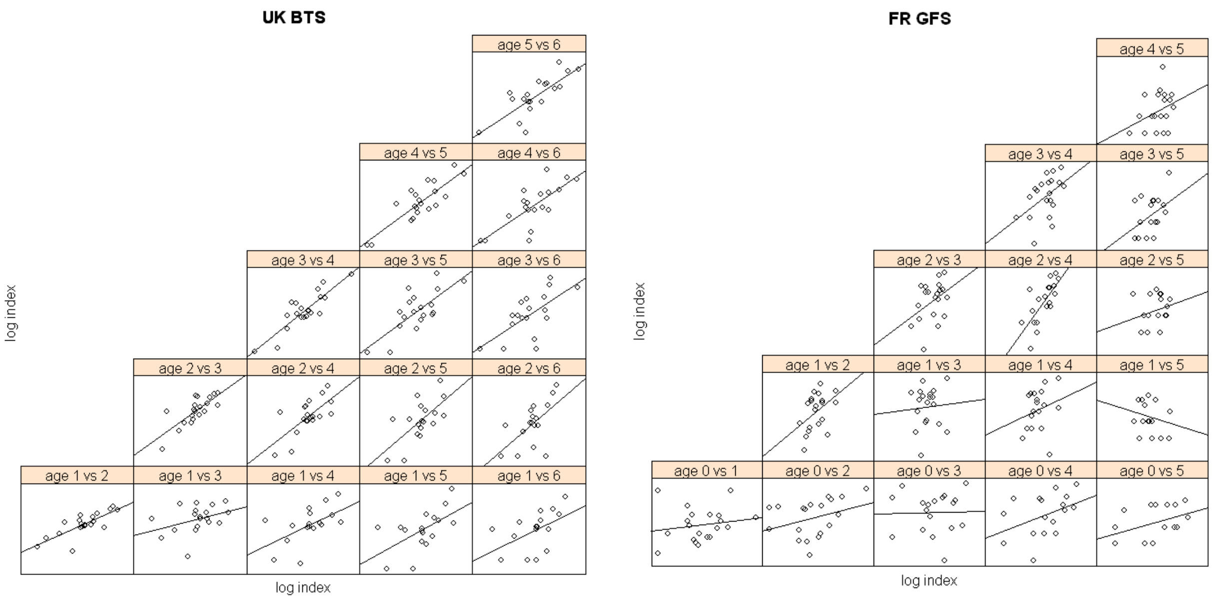


Figure 3.8.5. Plaice in VIId. UK BTS and FR GFS Internal consistency.

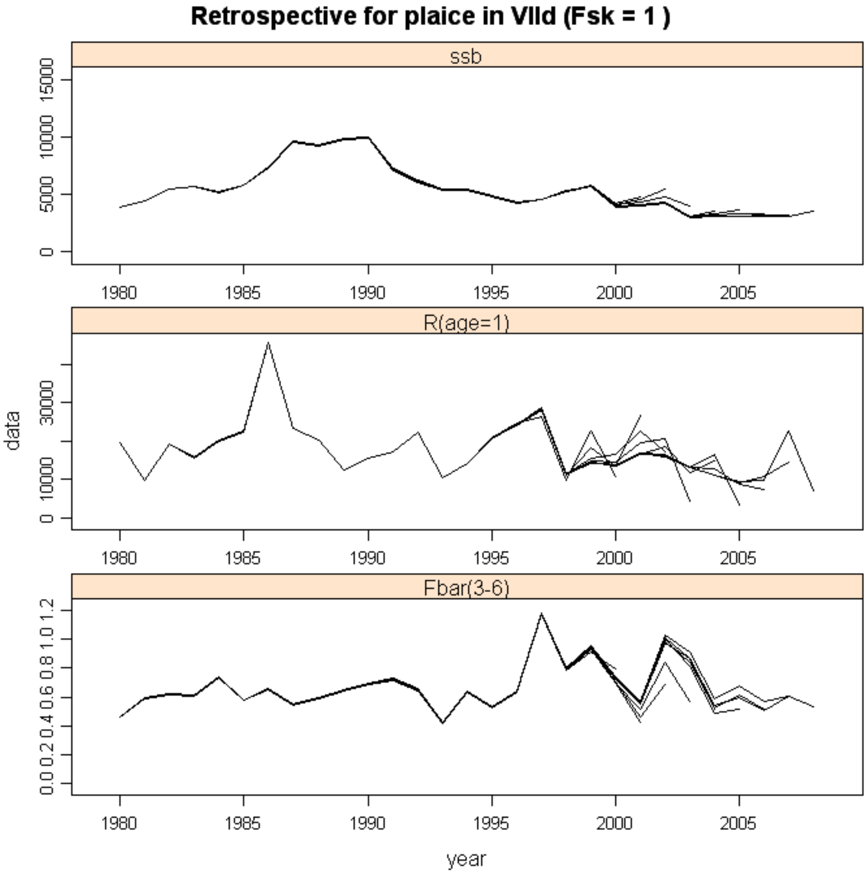


Figure 3.8.6. Plaice in VIId. Retrospective analysis with ages 1, 2 and 3 removed from UK BTS.

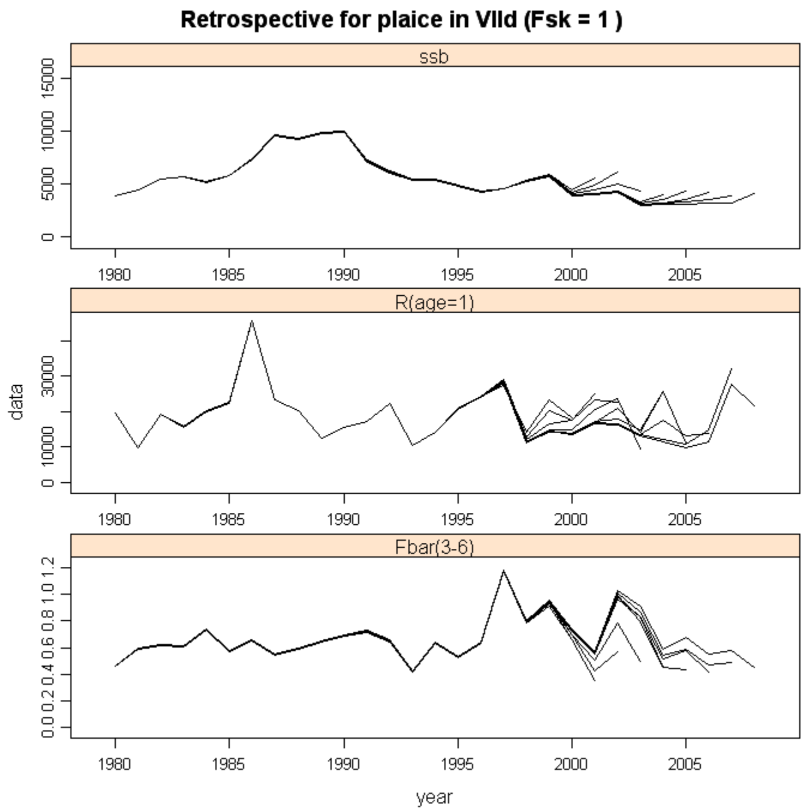


Figure 3.8.7. Plaice in VIId. Retrospective analysis with 65% removal of quarter 1 catches (in the commercial tuning-series, only the Belgian beam trawls series was kept).

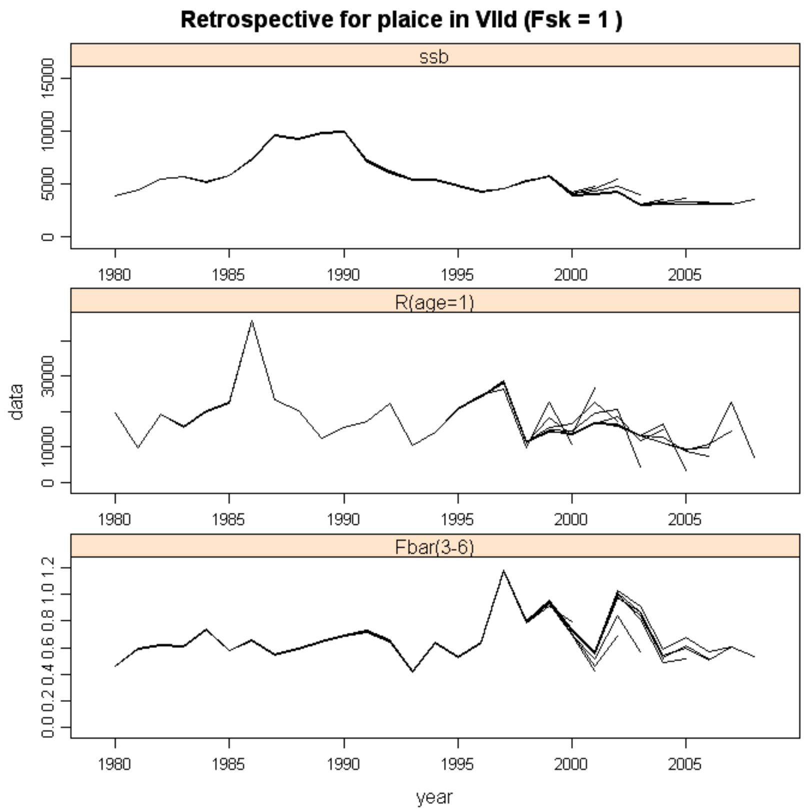


Figure 3.8.8. Plaice in VIId. Retrospective analysis with 65% removal of quarter 1 catches (in the commercial tuning-series, only the Belgian beam trawls series was kept) and ages 1, 2 and 3 removed from UK BTS.

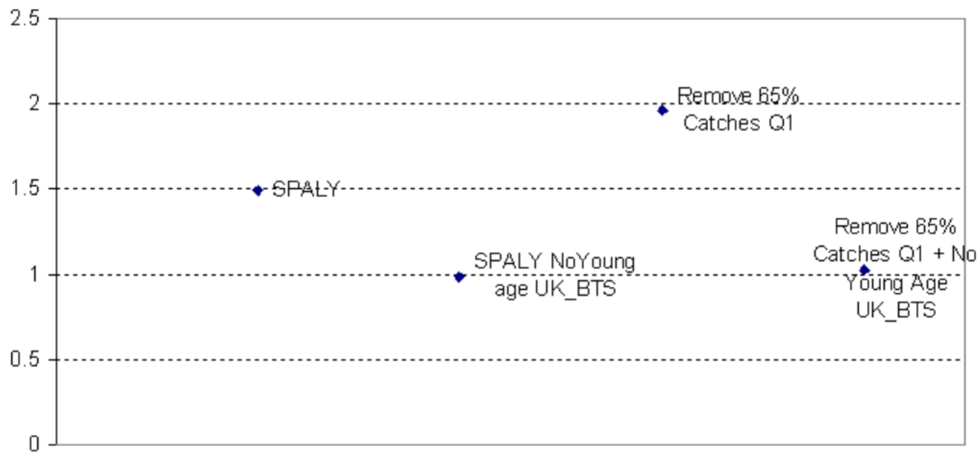


Figure 3.8.9. Plaice in VIId. Mohn's rho indicator on the different retrospective runs.

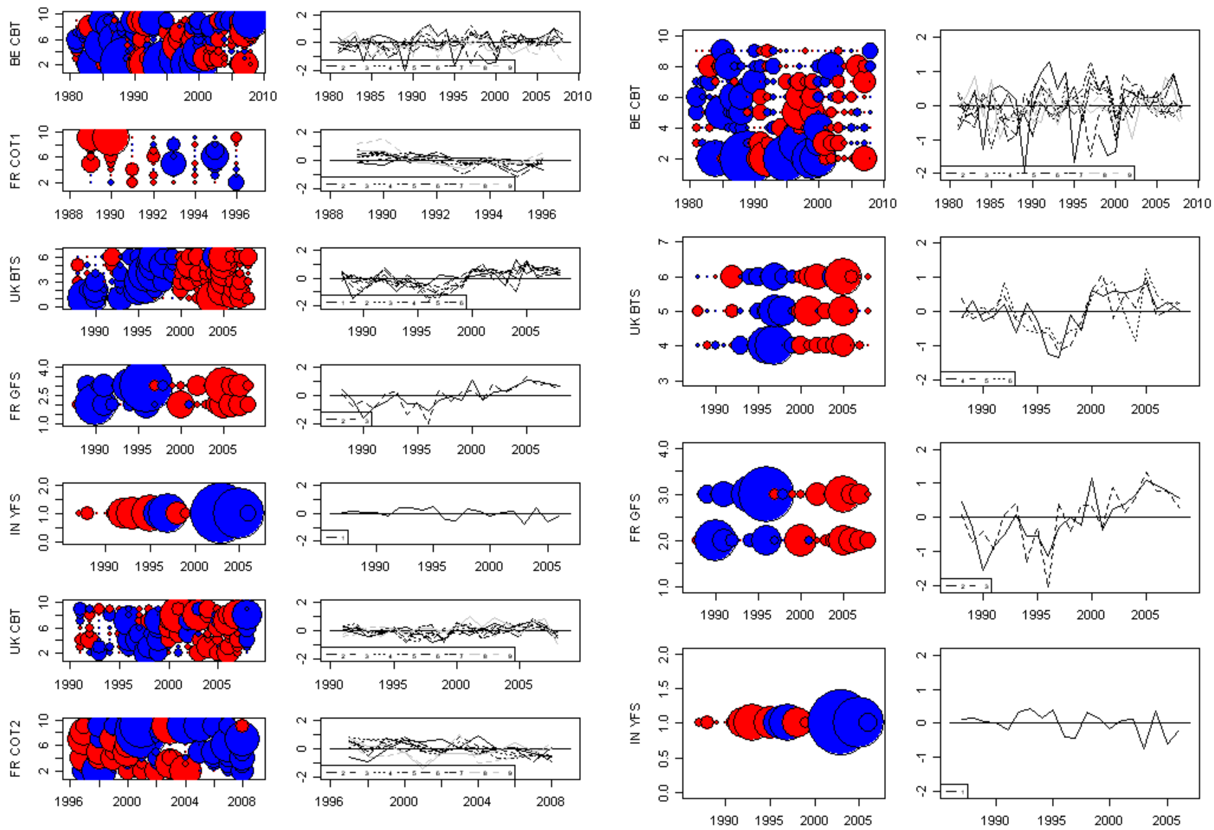


Figure 3.8.10. Plaice in VIId. Comparison of Log q residuals plot .Left panel: same settings as in 2009. Right panel: 65% removal of Q1. Only Belgian commercial tuning-series. Ages 1, 2 and 3 removed from UK BTS.

Stock Annex: Plaice in Division VIId

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Plaice in Division VIId
Date	05/03/2010
Revised by	Joël Vigneau (Joel.Vigneau@ifremer.fr) and Youen Vermard (Youen.Vermard@ifremer.fr)
Initial Contributors	Richard Millner (r.s.millner@cefas.cu.uk) and Joël Vigneau (Joel.Vigneau@ifremer.fr) 05/03/2003

A. General

A.1. Stock definition

The management area for this stock is strictly that for ICES Area VIId called the eastern Channel, although the TAC area includes the smaller component of VIIe (western Channel).

Major spawning centres were found in the eastern English Channel, the Southern Bight, the central North Sea and the German Bight. Other less important local spawning centres were found in the western English Channel and off the UK coast from Flamborough Head northwards to Moray Firth (Houghton and Harding, 1976; Harding and Nichols, 1987 in ICES PGEGGS, 2003c). The regions of plaice spawning are generally confined within the 50 meter depth contour (Harding *et al.*, 1978, in ICES PGEGGS, 2003c).

The stocks of plaice in the Channel and North Sea are known to mix greatly (Figure 1), especially during the spawning season (January–February). At this time many western Channel and North Sea plaice may be found in the eastern Channel. The comparable lack of spawning habitat in the western Channel alone suggests that this migration from VIIe to VIId during the first quarter may be of considerable importance.

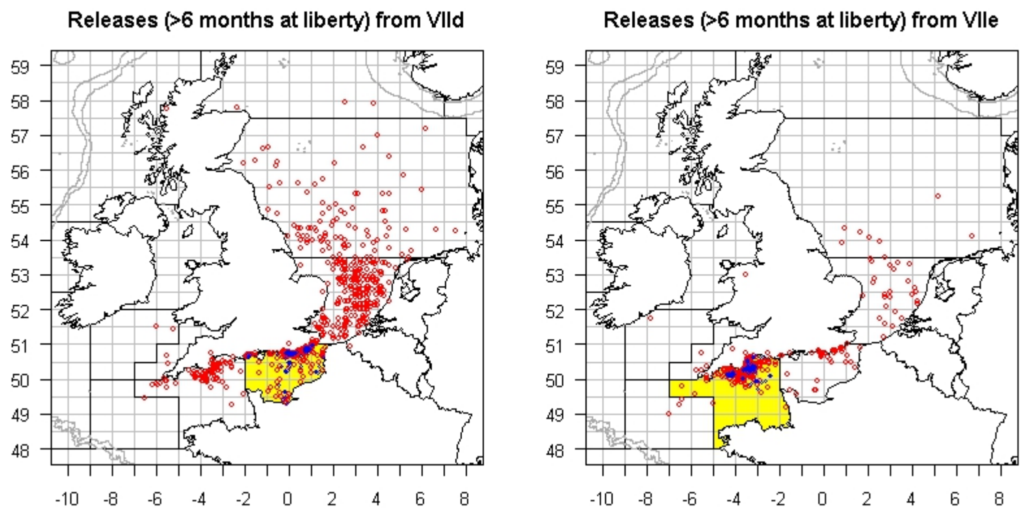


Figure 1. Locations of recaptures (red circles) after 6 or more months at liberty for tagged plaice released (blue crosses) in the English Channel: bottom left, released in the eastern (VIId) Channel and bottom right, released in western (VIIe) Channel.

From tagging experiments, it was possible to derive estimates of the proportion of fish in quarter 1 in VIId that would return, if not caught by the fishery, to VIIe and IV (Table 1). In summary, 14% of males and 9% of females would migrate to VIIe, while 52% of males and 58% of females would migrate to IV. To the nearest 5%, this suggests that 10 to 15% of the catch in Q1 in VIId should be allocated to VIIe, while between 50 and 60% of the catch in Q1 in VIId should be allocated to IV. These estimates are in agreement with previous analyses (based on the same data) reported by Pawson (1995), which suggest that 20% of the plaice spawning in VIIe and VIId spend summer in VIIe, while 56% migrate to the North Sea. Given the assumptions involved in these calculations and the relatively small numbers of adult tags returned the estimates of movement rates are subject to great variability. The limitations of the data do not permit an estimate of annual movement probabilities. Recent studies based on data storage tags suggest that the retention rate of spawning plaice tagged in the eastern English Channel is 28%, while 62% of spawning fish tagged were recaptured in the North Sea (Kell *et al*., 2004).

Table 1. Summary of estimated movement probabilities for plaice (≥270 mm) recaptured after 6 or more months at liberty, for data collected between 1960 and 2006.

Release Information		period			WEIGHTED BY INTN CATCH AND SSB pr(recap) after 6 or more months at liberty			
DIV	Sex	Release	Recapture	N	7A	7E	7D	4
VIIe	B	ALL		564	0.001	0.90	0.06	0.04
	M	Jan-Mar		2	0	0.74	0.26	0
	F			3	0	0.60	0.40	0
	M	Apr_Dec		180	0	0.91	0.05	0.03
	F			224	0.001	0.93	0.03	0.04
	M	Jan-Mar	Apr_Dec	17	0	0.66	0.11	0.23
	F			8	0	0.67	0.24	0.09
	M	Apr_Dec	Jan-Mar	68	0	0.83	0.12	0.05
	F			62	0	0.88	0.07	0.06
VIId	B	ALL		990	0.00	0.10	0.54	0.36
	M	Jan-Mar		31	0	0.04	0.73	0.22
	F			86	0	0.08	0.58	0.34
	M	Apr_Dec		144	0	0.10	0.76	0.14
	F			180	0	0.09	0.79	0.12
	M	Jan-Mar	Apr_Dec	144	0	0.14	0.35	0.52
	F			305	0	0.09	0.33	0.58
	M	Apr_Dec	Jan-Mar	31	0	0.20	0.57	0.23
	F			63	0	0.11	0.72	0.17
IVc	B	ALL		812	0	0.01	0.06	0.93
	M	Jan-Mar		54	0	0	0.03	0.97
	F			17	0	0	0.28	0.72
	M	Apr_Dec		172	0	0.01	0.06	0.92
	F			235	0	0.01	0.04	0.95
	M	Jan-Mar	Apr_Dec	102	0	0	0	1
	F			38	0	0	0	1
	M	Apr_Dec	Jan-Mar	54	0	0.02	0.05	0.93
	F			71	0	0.01	0.18	0.80

A.2. Fishery

Plaice is mainly caught in beam trawl and gillnet fisheries for sole or in mixed demersal fisheries using otter trawls. There is also a directed fishery during parts of the year by inshore trawlers and netters on the English and French coasts. The Belgian beam trawlers fish mainly in the 1st and 4th quarters and their area of activity covers almost the whole of VIId south of the six mile contour from the English coast. There is only light activity by this fleet between April and September. The second offshore fleet is mainly large otter trawlers from Boulogne, Dieppe and Fecamp. The target species of these vessels are cod, whiting, plaice, gurnards and cuttlefish and the fleet operates throughout VIId. The inshore trawlers and netters are mainly vessels <12 m operating on a daily basis within 12 miles of the coast. There are a large number of these vessels (in excess of 400) operating from small ports along the French and English coast. These vessels target sole, plaice, cod and cuttlefish.

The minimum landing size for plaice is 27 cm. Minimum mesh sizes for demersal gears permitted to catch plaice are 80 mm for beam trawling and 100 mm for otter trawlers. Fixed nets are required to use 100 mm mesh since 2002 although an exemption to permit 90 mm has been in force since that time.

There is widespread discarding of plaice, especially from beam trawlers. The 25 and 50% retention lengths for plaice in an 80 mm beam trawl are 16.4 cm and 17.6 cm respectively which are substantially below the MLS. Routine data on discarding is now available, and reveal plaice discards ratio between 20 and 60% depending on the métier. Discard survival from small otter trawlers can be in excess of 50% (Millner *et al.*, 1993). In comparison discard survival from large beam trawlers has been found to be between less than 20% after a 2 h haul and up to 40% for a one-hour tow (van Beek *et al.*, 1989).

A.3. Ecosystem aspects

Biology: Adult plaice feed essentially on annelid polychaetes, bivalve molluscs, coelenterates, crustaceans, echinoderms, and small fish. In the English Channel, spawning occurs from December to March between 20 and 40 m. depth. At the beginning, pelagic eggs float at the surface then progressively sink into deeper waters during development. Hatching occurs 20 (5–6°C) to 30 (2–2.5°C) days after fertilization. Larvae spend about 40 days in the plankton before migrating to the bottom and moving to coastal waters when metamorphosing (10–17 mm). The fry undergo relatively fast growth during the first year (Carpentier *et al., 2005*).

Environment: This bentho-demersal species prefers living on sand but also gravel or mud bottoms, from the coast to 200 m depth. The species is found from marine to brackish waters in temperate climate (Carpentier *et al., 2005*).

Geographical distribution: Northeast Atlantic, from northern Norway and Greenland to Morocco, including the White Sea; Mediterranean and Black Seas (Carpentier *et al., 2005*).

Vaz *et al*. (2007) used a multivariate and spatial analyses to identify and locate fish, cephalopod, and macrocrustacean species assemblages in the eastern English Channel from 1988 to 2004. Four sub-communities with varying diversity levels were identified in relation to depth, salinity, temperature, seabed shear stress, sediment type, and benthic community nature (Vaz *et al*., 2004). One group was a coastal heterogeneous community represented by pouting, poor cod, and sole and was classified as preferential for many flatfish and gadoids. It displayed the greatest diversity and was characterized by heterogeneous sediment type (from muds to coarse sands) and various associated benthic community types, as well as by coastal hydrology and bathymetry. It was mostly near the coast, close to large river estuaries, and in areas subject to big salinity and temperature variations. Possibly resulting from this potentially heterogeneous environment (both in space and in time), this sub-community type was the most diverse.

Community evolution over time: (From Vaz *et al*., 2007). The community relationship with its environment was remarkably stable over the 17 y of observation. However, community structure changed significantly over time without any detectable trend, as did temperature and salinity. The community is so strongly structured by its environment that it may reflect interannual climate variations, although no patterns could be distinguished over the study period. The absence of any trend in the structure of the eastern English Channel fish community suggests that fishing pressure and selectivity have not altered greatly over the study period at least. However, the period considered here (1988–2004) may be insufficient to detect such a trend.

More details on biology, habitat and distribution of plaice in VIId from the Interreg 3a project CHARM II, may be found in Carpentier *et al*. (2009)[1].

B. Data

B.1. Commercial catch

The landings are taken by three countries France (55% of combined TAC), England (29%) and Belgium (16%). Quarterly catch numbers and weights were available for a range of years depending on country; the availability is presented in the text Table below. Levels of sampling prior to 1985 were poor and these data are considered to be less reliable. Prior to 1989, UK age–length key was applied to the French length structure of the landings.

Belgian commercial landings and effort information by quarter, area and gear are derived from logbooks. Sampling for age and length occurs for the beam trawl fleet (main fleet operating in Belgium). Quarterly sampling of landings takes place at the auctions of Zeebrügge and Oostende (main fishing ports in Belgium). Length is measured to the cm below. Samples are raised per market category to the catches of both harbours. Quarterly otolith samples are taken throughout the length range of the landings (sexes separated). These are aged and combined to the quarterly level. The ALK is used to obtain the quarterly age distribution from the length distribution. From 2003, an on-board sampling programme is routinely carried out following the provision of the EU Regulation 1639/2001.

French commercial landings in tonnes by quarter, area and gear are derived from logbooks for boats over 10 m and from sales declaration forms for vessels under 10 m. These self declared production data are then linked to the auction sales in order to have a complete and precise trip description. The collection of discard data began in 2003 within the EU Regulation 1639/2001. This first year of collection was incomplete in terms of time coverage, therefore the use of these data should be c considered only from 2005. The length measurements were done by market commercial categories and by quarter into the principal auctions of Grandcamp, Port-en-Bessin, Dieppe and Boulogne until 2008. From 2009, concurrent sampling by métier was initiated following the provisions of EU Regulation 95/2008. Otoliths samples are taken by quarter throughout the length range of the landed catch for quarters 1 to 3 and from the October GFS survey in quarter 4. These are aged and combined to the quarterly level and the age–length key thus obtained is used to transform the quarterly length compositions. The lengths not sampled during one quarter are derived from the same year in the nearest available quarter. Weight, sex and maturity-at-length and at-age are obtained from the fish sampled for the age–length keys.

[1] Document also available on the internet: http://www.ifremer.fr/docelec/doc/2009/rapport-7377.pdf (page 310–322).

English commercial landings in tonnes by quarter, area and gear are derived from the sales notes statistics for vessels under 12 m which do not complete logbooks. For those over 12 m (or >10 m fishing away for more than 24 h), data are taken from the EC logbooks. Effort and gear information for the vessels <10 m is not routinely collected and is obtained by interview and by census. . No information is collected on discarding from vessels <10 m. Discarding from vessels >10 m has been obtained since 2002 under the EU Data Collection Regulation.

The gear group used for length measurements are beam trawl, otter trawl and net.

Separate-sex length measurements are taken from each of the gear groupings by trip. Trip length samples are combined and raised to monthly totals by port and gear group. Months and ports are then combined to give quarterly total length compositions by gear group; unsampled port landings are added in at this stage. Quarterly length compositions are added to give annual totals by gear. These are for reference only, as ALK conversion takes place at the quarterly level. Otoliths samples are taken by 2 cm length groups separately for each sex throughout the length range of the landed catch. These are aged and combined to the quarterly level, and include all ports, gears and months. The quarterly sex-separate age–length-keys are used to transform quarterly length compositions by gear group to quarterly age compositions.

A minimum of 24 length samples are collected per gear category per quarter. Age samples are collected by sexes separately and the target is 300 otoliths per sex per quarter. If this is not reached, the 1st and 2nd or 3rd and 4th quarters are combined.

The text Table below shows which country supplies which kind of data:

COUNTRY	NUMBERS	WEIGHTS-AT-AGE
Belgium	1981–present	1986–present
France	1989–present	1989–present
UK	1980–present	1989–present

Data are supplied as FISHBASE files containing quarterly numbers-at-age, weight-at-age, length-at-age and total landings. The files are aggregated by the stock co-ordinator to derive the input VPA files in the Lowestoft format. No SOP corrections are applied to the data because individual country SOPs are usually better than 95%. The quarterly data files by country can be found with the stock co-ordinator. The resulting files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format.

B.2. Biological

Natural mortality: assumed constant over ages and years at 0.1, as for plaice in the North Sea.

Maturity ogive: assumes that 15% of age 2, 53% of age 3 and 96% of age 4 are mature and 100% for ages 5 and older.

Weights-at-age: prior to 2001, stock weights were calculated from a smoothed curve of the catch weights interpolated to the 1st January. From 2001, second quarter catch weights were used as stock weights in order to be consistent with North Sea plaice. The database was revised back to 1990.

Both the proportion of natural mortality before spawning (M_{prop}) and the proportion of fishing mortality before spawning (F_{prop}) are set to 0.

B.3. Surveys

A dedicated 4 m beam trawl survey for plaice and sole has been carried out by England using the RV Corystes since 1988. The survey covers the whole of VIId and is a depth stratified survey with most samples allocated to the shallower inshore stations where the abundance of sole is highest. In addition, inshore small boat surveys using 2 m beam trawls were undertaken along the English coast and in a restricted area of the Baie de Somme on the French coast. In 2002, The English and French Young Fish Surveys were combined into an International Young Fish Survey. The dataset was revised for the period back to 1987. The two surveys operate with the same gear (beam trawl) during the same period (September) in two different nursery areas. Previous analysis (Riou *et al.*, 2001) has demonstrated that asynchronous spawning occurs for flatfish in Division VIId. Therefore both surveys were combined based on weighting of the individual index with the area nursery surface sampled (Cf. Annex 1). Taking into account the low, medium, and high potential area of recruitment, the French YFS got a weight index of 55% and the English YFS of 45%. The UK Young Fish Survey ceased in 2006, disrupting the ability to derive an International YFS.

A third survey consists of the French otter trawl groundfish survey (FR GFS) in October. Prior to 2002, the abundance indices were calculated by splitting the survey area into five zones, calculating a separate index for each zone each zone, then averaging to obtain the final GFS index. This procedure was not thought to be entirely satisfactory, as the level of sampling was inconsistent across geographical strata. A new procedure was developed based on raising abundance indices to the level of ICES rectangles, then by averaging those to calculate the final abundance index. Although there are only minor differences between the two indices, the revised method was used in 2002 and subsequently.

B.4. Commercial cpue

Three commercial fleets have been used in tuning: UK and Belgian Beam Trawlers and French Otter Trawlers.

The effort of the French otter trawlers is obtained by the logbook information on the duration of the fishing time weighted by the engine power (in KW) of the vessel. Only trips where sole and/or plaice have been caught are accounted for. The effort of the Belgian Beam Trawlers is corrected for engine power.

B.5. Other relevant data

None.

C. Historical stock development

Benchmark 2010

This stock was ‘benchmarked’ at the WKFLAT 2010 meeting where two main issues have been under review, (i) inclusion of a discards time-series in the assessment and (ii) an attempt to overcome the problematic retrospective pattern. Solutions explored included making an ‘allowance’ for migration patterns between the two Channel plaice stocks and the southern North Sea.

The combined assessment of the two Channel plaice stocks was examined. It was agreed that this would require further investigation as the inclusion of the North Sea stock would also need to be considered. Any combining of stocks would have a wide ranging impact on the assessment and any subsequent management.

The issue of including discard estimates was based on a working document provided to the Benchmark Workshop, where all on-board samples from Belgium, France and UK from 2002 to 2008 were gathered in an international dataset. An estimate of annual discards-at-age was produced for the period 2004–2008, and the flexible Statistical Catch-at-Age model developed by Aarts and Poos (2009) has been tested for reconstructing discards prior to 2004. The model did not succeed in providing reasonable and robust fit. The current discard time-series was considered too short and too variable to support proper model fitting. Further work on the data and method used for estimating the 2004–2008 series of discards is necessary before inclusion in the statistical model is considered further.

The persistent retrospective pattern in the assessment without discards was largely reduced, when 65% of quarter 1 catches were removed as well as removal of younger ages (1, 2 and 3) from the survey UK BTS. The patterns in log q residuals, already demonstrated in the previous assessment remained unchanged.

In conclusion, the proposed final settings (detailed below) improve the retrospective pattern, and take into account the acknowledged mixing between neighbouring areas, but the model is not entirely satisfactory in terms of quality of the assessment. The reasons are that the model still does not account for discards, removes younger ages from an internally consistent survey, and does not provide solutions for the patterns in log-catchability residuals.

The recommendation from WKFLAT is **that this assessment is useful in determining recent trends in F and SSB, and in providing a short-term forecast and advice on relative changes in F**. However, WKFLAT does not recommend this as an analytical assessment, as it will not be useful for calculation of reference points.

Because further work on including the discard estimates, on the relevance of the commercial tuning-series, and sensitivity of the assessment to the 65% adjustment to the Q1 catch-at-age need to be examined, **the information concerning the settings of the assessment model is only valid for WGNSSK 2010**.

Model used: XSA

Software used: IFAP/Lowestoft VPA suite for final assessment; FLR packages and SURBA software for exploratory analysis

Model Options chosen:

- Tapered time weighting not applied
- Catchability independent of stock size for all ages
- Catchability independent of age for ages >= 7
- 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 estimate are shrunk = 1.0
- Minimum standard error for population estimates derived from each fleet = 0.300
- Prior weighting not applied

- Input data types and characteristics:
  - Catch data available for 1980-present year. However, French age compositions before 1989 were derived from UK age–length keys.
  - Removal of 65% of quarter 1 catches in tonnes, catches-at-age and weight-at-age for all years.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch-in-tonnes	1980–Last yr	1–10+	No
Canum	Catch-at-age in numbers	1980–Last yr	1–10+	No
Weca	Weight-at-age in the commercial catch	1980–Last yr	1–10+	No
West	Weight-at-age of the spawning stock at spawning time.	1980–Last yr	1–10+	No
M_{prop}	Proportion of natural mortality before spawning	1980–Last yr	1–10+	No
F_{prop}	Proportion of fishing mortality before spawning	1980–Last yr	1–10+	No
Mat_{prop}	Proportion mature-at-age	1980–Last yr	1–10+	No
Natmor	Natural mortality	1980–Last yr	1–10+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	UK BeamTrawl	Excluded	
Tuning fleet 2	BE Beam Trawl	1981–Last yr	2–10+
Tuning fleet 3	FR Otter Trawl	Excluded	
Tuning fleet 4.	UK BTS	1988–Last yr	4–6
Tuning fleet 5	FR GFS	1988–Last yr	2–3
Tuning fleet 6	Int YFS	1987–2006	1

D. Short-term projection

No short-term forecast has been provided since 2005 as the Review Group deemed it unhelpful in the management of the stock given the strong retrospective bias in F.

Model used: Age structured

Software used: FLR package

Initial stock size:

1) the survivors at age 2 and greater from the XSA assessment;

2) N at age 1 = geometric mean over a long period (1998, last data year).

Maturity: same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages and all years

Weight-at-age in the stock: average stock and catch weights over the preceding 3 years.

Weight-at-age in the catch: average stock and catch weights over the preceding 3 years.

Exploitation pattern: The F vector used will be the average F-at-age in the last 3 years, scaled by the F_{bar} (2–6) to the level of last year.

Intermediate year assumptions:

Stock–recruitment model used: None, the long-term geometric mean recruitment-at-age 1 is used

Procedures used for splitting projected catches.

E. Medium-term projections

No medium-term projections can be done for this stock, until the quality of the assessment is improved.

F. Long-term projections

No long-term projections can be done for this stock, until the quality of the assessment is improved.

G. Biological reference points

Previous reference points:

B_{lim} = 5400 t.

B_{pa} = 8000 t.

F_{lim} = 0.54

F_{pa} = 0.45

The current assessment is indicative for trends only; therefore the biological reference points are not valid anymore for being used in the Advice.

H. Other issues

None.

I. References

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4 Plaice in the western Channel (VIIe)

4.1 Current stock status and assessment issues

Spawning stock biomass (SSB) was stable during the period 1981–1987, peaked above 4000 t during 1988–1990 following good recruitments in the mid-1980s, then decreased to 1700 t in 1995–1996. Following the good 1996 year-class, SSB increased but it has since declined to levels observed in the late 1970s. SSB in 2008 was estimated to be 1500 t, which is below B_{pa} (2500 t). Fishing mortality demonstrated a gradually increasing trend until the mid-1990s, then a slight decline followed by a sharp increase up to 2007. The most recent assessment demonstrated a marked fall in F in 2008 to 0.64, which is above F_{pa} (0.45). Two periods of below-average recruitments in the period 1989–1994 and from 1998–2006 have contributed to the decrease in yield and SSB. The assessment estimated that only two year-classes have been above the long-term $GM_{76–06}$ (4489) since 2000.

The retrospective analysis demonstrates a strong tendency to overestimate F and to underestimate SSB. Given that the degree of retrospective bias is not predictable, no short-term forecast was provided by the Working Group (WGSSDS) in 2006 or thereafter. The WG believed that the assessment was representative of the long-term trends in stock dynamics and recent recruitment, and that it is mainly the recent estimates of F that are affected. This retrospective trend appears to be caused by a difference in the mortality signals and level of decline in SSB suggested by commercial and survey information. The most plausible explanation for the difference is incomplete mixing or migration.

No short-term forecast has been accepted for this stock since 2004.

The settings used in the most recent assessments are shown in the Table below.

		2008 XSA	2009 XSA
Catch-at-age data		1976–2007, 1–10+	1976–2008, 1–10+
Fleets	UK-WECBTS – Survey	1986–2007, 1–8	1986–2008, 1–8
	UK WECOT – Commercial	1988–2007, 3–9	1988–2008, 3–9
	UK WECOT–Commercial historic	1976–1987, 2–9	1976–1987, 2–9
	UK WECBT – Commercial	1989–2007, 3–9	1989–2008, 3–9
	UK E+W FSP – Survey	2003–2007, 2–9	2003–2007, 2–9
Taper		No	No
Taper range		-	-
Ages catch dep. Stock size		None	None
q plateau		7	7
F shrinkage se		2.5	2.5
	Year range	5	5
	Age range	4	4
Fleet SE threshold		0.5	0.5
Prior weighting		-	-
Plus group		10	10
F_{Bar} Range		F(3–7)	F(3–7)

There is a heavy reliance on the age composition data derived from UK (E&W) sample data. Almost 30% of the landings for this stock come from countries that do not provide age based data. Survivor estimates for ages 1 and 2 are derived almost entirely from the UK beam trawl survey and the Review Group commented that some consideration should be given to using age 2 information from the commercial tuning fleets. WKFLAT 2010 considered that this information should not be used for tuning because discarding, although small, would be most noticeable in the younger age groups and may therefore corrupt the cohort signal coming from the survey.

UK Discard data indicate low discard levels in the second half of the year, and overall that discarding for this stock is variable but relatively low compared with other plaice stocks. As the time-series of data expands, the WG expects to be better able to better determine how to include these data in the assessment appropriately.

Both UK survey indices used in the assessment (Commercial BTS and the UK (E&W) FSP) are spatially restricted to the same area as the commercial tuning fleets and little information exists on stock dynamics on the French coast.

The stock unit (Division VIIe) does not correspond to the management unit (Divisions VIId and VIIe). This hampers effective management of plaice in the Western Channel.

Plaice are taken as a bycatch in the beam trawl fishery mainly targeting sole, and as part of a mixed demersal fishery by otter trawlers. Therefore the restrictions under the management plan for sole should also benefit the plaice stocks. In addition to the days-at-sea regulations there has been a recent UK decommissioning scheme that has reduced the number of beam trawlers in the southwest fleet.

4.2 Compilation of available data

4.2.1 Catch and landings data

In this area the plaice are taken mainly as a bycatch in beam trawls directed at sole and anglerfish. In 2008, the UK beam trawl fleet took almost 50% of the total landing of this stock with the UK otter trawl fleet taking almost 20%. The remainder of the landings is taken by the French fleets (24%) and Belgian fleets (8%). This stock is the smaller of the two stocks that make up the larger TAC Area of VIId,e. The landings from this stock in 2008 and 2007 amounted to around 20% of the combined area TAC. No 2009 landings data were available for this workshop.

Age information for the catch is provided solely by the UK using length distributions by fleet (beam trawl and otter trawl) and a combined ALK (by quarter for females and an annual one for males due to the smaller numbers of males in the otolith samples). The combined UK age composition was then raised to the total international landings.

WKFLAT 2010 recommends the use of a model taking account of migration patterns. The catch data for this model reassigns 15% of the first quarter Belgian, French and UK catch-at-age in VIId to the VIIe catch-at-age matrix used previously, to account for spawning migrations of VIIe fish into VIId. During the meeting, quarterly data for Belgium and France were available back to 1998 and UK data to 1997. In order to extend the time-series back to 1980 the first quarter landings and catch-at-age matrix for each country were inferred from the total annual international landings and catch-at-age data (which begin in 1980 for VIId). Total annual international catch-at-age data (1980–1997 for France and Belgium and 1980–1996 for UK) were adjusted downwards using the average proportion of catch-at-each-age in the first quarter by each country over the period in which quarterly data were available. Similarly, SOP corrected Q1 landings for each country were calculated back to 1980 using the mean (calculated over the period in which quarterly data were available) proportion of the annual landings that were landed in Q1 in VIId.

4.2.2 Biological data

In recent years, only the UK (E&W) have provided catch-at-age data based on a programme of length and age sampling from commercial catches and these account for almost 70% of the reported international landings. These international catch numbers and weights-at-age have been derived by raising UK (E&W) age composition data to the international landings.

Total international catch and stock weights-at-age are calculated as the weighted mean of the annual weight-at-age data (weighted by catch numbers), and smoothed in year using a quadratic fit so that:

$$Wt = a + b * Age + c * Age^2$$

Catch weights are calculated as mid-year values, stock weights are interpolated back to January 1st. Catch weights-at-age have been scaled to give a SOP of 100%, and the same scaling is applied to the stock weights-at-age. The Stock Annex describes the method for this derivation of the international catch numbers and the calculation of the catch and stock weights-at-age. No 2009 catch-at-age data were available to this workshop.

The standard settings used for natural mortality (0.12) and the proportions of F and M before spawning (both 0.0) have been in use for a number of years. These parameters are applied to all ages and all years in the assessment. The maturity ogive in use is based on UK (E&W) VIIfg survey data for March 1993 and March 1994 (Pawson and Harley, 1997).

Age	1	2	3	4	5+
Maturity	0	0.26	0.52	0.86	1.00

This ogive is applied to all years in the assessment. The Stock Annex contains further details regarding these settings.

4.2.3 Survey tuning data

There are two surveys that provide abundance estimates to the Working Group. The UK (E&W) commercial beam trawl survey provides indices for years 1986–2008. This survey has been conducted on the commercial beam trawler FV Carhelmar in most years. Detailed information on the survey protocols and area coverage can be found in the Stock Annex.

Since 2003 the Fisheries Science Partnership (FSP: Cefas-UK industry cooperative project) has been conducting a survey using commercial vessels with scientific observers and following a standard grid of stations extending from the Scilly Isles to Lyme Bay. The survey covers a substantially larger area than the other survey and as a result, is thought to be more representative of the stock in UK waters. This dataset was first included in the 2007 assessment, and the exploratory analysis can be seen in that report (ICES, 2007, Section 3.2.5). However, recently the vessel(s) used for the survey have changed from the FV Nellie and the FV Lady T, to the FV Carhelmar. In 2008, in addition to the vessel changes there have been other sample protocol changes, notably the change to using 4 m 'survey' beam trawls from the commercial 12 m beam trawls used previously by the other vessels, which have indicated a strong year effect despite the use of a linear correction for the beam length.

Data for the 2009 surveys was available for use at this workshop however no new catch data were available to the Workshop to examine possible effects of the 2009 FSP data on the assessment.

4.2.4 Commercial tuning data

Three UK (E&W) commercial tuning indices have been used previously in this assessment (beam trawl 1989–2008; otter trawl 1988–2008 and otter trawl [historical] 1976–1987. No new commercial tuning data were available to the Workshop, however exploratory XSA runs were carried out that involved either 'splitting' the commercial series time data further or truncating them to include recent data only because of the concerns regarding trends in the residuals of the full time-series (for further details see Section 4.8.3).

4.2.5 Discard data

Estimates of the length composition of both the discarded and the retained portions of catches from the UK (E&W) and French discard sampling programmes have previously been supplied to and presented by the Working Groups (WGSSDS and from 2009 WGCSE). Data is available for years 2002–2008 for both nations but for this workshop, UK (E&W) data were also available for 2009 (quarters 1–3 only).

No attempt has been made previously to either raise these estimates to the total catches for the fleets or to incorporate discards into the assessment. The Working Group (WGCSE 2009) stated that for this plaice stock, discarding is low compared with that of other plaice stocks and that discarding appears to be at its highest in quarters 1 and 2.

For this workshop, work was carried out to confirm these WG assumptions and to attempt to raise the discard data to total catch estimates. The Working Document on Western Channel (VIIe) plaice discard data describes the data exploration and analysis carried out.

This working document made the following summarized observations:

- The assumptions that discard rates are small, compared with other plaice stocks, and that most of the discarding takes place in quarters 1 and 2 appear robust. VIIe discard rates in numbers range from 9% in 2003 to 24% in 2008 with an average of 16%. Discarding is at its heaviest in quarters 1 and 2 with 26% and 19% discarded in these quarters and around 5% discarded in the remainder of the year. One of the reasons for this comparatively low discarding of plaice is likely a lack of overlap between the very limited nursery habitat and the fishery in VIIe.
- The discard rate appears to be increasing over time but is still at relatively low levels. Discard rates for VIIe plaice stock (16%) are much less than those for adjacent plaice stocks in VIId (57%) and VIIfg (73%).
- Sampling effort on discards is very good for the VIIe plaice stock and discard sampling effort is increasing over time. Most of the sampling effort has been carried out on beam and otter trawlers and this corresponds to the fleets where most catches and effort is observed.
- Most discard sampling was carried out on vessels of length 10 to <20 m and with engine power between 100 to <300 Kw.
- Around 10% by weight are discarded and this measure is increasing. The proportion discarded by weight has increased steadily from 5% in 2002 to

around 13% in 2008. This compares favourably with the adjacent stocks that have rates of around 40% in VIId and around 60% in VIIfg (in 2008).

- There is no evidence of any seasonal differences in the proportions discarded at length. The proportions of fish discarded at length for this stock demonstrate good levels of consistency over the time period and in addition the L50 values for each year are very close at around 27 cm. This is not the case for UK data from VIId and VIIfg stocks but for these stocks, the inconsistencies may be a feature of lower sample numbers.
- Around 60–70% of fish discarded are regarded as immature.
- Raising the discard sample data is possible by using either landings or effort but neither method is ideal. The major problem encountered in raising these data was the limited availability of age data at the smaller/larger lengths.
- In 2008, most discards were at age 2 and age 3, where an estimated 28% and 5% respectively would be added to the landings age composition. For 2008, the resulting age compositions from both raising methods were almost identical although this may not be the case for other years.
- The total weight of the discarded catch in 2008 is estimated to be approximately 55 t amounting to around 6% of the commercial landings.

The meeting discussed and agreed that given the confirmed low levels of discarding in this stock (16% by number and 10% by weight), that estimates of discarding would not be added to the assessment as part of this benchmark work. Given the stable levels of discarding over the observed period, low discarding of mature fish and stable proportions-at-length being discarded, the impact on SSB and fishing mortality of adding this catch component would be small. This workshop considered that the time-series of discard data available was insufficient to estimate discarding levels in earlier years.

Additionally, the Workshop had inadequate time to calculate estimates of the discarded catch for all years that sample data were available.

The Workshop did not consider the adding of discard estimates into this assessment as a high priority, as there were other issues (migration) that were more significant to the assessment.

4.2.6 Industry/stakeholder data inputs

Jim Portus as the RAC representative at the WG provided substantial anecdotal and qualitative information with regards to trends in fleet dynamics and important management issues to consider for the plaice VIIe stock.

4.3 Stock identity and migration issues

The current stock area for this stock is strictly that for ICES Area VIIe called the Western English Channel, although the TAC area includes the larger component of VIId (Eastern English Channel).

There are two known plaice spawning areas within VIIe and these are south of Start Point and south of Portland Bill. Spawning takes place between December and March with a peak in January and February. However, the spawning habitat in VIIe is much lesser than that available in VIId. Previous tagging studies have estimated that 87% of the recruits to the western Channel (VIIe) come from outside the area (34% from the eastern Channel VIId and 53% from the North Sea, Pawson 1995). Similarly, 38% of recruits to the eastern Channel are estimated to have come from the North Sea. The historical tagging data on which these studies were based also reveal that there is substantial mixing of adult plaice between the western and eastern Channel and between the English Channel and the North Sea, but very limited exchange between the English Channel and the Celtic and Irish Seas (Table 4.3.1; Burt *et al*., 2006).

At present separate assessments are made for plaice in VIIe, VIId and IV, but the abundance estimates obtained from these assessments may be questionable because they assume a closed population in each area. When there is mixing among areas, standard stock assessments that do not account for this are liable to overestimate present abundance in some areas and underestimate it in others. As a result, quotas based on the separate assessments can result in actual fishing mortality rates well above target in some areas and well below in others (Kell *et al*., 2004). The sum of the separate estimates should accurately estimate total historical abundance in all areas, but may or may not be accurate for total abundance in each individual area at a given time. Given the relative sizes of the three stock units, the effect of mixing is likely to have much greater impact on the assessment of the smaller components (in the English Channel) than on the larger one (North Sea).

The stocks of plaice in the Channel and North Sea are known to mix greatly during the spawning season (January–February). At this time many western Channel and North Sea plaice may be found in the eastern Channel (Figure 4.3.1; Pawson, 1995). The comparable lack of spawning habitat in the western Channel alone suggests that this migration from VIIe to VIId during the first quarter may be of considerable importance. The current flow from the far eastern Channel acts to sweep eggs and larvae back toward the southern Bight in the North Sea (Van der Veer *et al*., 1998). In contrast, the currents in the central Channel are variable, while in the western area an anticlockwise gyre of variable strength exists (Hill *et al*., 2008).

North Sea (IV) plaice have been demonstrated to spawn in VIId during January–February and subsequently return to the North Sea (Figure 4.3.2; Hunter *et al*., 2004). This migration is tracked by the international fleets fishing in the area: landings peak in January over the spawning grounds when migrant fish are present and track the movement towards the North Sea in February and March (Figure 4.3.3). A similar migration of plaice from the smaller VIIe stock into VIId during quarter 1 is believed to take place. Once fish have moved into VIId to spawn, they are then subject to fishing, largely by the Belgian and French trawlers that take the majority of their annual catch in January and February. Although, information from data storage tags is not available to verify the cyclical movement of fish between VIIe and VIId historical data are available from conventional tags. Conventional tags inform the recapture position and date of a tagged fish (with known release point) and such data has been investigated to estimate the likely movement rates of fish from VIId in quarter 1 into VIIe and IV. The movement rates can then be used to determine the proportion of the catch in VIId during quarter 1 that is due to immigrant spawning fish. The resulting estimates of the catch of fish from VIIe and IV that are caught in VIId can then be reallocated to the appropriate catch-at-age matrix.

There is evidence of significant adult site fidelity for NS plaice following the spawning migration, with different subpopulations of fish returning to the original area, so that this is clearly not a fully mixed population during quarters 2-4. As such the plaice stock complex represents neither a fully mixed nor an entirely unmixed-stock. The situation is further complicated, because the biological significance of the individual stock SSBs is unknown. If spawning in the same area, one might assume that the populations are mixed at the juvenile phases joining anyone of the subpopulations. In this case there would be no genetic separation and the relevant SSB to relate to recruitment would be the sum of all areas. Alternatively, spawning and subsequent settlement might be spatially or temporally discrete with migration patterns being genetically maintained in isolated populations and the SSB relevant to recruitment would be that of the individual stock. For the purpose of biomass reference points we will consider these stocks as separate biological units, although there is currently no genetic information available to support this assumption.

4.3.1 Analysis of historical tagging data; Methods

WKFLAT reanalysed data from historical tagging experiments on plaice, which were archived in the Cefas 'Tagfish' database (Burt *et al*., 2006). The tags were captured through the fisheries and most are returned to Cefas within a few months of release; however these fish, recaptured soon after release, have had little chance to migrate. Therefore data from tagged fish with <6 months at liberty were excluded from the analysis. Maps showing recapture positions for tagged plaice, with ≥6 months at liberty, that had been released in the Channel are shown in Figure 4.3.1. In order to focus on movement rates of fish that are available to the fishery only fish greater than the minimum landing size were considered for further analysis (Table 4.3.2). Because tags are returned via the fishery the probability that a tag will be caught depends on the level of catch of plaice in an area: the greater the catch taken the more likely the tag to be caught. However, the more fish that are present within an area the less likely a tag is to be caught. So that estimated movement probabilities can be comparable between areas and years, the probability that a tag is caught in an area (Number recaptured/Number released) in a particular period must be weighted by the ratio of biomass/catch in that area and year. The resulting weighted proportions of tags returned from each area provide estimates of the movement probabilities between areas (Table 4.3.3).

The best estimates of biomass in VIIe, VIId and IV were taken from the most recent stock assessments (WGNSSK and WGCSE 2009) and the total international catch of plaice in the three areas between 1950 and 2007 were gathered from FISHSTAT+. Prior to 1973, catches of plaice in the Channel were not disaggregated into VIId and VIIe. However, the average proportions of VIIe and VIId in the total Channel catch in the period 1973–2007 were investigated and found to vary around constant proportions (22% and 78% respectively). Thus, catches prior to 1973 were disaggregated by assuming that the constant proportion held in the period 1950–1972. The VIId plaice stock assessment covered the shortest period (1980–2008) of the three stock assessments and the area IV assessment the longest (1957–2008). The SSB data were similarly investigated and the stock size for VIId, prior to 1980, and VIIe, prior to 1976, was computed as relative proportions of the North Sea stock (2.8% and 0.9% respectively).

4.3.2 Analysis of historical tagging data; Results and conclusions

The numbers of tagged adult fish (length >270 mm) released in VIIa, d, e and IVc and subsequently recaptured are given in Table 4.3.2. Estimated movement probabilities are shown in Table 4.3.3. The best estimates of the proportion of fish in quarter 1 in VIId that would return, if not caught by the fishery, to VIIe and IV are circled in red in Table 4.3.3. So 14% of males and 9% of females would migrate to VIIe, while 52% of males and 58% of females would migrate to IV. To the nearest 5%, this suggests that 10 to 15% of the catch in Q1 in VIId should be allocated to VIIe, while between 50 and 60% of the catch in Q1 in VIId should be allocated to IV. These estimates are in agreement with previous analyses (based on the same data) reported by Pawson (1995), which suggest that 20% of the plaice spawning in VIIe and VIId spend summer in VIIe, while 56% migrate to the North Sea. Given the assumptions involved in these calculations (including identical tag return rates between different fishing nations and constant spatial patterns over time) and the relatively small numbers of adult tags returned the estimates of movement rates are subject to great variability. The limitations of the data do not permit an estimate of annual movement probabilities. Recent studies based on data storage tags suggest that the retention rate of spawning plaice tagged in the eastern Channel is 28%, while 62% of spawning fish tagged were recaptured in the North Sea (Kell *et al*., 2004).

WKFLAT explored impacts of various mixing rates on the assessments of the plaice stock components in VIId and VIIe, based on analyses of historical tagging experiments and published tagging results and studies (e.g. Burt *et al*., 2006; Hunter *et al*., 2004; Kell *et al*., 2004). For plaice in VIIe, an adjustment to the catch-at-age was carried out by adding 15% of Q1 landings from VIId to the catch in VIIe. For plaice in VIId, the catch-at-age was also adjusted for that change, and a further 50% of Q1 landings and catch-at-age in VIId were assumed to come from North Sea. Thus the Q1 catch-at-age for plaice in VIId was reduced by 65%. WKFLAT emphasized the importance of making corresponding adjustments if catch from one area is re-assigned to another.

Bias due to mixing can be avoided by combining areas and conducting a single assessment, but that approach raises some difficult issues. One is how to choose and combine series of relative abundance data that reflect trends in the combined area as a whole. A more difficult issue is how to apportion the estimated total quota among areas. Although there are examples of how this has been applied elsewhere (Clark and Hare, 2007), these issues require careful study for the plaice stocks. Therefore WKFLAT recommends that ICES set up a study group similar to SGHERWAY to explore the potential for performing a combined assessment of plaice in the North Sea and English Channel, and apportioning quota between them. Such a SG could also explore the possibility of modelling/assessing the three different “subpopulations” and trying to estimate migration factors between the areas, using tagging studies to ground-truth these results.

Table 4.3.1. Summary of flatfish tagging data collected between 1960 and 2006 showing numbers of (a) releases on the database, (b) recaptures on database, and (c) releases not yet entered on the database, by tag type, release decade and release area (ICES Subarea or Division) (adapted from Burt *et al.*, 2006).

Common name	Tag type	Decade		I	IIIa	IVa	IVb	IVc	Va	Vb	VIa	VIIa	VIId	VIIe	VIIf	VIIg	VIIh	Total
				ICES Sub-Area/Division														
Plaice	Conventional	1960s	a		141		21,277	5,548				1,029	338	398				28,731
			b		60		7,286	1,182					100	92				8,720
			c	198	526	249	4,510	2,654	5,217			17,073	71	6				30,504
		1970s	a			1,229	6,756	2,786				3,673	5,691	5,027				25,162
			b			706	2,934	1,042				971	1,858	2,010				9,521
			c				1,619	603				37		72				2,331
		1980s	a			792		5,260				3,459	2,198	115				11,824
			b			178		2,156				868	969	9				4,180
			c					27				108	537	88				760
		1990s	a				357	958				4,514	2,312		2,166			10,307
			b				153	249				997	1,012		490			2,901
			c				100											100
		2000s	a				207	74										281
			b				4	6										10
			c															

Table 4.3.2. Summary of tagged plaice (≥270 mm, where B = both sexes, M = male and F = female) recaptured after 6 or more months at liberty. The column on the far left indicates where the fish were released and the 12 rightmost column titles indicate where the fish were recaptured. The data were pooled for the period 1960 to 2006. The recapture period is specified in the fourth column but the release period is not constrained.

Release Information			Recaptures (N) of plaice (length ≥ 270mm on release) with >=6 months at liberty												
DIV	Sex	N	Recapture period	3A	4A	4B	4C	6A	7A	7D	7E	7F	7G	7H	7J
VIIe	B	**576**	ALL	0	0	9	30	0	1	38	**485**	7	1	4	0
	M	**71**	Jan-Mar	0	2	0	3	0	0	10	**55**	1	0	0	0
	F	**66**	Jan-Mar	0	2	0	3	0	0	5	**55**	0	0	1	0
	M	**199**	Apr_Dec	0	0	2	13	0	0	14	**168**	2	0	0	0
	F	**240**	Apr_Dec	0	2	0	12	0	1	11	**206**	4	1	3	0
VIId	B	**997**	ALL	0	3	94	302	0	0	**510**	81	4	2	1	0
	M	**64**	Jan-Mar	0	1	5	10	0	0	**39**	7	2	0	0	0
	F	**149**	Jan-Mar	0	0	12	35	0	0	**88**	14	0	0	0	0
	M	**291**	Apr_Dec	0	0	15	94	0	0	**152**	27	1	2	0	0
	F	**487**	Apr_Dec	0	2	62	161	0	0	**227**	33	1	0	1	0
VIIa	B	**519**	ALL	0	0	1	0	1	**464**	0	3	31	18	1	0
	M	**27**	Jan-Mar	0	0	0	0	0	**19**	0	0	7	1	0	0
	F	**40**	Jan-Mar	0	0	0	0	0	**26**	0	0	12	2	0	0
	M	**127**	Apr_Dec	0	0	0	0	0	**119**	0	2	5	1	0	0
	F	**325**	Apr_Dec	0	0	1	0	1	**300**	0	1	7	14	1	0
IVc	B	**815**	ALL	2	10	365	**369**	0	1	59	8	0	1	0	0
	M	**108**	Jan-Mar	0	1	41	**59**	0	0	6	1	0	0	0	0
	F	**88**	Jan-Mar	0	2	32	**36**	0	0	17	1	0	0	0	0
	M	**275**	Apr_Dec	1	2	128	**125**	0	0	16	3	0	0	0	0
	F	**325**	Apr_Dec	1	5	167	**132**	0	0	18	1	0	1	0	0

Table 4.3.3. Summary of estimated movement probabilities for plaice (≥270 mm) recaptured after 6 or more months at liberty, for data collected between 1960 and 2006.

Release Information		period			WEIGHTED BY INTN CATCH AND SSB pr(recap) after 6 or more months at liberty			
DIV	Sex	Release	Recapture	N	7A	7E	7D	4
VIIe	B	ALL		564	0.001	0.90	0.06	0.04
	M	Jan-Mar		2	0	0.74	0.26	0
	F			3	0	0.60	0.40	0
	M	Apr_Dec		180	0	0.91	0.05	0.03
	F			224	0.001	0.93	0.03	0.04
	M	Jan-Mar	Apr_Dec	17	0	0.66	0.11	0.23
	F			8	0	0.67	0.24	0.09
	M	Apr_Dec	Jan-Mar	68	0	0.83	0.12	0.05
	F			62	0	0.88	0.07	0.06
VIId	B	ALL		990	0.00	0.10	0.54	0.36
	M	Jan-Mar		31	0	0.04	0.73	0.22
	F			86	0	0.08	0.58	0.34
	M	Apr_Dec		144	0	0.10	0.76	0.14
	F			180	0	0.09	0.79	0.12
	M	Jan-Mar	Apr_Dec	144	0	0.14	0.35	0.52
	F			305	0	0.09	0.33	0.58
	M	Apr_Dec	Jan-Mar	31	0	0.20	0.57	0.23
	F			63	0	0.11	0.72	0.17
IVc	B	ALL		812	0	0.01	0.06	0.93
	M	Jan-Mar		54	0	0	0.03	0.97
	F			17	0	0	0.28	0.72
	M	Apr_Dec		172	0	0.01	0.06	0.92
	F			235	0	0.01	0.04	0.95
	M	Jan-Mar	Apr_Dec	102	0	0	0	1
	F			38	0	0	0	1
	M	Apr_Dec	Jan-Mar	54	0	0.02	0.05	0.93
	F			71	0	0.01	0.18	0.80

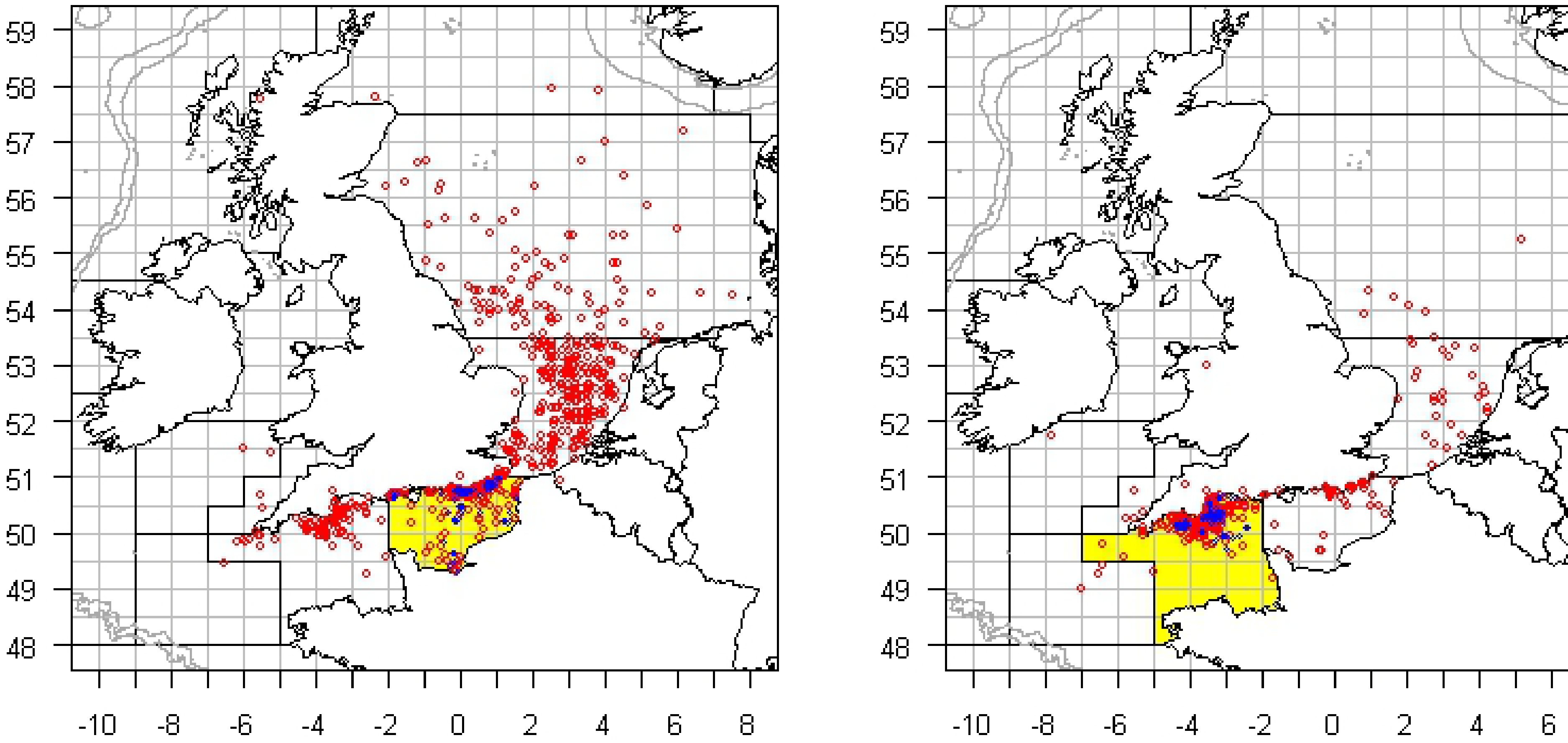

Figure 4.3.1. Locations of recaptures (red circles) after 6 or more months at liberty for tagged plaice released (blue crosses) in the English Channel: bottom left, released in the eastern (VIId) Channel and bottom right, released in western (VIIe) Channel.

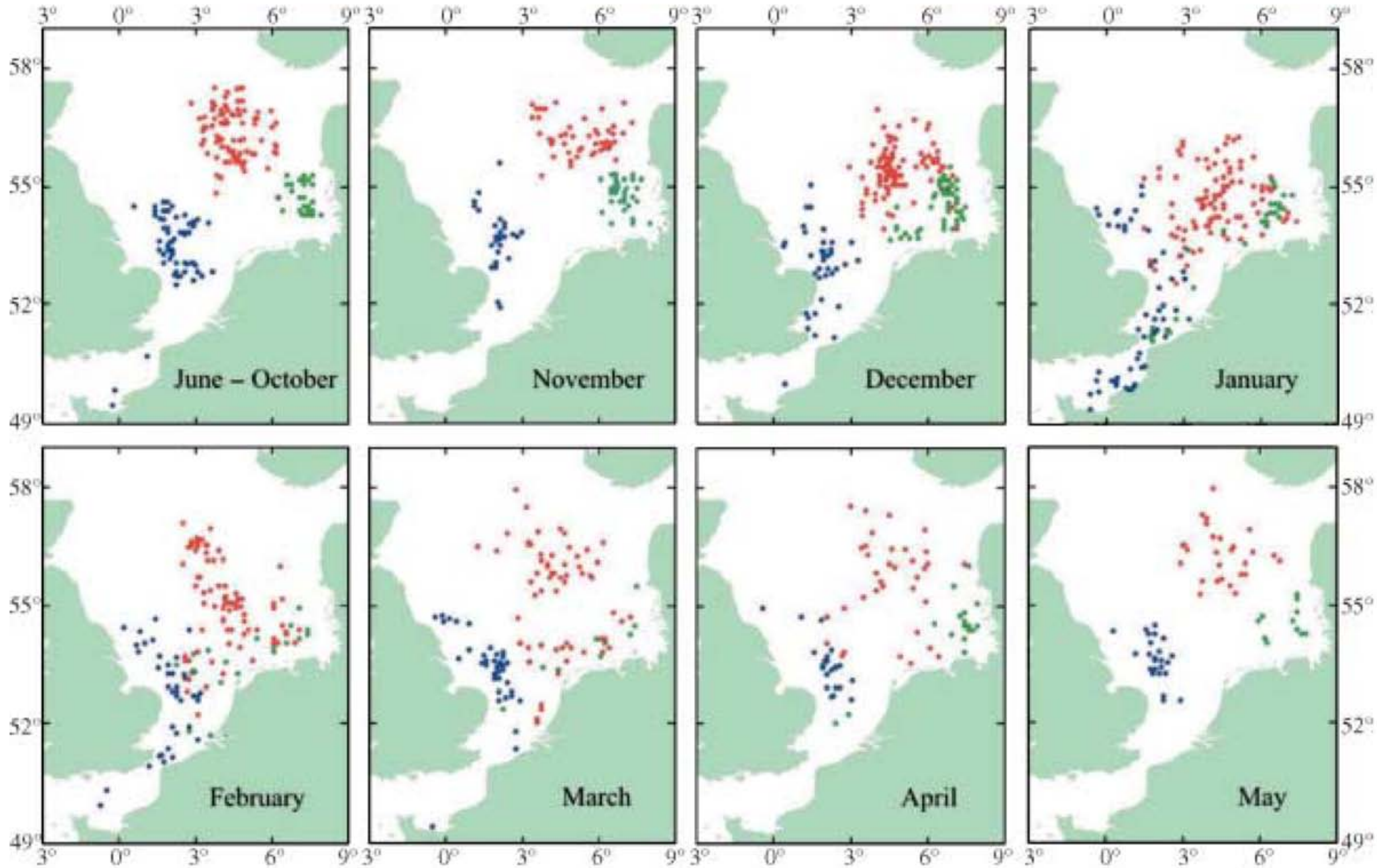

Figure 4.3.2. Monthly composite plots of locations for plaice carrying electronic data storage tags. Each filled circle represents a single location calculated from tidal data recorded when fish remained on the seabed for a full tidal cycle. The colours represent three geographically distinct subgroups: western subunit (blue) eastern subunit (green) and; northern subunit (red). Reproduced from Hunter *et al.*, 2004.

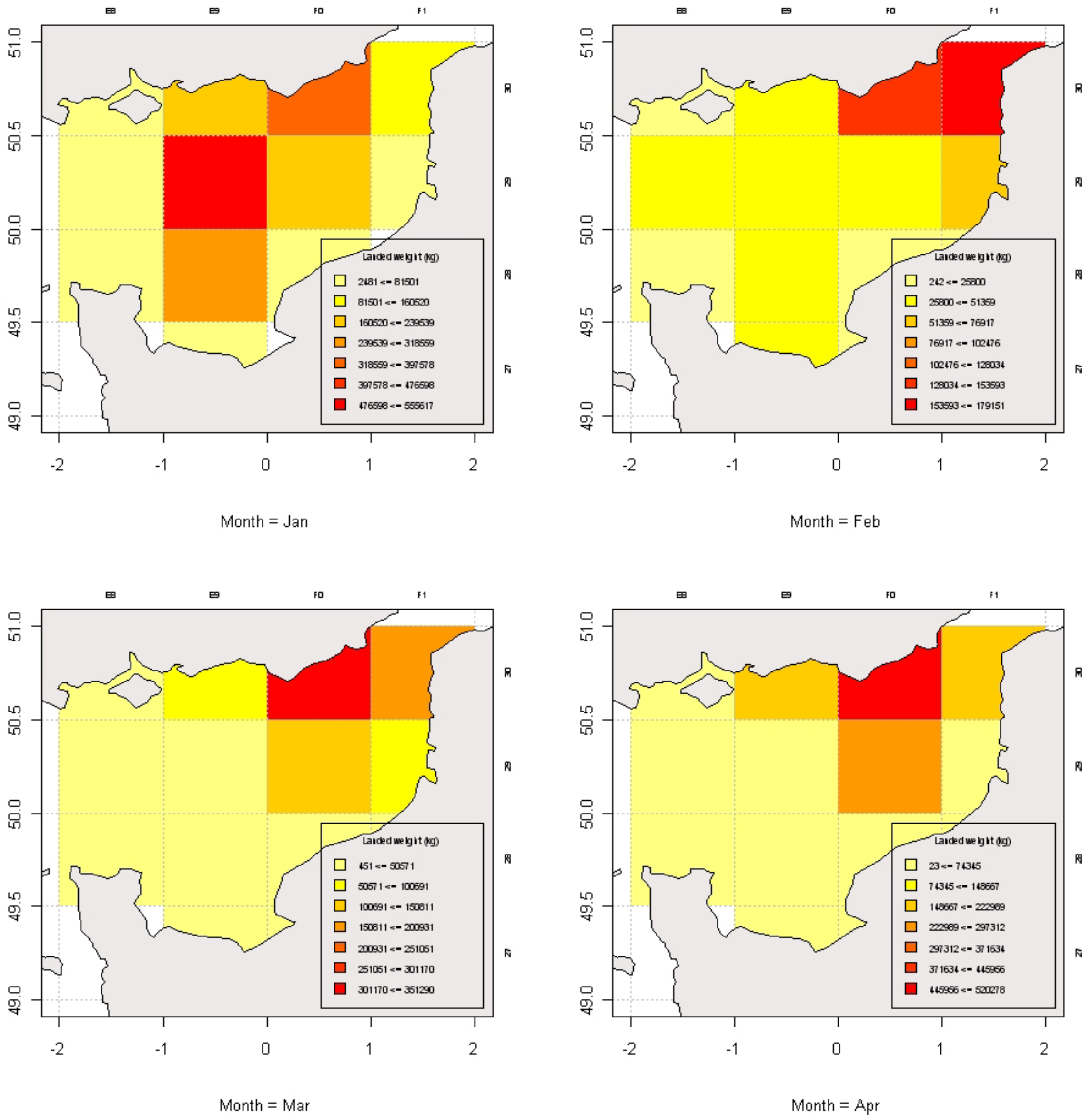

Figure 4.3.3. Mean monthly landings for the combined international fleets for the period 2003 to 2008 (top left, January; top right, February, bottom left, March and bottom right (April).

4.4 Spatial changes in the fishery and stock distribution

WKFLAT 2010 provided investigations of the spatial and temporal trends in effort and landings are provided in. These demonstrate that for the UK otter trawl fleet, effort is concentrated in the coastal areas on the south coast of Devon and Cornwall and this pattern has remained constant over the time period. This is entirely consistent with the type/size of vessel engaged in this fishery with most vessels being relatively small and working single-day trips.

The UK beam trawl fleet effort is concentrated in the Northern areas of VIIe from the Scilly Isles in the west to the Cherbourg peninsular in the east with most effort occurring in the three ICES rectangles close to Start Point. Very little UK beam trawl effort occurs in French waters and this is consistent with those areas having a hard seabed stratification that is generally unsuitable for this gear type. This pattern of effort also has remained consistent over the time period.

A working document presented to the Workshop also provided a detailed description of the methodology involved in correcting effort for spatial changes and fleet composition for the tuning-series. However, these were found to be mostly consistent with the current effort correction to registered tonnage. The new cpue modelled is likely to provide a more consistent pattern, but it is not clear to what degree historical estimates will continue to change as additional data are added to the model. As there was little effect of the changes to tuning information in the XSA assessment it was decided to retain the current method of determining cpue until the model can be evaluated over a longer time period.

4.5 Environmental drivers of stock dynamics

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 VIIe plaice.

Environment influences were considered by WKFLAT by incorporating sea surface temperature into the XSA model as a tuning fleet for age 1 catch numbers i.e. as an index of recruitment. The analysis managed to correlate well with the extremes of temperature, but intermediate values provided little quantitative information on the relative strength of intermediate cohorts.

There is some anecdotal evidence of range extension of some warm-water species such as langoustine, triggerfish, and black sea bream from warmer parts of the Atlantic into the Channel, thought to be associated with temperature increase in the area. Given the biology of plaice it could be hypothesized that such temperature changes would have a negative impact on the abundance and distribution of plaice.

4.6 Role of multispecies interactions

Not investigated during the Benchmark Workshop.

4.7 Impacts on the ecosystem

Not investigated during the Benchmark Workshop.

4.8 Stock assessment methods

4.8.1 Models

Two stock assessment models were compared at the WKFLAT 2010 to evaluate this stock because of the differences in their assumptions.

SS3

Stock Synthesis is a highly flexible statistical model framework not necessarily confined to catch-at-age analysis, but was implemented here using the catch-at-age information. It is able to include a large number of possible trends and dynamics with a framework to statistically evaluate the parsimony of such submodels. However, here it was investigated mainly as an exploratory assessment tool and as a way of obtaining a better understanding of the data and its uncertainties. The main conclusions of this work are summarized below.

XSA

XSA is the currently used assessment model and was implemented by WKFLAT, using FLR, in a variety of ways. The XSA method is well known to ICES so its assumptions are not further elaborated on here.

4.8.2 Evaluation of the models

SS3

These investigations reveal that there are significant benefits to the model flexibility offered in SS3 at least in terms of data exploration. Further investigations should be conducted to see if reasonably robust results can be obtained from such a model, which clearly has benefits in terms of both realism in the dynamics and its ability to provide more realistic estimation of the uncertainty in specific parameter estimates.

The complexity of the model does suggest that the time intensity in developing a robust model will significantly increase the time required at the WG to provide management advice, but we have also demonstrated that fundamentally the models are not significantly different as they rely mostly on the catch equation so that it should be possible to get simpler deterministic models to match the results produced by SS3 once the trends in the dynamics have been understood.

For VIIe plaice it is suggested that the exercise conducted here should be repeated with the new dataset which includes migration between VIIe and VIId and that the information in the tuning fleets is extended to a plus group of 15+ also. Furthermore it is desirable to remove the commercial tuning information from the "survey classification" in SS3 (as currently implemented) and replace their effects in separate fisheries, consistent with the samples collected. The aim here would be provide length and age information at the level of the samples, rather than as raised age information as is done for the deterministic models. Only in this way will it be possible to evaluate uncertainty properly.

It is clearly difficult to estimate absolute levels of F as it seems likely that there have been few significant fluctuations in F over the time period. SS3 appears to approach the problem from a low F, high SSB direction, where as XSA appears to have much higher levels of F inconsistent with the dynamics in the plus group which were only evaluated for the SS3 model. Further work is urgently needed to determine if XSA can make use of this information because for a number of cohorts abundances are low or absent especially in the survey information and XSA is unable to deal with 0 in the tuning information.

XSA

The current stock assessment model is carried out using XSA (WGCSE 2009). WKFLAT investigated numerous changes to the input data (e.g. changes to the tuning fleets), XSA settings (including q-plateau, F-shrinkage, and F bar range) and alternative models in order determine why retrospective patterns and trends in residual catchability exist in the current stock assessment model. Environmental influences were also considered by incorporating temperature into the XSA model as a tuning fleet for age 1 catch numbers i.e. as an index of recruitment.

In the current stock assessment model, the retrospective pattern in mean F for ages 3–7 indicates that there is typically an overestimation of F and this is coupled with an underestimation of SSB. WKFLAT investigated the retrospective pattern in fishing mortalities for each age and demonstrated that the problem extends across ages 4–7

(ICES Working Document 4.1). Given that the retrospective pattern in F does not extend to the early ages there is no suggestion that discarding is the cause of the pattern, which can be explained by the small amount of suitable nursery habitat available within VIIe itself. Even in the surveys few one-year-old plaice are caught in the area (see Section 4.2.5). It is more likely that the retrospective is caused by a conflict in the Z estimates coming from different fleets. This is signified by the pattern in the residuals particularly of the otter trawl fleet implying an apparent decrease in the fleet catchability over time. However, WKFLAT could not find any reasonable cause for such a decrease in catchability after examining fleet dynamics which would have justified cutting or trimming of the index.

Screening of the tuning indices suggests that each series is internally consistent. Catch-curve analyses suggest strong correlation between total mortality, Z, estimates from the commercial indices (beam and otter trawl) and the catch data, but poor correlation between the catch data and beam trawl survey estimates of Z.

Given our knowledge of the spawning migrations of plaice in the Channel and the opposite retrospective patterns in F and SSB in the eastern Channel (VIId) assessment, WKFLAT attempted a simple combined assessment for Channel VIId,e plaice. Because the VIId stock and landings are five times greater than those in VIIe, it is perhaps unsurprising that the combined VIId,e assessment model resembles the current VIId assessment (see Section 3; WGNSSK 2009) and suffers the same retrospective problem in F and SSB as the latter stock alone.

WKFLAT conducted an analysis of historical tagging data and used this information to create two separate XSA models for the eastern and western Channel stocks that correct the catch-at-age matrices for the migration patterns observed (see Section 4.3). These 'migration' models were considered further by WKFLAT in addition to an alternative model for VIIe plaice, the 'truncated model' that also removes the retrospective pattern in F and SSB (Section 4.8.4).

Two XSA models were proposed as candidate assessment models for VIIe plaice by the Benchmark. The preferred ("migration") model attempts to correct for the migration of plaice between the eastern and western Channel so that the fundamental assumption of a closed population of the stock assessment model is met. Tagging information suggested that 15% of the catch in VIId in quarter 1 ought to be reallocated to the VIIe dataset, in agreement with previous studies. The assessment model was considered biologically appropriate and suitable for management advice. The use of this 'migration' model for VIIe plaice necessitates a similar alteration to the VIId input data and has implications for the assessment of North Sea plaice. The detailed diagnostics, output from XSA, suggest that the 'migration' model is at least as stable and robust as the truncated model with less reliance on shrinkage.

The alternative model 'the truncated model' was also suggested as a suitable basis for management advice for VIIe plaice because the model did not suffer from retrospective problems and the detailed diagnostics did not reveal immediate problems. However, this model makes no account for the known spawning migration of plaice and therefore violates the closed population assumption. Although this is likely to cause bias in the estimated numbers, there is no evidence to suggest that the migration rate has changed over time and therefore the change in F estimates between years should be robust.

WKFLAT 2010 concluded that the migration model provides the most robust assessment of the plaice stock resident in VIIe during 2nd–4th quarter, as it best captures the dynamics of the stock as we understand them, particularly with regards to the information provided by the tagging data. As such, this model should form the basis of future ICES advice. However, WKFLAT acknowledges that such a change to the advice implies more complicated management actions, and further work for the assessment in IVbc with regards to the changes adopted for the VIId in order to remain consistent with the approach for VIIe (removal of quarter one catches attributable for the stocks resident in VIIe and IVbc). Should it not be possible to effect appropriate management for the three individual stocks (VIIe, VIId and IVbc) using the advice provided by the migration models, advice should be provided for VIIe on the basis of the truncated model. It is noteworthy in this case that the reference point issue would have to be revisited, see Section 4.12.

The 'truncated' model is identified by WKFLAT as a useable model for management, in the relative sense. It should be possible to provide relative advice in terms of a required reduction in the exploitation rate, but it cannot provide sound advice on an absolute basis (see also the Section on VIId plaice), nor is management action likely to have the desired effect, if the proportion of the VIIe stock taken in VIId during the first quarter changes from previous ratios. WKFLAT has provided the necessary details and settings for this model in case it is not possible to implement the migration model consistently.

4.8.3 Sensitivity analysis

Not investigated during the Benchmark Workshop.

4.8.4 Retrospective patterns

4.8.4.1 The 'migration' model

The migration model differs from the current model in that 15% of the commercial catch-at-age in quarter 1 in VIId is reallocated to the VIIe dataset. The reasoning is that these fish would have returned to VIIe had they not been caught by the fishery during their spawning migration. Once these data are included in the VIIe XSA assessment model, the estimates of SSB increase and the retrospective pattern in SSB is resolved (Figure 4.8.1). The retrospective pattern in F is substantially reduced and the F level remains relatively stable throughout the time-series.

Catchability residuals still suggest trends (reducing catchability over time) in the commercial fleets between 1990 and 2000 and WKFLAT discussed the appropriateness and significance of the trends. Given the lack of any evidence to suggest that there have been dramatic changes in the fleets (see Section 4.4) over the time period and relative stability of the catchability residuals in the more recent period since 2000, the trends were not considered to alter the perception of the stock or the reliability of the assessment estimates of F in the last decade.

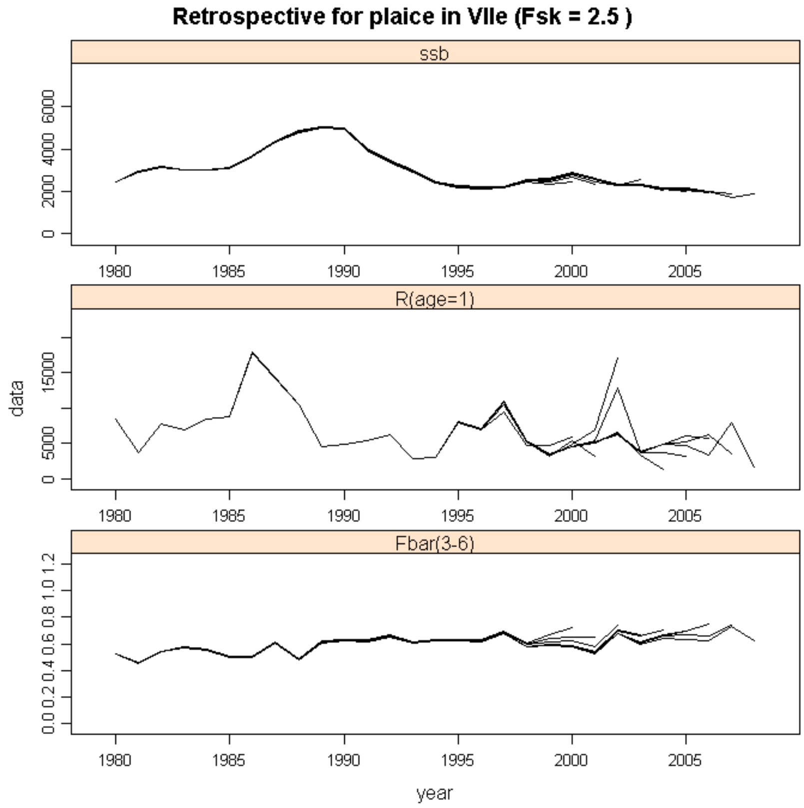

Figure 4.8.1. Retrospective plots of estimates of SSB (top), recruitment (age 1, middle), and average F for ages 3 to 6 (bottom). Model = migration model.

4.8.4.2 The 'truncated' model (the alternative)

Given that the XSA catchability residuals for the commercial tuning-series suggest downward trends in catchability the model was re-run, eliminating commercial data before 1998. The effect of this truncation is to remove the trends in residuals and eliminate the retrospective patterns in this model run (Figure 4.8.2).

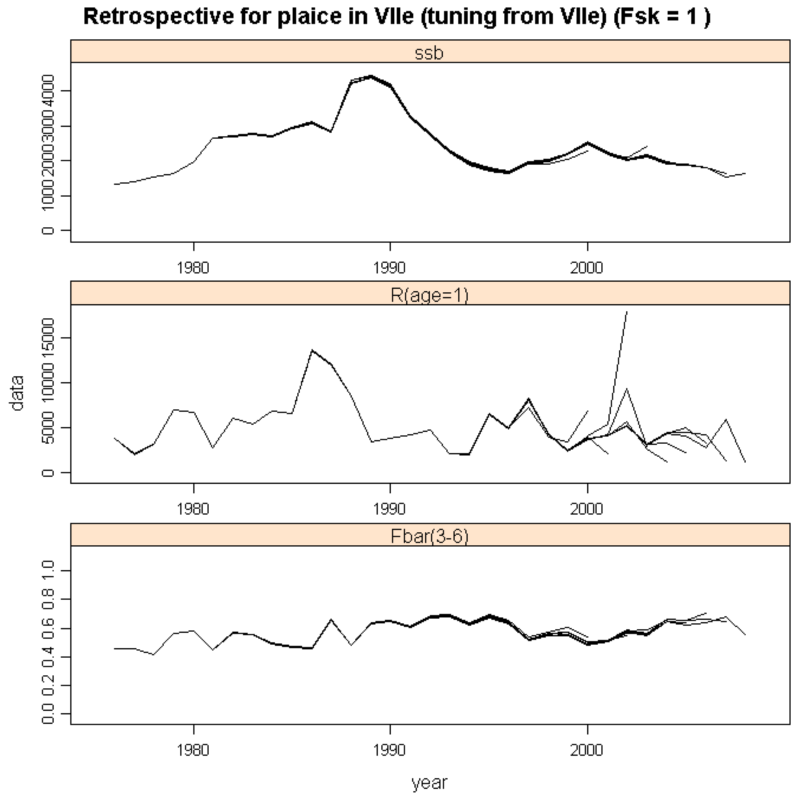

Figure 4.8.2. Retrospective plots of estimates of SSB (top), recruitment (age 1, middle), and average F for ages 3 to 6 (bottom). Model = truncation model. F-shrinkage is set to 1.0.

4.9 Stock assessment

The settings used in the Benchmark assessment and the alternative model are shown in the Table below alongside the 2009 WG settings (cell with alterations to the previous settings are in bold).

	2009 WG	2010 WK -1 Migration	2010 WK -2 Truncated
Catch-at-age data	1976–2008, 1–10+	1980–2008, 1–10+ add catch from 7d	1976–2008, 1–10+
UK-WECBTS – Survey	1986–2008, 1–8	1986–2008, 1–8	1986–2008, 1–8
UK WECOT – Commercial	1988–208, 3–9	1988–2008, 3–9	1998–2008, 3–9
UK WECOT–Commercial historical	1976–1987, 2–9	1980–2087, 2–9	
UK WECBT – Commercial	1989–2008, 3–9	1989–2008, 3–9	1998–2008, 3–9
UK E+W FSP - Survey	2003–2007, 2–9	2003–2007, 2–8	2003–2007, 2–8
Taper	No	No	No
Taper range	-	-	-
Ages catch dep. Stock size	None	None	None
q plateau	7	7	7
F shrinkage se	2.5	2.5	1
year range	5	5	5
age range	4	4	4
Fleet SE threshold	0.5	0.5	0.5
Prior weighting	-	-	-
Plus group	10	10	10
F Bar Range	F(3–7)	F(3–6)	F(3–6)

4.10 Recruitment estimation

WKFLAT considered the methods of recruitment estimation on the basis of the results of the new assessment methodology, which includes 15% of catches in Area VIId in the first quarter, see stock identity and assessment sections.

There is no evidence of a suitable stock–recruitment relationship to use in the estimation of recruitment. WKFLAT 2010 therefore considers the best estimate of recruitment to be geometric mean recruitment of the historically observed recruitment pattern.

At this present time it seems sensible to use a shortened time-series for estimation of recruitment 1998–current year -1 (2007) as the historical large recruitments have not been observed in the recent time-period. Should such large year classes be observed in future the choice of time-series should be reconsidered by WGCSE and if appropriate a longer time-series should be used in which case the final year chosen would be the current year–2 (2006).

This procedure is in line with the convention used at WGCSE and the historical treatment of the short-term forecast for this stock.

4.11 Short-term and medium-term forecasts

The diagnostics suggest that estimation of the recruiting year class (age 1) is poorly estimated in the assessment, both because catchability is very low in the commercial fisheries and because the surveys are very noisy at this age. Consequently, estimation of survivors from the recruiting age is poorly estimated and should not be used in the forecast. It was deemed more appropriate to estimate survivors at age 2 on the basis of the geometric mean abundance of historical recruitment. The time period chosen should be consistent with that chosen for estimating future recruitment. Currently this could be formulated as.

The short-term forecast uses:

1) the survivors at age 3 and greater from the XSA assessment;
2) N at age 2 = mean(ln(recruitment (1998–current year-1))*exp –(0.12 + mean(F(age 1)));
3) Stock and Catch weights = average stock and catch weights over the preceding 3 years, unless there is an indication that there are strong trends in these, in which case they will be need to be dealt with appropriately by WGCSE;
4) The F vector used will be the average F-at-age in the last 3 years, unless there is strong indication of a significant trend in F. In the latter case, the average selectivity pattern will be rescaled to the final F in the series;
5) The maturity ogive, M and F before spawning files as used in the assessment.

This procedure is in line with the convention used at WGCSE and the historical treatment of the short-term forecast for this stock.

Medium-term projections were not conducted for this stock at the Workshop

4.12 Biological reference points

WKFLAT 2010 examined the stock dynamics provided by the migration model to determine appropriate biological reference points for this stock on the basis of the new assessment. It concluded that the historical reference points for this stock were no longer appropriate as the new assessment indicated significant changes to the historical perspective of the stock caused by the inclusion of catches from VIId in the VIIe plaice stock.

In the event that alternate assessment models be used, these reference point discussions will need to be repeated on the basis of the alternative model, as our understanding of stock dynamics are likely to be different for such a model. However it is difficult to envision being able to provide useful biomass based reference points for what essentially amounts to a partial assessment of the stock.

Examination of the Biomass reference points indicated that recruitment to the stock was not negatively impacted by SSB levels greater than 2200 t (B_{loss} (1996) following which a significant recovery in SSB of the stock had been observed, MBAL.), but there was little or no evidence of stock collapse at lower SSB levels, although only 2 data points exist below 2200 tons SSB (Figure 4.12.1). Consequently, WKFLAT had difficulty in deciding whether this should be considered a limit reference point or a precautionary reference point. Dependent on this choice B_{pa} would either be 2200 t (with a commensurate B_{lim} set at 1600 t), or 3100 t (B_{lim} = 2200 t) on the basis that there should be a 40% buffer between the two reference points (procedure consistent with the development of reference points in WGCSE).

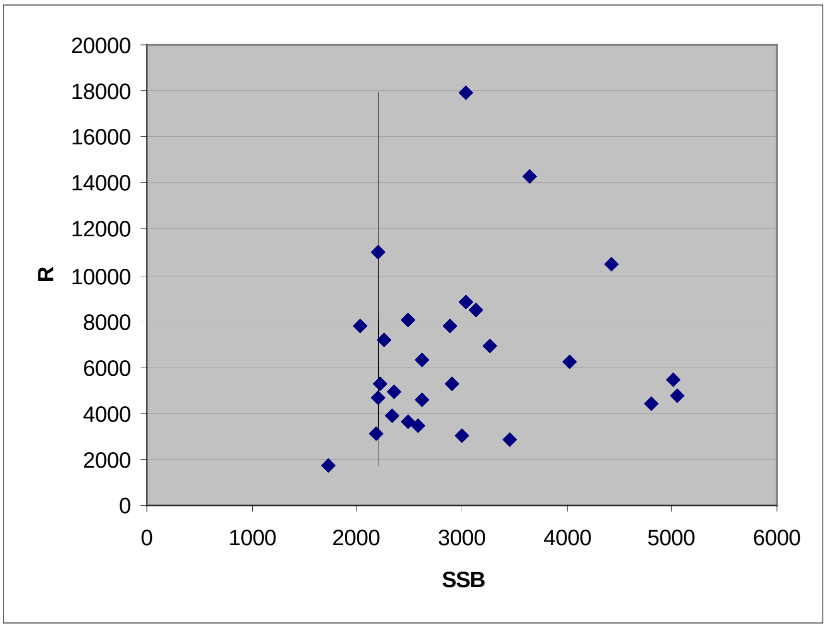

Figure 4.12.1. Stock recruitment plot for VII plaice, the black line indicating B_{loss} (1996) following which a significant recovery in SSB of the stock had been observed, MBAL.

F reference points consistent with these biomass reference points based on a short-term recruitment-series were calculated on the basis of the yield-per-recruit calculations and shown in the Table below as option 1 and 2. Bold numbers indicate the basis of the reference points for each option.

	OPTION 1	OPTION 2	OPTION 3
B_{lim}	1600	2200	2100
B_{pa}	2200	3100	3000
F_{lim}	0.55	0.7	0.60
F_{pa}	0.40	0.55	0.42

Option 1 indicates that B_{lim} is lower than the observed spawning-stock biomass for this stock (Figure 4.12.2), while option 2 suggests that F_{lim} is higher than levels of F observed in the stock (Figure 4.12.3), therefore both sets of reference points would move to areas of stock dynamics rarely observed, which WKFLAT considered risky.

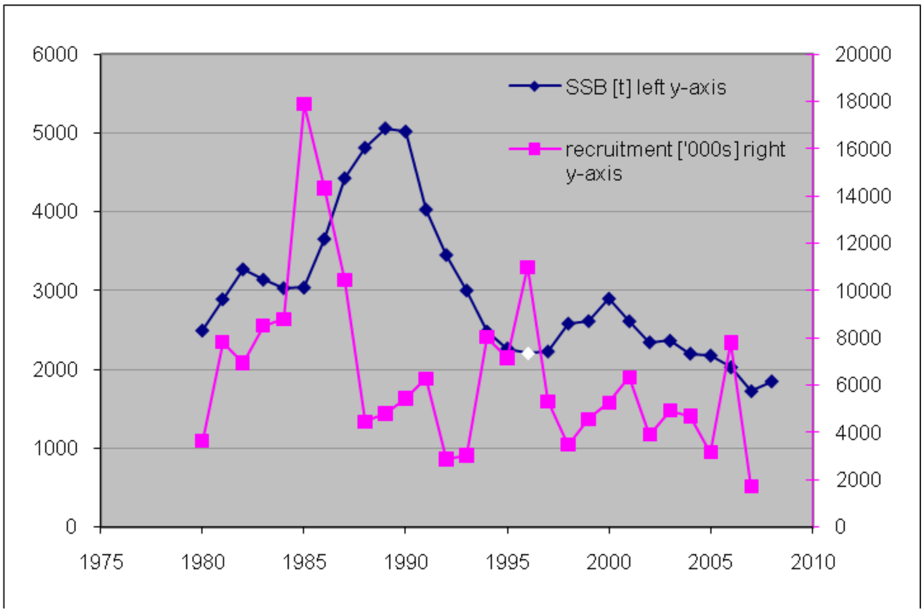

Figure 4.12.2. Showing the development of SSB and recruitment as estimated by the new assessment methodology.

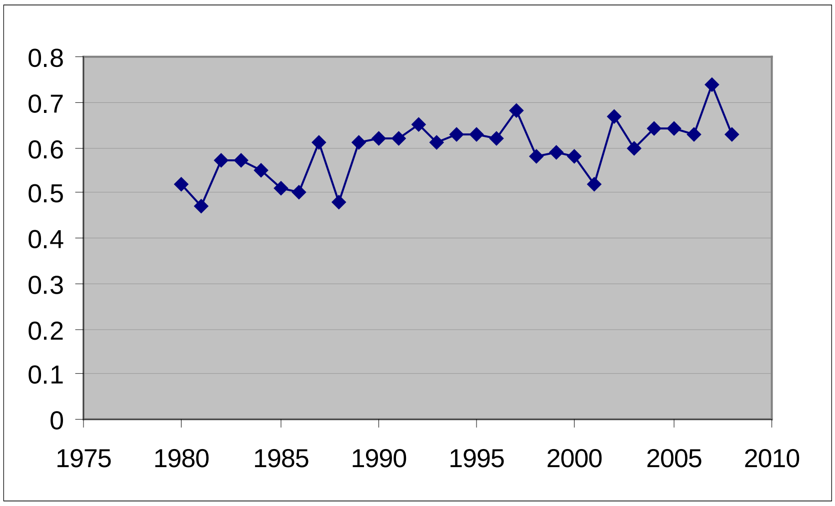

Figure 4.12.3. Showing the time-series in F (F_{bar} 3–6) as estimated by the new assessment methodology.

The new assessment indicates that the trend in F has been relatively flat since the late 1980s at levels around 0.6. Over this period SSB has increased and declined in response to recruitment, but without causing a collapse in the stock. It might therefore be considered as a limit reference point (F_{lim}), option (3).

The problem with this stock is that we have an insufficient understanding of the stock dynamics outside the relatively small range of F's and little or no response in recruitment to the range of SSB's observed. Consequently, each of the choices made in considering the calculation of the other reference points is also precautionary so that the final set of reference points invariably is ultra precautionary. The Group could not come to a consensus with regards to suitable precautionary reference points but clearly stated that F_{sq} is currently too high and should be reduced, while biomass dynamics below the reasonably well estimated SSB levels of 2200 t are poorly understood.

The Group felt more confident in using the 2200 t as a $B_{trigger}$ in the new Advisory framework based on MSY based management targets, provided that the management intervention at this level of SSB was sufficient to move the stock away from this level of SSB with considerable certainty. This is in contrast to the precautionary approach that would aim to maintain the stock above B_{pa}, but not necessarily intervene further beyond that. In any case it is deemed unlikely that low levels of SSB near $B_{trigger}$ would be reached if long-term management aimed to attain F levels near an appropriate proxy of F_{msy}.

No appropriate proxy was developed for F_{msy} given the current uncertainty over the basis for such advice, however WKFLAT 2010 commented that because plaice are taken largely in conjunction with sole in Area VIIe it is important that the target levels between the stocks are consistent especially because a management plan has been agreed for sole VIIe. The PA reference point software indicated that highest long-term yield would be achieved by F's in the region of 0.12 to 0.27 given the current selectivity pattern in the Table below.

REFERENCE POINT	DETERMINISTIC	MEDIAN	75TH PERCENTILE	95TH PERCENTILE	HIST SSB < REF PT %
MedianRecruits	5435	5435	6320	7802	
MBAL	2200				17.24
B_{loss}	1723				
SSB90%R90%Surv	2737	2841	3062	3408	51.72
SPR%ofVirgin	8.40	8.23	9.18	10.65	
VirginSPR	4.83	4.93	5.42	6.42	
SPRloss	0.43	0.36	0.41	0.49	

	Deterministic	Median	25th percentile	5th percentile	Hist F > ref pt%
F_{Bar}	0.63	0.63	0.61	0.58	24.14
F_{max}	0.27	0.26	0.24	0.20	100.00
$F_{0.1}$	0.12	0.12	0.11	0.10	100.00
F_{low}	0.25	0.31	0.29	0.25	100.00
F_{med}	0.54	0.53	0.48	0.42	79.31
F_{high}	0.98	0.96	0.85	0.73	0.00
F35%SPR	0.14	0.14	0.13	0.12	100.00
F_{loss}	0.60	0.71	0.61	0.50	58.62

However this assumes a monotinically increasing stock recruit relationship with a discrete change in slope at around 3000 t which is inconsistent with the conclusions made by the Working Group as can be seen from the plot below (Figure 4.12.4). Consequently, these values should be taken as no more than a rough guide of possible future management targets.

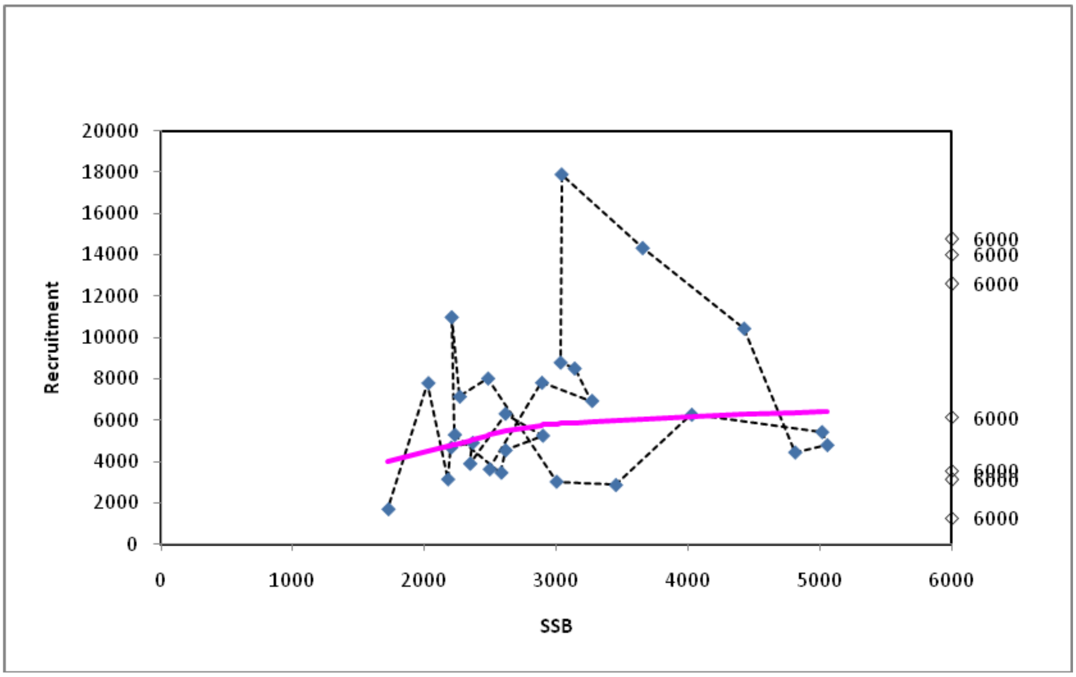

Figure 4.12.4. Stock–recruit relationship implied by PA-soft, which is inconsistent with the conclusions of the Working Group with regards to the assumed MBAL of around 2200 t.

4.13 Recommended modifications to the Stock Annex

Revise Stock Annex to describe the addition of a portion of quarter 1 catches from VIId by age to the raised catch-at-age matrix.

Revise assessment model setting to reflect the change in the assessment.

Reinstate the previous procedure for providing short-term forecasts.

4.14 Recommendations on the procedure for assessment updates

The Working Group had considerable debate over the most appropriate assessment model. WKFLAT felt that the biologically based approach, which incorporates the migration issue by including 15% of VIId quarter 1 catches in the assessment for VIIe is a sound basis for advice. However it recognizes that it depends on the assumption that historical patterns of migration have persisted and that the relative size of the subpopulations has been roughly stable. Certainly, tagging experiments should be reinitiated to provide a more up-to-date and precise estimate of the level of migration.

The WG recognizes that there may be implementation issues which were not reviewed by the meeting with regards to keeping other assessments, such as North Sea plaice, consistent with the information used here. In addition, WKFLAT was unable to anticipate all of the management problems that may arise from such a change. Therefore an alternative assessment methodology based on VIIe catches only was offered. The alternative ('truncated model') could be used as the basis for advice on a relative scale. However, subject to further investigation, it may not be suitable for comparison with biological reference points.

Given the improved performance of the assessment with regards to the retrospective pattern the WG recommends that the historical short-term forecast methodology is reinstated; this was previously removed because of retrospective bias in F and SSB in the assessment. The procedure for the short-term forecast is independent of the final model chosen for the assessment.

PA reference points need to be revised for this stock with the new assessment methodology. WKFLAT 2010 has provided a number of options for the preferred assessment methodology; none of which are entirely satisfactory, but suggest that a $B_{trigger}$ could reasonably be set at 2200 t provided that the move towards a suitable proxy of F_{msy} is effective to avoid further deterioration of SSB. F_{msy} for plaice needs to consider the management target set for sole 7e as plaice are taken largely as a bycatch in the same fisheries, and because there is a currently accepted management target of F=0.27 for sole VIIe.

4.15 Industry supplied data

Jim Portus as the RAC representative at the WG provided substantial anecdotal and qualitative information with regards to trends in fleet dynamics and important management issues to consider for the plaice VIIe stock.

4.16 References

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Stock Annex: Western Channel plaice VIIe

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Western Channel Plaice (VIIe)
Date	4th March 2010 (last revision at WKFLAT 2010)
Revised by	I. Holmes, S. Kupschus and C. Lynam (Cefas-Lowestoft).

A. General

A.1 Stock definition

The management area for this stock is strictly that for ICES Area VIIe called the western Channel, although the TAC area includes the larger component of VIId (eastern Channel).

Between 1965 and 1976, more than 5500 plaice were tagged and released around Start Point. Previous analysis of the recaptures from plaice tagged while spawning in the Channel (eastern and western areas) during January and February demonstrated that 20% spent summer in the western Channel, 24% in the eastern Channel, and approximately 56% migrated to the North Sea after spawning (Pawson, 1995). Few of the plaice tagged in the western Channel during April and May were recaptured outside the Channel however, suggesting that there is a resident stock that does not migrate to the North Sea after spawning in the Channel.

The main spawning areas are south of Start Point and south of Portland Bill. Spawning takes place between December and March with a peak in January and February. Figure A shows the spawning areas for VIIe plaice.

The spawning habitat in VIIe is much smaller than that in VIId and tagging studies have estimated that 87% of the recruits to the western Channel (VIIe) come from outside the area (34% from the eastern Channel VIId and 53% from the North Sea; Pawson, 1995). Similarly, 38% of recruits to the eastern Channel are estimated to have come from the North Sea. The historical tagging data on which these studies were based also reveal that there is substantial mixing of adult plaice between the western and eastern Channel and between the English Channel and the North Sea, but very limited exchange between the English Channel and the Celtic and Irish Seas (Burt *et al.*, 2006).

The stocks of plaice in the Channel and North Sea are known to mix greatly during the spawning season (January–February). At this time many western Channel and North Sea plaice may be found in the eastern Channel (Pawson, 1995). The comparable lack of spawning habitat in the western Channel alone suggests that this migration from VIIe to VIId during the first quarter may be of considerable importance. North Sea (IV) plaice have been demonstrated to spawn in VIId during January–February and subsequently return to the North Sea (Hunter *et al.*, 2004). This migration is tracked by the international fleets fishing in the area: landings peak in January over the spawning grounds, when migrant fish are present, and track the movement towards the North Sea in February and March. A similar migration of plaice from the smaller VIIe stock into VIId during quarter 1 is believed to take place. Once fish have moved into VIId to spawn they are then subject to fishing, largely by the Belgian and French trawlers that take the majority of their annual catch in January and February.

Conventional tags inform the recapture position and date of a tagged fish (with known release point) and such data has been investigated to estimate the likely movement rates of fish from VIId in quarter 1 into VIIe and IV. The movement rates can then be used to determine the proportion of the catch in VIId during quarter 1 that is due to immigrant spawning fish. The resulting estimates of the catch of fish from VIIe and IV that are caught in VIId can then be reallocated to the appropriate catch-at-age matrix.

WKFLAT re-analysed data from historical tagging experiments on plaice, which were archived in the Cefas 'Tagfish' database (Burt *et al.*, 2006). The tags were captured through the fisheries and most are returned to Cefas within a few months of release; however these fish have had little chance to migrate. Therefore data from tagged fish with <6 months at liberty were excluded from the analysis. In order to focus on movement rates of fish that are available to the fishery only fish greater than the minimum landing size were considered for further analysis. Because tags are re-turned via the fishery the probability that a tag will be caught depends on the level of catch of plaice in an area: the greater the catch taken the more likely the tag to be caught. However, the more fish that are present within an area the less likely a tag is to be caught. So that probabilities can be comparable between areas and years, the probability that a tag is caught in an area (Number recaptured/Number released) in a particular period must be weighted by the ratio of biomass/catch in that area and year. The resulting weighted proportions of tags returned from each area provide estimates of the movement probabilities between areas (see Table 4.3.2).

					WEIGHTED BY INTN CATCH AND SSB			
Release Information		**period**			**pr(recap) after 6 or more months at liberty**			
DIV	**Sex**	**Release**	**Recapture**	**N**	**7A**	**7E**	**7D**	**4**
VIIe	B	ALL		**564**	0.001	**0.90**	0.06	0.04
	M	Jan-Mar		**2**	0	**0.74**	0.26	0
	F			**3**	0	**0.60**	0.40	0
	M	Apr_Dec		**180**	0	**0.91**	0.05	0.03
	F			**224**	0.001	**0.93**	0.03	0.04
	M	Jan-Mar	Apr_Dec	**17**	0	**0.66**	0.11	0.23
	F			**8**	0	**0.67**	0.24	0.09
	M	Apr_Dec	Jan-Mar	**68**	0	**0.83**	0.12	0.05
	F			**62**	0	**0.88**	0.07	0.06
VIId	B	ALL		**990**	0.00	0.10	**0.54**	0.36
	M	Jan-Mar		**31**	0	0.04	**0.73**	0.22
	F			**86**	0	0.08	**0.58**	0.34
	M	Apr_Dec		**144**	0	0.10	**0.76**	0.14
	F			**180**	0	0.09	**0.79**	0.12
	M	Jan-Mar	Apr_Dec	**144**	0	0.14	**0.35**	0.52
	F			**305**	0	0.09	**0.33**	0.58
	M	Apr_Dec	Jan-Mar	**31**	0	0.20	**0.57**	0.23
	F			**63**	0	0.11	**0.72**	0.17
IVc	B	ALL		**812**	0	0.01	0.06	**0.93**
	M	Jan-Mar		**54**	0	0	0.03	**0.97**
	F			**17**	0	0	0.28	**0.72**
	M	Apr_Dec		**172**	0	0.01	0.06	**0.92**
	F			**235**	0	0.01	0.04	**0.95**
	M	Jan-Mar	Apr_Dec	**102**	0	0	0	**1**
	F			**38**	0	0	0	**1**
	M	Apr_Dec	Jan-Mar	**54**	0	0.02	0.05	**0.93**
	F			**71**	0	0.01	0.18	**0.80**

Summary of estimated movement probabilities for plaice (≥270 mm) recaptured after 6 or more months at liberty, for data collected between 1960 and 2006.

The best estimates of the proportion of fish in quarter 1 in VIId that would return, if not caught by the fishery, to VIIe and IV suggest that 14% of males and 9% of females would migrate to VIIe, while 52% of males and 58% of females would migrate to IV. To the nearest 5%, this suggests that 10 to 15% of the catch in Q1 in VIId should be allocated to VIIe, while between 50 and 60% of the catch in Q1 in VIId should be allocated to IV. These estimates are in agreement with previous analyses (based on the same data) reported by Pawson (1995), which suggest that 20% of the plaice spawning in VIIe and VIId spend summer in VIIe, while 56% migrate to the North Sea. Given the assumptions involved in these calculations and the relatively small numbers of adult tags returned the estimates of movement rates are subject to great variability. The limitations of the data do not permit an estimate of annual movement probabilities. Recent studies based on data storage tags suggest that the retention rate of spawning plaice tagged in the eastern Channel is 28%, while 62% of spawning fish tagged were recaptured in the North Sea (Kell *et al*., 2004).

WKFLAT 2010 adopted a 15% movement of catches from VIId into VIIe in Q1 and similarly an additional 50% movement in Q1 from VIId to IV.

A.2 Fishery

In the western Channel, plaice are taken largely as a bycatch in beam trawls directed at sole and anglerfish. The main plaice fishery is concentrated to the south and west of Start Point. Although plaice are taken throughout the year, landings are usually heaviest during February/March and October/November. The fisheries taking plaice in the western Channel mainly involve vessels from the bordering countries: UK, France and Belgium.

Main métiers

There are ten main métiers that exploit important fish and shellfish stocks in the Channel. Otter trawling accounts for a wide range of target species in season; cuttlefish, anglerfish, gurnard, rays, cod, whiting, plaice, sole, squid and lemon sole; involving boats from France (600), England (470), Belgium (15) and the Channel Islands (11). Beam trawling is also important for boats from the three former nations (26, 83 and 65 respectively), targeting sole, anglerfish and plaice, with up to 25 of the Belgian boats extending this fishery into the Bay of Biscay. Many boats from France (626) and England (80) join two Channel Islands vessels dredging for scallops and taking a valuable bycatch of sole and anglerfish. The other main towed gear is mid-water trawls, used either for the small pelagic species; mackerel, sprat, pilchard and herring; or for bass and black bream with a bycatch of gadoids by French (40) and English (25) boats. Purse seines are used by eight UK vessels to take mainly mackerel and pilchard in the western Channel.

The fixed netting métier in the Channel is really composed of several métiers using specific net gears and mesh sizes depending on target species, the most important being with gillnets and trammelnets (580 French and 380 English boats) for sole, cod, ling, pollack, hake, plaice, bass and spider crab. Rays, anglerfish, turbot, crabs, lobster and crawfish are also taken in tanglenets (305 Fr., 300 Eng. and seven CI).

Similarly, potting (960 Fr., 275 Eng and 560 CI) uses several distinct gears to catch brown (edible) crabs, spider crabs, cuttlefish, lobsters and whelk, both inshore and offshore, and there are zones in the western Channel partitioning potting and towed gears for alternating periods. Longlining has been replaced by fixed net in many cases, but conger eel, sharks, rays and bass are still taken (260 Fr., 60 Eng and 13 CI). Handlines are used for mackerel, bass, pollack and ling by small boats working along both the English (390) and French (120 Fr and 90 CI) coasts of the Channel. This information is accurate as at Report of the Working Group on the Assessment of Southern Shelf Demersal Stocks (WGSSDS) 2007.

A.3 Ecosystem aspects

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 VIIe plaice. Environment influences were considered by WKFLAT by incorporating sea surface temperature into the XSA model as a tuning fleet for age 1 catch numbers i.e. as an index of recruitment (ICES Working Document 4.3). The analysis managed to correlate well with the extremes of temperature, but intermediate values provided little quantitative information on the relative strength of intermediate cohorts.

There is some anecdotal evidence of range extension of some warm-water species such as langoustine, triggerfish, and black sea bream from warmer parts of the Atlantic into the Channel thought to be associated with temperature increase in the area. Given the biology of plaice it could be hypothesized that such temperature changes would have a negative impact on the abundance and distribution of plaice.

B. Data

B.1 Commercial catch

Landings

The fisheries that take place in the western Channel mainly involve vessels from the bordering countries: UK vessels report about 68%, France 24% and Belgium 8% of the total plaice landings from ICES Division VIIe (based on 2007/2008). Although plaice are taken throughout the year, landings are usually heaviest during February/March and October /November. Landings reached a peak of around 2600 tonnes in 1990 after a series of good recruitments in the late 1980s. Landing levels then declined rapidly once recruitment levels returned to average levels. Since 1994, landings have been stable at around 1200 tonnes; however, in 2007 and 2008 landings have been below this level.

Most of the landings are made by beam trawlers with around 70% of the UK landings being reported by these vessels and another 25% being landed by otter trawlers. The unallocated landings reported in the WG landings table in recent years are generally additional French landings derived from sales note information.

Sampling and data raising

Quarterly age compositions were available only from UK (England and Wales) landings for the years 1995–2008 (and 1989), which accounted for approximately 68% of total international landings. The total international age composition was obtained by raising the combined gears quarterly UK (England and Wales) age compositions to include the landings of the Channel Isles, France and Belgium, and summing to give an annual total.

For the earlier years of 1990–1994, French age compositions were also available. For these years, the UK (England and Wales) age compositions were raised to UK (Total) by including landings from the Channel Islands. Finally, UK (Total) and French age compositions were combined and raised to include Belgian landings. Prior to this, the stock data were aggregated for Area of VIId and VIIe. For these years, Belgium also provided age compositions data and this was combined with UK (Total) and French age compositions. French age compositions were based on age data provided by the UK.

WKFLAT 2010 recommended a 'migration' model; this model reassigns 15% of the first quarter Belgian, French and UK catch in VIId to the VIIe catch-at-age matrix and similarly raises the landings by including 15% of the first quarter landings in VIId for each country. During the meeting, quarterly data for Belgium and France were available back to 1998 and UK data to 1997. In order to extend the time-series back to 1980 the first quarter landings and catch-at-age matrix for each country were inferred from the total annual international landings and catch-at-age data (which begin in 1980 for VIId). Total annual international catch-at-age data (1980–1997 for France and Belgium and 1980–1996 for UK) were down-raised using the average proportion of catch-at-each-age in the first quarter by each country over the period in which quarterly data were available. Similarly, SOP corrected Q1 landings for each country were calculated back to 1980 using the mean (calculated over the period in which quarterly data were available) proportion of the annual landings that were landed in Q1.

Age data representing French landings were available for 2002 and 2003, but were not used in the assessment.

Table A shows the national data availability for VIIe plaice stock for the time period 1981–2008.

Table B shows a time-series of CV's of numbers-at-age for sampling; UK (E&W) all fleets combined.

Weights-at-age

Total international catch and stock weights-at-age were calculated as the weighted mean of the annual weight-at-age data supplied (weighted by landed numbers), and smoothed using a quadratic fit:

[e.g.: $Wt = (0.1109*Age) - (0.0004*(Age^2)) - 0.008$; $R^2 = 0.98$]

where catch weights-at-age are mid-year values (age = 1.5, 2.5, etc.), and stock weights-at-age are 1st January values (age = 1.0, 2.0, etc.). Catch weights-at-age have been scaled to give a SOP of 100%, and the same scaling has been applied to stock weights-at-age. The process is applied separately for each year.

This technique has been used for many years (at least since stock has been assessed by the Southern Shelf Demersal WG. In early years in the time-series, weights-at-age were averaged over a period of years, and derived from separate-sex mean weights-at-age.

WKFLAT 2010 recommended a 'migration' model that alters the catch-at-age data. However, this model does not alter the weight-at-age matrix because it is not possible to distinguish which weight measurements in VIId are from VIIe migratory spawners.

B.2 Biological

The main spawning areas for plaice in the western Channel are south of Start Point and Portland Bill. Spawning takes place from December to March, with a peak in January and February.

On average, about a quarter of plaice in the western Channel are mature at age 2, half are mature-at-age 3 and all are mature-at-age 5. The majority of plaice landed in the western Channel in 2001, for example, were at ages 2–5, and therefore it is estimated that 73% of those landed were mature.

Natural mortality and maturity ogives

Initial estimates of natural mortality (0.12 for all years and all ages) and maturity were based on values estimated for Irish Sea plaice (Siddeek, 1981). 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+
Old Maturity	0	0.15	0.53	0.96	1.00
New 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 prior to the 1994 Southern Shelf Demersal Working Group as it was considered that these settings were more robust to seasonal changes in fishing patterns, especially with respect to the medium-term projections.

B.3 Surveys and survey tuning data

An annual 4 m beam trawl survey has taken place in the Lyme Bay area of the western Channel since 1984, initially aboard chartered fishing Vessels (MV BOGEY 1 and latterly MV CARHELMAR) and more recently aboard the Cefas research vessel CORYSTES, coming back to MV CARHELMAR in 2005.

Appendix A provides a history of the survey and details the survey methodology and objectives.

The western Channel beam trawl survey data are used to calculate assessment tuning data for both VIIe plaice and sole. Indices of abundance-at-age for years 1986 to the present, and for ages 1–5 have been used. Since 2007, this age range has been extended to include data for ages 1–8. Appendix A also describes how these indices of abundance-at-age are derived.

Since 2003 a Fisheries Science Partnership (FSP: Cefas-UK industry cooperative project) has been conducting a survey using commercial vessels with scientific observers and following a standard grid of stations extending from the Scilly Isles to Lyme Bay. The survey covers a substantially larger area than the current survey (UK-WECBTS) and is thought to be more representative of the stock in UK waters. This dataset was first included in the 2007 assessment, and the exploratory analysis can be seen in that report (ICES, 2007; Section 3.2.5). However, recently the vessel(s) used for the survey have changed from the FV Nellie and the FV Lady T, to the FV Carhelmar. In 2008, in addition to the vessel changes there have been other sample protocol changes, notably the change to using 4 m ‘survey’ beam trawls from the commercial 12 m beam trawls previously used by the other vessels. The Working Group, WGCSE 2009, decided to leave out the 2008 data from the FSP survey because it had an undue influence on estimates of SSB and F.

B.4 Commercial lpue

The UK (E&W) commercial lpue data are calculated for two gear groups (beam trawl, and otter trawlers both over 40 ft) and for three sectors within VIIe (VIIe north, VII south and VIIe west) made up of 'collections' of ICES rectangles. The lpue values are corrected for fishing power using a given relationship between fishing power and gross tonnage and are calculated using the total effort for a month/sector not species-directed effort. This relationship is FP=0.0072*GRT+0.6017 and this is standardized fit to pass through the mean GRT of Irish Sea trawlers in 1979 (Brander, unpublished).

Beam trawl lpue in the North of VIIe reached a peak in 1990, fell sharply to 1994 and now fluctuates at low levels. The south and west sectors both peaked in the early 1990s but have steadily declined since. Otter trawl lpue in north of VIIe peaked in 1988 before falling sharply until 1995. Since then it has remained at these much lower levels. Lpue in the south is generally lower, but fluctuates to high peaks throughout the time-series, whereas in the west it has remained stable at a lower level for the duration of the time-series.

UK beam trawl effort has increased rapidly over the time-series, reaching record high levels in 2003 and has remained at this high level since. UK trawl effort has slowly decreased over the time-series, reaching a record low level in 2008. Effort is calculated as fishing power corrected using GRT.

Figures B and C show plots of UK effort for 1998–2008 by ICES rectangle for otter trawl and beam trawl gears, respectively.

Commercial tuning data

Commercial tuning information for this stock comprises of the UK (E&W) otter trawl fleet and the UK (E&W) beam trawl fleet. These fleets have been used by Working Groups for a number of years, and initially contained data for years back to 1976 (otter) and 1978 (beam). However in the most recent assessments carried out for this stock, otter trawl fleet data are currently used only for years 1988 to the present and for ages 3–9 and Beam trawl fleet is currently used for years 1989 to the present, and ages 3–9. Since 2004, an historical otter trawl fleet (1976–1987) has been reintroduced using ages 2–9 and this is calculated differently from the later data.

WKFLAT proposed a 'migration' model for western Channel plaice, which does not alter the commercial tuning fleets.

An alternative model, the 'truncate model', was suggested at WKFLAT, which would require that the commercial beam trawl and commercial otter trawl fleets are truncated so that the first year of the time-series is 1998 and the last year is the most recent year. The 'truncated' model does not use the historical commercial otter trawl fleet, but has F-shrinkage increased from 2.5 to 1.0 to compensate for the increased variability of estimates of F.

B.5 Other relevant data

Discarding

Discard length summary data from the UK (E&W) and French discard sampling programmes has been made available to ICES working groups for the period 2002–2009. These data indicate that discarding is at its highest in quarters 1 and 2 in this fishery, but is still low compared with other plaice stocks.

For the 2010 Benchmark meeting (WKFLAT), an analysis was carried out to determine the true level of discarding including trends in sampling effort, discarding patterns and an attempt to raise the sampling to an estimate of total discards. This work was presented to the meeting as ICES WKFLAT 2010, Working Document 4.4 'western Channel (VIIe) plaice discard data availability, trends and raising estimates to total landings, and comparisons with the trends of adjacent plaice stocks. The summary points made were as follows:

- Previous assumptions made by the Working Group that discarding is small compared with other plaice stocks, and that most discarding takes place in Quarter 1 and 2 appear robust. VIIe discard rates by number range from 9% in 2003 to 24% in 2008 with an average of 16%. Discarding is at its heaviest in quarters 1 and 2 with 26% and 19% discarded in these quarters and around 5% discarded in the remainder of the year.
- The discard rates appear to be increasing over time but are still at relatively low levels. Discard rates for VIIe plaice stock (16%) are much less than those for adjacent plaice stocks in VIId (57%) and VIIfg (73%).
- Sampling effort on discards is very good for the VIIe plaice stock and discard sampling effort is increasing. Most of the sampling effort has been carried out on beam and otter trawlers.
- Most discard sampling was carried out on vessels of length 10<20 m and with engine power between 100<300 Kw.
- Around 10% by weight are discarded and this measure is increasing. The proportion discarded by weight has increased steadily from 5% in 2002 to around 13% in 2008. This compares favourably with the adjacent stocks that have rates of around 40% in VIId and around 60% in VIIfg (in 2008).
- There is no evidence of seasonal differences in the proportions discarded at length. The proportions of fish discarded at length for this stock display good levels of consistency over the time period and in addition the L50 values for each year are very close. This is not the case for the VIId and VIIfg stocks but for these stocks, the inconsistencies may be a feature of lower sample numbers.
- Around 60–70% of fish discarded are regarded as immature.
- Raising the discard sample data is possible by using either landings or effort but neither method is perfect. The main problem encountered was the limited availability of age data at the smaller/larger lengths.
- Most discards are at age 2 and age 3, where an estimated 28% and 5% respectively would be added to the landings age composition. For 2008, the resulting age compositions from both raising methods were almost identical although this may not be the case for other years.
- The total weight of the discarded catch in 2008 was estimated to be approximately 55 t amounting to around 6% of the commercial landings.

The Workshop considered the possible effects of the lack of discards in this assessment and recommended that further investigations are conducted to include discard information in future assessments, but not to include the preliminary information available as it may reduce the management of the exploited portion of the stock. The data suggests discarding is minor in the years for which it has been raised to the fleet level. It was therefore concluded that the effect of including these data in the assessment would at best change the level of F and SSB over the whole time-series and at worst obscure the trends now seen because of the short and variable time-series of discard data available.

Potential discard raising methods

Two methods were used to raise the discard sample data to total discards.

1) Using landings. Sample data for the two main gear groups of beam trawl (gear code 1) and otter trawl (gears 2,3,7) and the remaining gears (other) were extracted by quarter. For each gear group and quarter, the weight of the total catch from the sampled trips was calculated by quarter using the formula (W=aL^b * N) where 'a' and 'b were quarterly condition factors for the stock in use within Cefas stock processing. The discarded Length Distributions (LD's) were then raised to total catches using the ratio of total reported catch/weight of discard trip catches.

   An age–length key (ALK) was applied to each raised quarterly LD to produce quarterly age compositions (AC) for each gear group/quarter. The ALK data used was taken from the age samples from the discard programme. Due to the small quantity of discard age data available, the ALK used was at the annual level. However even the ALK at this level only had small numbers of fish and did not cover the full length range of the discard LDs. In these instances, the discard ALK was supplemented by supplements by annual ALK data from the relevant commercial landings samples. At the smallest lengths without age data, an assumption about the age structure was made, but these were generally considered to be age 1.

   These discarded ACs were then combined across gears then across quarters to give an annual estimate of discarded catches.

2) Using effort data. Given the recognized difficulties is assessing the 'true' effort levels of gears such as gillnetters and longlines, discard sample data only for the two main gear groups of beam trawl (gear 1) and otter trawl (gears 2,3,7) were extracted by quarter. The discarded LDs were raised to total catches using the ratio total reported effort (hours fished) catch/hours fished on sampled trips.

   The same ALK as constructed above was applied to the quarterly raised LDs to give quarterly age compositions by gear/quarter. At the quarterly level, the two age compositions were combined then raised to include the catches form the 'other' gears. These ACs were then combined across gears then across quarters to give an annual estimate of discarded catches.

C. Historical stock development

This stock was assessed by the ICES Southern Shelf Demersal WG from 1992 to 2008. In 2009, this stock was assessed at the newly formed ICES Celtic Seas Ecoregion Working Group. The stock has been managed by a TAC since 1984 and the TAC is applicable to VIId (Eastern Channel) and VIIe combined.

Benchmark 2010

This stock was 'benchmarked' at the WKFLAT 2010 meeting where the main issue under review was to overcome the problematic retrospective pattern that meant that forecasts had not been possible for some years. Solutions explored included making an allowance for migration patterns between the two channel plaice stocks, termed the 'migration model'; this clearly had a knock-on effect on the eastern channel stock and the North Sea where there was also migration issues. Another option considered (the 'truncate model') involves truncating the commercial otter and commercial beam fleets back to 1998. The 'truncate' model did not suffer from retrospective problems and the detailed diagnostics did not reveal immediate problems. However, this model makes no account for the known spawning migration of plaice and therefore violates the closed population assumption. Although, this is likely to cause bias in the estimated numbers there is no evidence to suggest that the migration rate has changed over time and therefore the change in F estimates between years should be robust. Additionally, the 'truncate' model excludes the commercial historical otter trawl time-series and increases F-shrinkage from 2.5 to 1.0.

WKFLAT 2010 also recommended that the F_{bar} range is altered to 3–6 because very few age 7 fish are caught by the fishery (<4% of the catch numbers). The age range of the FSP survey was reduced to 2–8 because very few age 9 are caught by the survey and that age created positive residuals in catchability for every year.

Outcome: The Workshop considered making an allowance for migration between the two Channel plaice stocks. Having further examined tagging evidence available it was agreed that an allowance of 15% of quarter 1 catches (both landings and the catch numbers-at-age) from VIId needed to be added into quarter 1 of the VIIe. This was required from all contributing nations.

The combination of the two Channel plaice stocks was examined. It was agreed that this would require further investigation as the inclusion of migrants caught in the Channel to the North Sea stock would also need to be considered. Any combining of stocks would a have a wide ranging impact on the assessment and any subsequent management.

The issue of including discard estimates was also considered, but based on the short time-series of data available and the limited impact on the assessment outcome, this inclusion was deferred until a longer time-series of data was available.

Technical measures in force

Technical measures currently in force in the western Channel are a minimum mesh size of 80 mm for otter and beam trawlers and 70 mm for *Nephrops* trawlers. Panels of 75 mm square mesh are compulsory in all *Nephrops* fisheries in ICES Subarea VII.

There is also a minimum landing size (MLS) on 27cm in force for plaice in 7e.

Model used: XSA

Software used: Lowestoft VPA suite

Model Options chosen:

Input data types and characteristics

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1976–2008	-	Yes
Canum	Catch-at-age in numbers	1976–2008	1–15	Yes
Weca	Weight-at-age in the commercial catch	1976–2008	1–15	Yes
West	Weight-at-age of the spawning stock at spawning time.	1976–2008	1–15	Yes
M_{prop}	Proportion of natural mortality before spawning	1976–2008	1–15	No
F_{prop}	Proportion of fishing mortality before spawning	1976–2008	1–15	No

Mat^prop	Proportion mature-at-age	1976–2008	Age1-0%; Age2-26% Age3-52%, Age4-86% Age 5+-100%	No
Natmor	Natural mortality	1976–2008	1–15 (0.12)	No

Tuning data: 'migration model'

Type	Name	Year range	Age range
Survey fleet 1	UK Western beam trawl survey (UK-WEC-BTS)	1986–2008	1–8
Commercial fleet 1	UK Western Channel Otter Trawl (UK-WECOT)	1988–2008	3–9
Commercial fleet 2	UK Western Channel Beam Trawl (UK-WECBT)	1989–2008	3–9
Commercial fleet 3	UK Western Channel Otter Trawl - Historic (UK-WECOT historic)	1980–1987	2–9
Survey fleet 2	UK FSP Survey (UK(E+W) FSP)	2003–2007	2–8

Tuning data: 'truncated model'

Type	Name	Year range	Age range
Survey fleet 1	UK Western beam trawl survey (UK-WEC-BTS)	1986–2008	1–8
Commercial fleet 1	UK Western Channel Otter Trawl (UK-WECOT)	1998–2008	3–9
Commercial fleet 2	UK Western Channel Beam Trawl (UK-WECBT)	1998–2008	3–9
Commercial fleet 3	UK Western Channel Otter Trawl - Historic (UK-WECOT historic)	excluded	-
Survey fleet 2	UK FSP Survey (UK(E+W) FSP)	2003–2007	2–8

History of assessment methods and settings investigations

The standard settings for a catch data screening run using a separable VPA are reference age of 4; F set to 0.7 and S set to 0.8.

In 1991 the stock was assessed using a Laurec-Shepherd tuned VPA. Concerns about deteriorating data quality prompted the use in 1992 of XSA.

Trial runs have, over the years, explored most of the options with regards XSA settings:

- The effect of the power model on the younger ages was explored in 1994; 1995; 1996; 1998, 2004 and 2010.
- The use of P shrinkage was investigated in 2001; 2004.
- Different levels of F shrinkage were explored in 1994; 1995; 2000; 2002; 2004 and 2010.
- The level of the + group was examined in 1995, 2004 and 2010.
- The effect of different time tapers was investigated in 1996.
- The S.E. threshold on fleets was examined in 1996; 2001 and 2007.
- The level of the catchability plateau was investigated in 1994; 1995; 2002; 2004 and 2010.

Table C shows the history of VIIe plaice assessments and details the parameters used.

D. Short-term projection

Standard ICES software is used for the short-term projections: MFDP.

No short-term forecast has been provided since 2006 as the Review Group deemed it unhelpful in the management of the stock given the strong retrospective bias in F.

However WKFLAT was able to carry out a forecast following the removal of the strong retrospective bias in F.

The diagnostics suggest that estimation of the recruiting year class (age 1) is poorly estimated in the assessment, both because catchability is very low in the commercial fisheries and because the surveys are very noisy at this age. Consequently, estimation of survivors from the recruiting age is poorly estimated and should not be used in the forecast. It was deemed more appropriate to estimate survivors at age 2 on the basis of the geometric mean abundance of historical recruitment. The time period chosen should be consistent with that chosen for estimating future recruitment. Currently this could be formulated as.

The short-term forecast uses:

1) the survivors at age 3 and greater from the XSA assessment
2) N at age 2 = mean(ln(recruitment (1998–current year-1))*exp –(0.12 + mean(F(age 1)))
3) Stock and Catch weights = average stock and catch weights over the preceding three years, unless there is an indication that there are strong trends in these, in which case they will be need to be dealt with appropriately by WGCSE.
4) The F vector used will be the average F-at-age in the last three years, unless there is strong indication of a significant trend in F. In the latter case the average selectivity pattern will be rescaled to the final F in the series.

This procedure is in line with the convention used at WGCSE and the historical treatment of the short-term forecast for this stock.

E. Medium-term projections

Not carried out for this stock.

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

Standard ICES software is used for the long-term projections: MFYPR.

As with most plaice stocks, there is no clear stock–recruitment relationship evident.

Not carried out for this stock since 2006.

G. Biological reference points

WKFLAT 2010 examined the stock dynamics provided by the new preferred XSA model based on migration-at-length to determine appropriate biological reference points for this stock on the basis of the new assessment. It concluded that the historical reference points for this stock were no longer appropriate as the new assessment indicated significant changes to the historical perspective of the stock caused by the inclusion of catches from VIId in the VIIe plaice stock.

In the event that alternate assessment models be used, these reference point discussions will need to be repeated on the basis of the alternative model, as our understanding of stock dynamics are likely to be different for such a model.

Examination of the Biomass reference points indicated that recruitment to the stock was not negatively impacted by SSB levels greater than 2200 t (B_{loss} (1996) following which a significant recovery in SSB of the stock had been observed, MBAL.), but there was little or no evidence of stock collapse at lower SSB levels, although only two data points exist below 2200 tonnes SSB (Figure 4.12.1). Consequently, WKFLAT had difficulty in deciding whether this should be considered a limit reference point or a precautionary reference point. Dependent on this choice B_{pa} would either be 2200 t (with a commensurate B_{lim} set at 1600 t), or 3100 t (B_{lim} = 2200 t) on the basis that there should be a 40% buffer between the two reference points (procedure consistent with the development of reference points in WGCSE).

F reference points consistent with these biomass reference points based on a short-term recruitment-series were calculated on the basis of the yield-per-recruit calculations and shown in the Table below as option 1 and 2. Bold numbers indicate the basis of the reference points for each option.

	OPTION 1	OPTION 2	OPTION 3
B_{lim}	1600	2200	2100
B_{pa}	2200	3100	3000
F_{lim}	0.55	0.7	0.60
F_{pa}	0.40	0.55	0.42

Option 1 indicates that B_{lim} is lower than the observed spawning-stock biomass for this stock, while option 2 suggests that F_{lim} is higher than levels of F observed in the stock, therefore both sets of reference points would move to areas of stock dynamics not previously observed which the Group considered risky. The new assessment indicates that the trend in F has been relatively flat since the late 1980s at levels around 0.6. Over this period SSB has increased and declined in response to recruitment, but without causing a collapse in the stock. It might therefore be considered as a limit reference point (F_{lim}), option (3).

The problem with this stock is that we have an insufficient understanding of the stock dynamics outside the relatively small range of F's and little or no response in recruitment to the range of SSB's observed. Consequently, each of the choices made in considering the calculation of the other reference points is also precautionary so that the final set of reference points invariably is ultra precautionary. The Group could not come to a consensus with regards to suitable precautionary reference points but clearly stated that F_{sq} is currently too high and should be reduced, while biomass dynamics below the reasonably well estimated SSB levels of 2200 t are poorly understood.

The Group felt more confident in using the 2200 t as a $B_{trigger}$ in the new Advisory framework based on MSY based management targets, provided that the management intervention at this level of SSB was sufficient to move the stock away from this level of SSB with considerable certainty. It is deemed unlikely that low levels of SSB near $B_{trigger}$ would be reached if long-term management aimed to attain F levels near an appropriate proxy of F_{msy}.

No appropriate proxy was developed for F_{msy} given the current uncertainty over the basis for such advice, however the WKFLAT 2010 commented that because plaice are taken largely in conjunction with sole in Area VIIe it is important that the target levels between the stocks are consistent especially because a management plan has been agreed for sole VIIe.

Previous biological reference points proposed for this stock by the 1998 Working Group have been in use until 2009 (as below).

F_{lim}	Not defined	F_{pa}	0.45	(low probability that $SSB_{MT}<B_{pa}$)

B_{lim} 1300 t (equal to B_{loss}) B_{pa} 2500 t (equal to MBAL)

The recent Working Groups view of these reference points had been that they were considered unreliable.

H. Other issues

I. References

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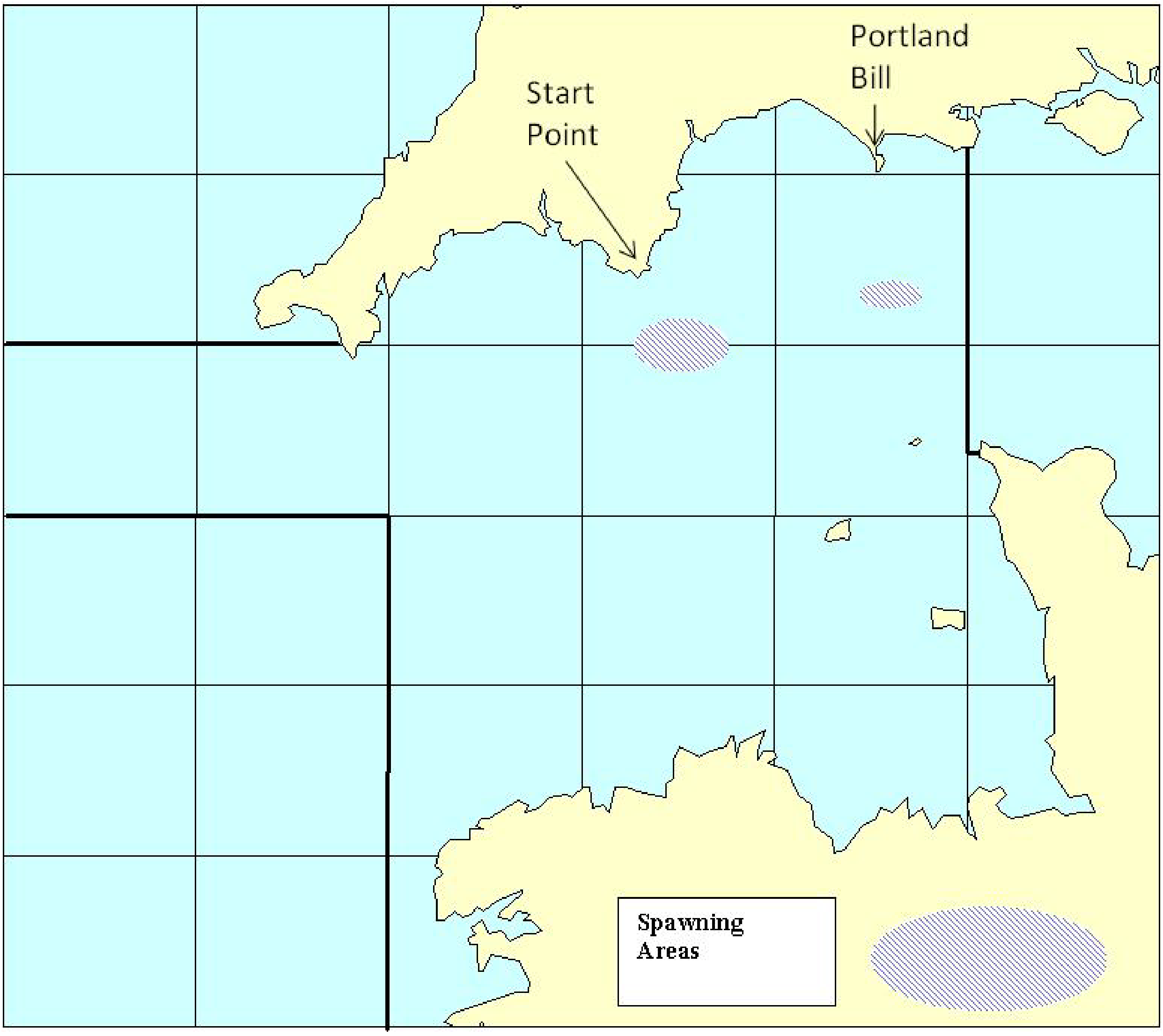


Figure A. Map of spawning areas for VIIe plaice.

Table A. VIIe plaice. Catch derivation Table for assessment years 1981–2008

		SOURCE				
Year of WG	Data	UK	Belgium	France	derivation of international landings	% sampled
1981*	length composition	quarterly	quarterly	quarterly	UK ALK used with French LDs	100
	ALK	quarterly	quarterly	-	UK+Belgium+France combined to total international	
	Age composition	quarterly	quarterly	-	No analytical assessment carried out	
1982*		As for 1981	As for 1981	As for 1981	As for 1981	100
1983*		As for 1981	As for 1981	As for 1981	As for 1981	100
1984*		As for 1981	As for 1981	As for 1981	As for 1981	100
1985*		As for 1981	As for 1981	As for 1981	As for 1981	100
1986*		As for 1981	As for 1981	As for 1981	As for 1981	100
1987*		As for 1981	As for 1981	As for 1981	As for 1981	100
1988*		As for 1981	As for 1981	As for 1981	As for 1981	100
1989*	length composition	quarterly	-	-	UK raised to total international	70
	ALK	quarterly	-	-		
	Age composition	quarterly	-	-		
1990	length composition	quarterly	-	quarterly	UK+France raised to total international	96
	ALK	quarterly	-	quarterly		
	Age composition	quarterly	-	quarterly		
1991		As for 1990	-	As for 1990	As for 1990	97
1992		As for 1990	-	As for 1990	As for 1990	97
1993		As for 1990	-	As for 1990	As for 1990	98
1994	length composition	quarterly	-	quarterly	UK ALKs applied to French LDs	96
	ALK	quarterly	-	-	UK+France raised to total international	
	Age composition	quarterly	-	-		
1995		As for 1989	-	-	As for 1989	83
1996		As for 1989	-	-	As for 1989	82
1997		As for 1989	-	-	As for 1989	78
1998		As for 1989	-	-	As for 1989	79
1999		As for 1989	-	-	As for 1989	75
2000		As for 1989	-	-	As for 1989	72
2001		As for 1989	-	-	As for 1989	72
2002		As for 1989	-	-	As for 1989	78
2003		As for 1989	-	-	As for 1989	81
2004		As for 1989	-	-	As for 1989	79
2005		As for 1989	-	-	As for 1989	74
2006		As for 1989	-	-	As for 1989	74
2007		As for 1989	-	-	As for 1989	67
2008		As for 1989	-	-	As for 1989	69

*** stock assessed as VIId,e plaice**

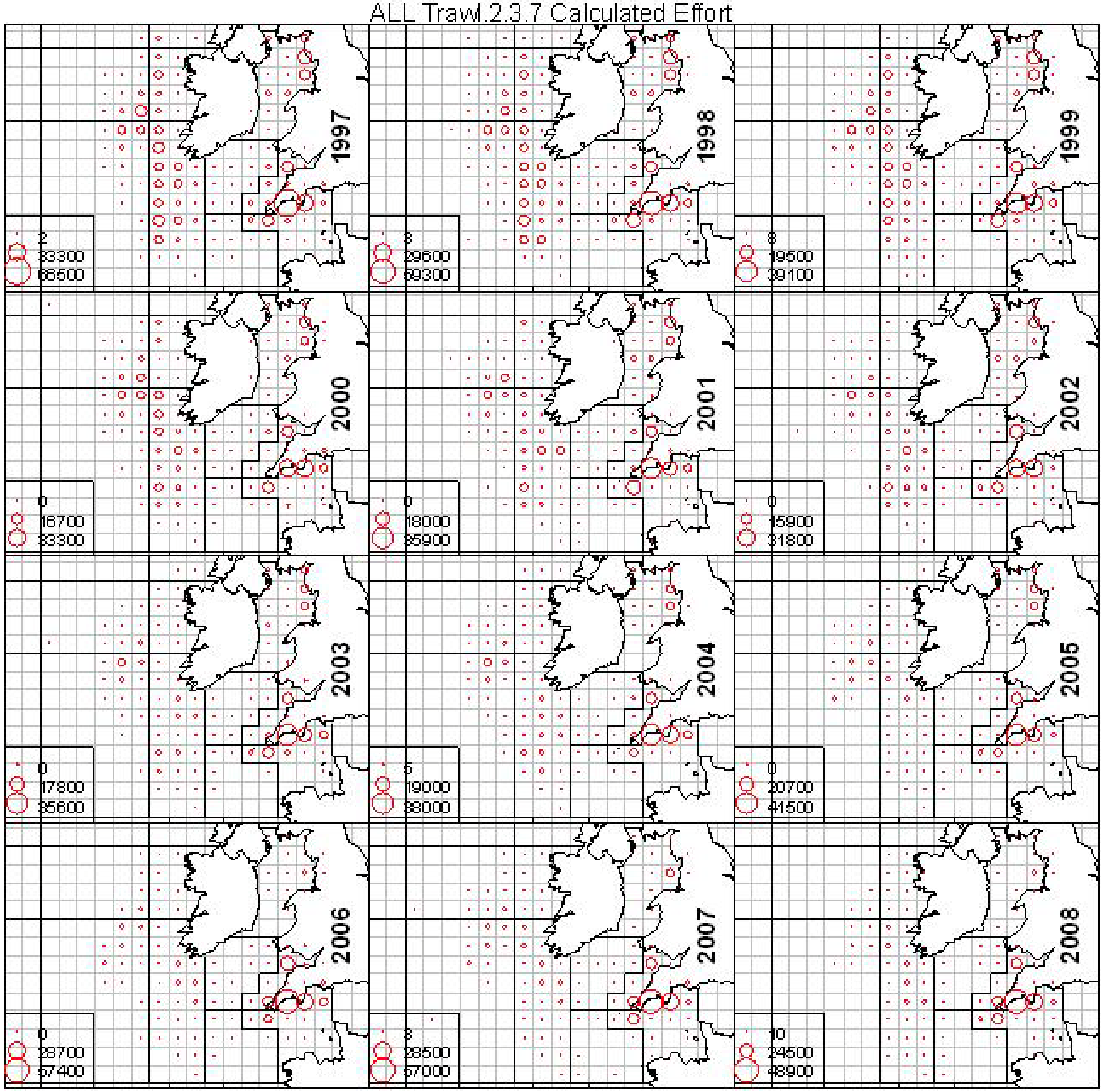


Figure B. UK (E&W) Otter trawl fleet effort (hours fished); based on demersal landings.

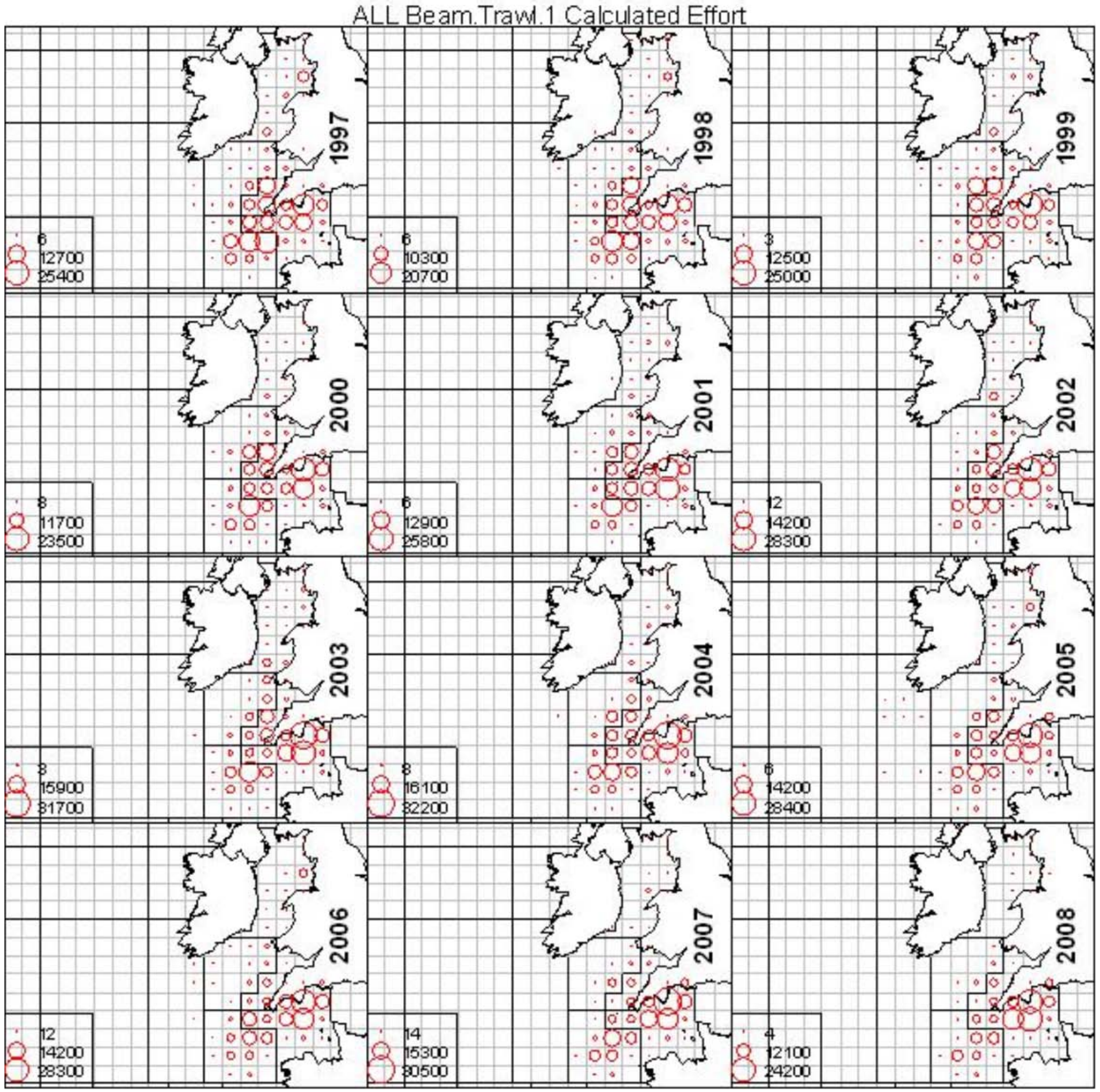


Figure C. UK (E&W) Beam trawl fleet effort (hours fished); based on demersal landings.

Table B. CV of numbers-at-age for commercial sampling.

		CV BY AGE								
YEAR	COUNTRY	1	2	3	4	5	6	7	8	9
2005	UK(E+W)	18%	3%	3%	3%	6%	7%	11%	10%	9%
2006	UK(E+W)	21%	4%	3%	5%	5%	8%	10%	15%	14%
2007	UK(E+W)	42%	5%	3%	4%	6%	6%	9%	13%	20%
2008	UK(E+W)	42%	4%	4%	5%	6%	8%	8%	10%	14%

Table C. History of VIIe plaice assessments.

Assessment parameters used (1991-2008)																			
	1991*	1992*	1993*	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Assessment Age Range	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+
Fbar Age Range	3-8	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7	3-7
Assessment Method	LS/Trad VPA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets :																			
UK trawl yrs	76-90	76-91	76-92	84-93	84-94	86-95	87-96	88-97	88-98	88-99	88-00	88-01	88-02	88-03	88-04	88-05	88-06	88-07	88-08
Ages	1-9	1-9	1-9	2-9	2-9	2-9	2-9	2-9	2-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9
UK trawl (historic) yrs														76-87	76-87	76-87	76-87	76-87	76-87
Ages														2-9	2-9	2-9	2-9	2-9	2-9
UK beam yrs	78-90	78-91	78-92	84-93	84-94	86-95	87-96	89-97	89-98	89-99	89-00	89-01	89-02	89-03	89-04	89-05	89-06	89-07	89-08
Ages	1-9	1-9	1-9	2-9	2-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9	3-9
UK b/trawl survey yrs		86-91	86-92	86-93	86-94	86-95	87-96	88-97	86-98	86-99	86-00	86-01	86-02	86-03	86-04	86-05	86-06	86-07	86-08
Ages		1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-5	1-8	1-8	1-8
UK FSP survey yrs																	03-06	03-07	03-07
Ages																	1-8	1-8	1-8
Time taper		20yr tri	20yr tri	20yr tri	20yr tri	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Power model ages		1	1	1	1-3	1-3	1-3	0	1	1-5	1-5	1-5	1-5	0	0	0	0	0	0
P shrinkage		TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Q plateau age		8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
F shrinkage S.E		0.3	0.3	0.3	0.8	1.5	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Num yrs		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Num ages		5	5	5	4	4	4	4	4	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	0.3	0.3	0.3	0.3	0.3	0.3

* Early version of XSA/VPA and tuning fleet age/year ranges used not specified. Assumed all years used but age

Appendix A: Beam trawl surveys IN the western Channel (VIIe)

1. History of the survey

Complaints from the fishing industry in the southwest about the lack of scientific investigation and knowledge of the local sole stock provided the catalyst for the survey in VIIe. Following enquiries of the local fishery officers and normal tendering procedures, a skipper-owned 300-hp beam trawler-the Bogey 1-was selected. The first year (1984) the survey consisted of a collection of tows on the main sole grounds. In 1989 the Bogey 1 was replaced with the Carhelmar and the survey continued unchanged until 2002 when R.V. Corystes took over the survey as an extension to its 'near-west groundfish survey'.

Due to the changes occurring through the time-series, the surveys completed on R.V. Corystes (2002 onwards) will be described separately to the 'previous' surveys (pre-2002).

2.a. Survey objectives (1984 to 2001, and 2005 onwards)

To provide independent (of commercial) indices of abundance of all age groups of sole and plaice on the west Channel grounds, and an index of recruitment of young (1–3-year-old) sole prior to full recruitment to the fishery.

2.b. Survey objectives (2002 to 2004)

The primary objectives of the Irish Sea beam trawl survey are to (a) carry out a 4 m beam trawl survey of groundfish to i) obtain fisheries independent data on the distribution and abundance of commercial flatfish species, and ii) derive age compositions of sole and plaice for use in the assessment of stock size; and (b) to collect biological data, including maturity and weight-at-age, for sole, plaice, lemon sole and other commercially important species. The epibenthic bycatch from these catches has been quantified, and these surveys are also used to collect biological samples in support of other Cefas projects and training courses.

3.a. Survey methods (1984 to 2001, and 2005 onwards)

For the years 1984–1988 the vessel was unchanged and was equipped with two 6 m chain mat beam trawls with 75 mm codends. For the survey hauls one of the codends was fitted with a 60 mm liner. In 1989 the Bogey 1 was replaced by the latest design 24 m 300 hp (220 kw) beam trawler Carhelmar. In 1988 two commercial chain mat 4 m-beam trawls (measured inside the shoe plates) were purchased by MAFF as dedicated survey gear. Both beams were fitted with the standard flip-up ropes and 75 mm codend. For years 1989 and 1990 only 1 codend was fished with a 40 mm liner but from 1991 with the introduction of 80 mm codends both were fitted with 40 mm liners. The vessel and gear has remained unchanged since 1991.

Between 1989 and 2001 the survey remained relatively unchanged apart from small adjustments to the position of individual hauls to provide an improved spacing. In 1995 two inshore tows in shallow water (8–15 m) were introduced. The survey now consists of 58 tows of 30 minutes duration, with a towing speed of 4 knots in an area within 35 miles radius of Start Point. The survey design is stratified by 'distance from the coast' bands, in contrast to the VIIa,f and g survey that is stratified by depth bands. The reason for this is that the coastal shelf with a depth of water less than 40 m is relatively narrow and in addition is often fished with fixed gear. The survey bands (in miles) are 0–3, 3–6, 6–12, 12+ inshore, and 12+offshore.

3.b. Survey methods (2002 to 2004)

The standard gear used is a single 4 m beam trawl with chain mat, flip up rope, and a 40 mm codend liner to retain small fish. The gear is towed at 4 knots (over the ground) for 30 minutes, averaging 2 nautical miles per tow. Fishing is only carried out in daylight, shooting after sunrise and hauling no later than sunset, as the distribution of some species is known to vary diurnally.

Once on board the catch is sorted to species level, with the exception of small gobies and sandeels, which are identified to genus. Plaice, sole, dab, and elasmobranchs are sorted by sex, all fish categories weighed, and total lengths are measured to the full centimetre below, or half centimetre if the species is pelagic. Area stratified samples of selected species are sampled for weight, length, sex, maturity, and otoliths or scales removed for ageing.

The standard grid of 58 stations was fished in 2002 and 2003 (see map), and although other stations have been fished in this period, they were for exploratory purposes and were not included in the assessment.

4. Abundance index calculation

Plaice and sole abundance indices are calculated by allocating the appropriate ages to the fish that are caught. This gives the age composition (AC) of the catch, and this is used in the appropriate working group analysis.

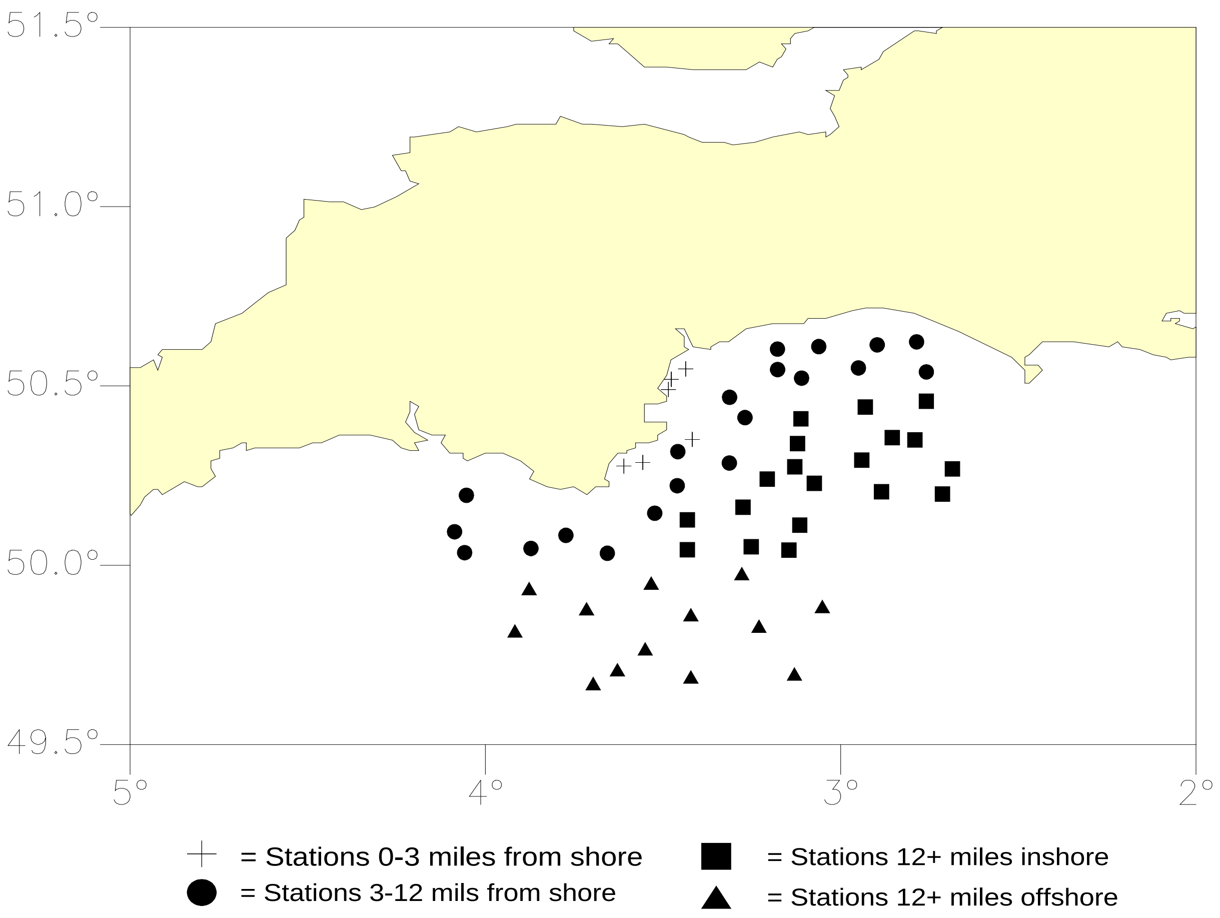
The AC's are calculated by proportioning a length distribution (LD) to an appropriate age–length key (ALK). To account for possible population differences within ICES Division VIIe, biological samples are taken from sectors stratified by distance from shore (see map). The survey bands (in miles) are 0–3, 3–12, 12+ inshore, and 12+ offshore. Where appropriate the ALK's are separated by sex, and this allows a particular 'sector, depth-band and sex' ALK to be raised to the corresponding LD to give an accurate AC for that particular habitat. The AC's can then be combined as required to give results in the form of 'numbers-at-age, per distance or time'.

Between 1984 and 1990 a total survey age–length key was applied to the 'grid' length distribution, but from 1990 onwards stratum stratified age–length keys were used.

The Table below show the stratifications currently used to calculate the 'near-west groundfish survey' abundance indices.

5. Map of survey grid

Additional stations have been fished throughout the time period, but as these stations are not consistently fished, they are excluded from this map.



6. Summary

Area covered	-	ICES Division VIIe
Target species	-	Flatfish, particularly prerecruit plaice and sole
Time period	-	September-October. 1988 to present.
Gear used	-	1984–1988 – 2 * 6m beam trawls
	-	1989–2001 – 2 * 4m beam trawls
	-	2002–2004 – 1* 4m beam trawl
	-	2005–Present – 2 * 4m beam trawls
Mean towing speed	-	4 knots over the ground
Tow duration	-	30 minutes
Vessel used	-	1984–1988 - F.V. Bogey 1
	-	1989–2001 - F.V. Carhelmar
	-	2002–2004 - R.V. Corystes
	-	2005–Present - F.V. Carhelmar

5 Sole in IIIa

5.1 Current stock status and assessment issues

In its recent advice for 2010 ICES has assessed the status of sole in IIIa as "Based on the most recent estimates of SSB (in 2009) and F (in 2008), ICES classifies the stock as having full reproductive capacity and being harvested sustainably. SSB has decreased since 2005 but is still well above B_{pa}. Fishing mortality has increased from 0.22 in 2007 to 0.28 in 2008. Recruitment has been below average in recent 4 years."

Similarly ICES commented on the uncertainty of that assessment: "The assessment is considered uncertain; in recent years there is a tendency to overestimate SSB. There is a need for fishery-independent data as the current survey does not target sole. A sole-directed research survey was initiated in 2004, and the time-series of catch rates will be considered in 2010 when it is sufficiently long and when the survey has been evaluated as an abundance index.

If the share of catches in the Belt Sea remains important and if the population in that area belongs to the IIIa stock, the basis for the assessment and advice should include catches from the Belt Sea." Presently sole in IIIa is assessed as a stock unit in IIIa using landings from IIIa. The increasing fishery in the Belts adjacent to the southern Kattegat (IIIaS) has not been included, but the advice and following management TACs apply to the entire fishing area, i.e. IIIa and the Belts.

ICES addressed a serious problem on the retrospective perception of important stock parameters: "The present assessment has revised the perception of the recent levels of SSB and F as SSB in 2008 has been overestimated by 30%, while estimates of F in 2007 has been underestimated by 5%. The basis for present advice is the same as last year."

Current benchmark assessment has therefore focused on following points:

- Use of new fishery-independent information; Fisherman-DTU Aqua sole directed survey as tuning fleet,
- Necessary examination of remaining tuning fleets, incl. effect of ceasing private logbook series;
- Examination of the inclusion of the Belt Sea in the assessment/advice;
- Implementation of a state-space assessment model (SAM) in order to improve estimates of uncertainty and year-to-year variability of point estimates;
- Establishment of appropriate biological reference points in accordance with MSY concept.

5.2 Compilation of available data

Landings data used in present benchmark assessment are up to 2008 including landings data from the Belts (Division IIIa and Subdivision 22 and 23) in the final evaluations. Biological input data to assessment are unchanged from WGBFAS 2009. Tuning fleets are changed, the Danish KASU survey is substituted with the new Fisherman-DTU Aqua survey, and the two private logbook series, from trawlers and gillnetters, will not be updated after 2008.

5.2.1 Catch and landings data

The officially reported landings by area, gear and country for 2008 are given in Table 5.2.1.1. Denmark takes about 86% of the total Kattegat-Skagerrak catch. Kattegat is traditionally the most important area accounting for 70–80% of the annual catches. The proportion of Danish landings from the Skagerrak in 2008 (23%) equals the long-term mean (24%). Landings from the adjacent Belts (IIIb,c) amount to approx 100 tonnes annually for recent 4 years.

Historical catches including the Working Group corrections are given in Table 5.2.1.2 and Figure 5.2.1.1. Including Working Group estimates of misreporting and discard ratios in 2002–2005, landings fluctuated between 600 and 800 t. Since then landings have decreased to 543 t and 544 t in 2007 and 2008.

Landings in the Belts Area (i.e. Subdivisions 22 and 23) have gradually increased since 2004, from less than 20 t annually prior to 2004 to more than 100 t annually in recent years. Table 5.2.1.3 and Figure 5.2.1.2 provide the official figures of landings in the region.

The gillnet fishery traditionally takes place in late spring, while the trawl fishery is mainly conducted in autumn/winter. Figure 5.2.1.3 provides the Danish catches cumulated by month since 1998, indicating the two main periods of fishery.

The available discard data are incomplete but discard is assumed to be negligible in the fishery (Table 5.2.1.4).

5.2.2 Biological data

Age structure of the landings was only available for the Danish fishery (Table 5.2.2.1) and the age structure of the Danish catch was assumed to apply to the total international catch (Table 5.2.2.2).

Denmark provided statistics on catch age sampling for the Kattegat and Skagerrak (Table 5.2.2.1).

Data for mean weight-at-age were derived using the same sample allocation as used in the computation of catch-at-age. The mean weight-at-age in the catch is shown in Table 5.2.2.3 and Figure 5.2.2.1.

Due to lack of biological information on maturity, the present assessment uses knife-edge maturity-at-age 3, as in all assessments since 1996.

The natural mortality was assumed to be 0.1 per year for all ages as in previous assessments.

5.2.3 Survey tuning data

The following surveys are available as biomass indicators for sole in IIIa.

- Havfisken Survey (KASU) 4th quarter 1999–2008
- Fisherman-DTU Aqua survey November–December 2004–2008

The KASU survey is currently used as the only fishery-independent information in the sole assessment as a tuning fleet while the Fisherman-DTU Aqua survey series has been too short to include in previous assessments. The present benchmark assessment recommends to use the new Fisherman-DTU Aqua survey as a tuning fleet (5 years of survey available) and to omit the KASU survey due to its poor performance in catching sole, and its different perception of stock development.

The Fisherman-DTU Aqua survey

A survey series targeting sole in Kattegat and Skagerrak (ICES Division IIIa) was initiated in 2004 in order to establish a time-series of catch and effort data independent of the commercial fishery. The cpue time-series is based on 120 fixed stations. In 2005 the survey design was adjusted in order to facilitate estimation of swept-area biomass and abundance based on 70 randomly selected fixed stations distributed over the entire survey area. The survey design, gear, coverage, and results from the first five years are provided in a working document (O.A. Jørgensen, 2009; WGBIFS and WGBFAS in 2009).

After having conducted the survey for 5 years, an adequate time-series has been established in order to use it to calibrate the analytical assessment of the sole stock in Division IIIa (Kattegat and Skagerrak). This assessment has for a while suffered from poor fishery-independent data, as only a Danish HAVFISKEN survey, mainly targeting species other than sole, has been available. The HAVFISKEN survey was conducted in daytime when no commercial fishery takes place, while the new survey is conducted in night-time and in cooperation with fishermen, thereby utilizing their knowledge of design and areas fished.

The Fisherman-DTU Aqua survey covers the main range of the distribution of the fishery in Kattegat, and in addition a part of Skagerrak (Figure 5.2.3.1). The main distribution of all ages groups is in southern Kattegat (Figure 5.2.3.2), and little spatial variation exists among the age groups 1–3+. The annual variation in distribution of age groups 1–5 (Figure 5.2.3.3) also indicates relative little variation, with the major part being observed in mid-Kattegat. Based on the log transformed data a GAM standardization including depth, station type and geographic position as an explanatory variable, provides annual abundance distributions (Figure 5.2.3.4). The main area with highest sole abundance in all surveyed years is in the southwest Kattegat at rather low depths.

Internal consistency measured as the ability to follow cohorts in the survey, are provided in Figures 5.2.3.5 and 5.2.3.6. From Figure 5.2.3.5 it is obvious that abundance of ages 2–5 is tracked well in the survey, while ages older than 5 are poorly tracked. Figure 5.2.3.6 provides as measure of survey abundance by year-class as observed by age group. The high abundance of 1999 yr-class observed at ages 8 and 9 is not observed for the remaining ages 5–7. The relatively high yr-class 2002 is more consistently reflected by all age groups.

Although the Fisherman-DTU Aqua survey is a short series, the survey corresponds well with the commercial tuning fleets and also represents a relatively large proportion of the survivor estimation, especially for the youngest ages (see Section 5.8.2).

5.2.4 Commercial tuning data

The currently used series of commercial catch and effort data in the assessment are as follows:

- Official logbooks from trawlers, 12–20 m, 90–104 mm mesh, April–August 1994–2008;
- Private logbooks, 7 trawlers, October–January 1987–2008;
- Private logbooks, 3 gillnetters, April–October 1994–2007.

Private logbook data

In order to establish consistent time-series of cpue data from the commercial fishery to be used for calibrating the XSA sole assessment collaboration between the Danish Fishermen Organisation and DIFRES was initiated in 2004 to establish a database with data from private logbooks.

Since 2005 catch rate indices from private logbooks have been used to calibrate the XSA assessment of sole in IIIa. The private logbook data covers the period from 1987 to 2008 and provides information on effort (number of hours trawling/number of nets) catches (kg by major species or species group) and location (name of fishing ground) from 7 trawlers and 3 gillnetters ranging in size from 15 BRT to 111 BRT and with an engine capacity of 150 to 450 HP.

The number of vessels participating in the voluntary arrangement has diminished over time. Thus, in 2008 no gillnetters provided data and only five trawlers submitted their logbooks.

Although the private logbook data covers the entire fishery of the vessels, only data from the main sole fishing areas (Central Kattegat, KC, and Southern Kattegat, KS) and the main seasons (October to January for trawlers and April to October for gill-netters) are applied in the assessment. Figure 5.2.4.1 indicates the major fishing banks in Kattegat.

Including 2008, the database covers more than 66 000 trawl hours and 204 000 netsettings from fishery in KC and KS (Tables 5.2.4.1 and 5.2.4.2). As indicated in the Tables 5.2.4.3 and 5.2.4.4 the total trawl catches were 416 tonnes and the gillnet catches 94 tonnes.

All trawlers apply the major part of their effort in the Central Kattegat during the trawl season and only one trawler (TR6) applies a significant amount of its effort in the Southern Kattegat. The average trawl catch and effort distributions in the period 1987 to 2008 are indicated in Figures 5.2.4.2 and 5.2.4.3.

Analysis indicates that there are both seasonal and annual differences in distribution of effort in the trawl fishery (Figure 5.2.4.4 A–D). The difference in the effort-weighted latitudes (Figure A) indicates that within the sole season the effort is more northerly distributed than outside the season. Furthermore, the declining trend in mean latitudes indicates that a southward movement of fishing effort took place during the 1990s both within and outside the sole season. During the 1990s, the effort also moved more easterly as indicated by the increasing trend in the effort weighted longitudes (Figure C). However, after 2000 the effort seems to have moved westward again.

The standardized catch rate indices for trawl and gillnet (kg per hour and kg per net standardized to their means) are indicated in Figure 5.2.4.5. Both series indicate that the sole stock increased during the first half of the 2000s and that it declined significantly in both 2006 and 2007.

There seems to be a good correlation between the private logbook and the survey indices as indicated in Figure 5.2.4.5 also.

To be used for calibration of the assessments the catches (by fleet, area, year and quarter) were distributed by age group in a two step procedure. First, the total catches were split into the two commercial size groups used by the industry assuming that the private logbook catches have the same size distribution as catches included in the official logbook database. Subsequently, the catch of each of the two commercial size groups were distributed into age groups assuming that the age structure of catches recorded in the private logbooks is similar to the age structure of the official landings estimated on the basis of data from the Danish harbour sampling programme.

Details on the private logbook programme can be found in Christensen (2006).

Information on the internal consistency within the two fleets is provided in Figure 5.2.4.6. The internal consistency is generally poor for both trawlers and gillnetters. This might reflect problems with the sampling programme and deserves further investigation.

The cpue indices from the two fleets are shown by age in Figure 5.2.4.7. The decrease in cpue observed in 2007 for all ages are continued in 2008. Recruitment (age 2) has been low and stable since 2006.

The consistency, reliability and applicability of private logbooks were discussed. WKFLAT noted that cpue trends from the private logbooks concurred with cpue from the official logbooks (Figure 5.2.4.5). Furthermore, WKFLAT considered that although the historical data were likely unbiased, this might not necessarily be the case in future, also due to the increased awareness of their impact on the assessment. Also taking into consideration that the number of vessels participating in the voluntary logbook programme has declined over time, it was therefore concluded that the private logbook tuning-series should be maintained in the assessment without being updated in future.

Official logbook data

Indicated by a significant increase in the proportion of vessels reaching the upper ceiling of their rations, a study (Hovgaard, 2005) suggested that from 2000 to 2004 the catch rations (allocated as individual weekly or half monthly rations) became increasingly restrictive during the sole fishing seasons. During these periods with full utilization of the ration the incentive to misreport is considered to have been high. Furthermore, the study found that outside the peak seasons for sole fishing (i.e. April to August for trawlers and January to April for gillnetters) mostly the sole rations were not fully utilized and therefore not constraining the fishery. During these periods the incentive to misreport sole catches is considered to have been limited.

Based on analysis of official logbook data from Kattegat outside the peak sole seasons (i.e. when the incentive to misreport was limited) four potential tuning fleet candidates were identified and applied in the 2005 assessment as indicated in text Table 1.

Text Table 1. Tuning fleets based on official logbooks applied in the 2005 assessment.

Fleet	Area	Period
Small trawlers	Kattegat	April to August
Large trawlers	Kattegat	April to August
Small gillnetters	Kattegat	January to April
Large gillnetters	Kattegat	January to April

In the 2006 and 2007 assessments the small and large trawlers were combined as were the small and large gillnetters. From 2008 the gillnetters were not included due to poor statistical performance.

As indicated in Figure 5.2.4.5 the aggregated catch rates indices based on the official logbooks from trawlers fishing outside the sole season (April to August) are consistent with the indices from private logbooks.

The official logbook catch rate indices from trawlers fishing outside the sole season (April to August) used to calibrate the sole assessment since 2008, and the average annual catch rates (covering January to December) used to calibrate the sole assessment until 2004, are both shown in Figure 5.2.4.8. A comparison indicates that during the period 2000 to 2005, when the quotas were restrictive, the off season indices were indeed closer to the private logbook indices than were the annual average indices. Furthermore, the catch rates from the official logbooks off season and the private logbooks both indicate a significant decline in catch rates after 2006 that is not seen in the annual indices from the official logbooks including all months (i.e. including also the sole fishing season).

In conclusion the WKFLAT considered that the catch rate indices from the private logbooks, the off season official logbooks and the sole survey were consistent and relevant to calibration of the assessment of sole in IIIa.

5.2.5 Industry/stakeholder data inputs

Information from fishermen's private records has been used previously in parallel with their mandatory logbook information as an input to the analytical assessment.

5.3 Stock identity and migration issues

Establishment of the sole stock in ICES Division IIIa as a biological unit for assessment and management purposes was in the past mainly based on fishery data because biological entities of sole in Skagerrak and Kattegat were basically unknown. The southern border of the IIIa sole, the Danish Belts and Øresund (ICES Subdivisions 22 and 23) between Denmark and Sweden, thus constitutes a more or less artificial border as there has been virtually no fishery for sole in that area before 2004. However, since 2004 the fishery for sole in the Belts has increased markedly and now constitutes about 20% of total catches in IIIa. The ICES Advice and TAC of sole in IIIa applies to all of Division IIIa and Subdivisions 22 and 23, i.e. all of Skagerrak, Kattegat, the Belts and the Baltic Sea, although the assessment is only based on catch data from IIIa. With the increasing fishery in the Belts, the basis for advice and the management regime are not satisfactory and there is an increasing interest to determine stock structure for sole in the Belts and consequently to include this knowledge in assessment and advice.

Presently no biological studies are available to reveal the accurate stock affinity of sole in the Belts, historical information is limited, and hence, no conclusive statements can be drawn on stock structure within the area.

Landings from the Belts have increased since 2004 from less than about 20 tonnes annually to approx. 120 tonnes in recent years (Table 5.3.1). In comparison the landings in Kattegat and Skagerrak (IIIa) have remained between 500 and 900 t from 2001 to 2008 (Figure 5.3.1). In the present exploratory assessment runs, Belt landings from 2004 onward were included, because landings prior to 2004 were negligible (Figure 5.3.1). The landings distribution in the entire area Skagerrak, Kattegat and the Belts is provided in Figure 5.3.2 and shows the gradual increase of landings from the Belts simultaneous with a shift in distribution of the fishery in IIIa towards southern Kattegat. Catch in numbers estimated for the areas (22 and 23) are based on port samplings from the Belts while age readings and mean weight-at-age are assumed equal to southern Kattegat. An XSA was run with same settings as the baseline run as accepted for the 2010 Advice and calibrated with same fleets. Stock summary of the assessment is shown in Figure 5.3.3 and compared with the baseline assessment. The increased landings (20%) as a result of including the Belts landings, result in a similar higher fishing mortality (from 0.28 to 0.33) and a slightly higher SSB (6%). The estimated fishing mortality-by-age is provided in Figure 5.3.4. A comparison of retrospective runs for an XSA including the Belts with the baseline run is provided in Section 5.8.3.

Conclusions and recommendations

The concurrent increase of landings from the Belts along with the continuous move of the main fishery in IIIa towards the southern Kattegat, indicates a strong connectivity between the populations in Kattegat and the Belts. Despite few biological parameters to draw any conclusive statements on the origin of the Belt sole, the sole distribution as outlined from the sole survey (Fisherman-DTU Aqua survey), demonstrates high catch rates up to the border to the northern Belts, indicating that sole in the Belts is likely to be a part of the Kattegat population.

A status quo situation with a biological advice for IIIa and the Belts based on IIIa landings only is fundamentally illogical, and it is therefore **recommended to include fishery information from the Belts into the IIIa assessment in order to provide advice for the entire area Division IIIa and Subdivisions 22 and 23.** Any outcome of future studies on stock structure and biological entities for sole in the area should be used to correct or confirm this perception.

5.4 Spatial changes in the fishery and stock distribution

Spatial change in fishery and/or stock distribution was evaluated for the assessment and is presented in Section 5.3 on stock identity and migration issues.

Large spatial changes in fishery are expected to take place since 2009 due to the implementation of seasonal and permanently closed areas in Kattegat.

5.5 Environmental drivers of stock dynamics

Major environmental influence on the dynamics of sole in IIIa has not been identified. The present state of knowledge in the field is summarized in Stock Annex.

5.6 Role of multispecies interactions

5.6.1 Trophic interactions

The role of trophic interactions has not been considered by the Benchmark Group.

5.6.2 Fishery interactions

The role of fishery interactions has not been considered by the Benchmark Group.

5.7 Impacts on the ecosystem

Impacts of fishing on the ecosystem have not been considered by the Benchmark Group.

5.8 Stock assessment methods

Presently an age-based assessment is conducted with XSA for the sole in IIIa. The basic assumptions for using XSA have been violated in the past, especially for the years 2002–2004 when misreporting in the range of 20–100% has been estimated. Several flaws in input data have been identified that violate assumptions of exact catch-at-age, e.g. insufficient sampling procedures/scheme and uncertainty in age reading. Therefore one of the tasks for the WKFLAT Benchmark for sole in IIIa was to evaluate alternative assessment models that were less dependent on accurate removal data.

5.8.1 Models

A stochastic state-space assessment model (SAM) (Nielsen, 2008) which previously has been evaluated by WGMG in 2009, was used to assess the state of the sole IIIa and results was compared with the present XSA assessment. The SAM model was run using the same input as for the XSA. Details on the model and assumptions are found in ICES WGMG 2009 and at http://www.nielsensweb.org/sole3a.pdf.

5.8.2 Sensitivity analysis

Sensitivity analyses of both the XSA and the SAM models were performed by running single fleet runs for the XSA, while for the SAM model runs excluding one fleet at a time were performed. The justification for the slightly different procedure for the SAM model was due to the fact that SAM will not perform satisfactory with only one fleet in addition to the catch matrix. SSB, F and R for single runs with XSA are given in Figure 5.8.2.1, model residuals in Figure 5.8.2.2, and point estimates in Figure 5.8.2.3. Similar figures are shown for the SAM model runs where one fleet is omitted at a time (Figure 5.8.2.4), and the corresponding log q residuals are in Figure 5.8.2.5. In addition, for the XSA, fleet weighting in the F and survivor estimation for a combined run in order to illustrate the relative importance of the fleets is shown in Figure 5.8.2.6.

Section 5.2.4. described the difficulties in continuing the use of the private logbooks in recent years and elaborates on their additional value as biomass indicator to the official logbooks. One of the consequences might be a cessation of the series, although the private gillnetters already ceased in 2008. Figure 5.8.2.7 provides stock scenarios for successive omission of the series back in time. The fleet weight in the present (2009) stock assessment is provided in Figure 5.8.2.6.

The main conclusions of the sensitivity analyses are that i) the Danish Havfisken survey (KASU) perceives the stock assessment to be markedly more optimistic than do the other biomass indices in the recent 4–5 years (Figures 5.8.2.1 and 5.8.2.3). This trend is visible for all ages , and the index is therefore down weighted in the XSA when all other indices are included (Figure 5.8.2.6), ii) the Fisherman-DTU Aqua survey behaves well with regard to perception of stock and residuals, and is therefore suggested to replace KASU as a fishery-independent index.

5.8.3 Retrospective patterns

Retrospective patterns were evaluated and not considered to have systematic bias in recent years for any of the two models considered, namely XSA and SAM (Figures 5.8.3.1 and 5.8.3.2).

5.8.4 Evaluation of the models

The following issues were considered in the evaluation of the models used to assess the sole stock in IIIa: i) treatment of catch data as being associated with noise, ii) retrospective patterns, iii) estimation of uncertainty on estimates, and iv) objective procedures built into models.

A number of problems associated with XSA have recently been listed by WGMG (2009), e.g.. the use of shrinkage to the mean and convergence of the model. WGMG (2009) recommended SAM alternately to XSA specifically on the objective shrinkage function. Given that removals from the sole in IIIa stock are considered imprecise due to historical misreporting, a scattered sampling scheme and possible age reading problems, the catch data cannot be considered precise. The SAM model does not assume accurate catch data and is therefore in this case a better model given the data.

Both models did display the same trends for SSB, F and recruitment, but the XSA estimates on F varied substantially between years, but within the estimated confidence limits of estimates from SAM model (Figure 5.8.4.1). Thus, the choice of changing to SAM to assess the stock does not reveal any major changes in stock perception, although SSB in 2008 is estimated 9% lower by the SAM model as compared with the XSA estimate for 2008 (Tables 5.8.4.1–5.8.4.4).

5.9 Stock assessment

The perception of development and stock status for the sole in Division IIIa is unchanged from the 2009 assessment (WGBFAS, 2009) disregarding inclusion of landings from Subdivision 22 and 23 (Figure 5.3.3), change in tuning-series and choice of stock assessment model (Figure 5.8.4.1).

5.10 Recruitment estimation

Recruitment estimation has not been considered by the Benchmark Group.

5.11 Short-term and medium-term forecasts

Given that perception of the stock largely remains unchanged after approved assessment option changes by WKFLAT 2010, short-term and medium-term forecasts were not considered by the Benchmark Group. The candidate for F_{msy} and a biomass trigger point (see Section 5.12), and the similar rejection of existing PA reference points, leaves the catch forecast unresolved with respect to procedure for catch advice for 2011.

5.12 Biological reference points

Present established biological reference points for sole in IIIa were estimated in the past (1999) when the stock perception was rather different from now and under different criteria for defining reference points. The established PA reference points for sole in IIIa are not mutually consistent as fishing at F_{pa} will lead to SSB of around two to three times the size of B_{pa}. Analyses were therefore conducted to establish new reference points that correspond to the MSY approach recently approved by ICES.

An operating model in the FLR framework was set up for sole in IIIa: XSA using tuning-series as adopted by the Benchmark Group (see Section 5.2.4) as the basis for the annual assessment of the stock. The additional input for the XSA is equal to the baseline survey as of WGBFAS 2009. The stock was forward projected in an operating model (OM) based on the following assumptions and targets: recruitment was drawn from a Ricker stock–recruit function including uncertainty, mean weight-at-age and F pattern was assumed equal to previous 3 yrs average, and F was based on management decisions of a TAC. The management decisions (catches) the following year were based on a specific F target and fixed (ranging from 0.05 to 1.1 in the scenarios) for the time period projected (20 yrs), and on a forecast using geometric mean recruitment 1994-present date. Various TAC bounds were applied to the scenarios (from 15%, as currently adopted by EU, up to 50%).

Given a target fishing mortality, an associated probability of SSB being below a defined $B_{trigger}$ (ICES, 2009) over a time range can be estimated. Present B_{pa} at 1060 t is based on the first two observations in the time-series and is most probably invalid. A conservative $B_{trigger}$ of approx. 2000 t is suggested (lowest SSB disregarding the first two years in the assessment with the two lowest SSB estimates).

The probability profile over the explored F range demonstrates that at target F's less than approx. 0.25–0.30 results in probabilities of less than 5% of SSB being smaller than $B_{trigger}$, and also that yield will not increase significantly further above this F_{target} level. The 5% level is considered a sufficient level to avoid being below $B_{trigger}$ (Figure 5.12.1). Figure 5.12.2 provides the estimated development of SSB, F, R and landings over time for a target F of 0.3.

A stock production model (ASPIC) was attempted based on the landings and associated effort, in order to estimate real MSY parameters for the stock. However, the model was unable to run, probably due to little contrast in the data within the available time-series.

A potential candidate for F_{msy} equals 0.3, as yield above this level, only increases insignificantly and the associated risk of exceeding the defined $B_{trigger}$ is less than 5%. A potential $B_{trigger}$ is 2000 t, which is lowest observed SSB apart from the first two observations in the time-series. Stock production dynamics below this SSB are therefore considered uncertain.

WKFLAT considered the scenarios and concluded that WGBFAS 2010 should make a final evaluation of this based on guidelines adopted by WKFRAME in March 2010.

5.13 Recommended modifications to the Stock Annex

Based on the above suggestions for improvement of input to assessment and assessment models, the Benchmark Group agreed on following recommended modifications to be added to the Stock Annex as procedure for forthcoming assessments updates:

i) Indices (fleets) used in assessment calibration of fishing mortality have changed: the new Fisherman DTU Aqua survey will replace the previous KASU survey; the commercial tuning-series based private logbooks (gillnetters and trawlers) will cease as of 2010, but remain as historical tuning series.

ii) The stock area of the assessment has changed from Skagerrak and Kattegat (Division IIIa) to include the Danish Belts (Subdivisions 22 and 23).

iii) SAM model should be applied to assess this sole stock and used as basis for catch forecast. In parallel, XSA should continue to be run as a comparison of stock perception from that model.

5.14 Recommendations on the procedure for assessment updates

Suggested revisions of biological reference for the sole IIIa stock were discussed during the Benchmark Workshop. Because ICES currently has not yet set up clear guidelines on establishment of MSY reference points and especially biomass trigger points, the Group agreed to postpone final defined reference point to WGBFAS in April. Thereby analyses and guidelines provided by WKFRAME will also be available.

For remaining recommendations on assessment updates procedures, see Section 5.13.

5.15 Industry supplied data

None.

5.16 References

ICES. 2009. Workshop on the Form of Advice. CM 2009/ACOM:53.

Table 5.2.1.1. Sole IIIa. Landings (t) of sole in 2008 by area, nation, quarter and gear.

SKAGERRAK	QUARTER					GEAR			TOTAL
Nation	1	2	3	4	Unkn qrt	Trawl	Gillnet	other	
DK	13	54	9	29		49	57		106
Sweden	2	0	0	0				3	3
Nederland					3			3	3
Germany	0	12	5	15				32	32
Norway					7			7	7
Total	15	67	15	44	10	49	57	45	151

KATTEGAT	QUARTER					GEAR			TOTAL
Nation	1	2	3	4	Unkn qrt	Trawl	Gillnet	other	
DK	56	64	68	174		266	95		361
Germany	0	0	0	0				0	0
Sweden	9	13	9	0				31	31
Total	66	77	76	174	0	266	95	32	393

Table 5.2.1.2. Sole in Division IIIa. Catches (tons) in the Kattegat and Skagerrak 1952–2008. Official statistics and Expert Group corrections. For Sweden there is no information 1962–1974.

YEAR	DENMARK		SWEDEN	GERMANY	BELGIUM	NETHERLANDS	EG	TOTAL
	Kattegat	Skagerrak	Skag+Kat	Kat+Skag	Skagerrak	Skagerrak	Corrections	
1952	156		51	59				266
1953	159		48	42				249
1954	177		43	34				254
1955	152		36	35				223
1956	168		30	57				255
1957	265		29	53				347
1958	226		35	56				317
1959	222		30	44				296
1960	294		24	83				401
1961	339		30	61				430
1962	356			58				414
1963	338			27				365
1964	376			45				421
1965	324			50				374
1966	312			20				332
1967	429			26				455
1968	290			16				306
1969	261			7				268
1970	158	25						183
1971	242	32		9				283
1972	327	31		12				370
1973	260	52		13				325
1974	388	39		9				436
1975	381	55	16	16		9	-9	468
1976	367	34	11	21	2	155	-155	435
1977	400	91	13	8	1	276	-276	513
1978	336	141	9	9		141	-141	495
1979	301	57	8	6	1	84	-84	373
1980	228	73	9	12	2	5	-5	324
1981	199	59	7	16	1			282
1982	147	52	4	8	1	1	-1	212
1983	180	70	11	15		31	-31	276
1984	235	76	13	13		54	-54	337
1985	275	102	19	1	+	132	-132	397
1986	456	158	26	1	2	109	-109	643
1987	564	137	19		2	70	-70	722
1988	540	138	24		4			706
1989	578	217	21	7	1			824
1990	464	128	29	-	2		+427	1050
1991	746	216	38	+			+11	10111
1992	856	372	54				+12	12941
1993	1016	355	68	9			-9	14391
1994	890	296	12	4			-4	1198
1995	850	382	65	6			-6	1297
1996	784	203	57	612			-597	1059
1997	560	200	52	2				814
1998	367	145	90	3				605
1999	431	158	45	3				637

Year	Denmark		Sweden	Germany	Belgium	Netherlands	EG	Total
2000	399	320	34	11			-132[2]	633[2]
2001[1]	249	286	25				-103[2]	455[2]
2002	360	177	15	11			+281[3]	844
2003	195	77	11	17			+301[3]	602
2004	249	109	16	18			+392[3]	784
2005	531	132	30	34	Norway		+145[3]	727
2006	521	114	38	43	9	4		729
2007	366	81	45	39	9			541
2008	353	102	34	35	7	3		534

[1]Considerable non-reporting assumed for the period 1991–1993. [2]Catches from Skagerrak were reduced by these amounts because of misreporting from the North Sea. The subtracted amount has been added to the North Sea sole catches. Total landings for these years in IIIA have been reduced by the amount of misreporting. [3]Assuming misreporting rates at 50, 100, 100 and 20% in 2002-2005, respectively.

Table 5.2.1.3. Sole in IIIa. Official Danish landings (t) of sole in Subdivisions 22 and 23. Landings prior to 2001 are considered insignificant and not currently available.

	Subdivision		
	22	23	Total
2001	20	8	28
2002	18	9	27
2003	17	8	25
2004	39	16	55
2005	115	30	145
2006	105	33	138
2007	90	26	116
2008	111	25	136
2009	127	12	139

Table 5.2.1.4. Sole in IIIa. Discards from active gear as obtained from observers.

	Number (thousands)								
	Year								
Age	1999	2000	2001	2002	2003	2004	2005	2006–2008	Total
1		148							148
2		293		44	254				591
3		1114			64		53		1231
4		56		43	71				170
5				18	6				24
6					6				6
7					1				1
8					1				1
9									
10					1				1
Total		1611		105	404		53		2173

	Mean weight (gramme)							
	Year							
Age	1999	2000	2001	2002	2003	2004	2005	2006–2008
1		54						
2	82	126		98	96			
3	88	107			110			
4		82		97	146			
5	116			109				
6	124				98			
7					158			
8	183				123			
9								
10					158			

Table 5.2.2.1. Sole in Division IIIa. Number of sole samples and individuals measured and aged by Denmark in 2008 in Kattegat and Skagerrak.

	Kattegat			Skagerrak		
Quarter	Samples	Measured	Aged	Samples	Measured	Aged
1	2	273	270			
2	1	180	178			
3	1	197	193			
4	3	276	273	1	107	103
Total	7	926	914	1	107	103

Table 5.2.2.2. Sole IIIa. Catch in numbers (thousands) by year and age.

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

	YEAR,	1984,	1985,	1986,	1987,	1988,
	AGE					
	2,	64,	786,	258,	391,	516,
	3,	638,	594,	1255,	857,	1035,
	4,	240,	190,	671,	1018,	897,
	5,	117,	55,	210,	434,	484,
	6,	31,	60,	33,	174,	129,
	7,	33,	16,	36,	64,	37,
	8,	40,	8,	33,	31,	23,
	+gp,	175,	69,	63,	87,	60,
0	TOTALNUM,	1338,	1778,	2559,	3056,	3181,
	TONSLAND,	337,	397,	643,	722,	706,
	SOPCOF %,	99,	100,	100,	100,	100,

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

	YEAR,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,
	AGE										
	2,	863,	1209,	530,	506,	523,	127,	272,	316,	54,	303,
	3,	613,	1300,	1301,	1178,	1804,	1037,	622,	1015,	251,	146,
	4,	847,	651,	928,	939,	1251,	1451,	1359,	537,	440,	212,
	5,	592,	564,	334,	493,	826,	752,	1226,	691,	365,	299,
	6,	404,	310,	345,	320,	418,	444,	600,	440,	505,	267,
	7,	83,	167,	302,	178,	117,	152,	385,	232,	360,	250,
	8,	30,	27,	180,	166,	137,	45,	142,	148,	262,	218,
	+gp,	52,	31,	76,	239,	157,	59,	104,	203,	263,	292,
0	TOTALNUM,	3484,	4259,	3996,	4019,	5233,	4067,	4710,	3582,	2500,	1987,
	TONSLAND,	824,	1050,	1011,	1294,	1439,	1198,	1297,	1059,	814,	605,
	SOPCOF %,	100,	100,	95,	93,	100,	99,	98,	98,	100,	100,

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

	YEAR,	1999,	2000,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,
	AGE										
	2,	249,	141,	165,	642,	48,	184,	201,	110,	254,	264,
	3,	826,	476,	354,	746,	424,	572,	912,	353,	376,	274,
	4,	150,	756,	346,	279,	470,	774,	957,	745,	333,	292,
	5,	228,	112,	338,	413,	272,	452,	509,	641,	497,	250,
	6,	177,	127,	65,	462,	334,	244,	242,	439,	257,	416,
	7,	165,	120,	81,	93,	192,	178,	102,	145,	120,	202,
	8,	167,	132,	35,	84,	24,	82,	88,	58,	68,	152,
	+gp,	233,	302,	200,	458,	204,	162,	78,	101,	93,	176,
0	TOTALNUM,	2195,	2166,	1584,	3177,	1968,	2648,	3089,	2592,	1998,	2026,
	TONSLAND,	638,	633,	455,	845,	600,	782,	878,	729,	542,	543,
	SOPCOF %,	100,	100,	100,	100,	99,	99,	100,	98,	95,	102,

Table 5.2.2.3. Sole IIIa. Weight-at-age (kg) in the catch and in the stock.

Catch weights-at-age (kg)

YEAR,	1984,	1985,	1986,	1987,	1988,
AGE					
2,	.1830,	.1740,	.1650,	.1600,	.1590,
3,	.2130,	.2340,	.2310,	.1940,	.1970,
4,	.2570,	.2830,	.2870,	.2450,	.2350,
5,	.2940,	.2910,	.2970,	.2740,	.2510,
6,	.2970,	.3350,	.4090,	.3190,	.3350,
7,	.2800,	.2920,	.2670,	.3600,	.3480,
8,	.3210,	.2790,	.2620,	.4170,	.3630,
+gp,	.3677,	.3640,	.3830,	.3610,	.3517,
0 SOPCOFAC,	.9932,	.9984,	.9995,	1.0027,	1.0032,

Catch weights-at-age (kg)

YEAR,	1989,	1990,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,
AGE										
2,	.1760,	.1800,	.1740,	.2130,	.1780,	.1740,	.1870,	.1760,	.1980,	.1610,
3,	.2210,	.2280,	.2290,	.2520,	.2240,	.2290,	.2000,	.2180,	.2720,	.2190,
4,	.2550,	.2510,	.2750,	.3360,	.2740,	.2800,	.2480,	.2670,	.2960,	.3160,
5,	.2660,	.3080,	.2920,	.4120,	.3280,	.3420,	.2910,	.3070,	.3080,	.3220,
6,	.2710,	.3330,	.3460,	.4300,	.3740,	.3880,	.3510,	.3390,	.3450,	.3500,
7,	.3520,	.4000,	.3090,	.4910,	.4030,	.4450,	.3820,	.4040,	.3590,	.3580,
8,	.3000,	.5470,	.3860,	.5660,	.3880,	.4480,	.4320,	.4570,	.3640,	.3770,
+gp,	.3547,	.5550,	.5027,	.6220,	.4737,	.3937,	.3830,	.6637,	.3610,	.3267,
0 SOPCOFAC,	.9964,	.9970,	.9509,	.9304,	.9980,	.9931,	.9767,	.9827,	.9983,	1.0007,

2 Catch weights-at-age (kg)

YEAR,	1999,	2000,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,
AGE										
2,	.1620,	.1690,	.1840,	.1730,	.1750,	.2050,	.1890,	.2010,	.2080,	.2110,
3,	.2320,	.2360,	.2410,	.2050,	.2090,	.2380,	.2210,	.2140,	.2230,	.2410,
4,	.3040,	.3030,	.2880,	.2930,	.2450,	.2920,	.2960,	.2620,	.2960,	.2620,
5,	.3680,	.3430,	.3770,	.3720,	.3580,	.3290,	.3190,	.3160,	.3020,	.2760,
6,	.3600,	.3180,	.3430,	.3850,	.3800,	.3720,	.3620,	.3380,	.3610,	.2860,
7,	.3780,	.3620,	.3030,	.2120,	.4290,	.4010,	.3680,	.3180,	.3410,	.2910,
8,	.3970,	.3500,	.3580,	.2920,	.2590,	.3710,	.4170,	.2870,	.3880,	.2950,
+gp,	.3497,	.3267,	.2757,	.2737,	.3823,	.3147,	.3583,	.3677,	.2380,	.2440,
0 SOPCOFAC,	1.0042,	1.0011,	.9951,	.9978,	.9950,	.9872,	1.0035,	.9803,	.9550,	1.0192,

1

Table 5.2.4.1. Sole in IIIa. Number of hours trawling in Central and Southern Kattegat.

	Trawler ID							
Year	TR1	TR2	TR3	TR4	TR5	TR6	TR7	Total
1987			894					894
1988			1216					1216
1989		249	927					1176
1990		568	951					1519
1991		1041	1156					2197
1992		1082	915	1116	7	221		3340
1993		263	1251	1163	14	1400		4090
1994		1858	833	2194	203	2359		7446
1995		732	508	672	252	1332		3495
1996		987	473	1370	434	1064		4327
1997		1204	1130	1264	669	984		5250
1998		353	220	175	486	801		2036
1999		137	567	455	494	1005		2657
2000		210	623	840	872	1068		3612
2001		116	1209	270	394	1169		3157
2002		320	600	21	121	399		1461
2003	371	378	581	175	217	1253		2975
2004	417	289	721	296	558	1192	639	4111
2005	854	81	644	46	198	1236	271	3329
2006	389	207	514	611	410	893	637	3659
2007	651	270		301	746	669	473	3108
2008	184	46		595	95		130	1048
Total	2865	10 386	15 932	11 561	6167	17 042	2149	66 102

Table 5.2.4.2. Sole in IIIa. Number of net settings in Central and Southern Kattegat.

	Vessel ID			
Year	G1	G2	G3	Total
1993			764	764
1994	7006		240	7246
1995	5900			5900
1996	5136	17 780	1370	24 286
1997	3030	15 835	1170	20 035
1998	5959	13 265		19 224
1999	4542	13 645	1730	19 917
2000	8440	13 155	2050	23 645
2001	4916	11 425	1750	18 091
2002	5172	12 540	2218	19 930
2003	4812	8140	860	13 812
2004	5518			5518
2005	7037		2110	9147
2006	6764		3592	10 356
2007	6206			6206
Total	80 438	105 785	17 854	204 077

Table 5.2.4.3. Sole in IIIa. Seasonal (October to January) sole (kg) catches by trawlers in central and southern Kattegat.

	Vessel ID							
Year	TR1	TR2	TR3	TR4	TR5	TR6	TR7	Total
1987			4018					4018
1988			6246					6246
1989		850	5121					5971
1990		4584	7611					12 195
1991		7146	8962					16 108
1992		9210	10 236	11 336	0	690		31 472
1993		1786	7492	7655	102	5680		22 714
1994		13 879	4338	13 027	1235	12 168		44 647
1995		5859	4148	5265	1729	6229		23 229
1996		9102	2976	9703	3938	7589		33 308
1997		5728	3246	5953	2347	4665		21 939
1998		1385	1057	456	1921	2077		6896
1999		1408	2955	3032	4218	4439		16 052
2000		808	2935	5221	5038	2878		16 879
2001		719	5430	384	2210	3052		11 794
2002		3302	5367	259	1443	725		11 096
2003	4287	3239	3470	2004	2033	5732		20 765
2004	3369	1771	9487	2654	3265	7007	5764	33 317
2005	6794	713	4859	437	2436	9508	3117	27 863
2006	2864	1353	4547	4123	3427	7496	5711	29 521
2007	3444	1015		622	3502	3842	2138	14 563
2008	515	180		3201	276		850	5022
Total	21 273	74 035	104 499	75 330	39 119	83 777	17 580	415 612

Table 5.2.4.4. Sole in IIIa. Seasonal (April to October) gillnet sole catches (kg) in Central and Southern Kattegat.

	Vessel ID			
Year	G1	G2	G3	Total
1994	4836			4836
1995	3528			3528
1996	2169	8100		10 269
1997	1158	7820		8978
1998	1545	4265		5810
1999	2391	5240		7631
2000	4862	4265		9127
2001	2622	4625		7247
2002	3452	6072		9524
2003	2468	5407		7875
2004	3361			3361
2005	5297		639	5936
2006	4963		2248	7211
2007	2506			2506
Grand Total	45 158	45 794	2887	93 839

Table 5.3.1. Sole in IIIa. Official landings (t) from Division IIIa and Subdivisions 22, 23 and 24 (the Belts and western Baltic) in the years 2001–2009.

	Subdivision			Total	
	22	23	24	Belts	IIIa
2001	20	8	.	28	455
2002	18	9	.	27	845
2003	17	8	0	25	600
2004	39	16	0	55	782
2005	115	30	0	145	878
2006	105	33	0	138	729
2007	90	26	0	116	542
2008	111	25	0	136	543
2009	127	12	0	139	519

Table 5.8.4.1. Sole in IIIa. Fishing mortality-at-age from final run by XSA.

YEAR\AGE	2	3	4	5	6	7	8	9+
1984	0.025	0.532	0.582	0.443	0.193	0.616	0.475	0.475
1985	0.142	0.297	0.263	0.223	0.380	0.129	0.259	0.259
1986	0.053	0.312	0.564	0.458	0.181	0.366	0.377	0.377
1987	0.084	0.224	0.398	0.780	0.760	0.555	0.545	0.545
1988	0.163	0.297	0.342	0.297	0.491	0.311	0.349	0.349
1989	0.172	0.265	0.374	0.353	0.385	0.599	0.396	0.396
1990	0.194	0.376	0.439	0.407	0.281	0.241	0.350	0.350
1991	0.081	0.293	0.446	0.375	0.414	0.430	0.393	0.393
1992	0.060	0.232	0.317	0.401	0.658	0.346	0.395	0.395
1993	0.086	0.281	0.366	0.451	0.620	0.471	0.434	0.434
1994	0.038	0.219	0.340	0.347	0.413	0.423	0.296	0.296
1995	0.089	0.238	0.438	0.475	0.456	0.673	0.785	0.785
1996	0.163	0.482	0.297	0.369	0.276	0.283	0.523	0.523
1997	0.051	0.169	0.352	0.301	0.448	0.339	0.525	0.525
1998	0.071	0.168	0.189	0.382	0.333	0.370	0.314	0.314
1999	0.081	0.250	0.233	0.284	0.362	0.315	0.401	0.401
2000	0.063	0.198	0.346	0.249	0.232	0.408	0.408	0.408
2001	0.049	0.206	0.199	0.235	0.207	0.206	0.178	0.178
2002	0.137	0.285	0.217	0.337	0.496	0.432	0.295	0.295
2003	0.010	0.113	0.263	0.306	0.446	0.352	0.173	0.173
2004	0.038	0.145	0.286	0.399	0.451	0.412	0.227	0.227
2005	0.096	0.255	0.372	0.304	0.378	0.338	0.367	0.367
2006	0.065	0.215	0.316	0.412	0.415	0.372	0.294	0.294
2007	0.177	0.294	0.293	0.328	0.261	0.165	0.273	0.273
2008	0.146	0.276	0.383	0.344	0.446	0.307	0.305	0.305

Table 5.8.4.2. Sole in IIIa. Fishing mortality-at-age from final run by SAM.

YEAR\AGE	2	3	4	5	6+
1984	0.083	0.381	0.443	0.365	0.375
1985	0.088	0.345	0.394	0.359	0.314
1986	0.090	0.331	0.407	0.383	0.348
1987	0.094	0.316	0.408	0.398	0.421
1988	0.097	0.314	0.408	0.386	0.380
1989	0.098	0.307	0.411	0.401	0.412
1990	0.096	0.302	0.415	0.406	0.385
1991	0.091	0.285	0.396	0.404	0.480
1992	0.087	0.274	0.383	0.415	0.565
1993	0.085	0.275	0.384	0.433	0.574
1994	0.082	0.263	0.367	0.421	0.494
1995	0.081	0.272	0.360	0.406	0.519
1996	0.080	0.282	0.353	0.380	0.448
1997	0.077	0.254	0.331	0.361	0.418
1998	0.075	0.226	0.313	0.355	0.385
1999	0.072	0.214	0.299	0.340	0.345
2000	0.070	0.209	0.293	0.333	0.316
2001	0.068	0.197	0.262	0.322	0.260
2002	0.067	0.190	0.250	0.322	0.311
2003	0.065	0.171	0.238	0.304	0.295
2004	0.068	0.191	0.264	0.313	0.330
2005	0.072	0.220	0.282	0.314	0.380
2006	0.075	0.233	0.296	0.330	0.355
2007	0.081	0.256	0.321	0.349	0.311
2008	0.084	0.269	0.346	0.370	0.348

Table 5.8.4.3. Sole in IIIa. Stock in numbers-at-age from final run by XSA.

Year\Age	2	3	4	5	6	7	8	9+
1984	2756	1625	572	344	186	75	111	485
1985	6263	2433	863	289	200	139	37	317
1986	5243	4919	1637	601	209	124	110	210
1987	5097	4499	3257	843	344	158	78	217
1988	3606	4240	3256	1979	350	145	82	214
1989	5728	2772	2852	2092	1330	194	96	166
1990	7220	4362	1925	1775	1330	819	96	110
1991	7171	5383	2710	1123	1069	909	583	245
1992	9093	5985	3633	1570	698	640	535	767
1993	6674	7746	4295	2394	951	327	409	467
1994	3541	5542	5293	2696	1380	463	185	242
1995	3368	3083	4028	3409	1724	827	274	200
1996	2206	2789	2198	2352	1918	989	382	521
1997	1152	1695	1558	1478	1471	1317	675	674
1998	4663	991	1295	991	990	850	849	1134
1999	3385	3931	758	970	612	642	532	739
2000	2451	2826	2771	543	661	386	424	957
2001	3725	2083	2098	1774	383	475	232	1319
2002	5394	3209	1534	1556	1269	282	349	1902
2003	5226	4257	2183	1117	1005	699	166	1388
2004	5444	4683	3442	1518	744	583	445	883
2005	2647	4740	3665	2340	922	429	349	311
2006	2046	2176	3324	2286	1563	572	277	478
2007	1899	1735	1588	2192	1370	934	357	474
2008	2419	1440	1170	1072	1429	955	717	806

Table 5.8.4.4. Sole in IIIa. Stock in numbers-at-age from final run by SAM.

Year\Age	2	3	4	5	6	7	8	9+
1984	2629	1881	615	393	107	96	132	545
1985	4778	2285	752	218	230	73	36	297
1986	4140	4568	1978	653	138	135	99	230
1987	4107	3475	3167	1276	461	159	92	251
1988	4133	3923	2786	1727	480	145	79	197
1989	5751	2484	2634	1810	1187	246	91	158
1990	7731	4944	1862	1722	1042	611	102	115
1991	6965	5713	3044	1098	967	773	488	193
1992	8198	5420	3275	1566	677	470	399	516
1993	5924	7378	3853	2255	944	292	292	369
1994	2832	5178	5106	2260	1214	360	146	193
1995	3471	2722	4705	3745	1561	892	293	264
1996	2295	3616	1760	2345	1462	724	401	531
1997	1269	1164	1675	1303	1639	1115	727	745
1998	3434	828	841	1040	807	840	765	924
1999	3680	4670	626	835	680	583	531	900
2000	2620	2591	2860	410	516	465	475	1123
2001	3794	2235	1791	1405	324	455	191	1057
2002	6188	4132	1340	1442	1524	354	371	1483
2003	3314	3891	2942	1234	1405	769	138	903
2004	3997	3701	3501	1812	960	714	372	603
2005	3016	4719	4436	2422	873	327	300	353
2006	2601	2144	3647	2825	1757	529	248	409
2007	2108	1849	1463	2088	1170	681	338	435
2008	2302	1390	1148	910	1587	832	634	671

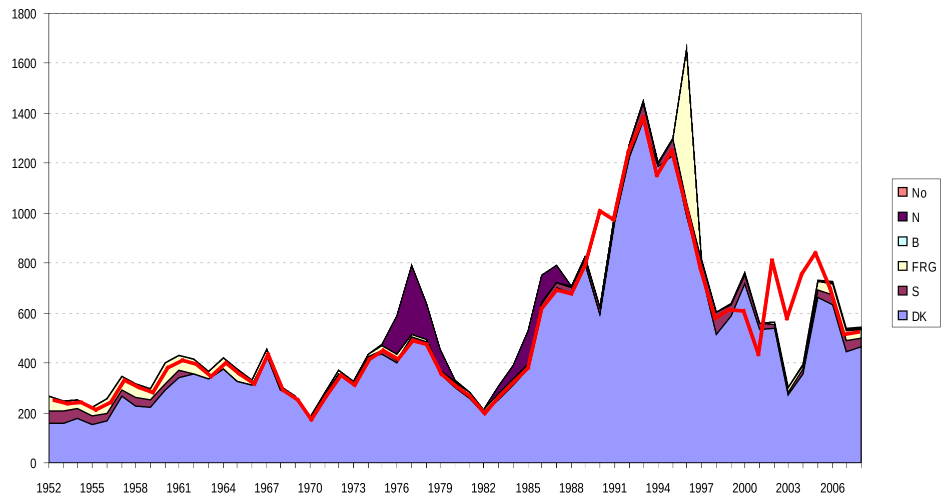
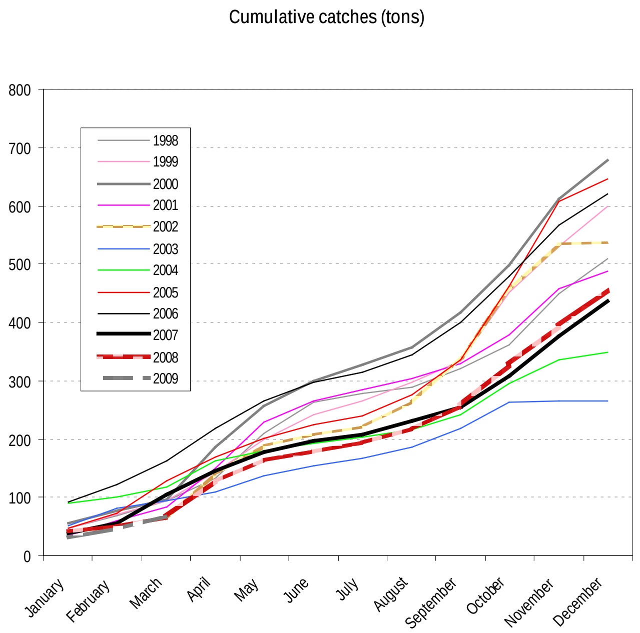


Figure 5.2.1.1. Sole IIIa. Landings of sole in Skagerrak and Kattegat (IIIa) by nation since 1952. Bold red line indicates estimated total landings including misreporting, as estimated by the WG.

Figure 5.2.1.2. Sole in IIIa. Official landings from Division IIIa (red bars on right y-axis) and from Subdivisions 22 and 23 (blue and grey bars on left y-axis).



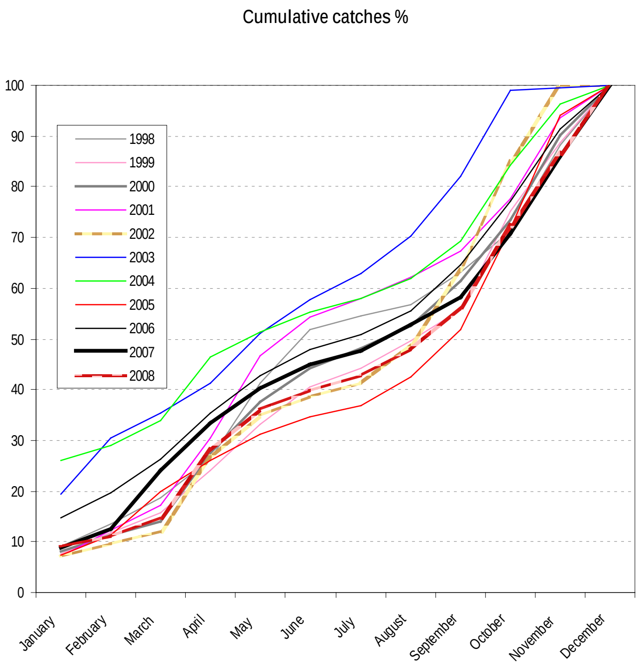


Figure 5.2.1.3. Sole IIIa. Cumulative Danish landings of sole by month.

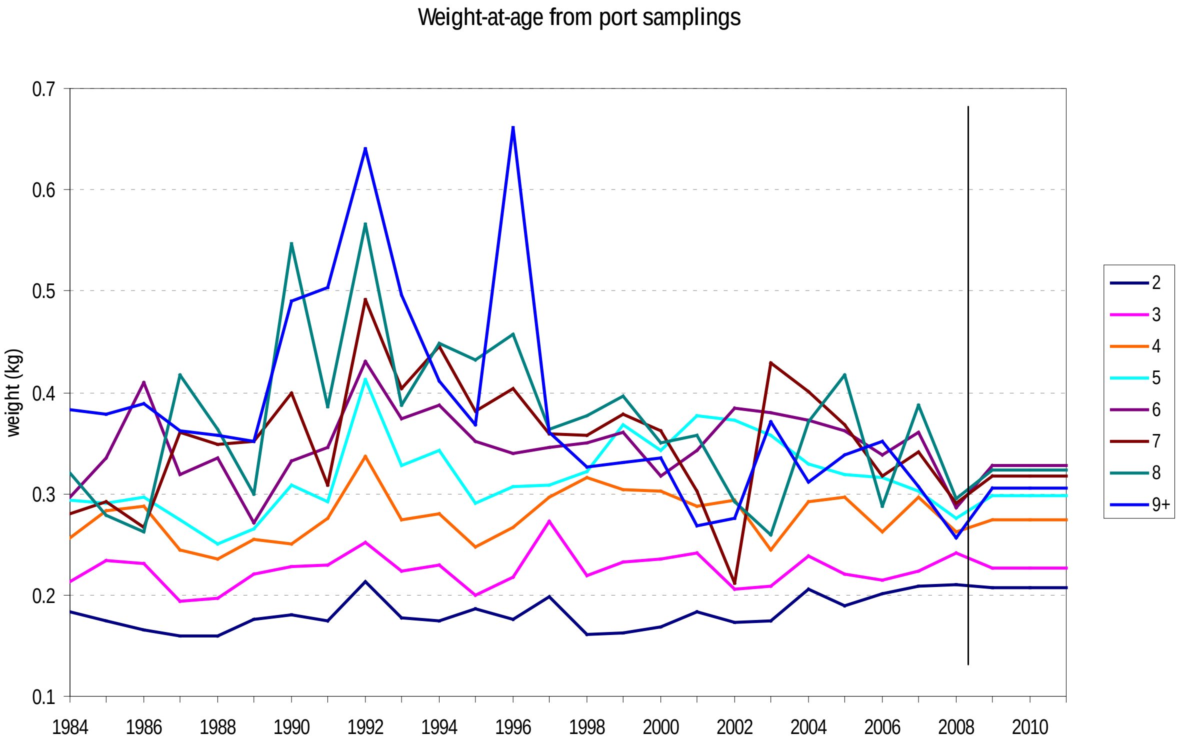


Figure 5.2.2.1. Sole IIIa. Landings weight-at-age. Weights for 2008–2010 are average weights used for short-term prediction.

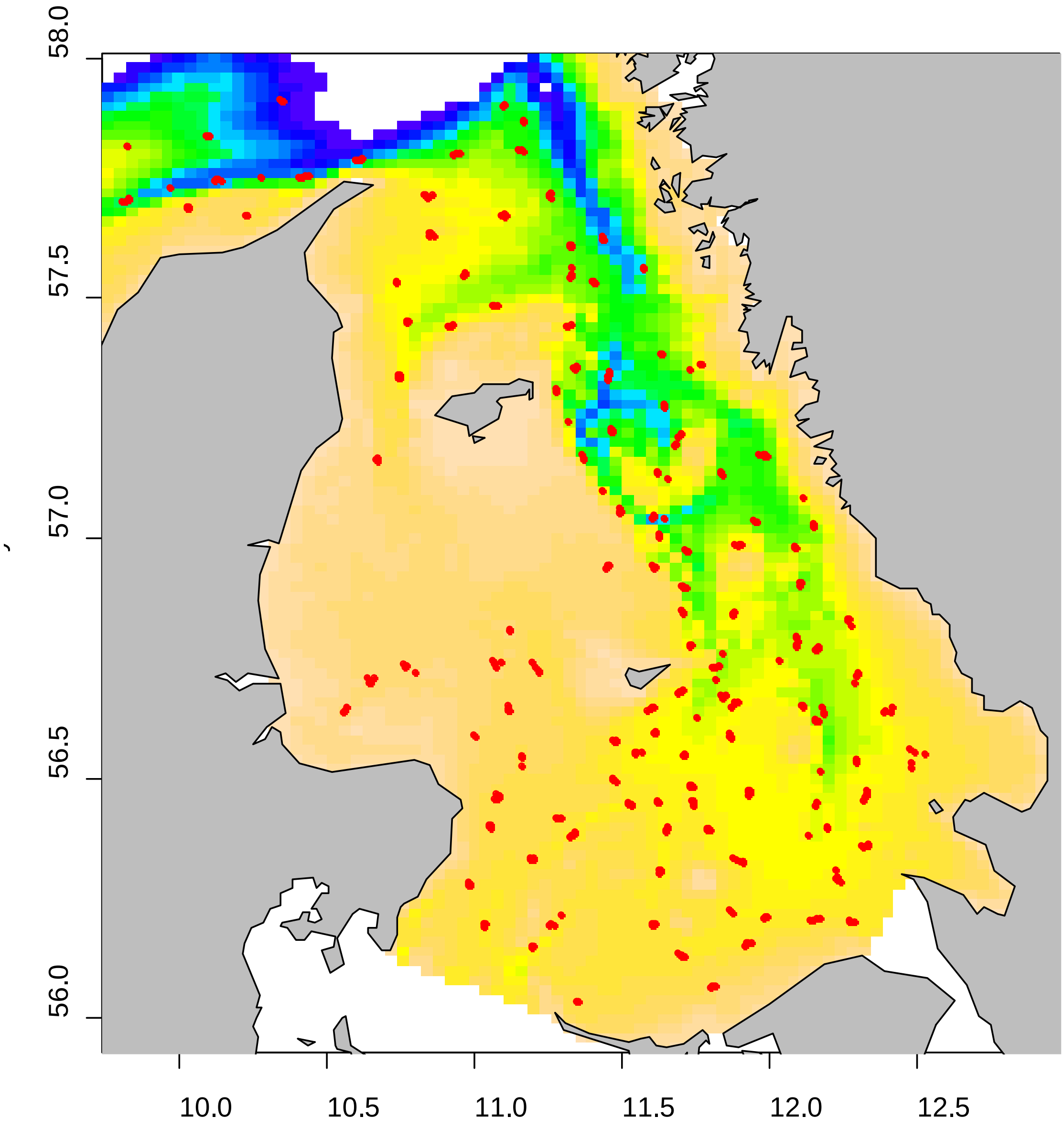
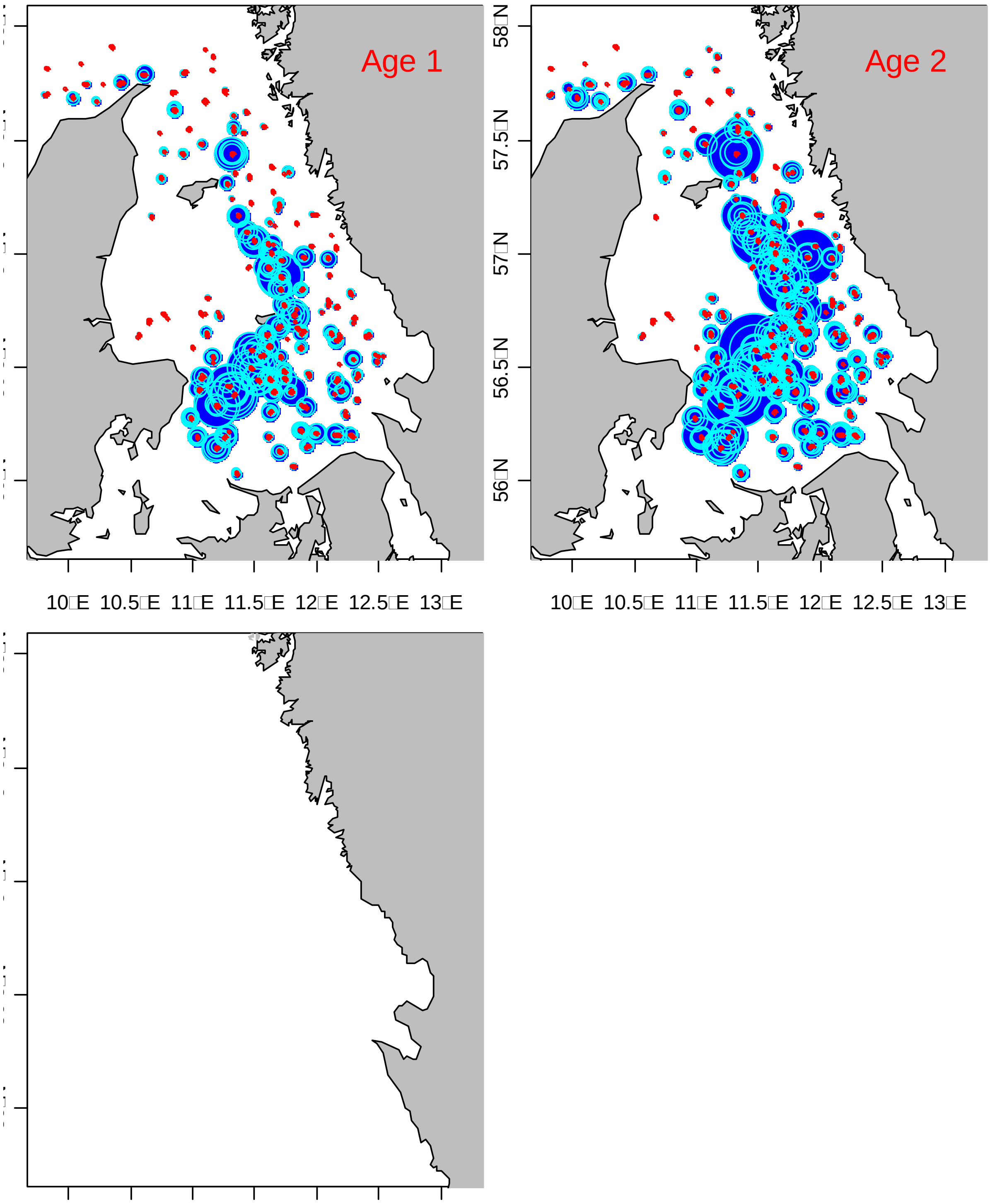
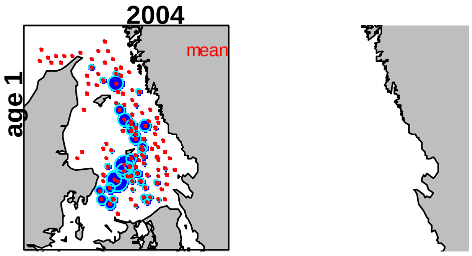


Figure 5.2.3.1. Sole in IIIa. Distribution of trawl stations (red points) and depth contours (0–100 m) from the 2004–2008 Fishermen-DTU Aqua survey.


Age 1
Age 2


2004
age 1
mean

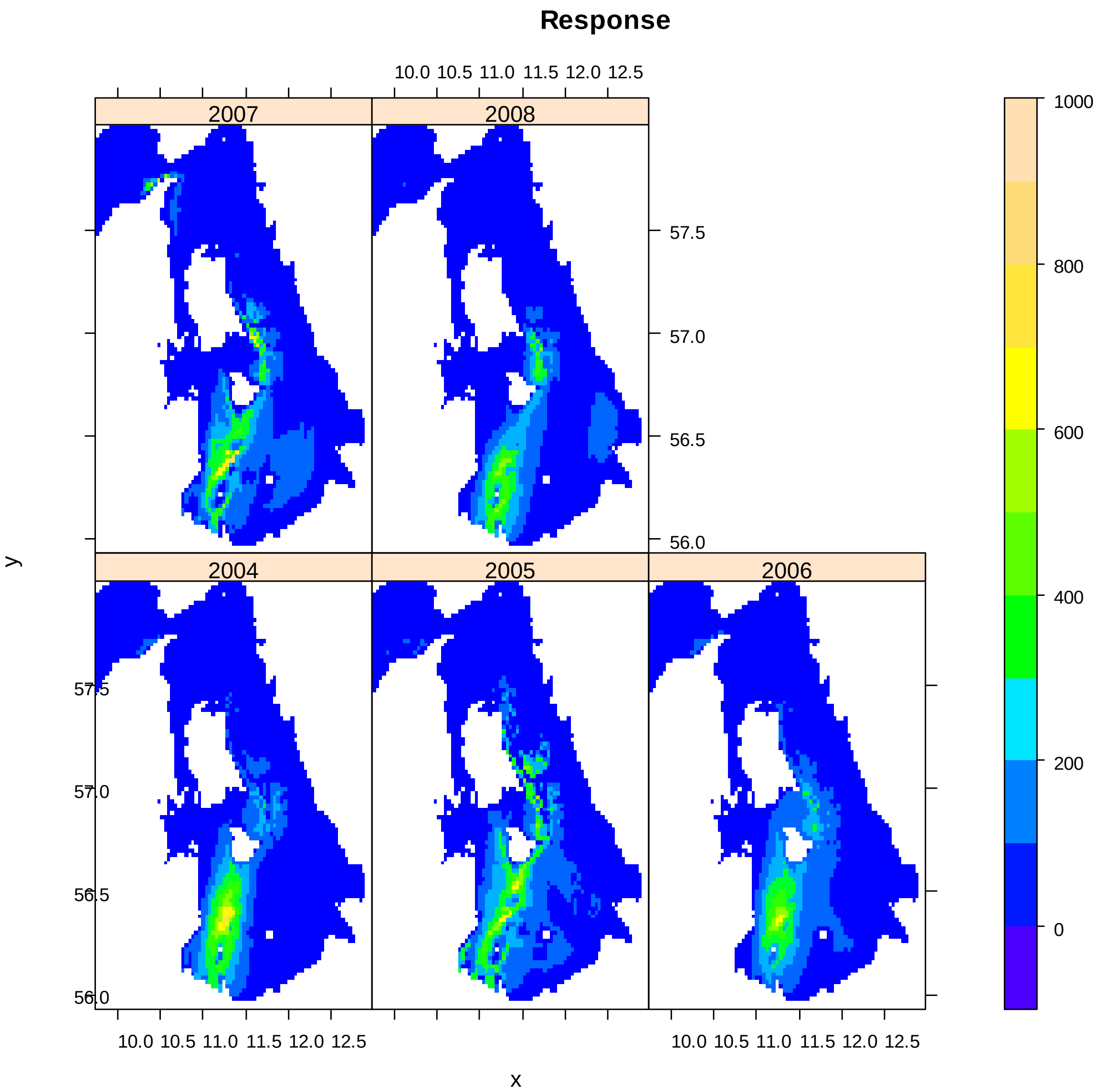


Figure 5.2.3.4. Sole in IIIa. Fisherman-DTU Aqua survey. Standardised cpue distribution (GAM) as a function of station-type, depth and positions for the years 2004–2008.

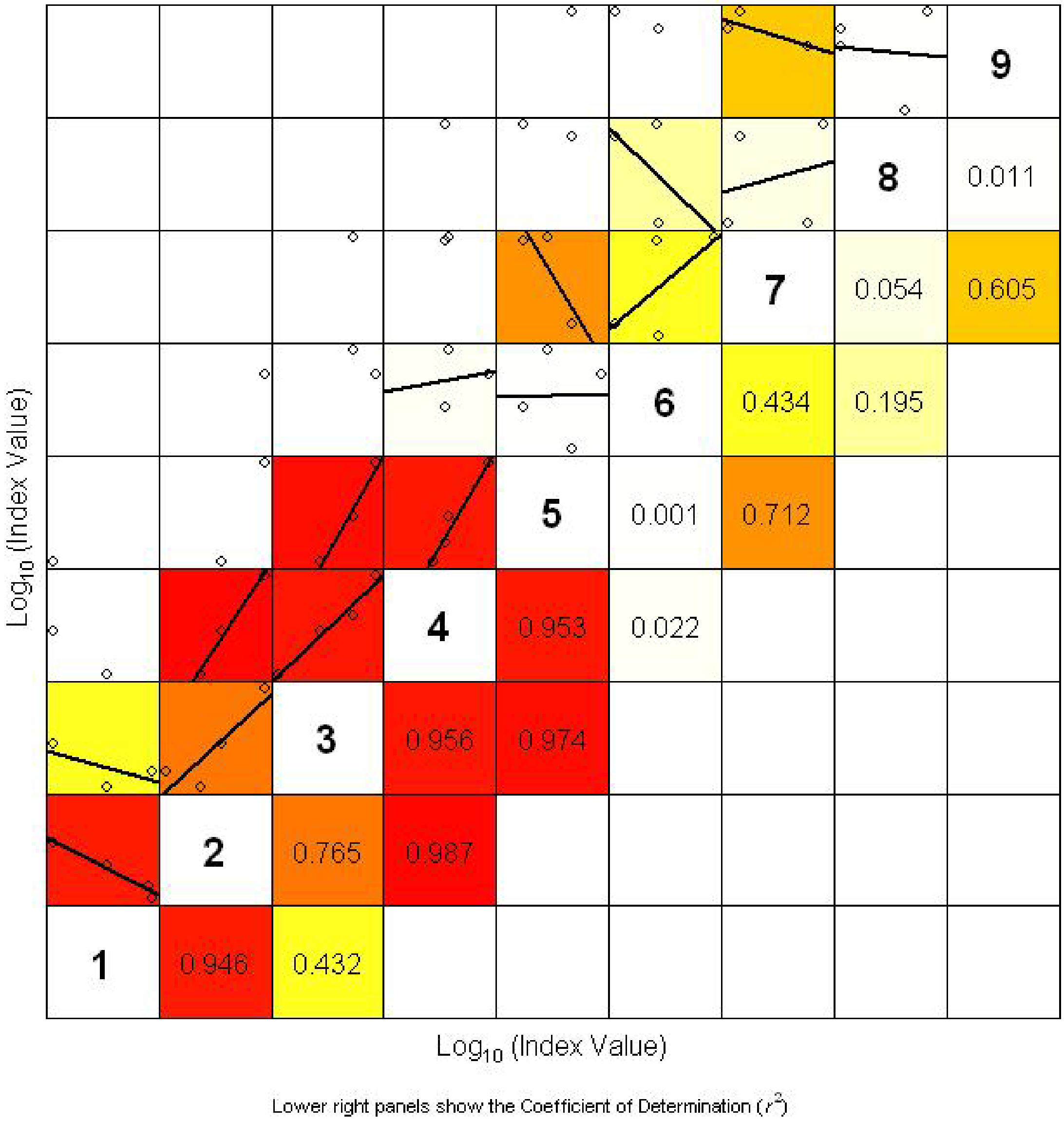


Figure 5.2.3.5. Sole in IIIa. Fisherman-DTU Aqua survey Internal consistency plot; log abundance of age at yearvs.age+1 at year+1.

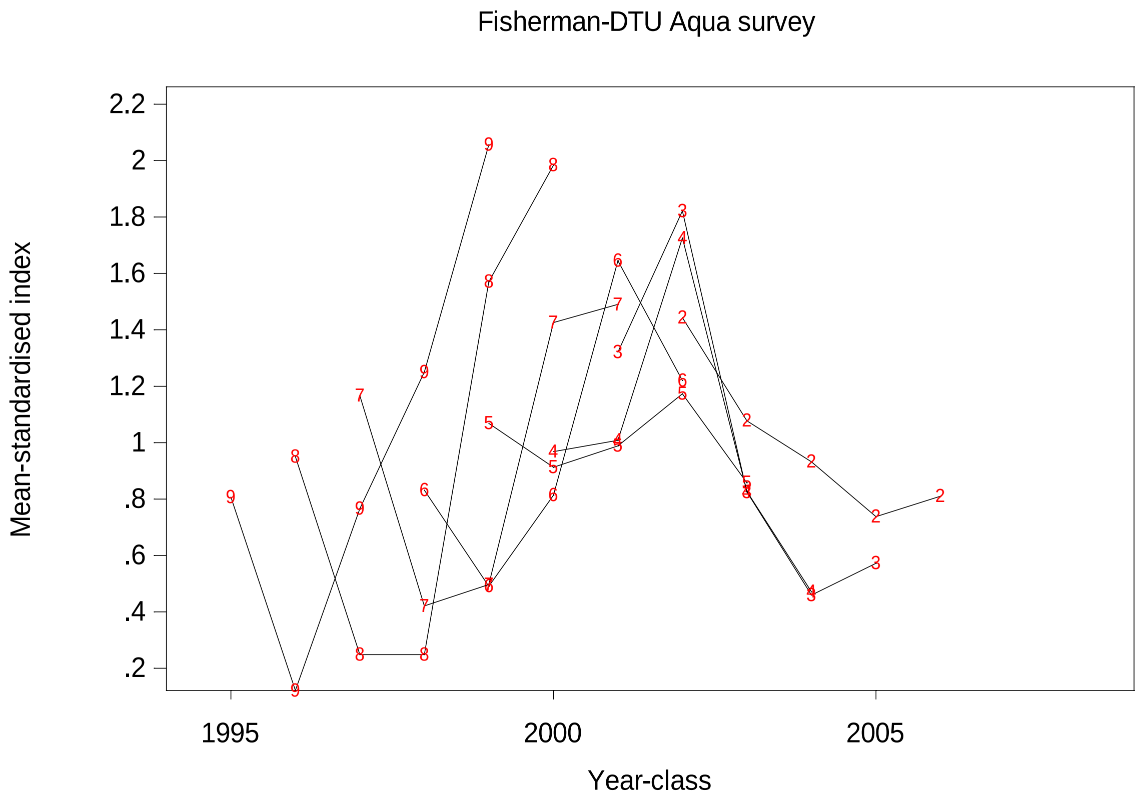


Figure 5.2.3.6. Sole in IIIa. Fisherman-DTU Aqua survey. Year-class abundance by age.

Figure 5.2.4.1. Sole in IIIa. Some major fishing grounds in Kattegat.

Figure 5.2.4.2. Sole in IIIa. Distribution of total effort (hours trawling) on major fishing banks.

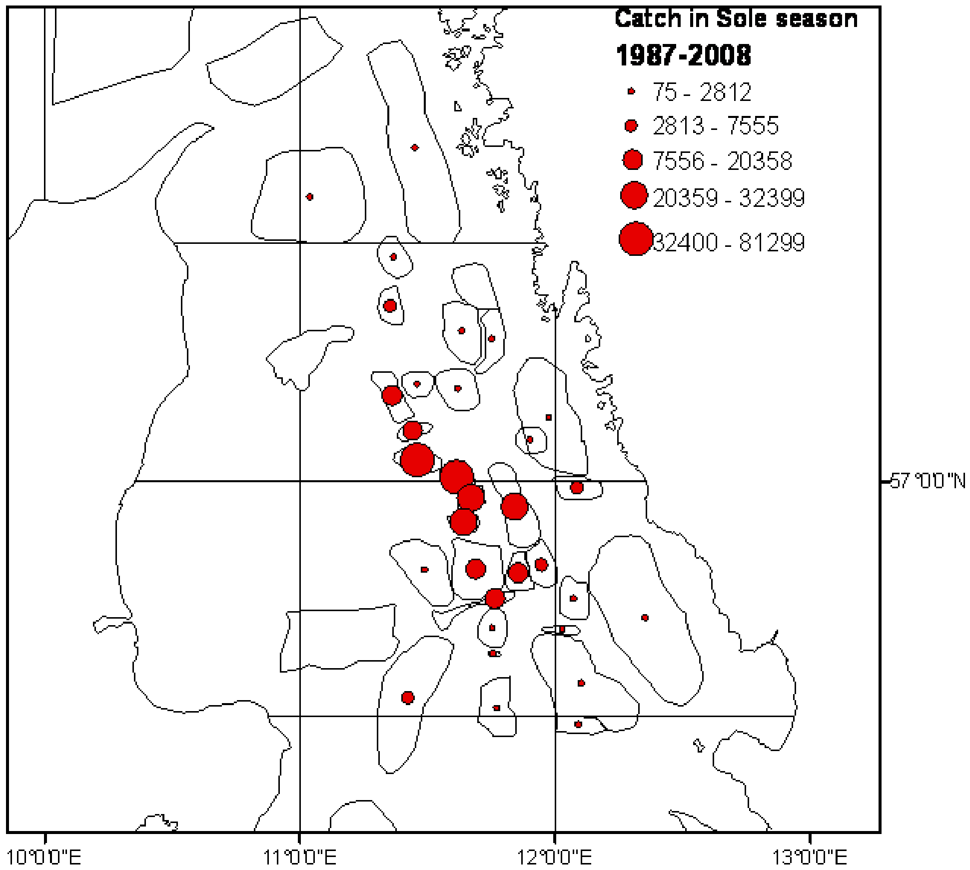


Figure 5.2.4.3. Sole in IIIa. Distribution of total trawl catches on major fishing grounds.

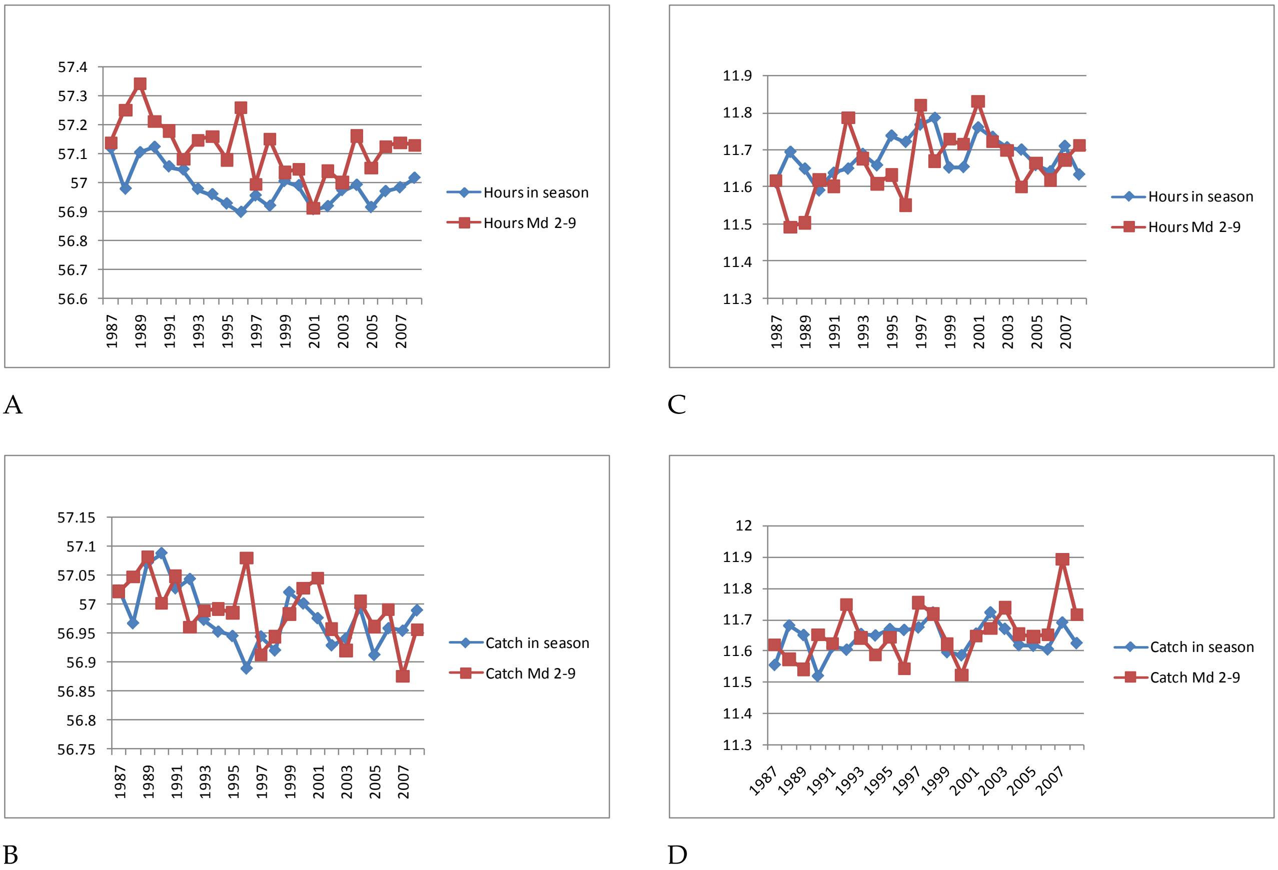


Figure 5.2.4.4. Sole in IIIa. Effort and catch weighted latitudes (A and B) and longitudes (C and D) of the trawl fishing in Kattegat 1987 to 2008.

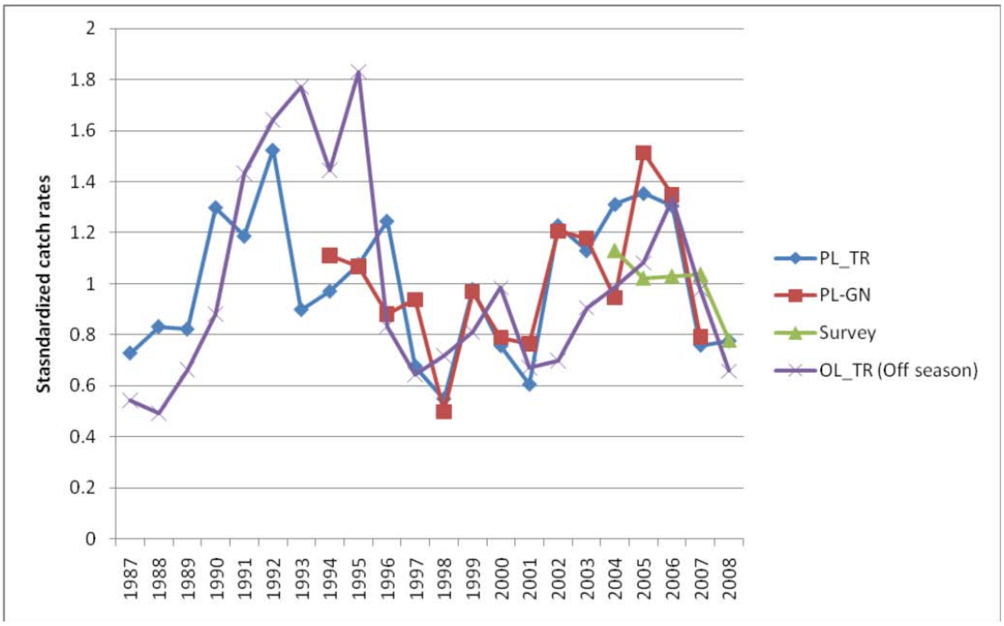


Figure 5.2.4.5. Sole in IIIa. Catch rate indices from private logbooks trawlers (PL-TR), private logbook gillnetters (PL_GN), official logbook trawlers outside the sole season (OL_TR) and from the sole trawl survey (Survey). The trawl indices are all measured as kg per hour trawling and the gillnet indices as kg per net. For comparison the annual indices are standardized to the means of the entire period.

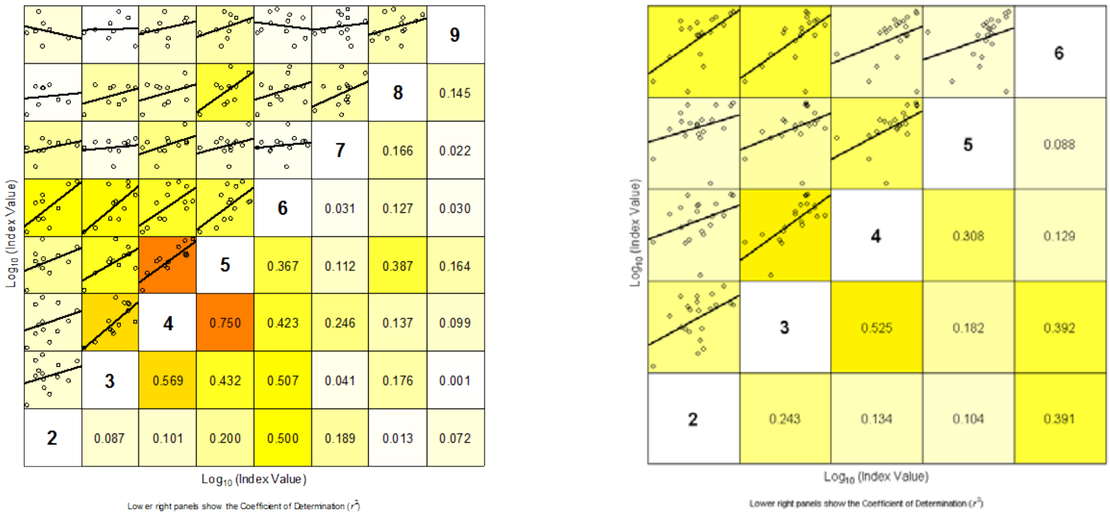


Figure 5.2.4.6. Sole in IIIa. Internal consistency for Private logbook cpue indices from gillnetters (left) and trawlers (right) by age.

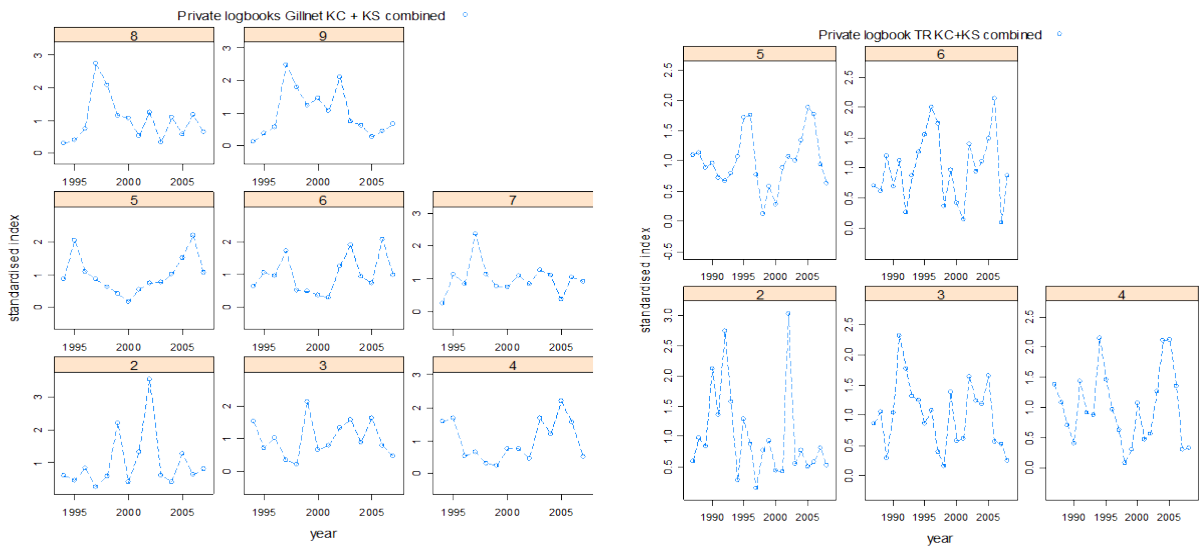


Figure 5.2.4.7. Sole in IIIa. Indices by age from private logbooks gillnetters (left) and trawlers (right).

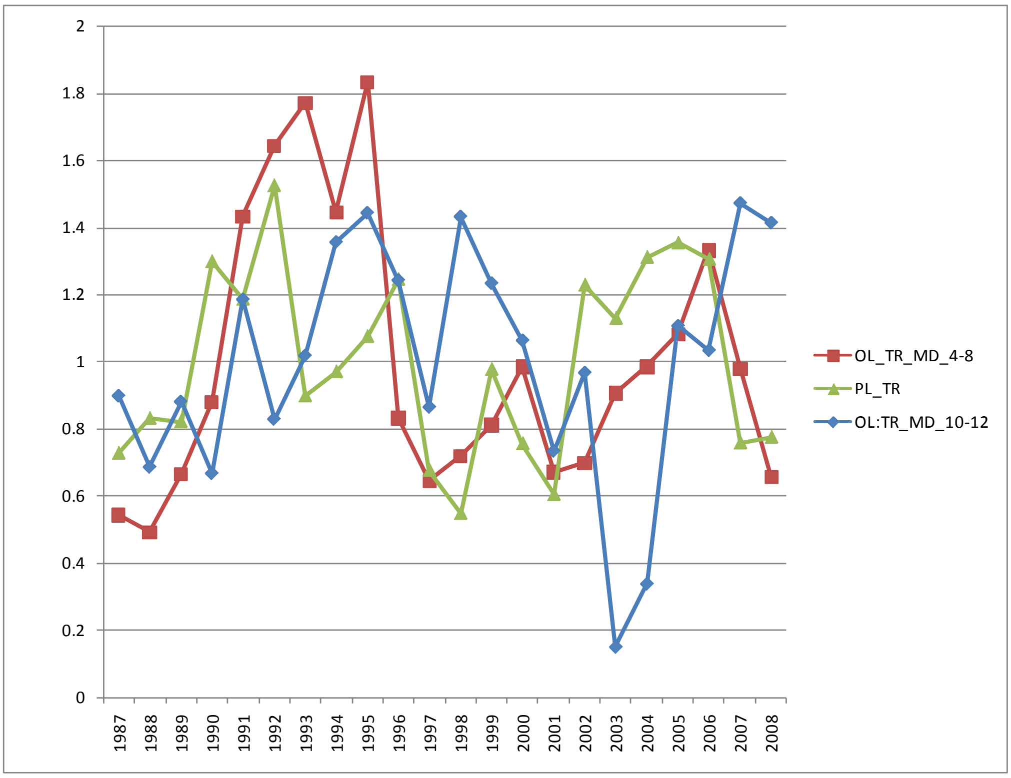


Figure 5.2.4.8. Sole in IIIa. Catch rate indices from trawlers based on private logbooks covering October to January (PL-TR), official logbooks covering April to August (OL_TR, MD_4–8) and official logbooks covering October to December (OL_TR, MD_10–12). The trawl indices are all measured as kg per hour trawling. For comparison the annual indices are standardized to the means of the entire period.

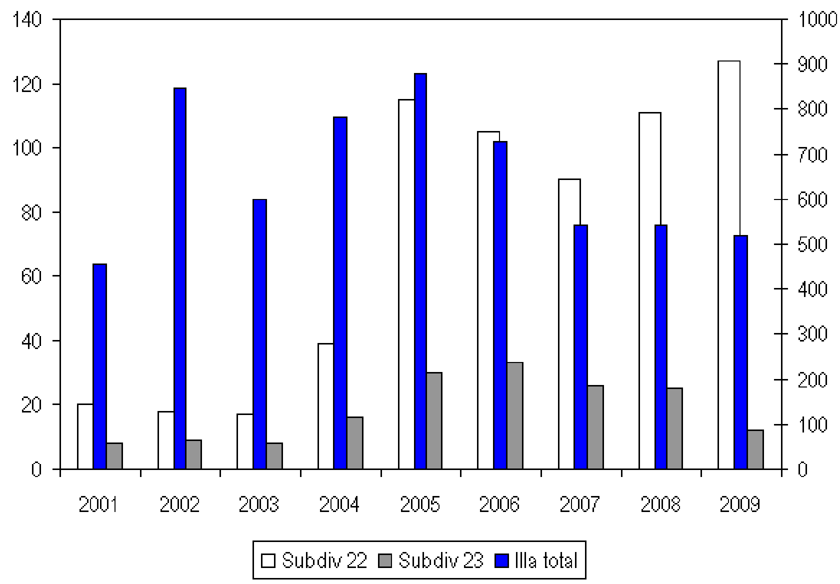


Figure 5.3.1. Sole in IIIa. Official landings (t) from Division IIIa (right y-axis) and Subdivisions 22, 23 and 24 (the Belts and western Baltic, left y-axis) in the years 2001–2009.

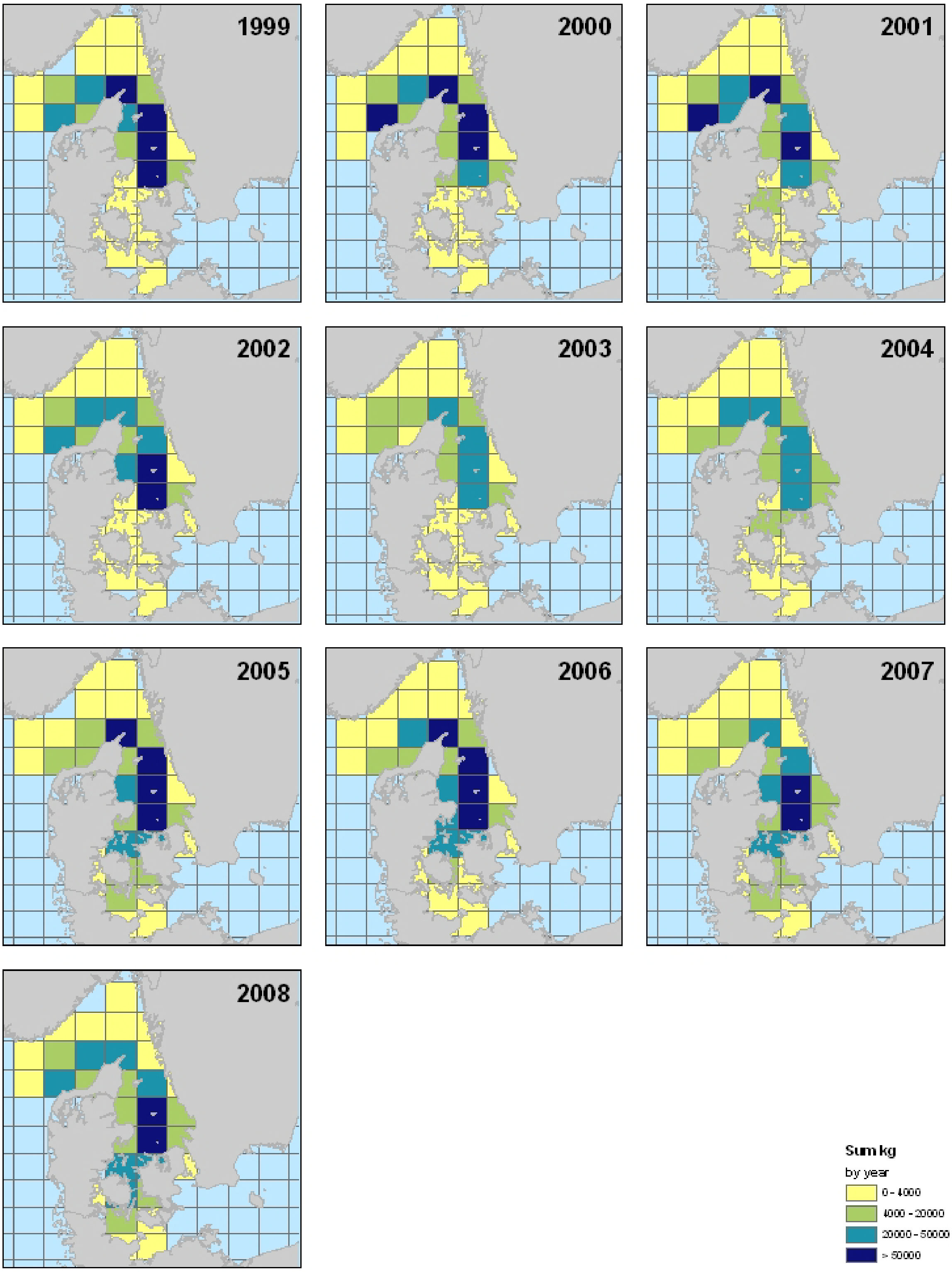


Figure 5.3.2. Sole in IIIa. Distribution of Danish sole landings by ICES square 1999–2008.

Figure 5.3.3. Sole in IIIa. Stock summary of baseline XSA (as of 2009 assessment) compared with an XSA including the Belt landings.

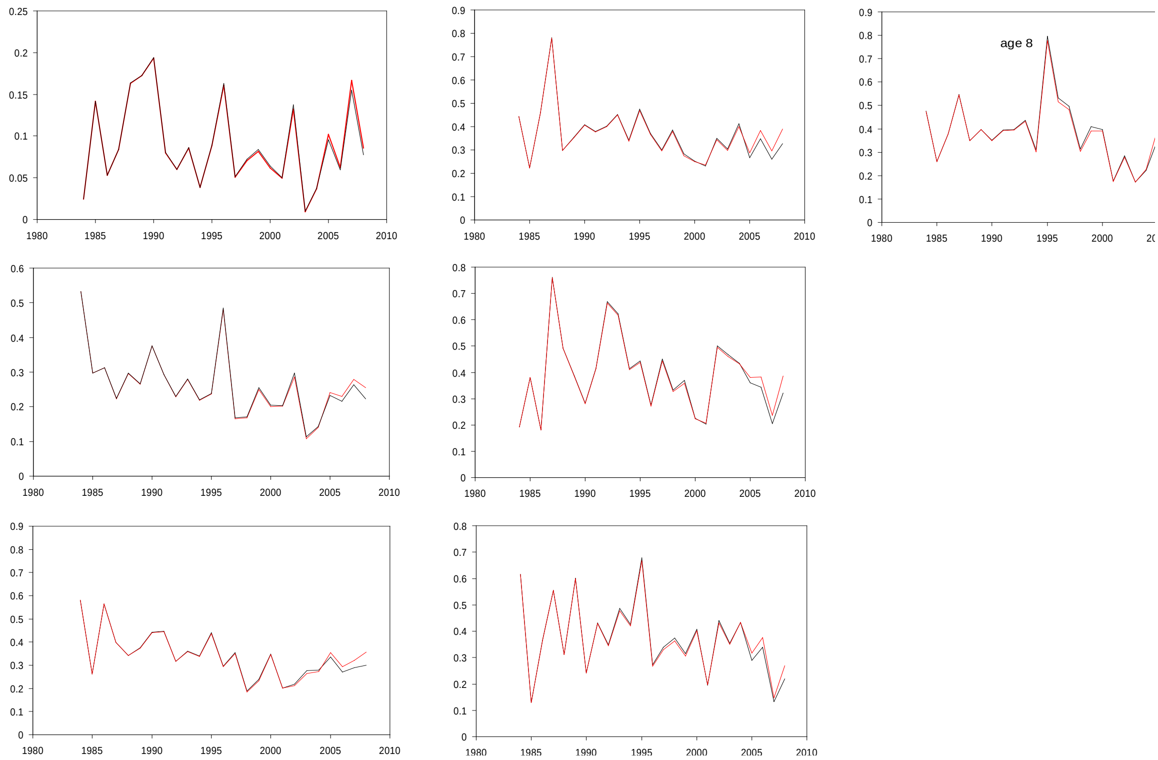


Figure 5.3.4. Sole in IIIa. Fishing mortality by age 2–8, SPALY (2009) XSAvs.XSA with Belt landings included.

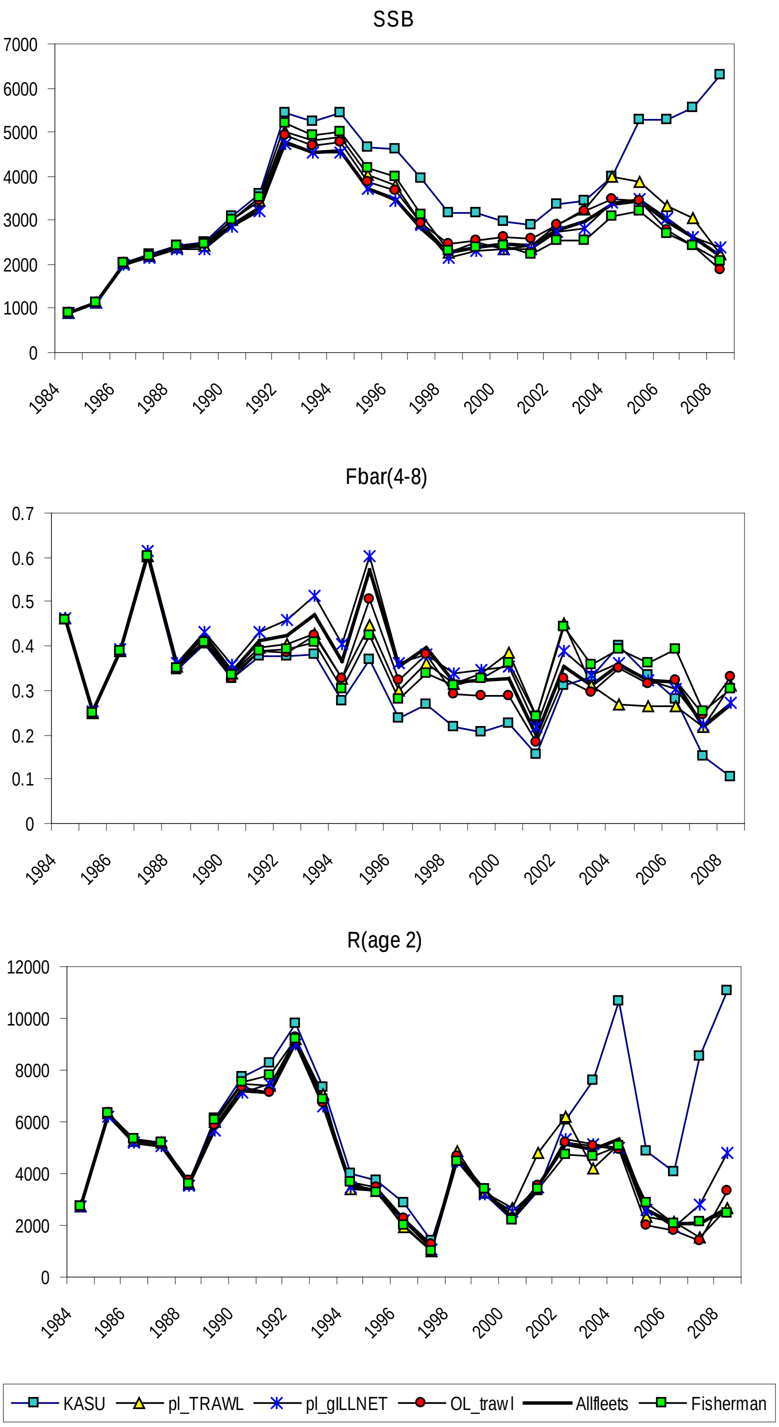


Figure 5.8.2.1. Sole in IIIa. Sensitivity analysis sole IIIa. Stock summary (SSB, F and R) from single fleet XSA runs.

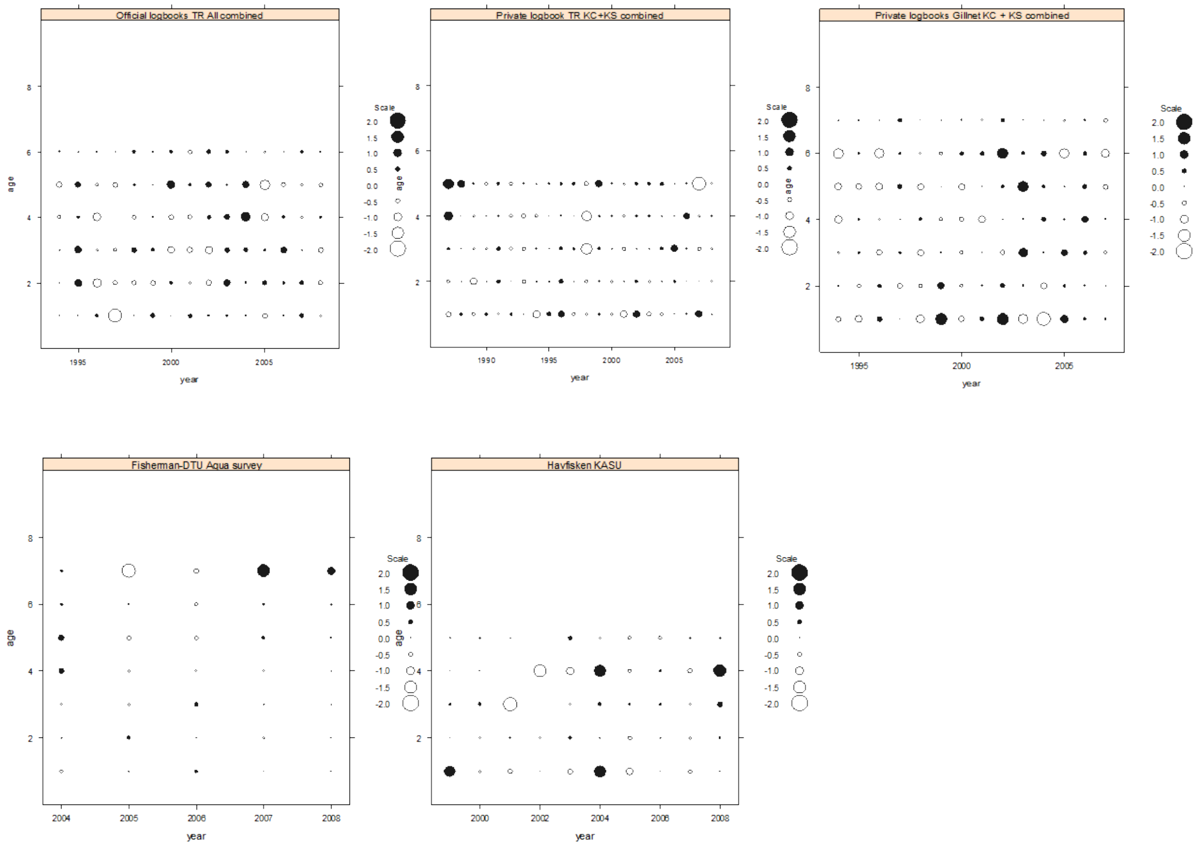


Figure 5.8.2.2. Sole in IIIa. Log catchability residuals from single XSA runs (y-axes are erroneously shifted by one, all indices start correctly with age 2).

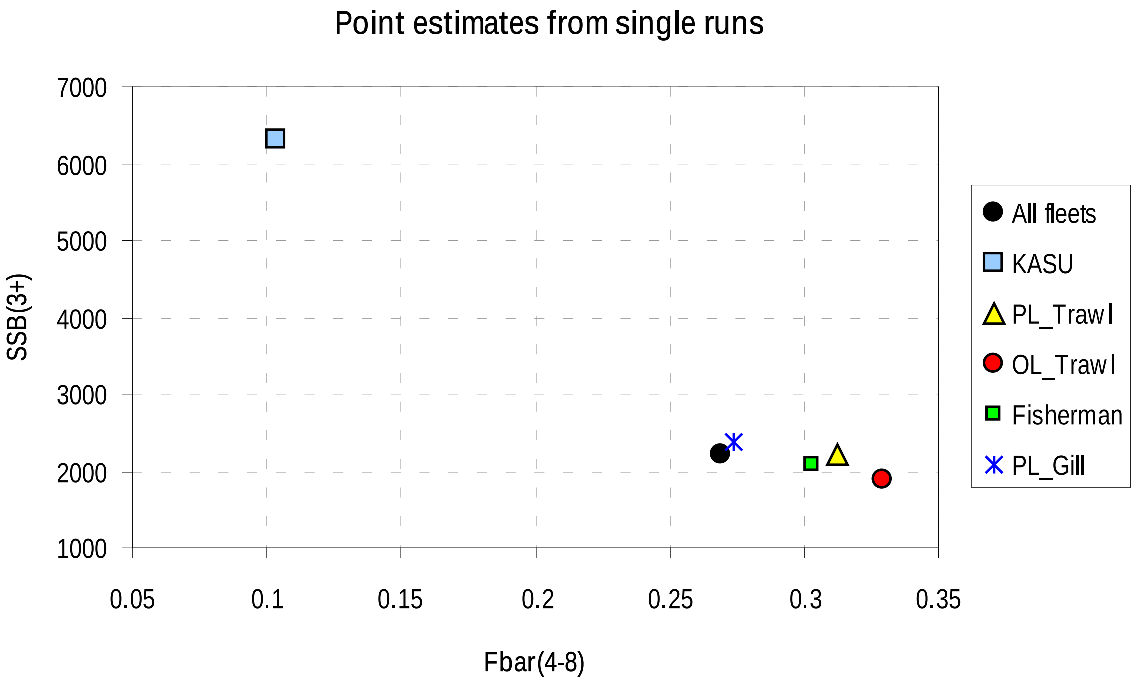


Figure 8.5.2.3. Sole in IIIa. Point estimates of SSB and F from single fleet XSA runs.

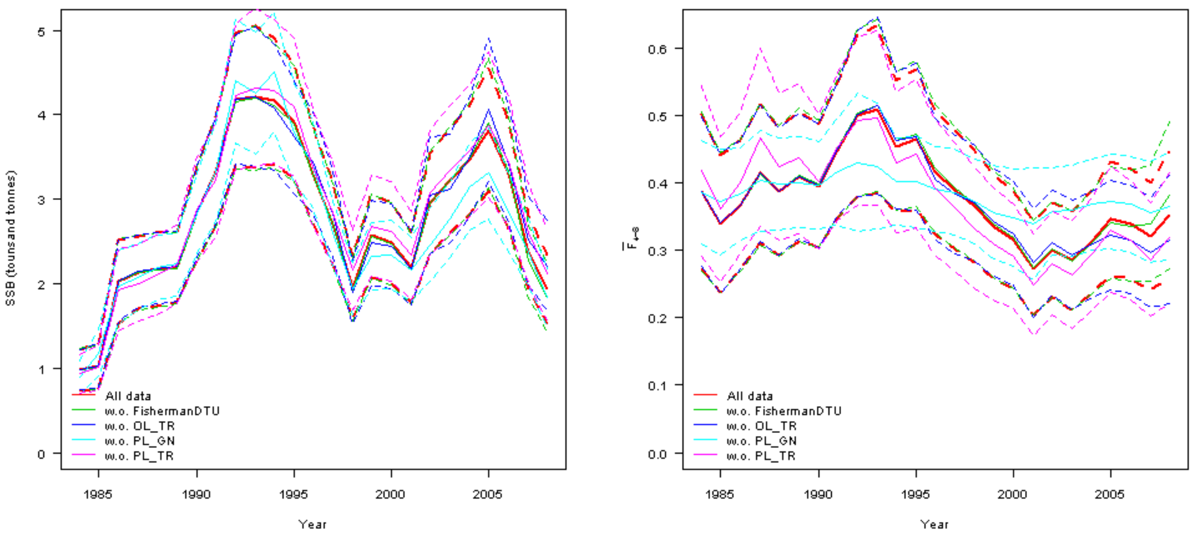


Figure 5.8.2.4. Sole in IIIa. SAM sensitivity runs (SSB and F) with one fleet omitted at a time. Conf. limits also shown.

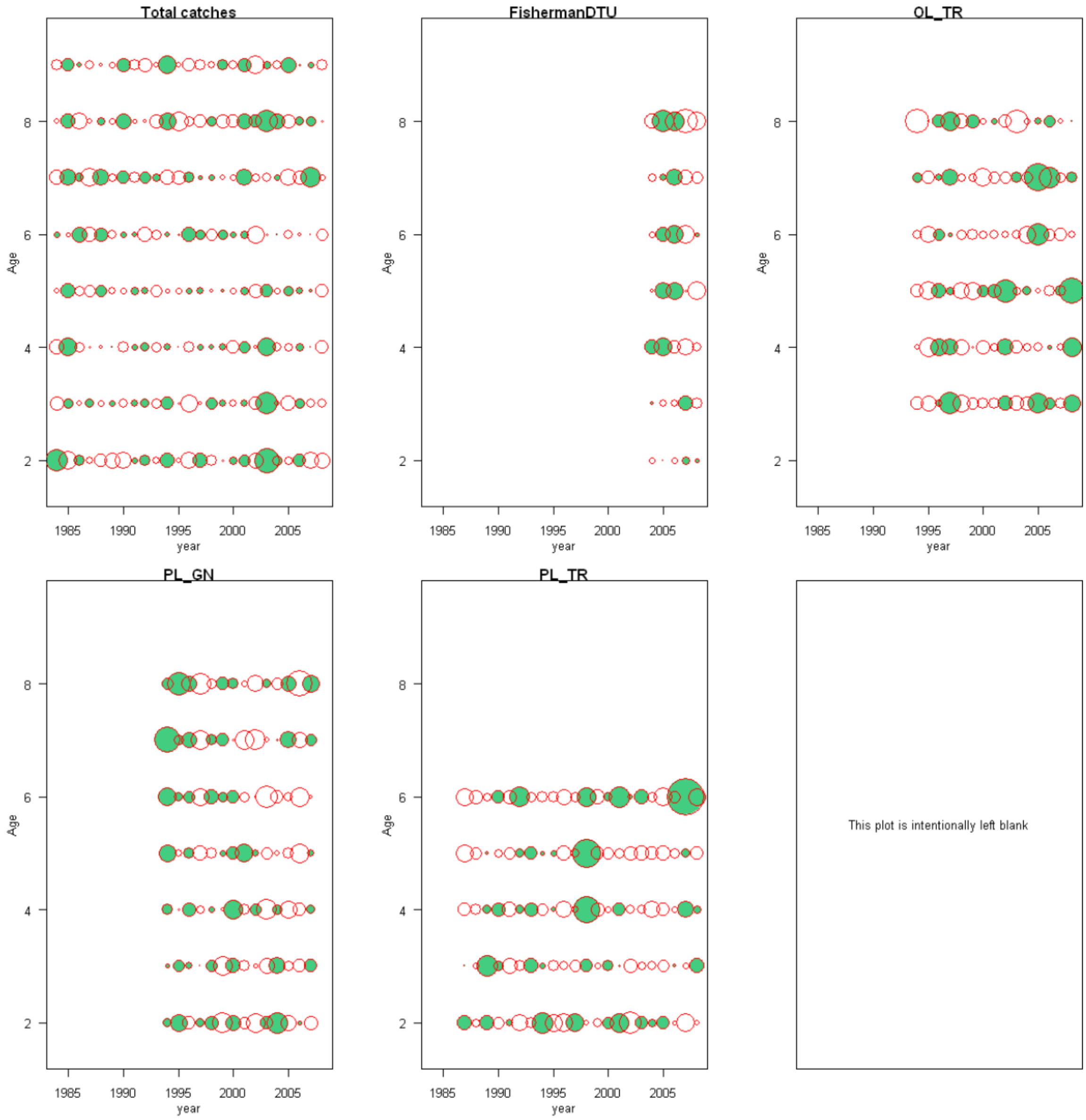


Figure 5.8.2.5. Sole in IIIa. SAM runs. Residuals of the model.

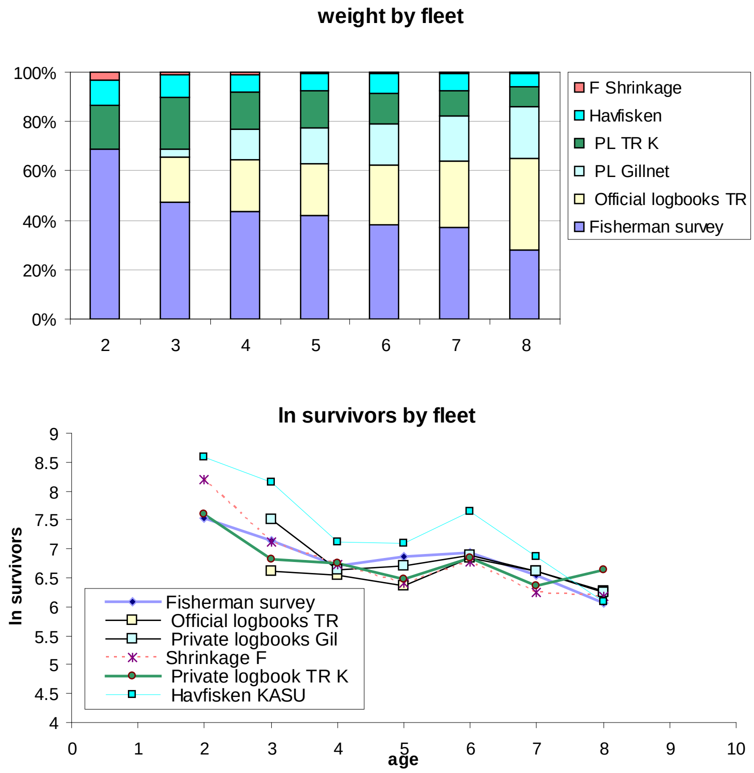


Figure 5.8.2.6. Sole in IIIa. Fleet weighting in an XSA with all available indices and survivor estimates provided by each fleet.

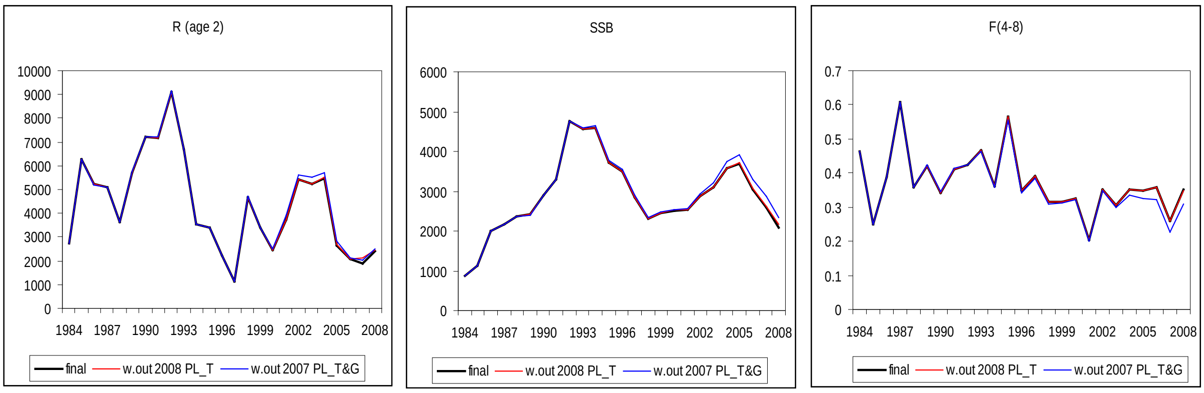


Figure 5.8.2.7. Sole in IIIa. XSA runs successively omitting the Private logbook series back to 2007 compared with the SPALY run – black curve. (red indicates omission of Private logbooks series trawlers in 2008, blue indicates additional omission of both private logbook series in 2007).

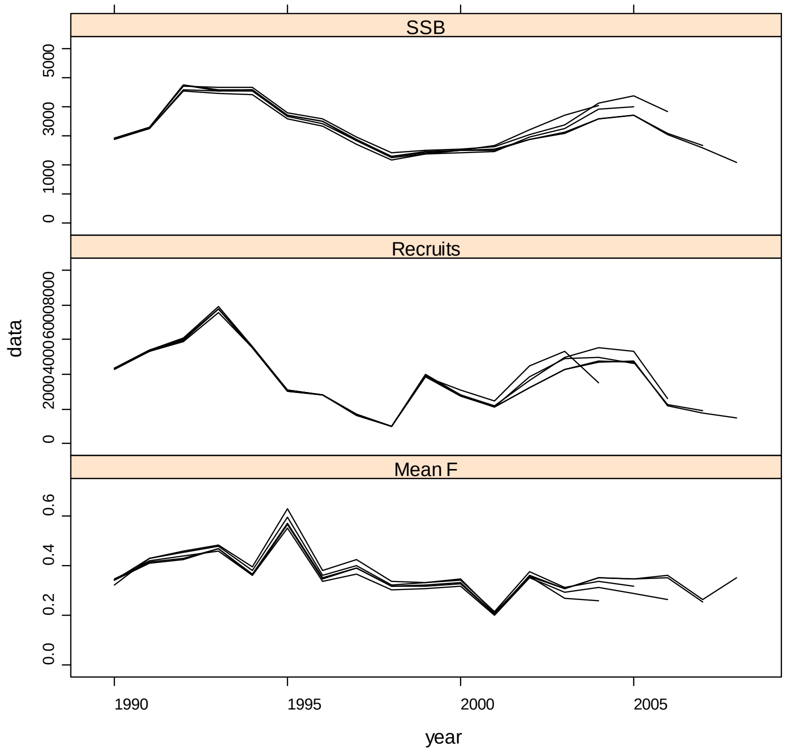


Figure 5.8.3.1. Sole in IIIa. SSB, F and R for retrospective runs of an XSA using final settings as adopted by WKFLAT 2010.

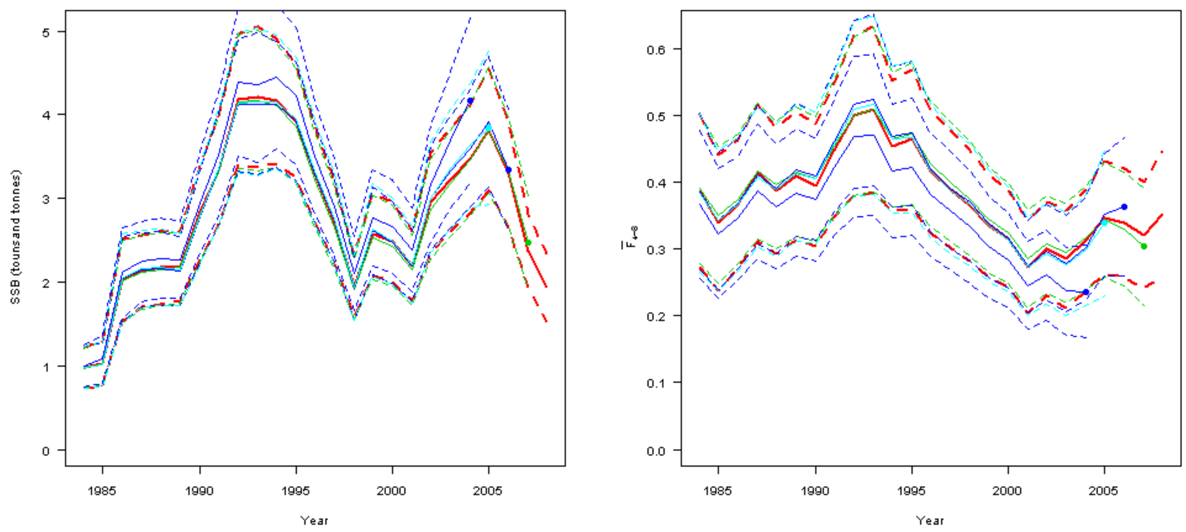


Figure 5.8.3.2. Sole in IIIa. Retrospective analysis of SSB and F using the SAM model (dashed lines are confidence limits). The model was calibrated tuning series as finally agreed on WKFLAT.

Figure 5.8.4.1. Sole in IIIa. Comparison of XSA and SAM runs, each with final settings as approved by WKFLAT 2010.

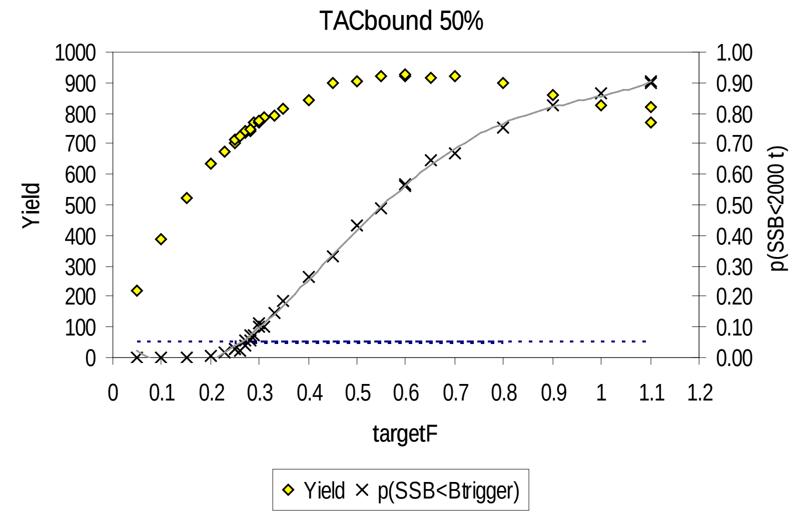
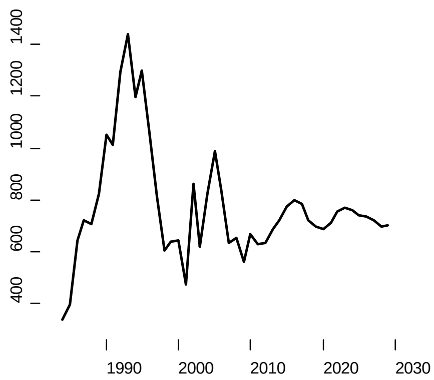


Figure 5.12.1. Sole in IIIa. Probability profile of p(SSB>2000 t) within the period 2013–2018 of scenarios with a range of target F's between 0.05 and 1.1. TAC in first year set to 800 t, $B_{trigger}$ set to 2000 t and maximum allowed TAC change between years set to 50%.

Sole in IIIa



Stock Annex: Sole in Division IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sole in Division IIIa
Working Group	Baltic Fisheries Working Group
Date	16 March 2010

A. General

A.1. Stock definition

Division IIIa represents the Skagerrak (ICES Subdivision 20) and Kattegat (ICES Subdivision 21), and is therefore part of the transition area between the North Sea and Baltic Sea. Sole are more abundant in the Kattegat than Skagerrak and spawning areas are believed to be located in the Kattegat and Skagerrak. Distribution of sole beyond the Kattegat into the Baltic Sea is limited by salinity which decreases further eastward. Sole are therefore found only in low abundances in the Belt Sea (ICES Subdivision 22) and the Øresund (ICES Subdivision 23). However, since 2004 the fishery for sole indicates that the share of the population inhabiting the Belts has been increasing, and therefore since 2010 sole in the Belts (Subdivisions 22–24) are included in this assessment (WKFLAT 2010).

Sole in the Skagerrak and Kattegat are geographically close to the northern limit of the long-term geographical distribution of the species (Muus and Nielsen, 1999), which ranges from Scotland and southern Norway south to the Mediterranean and Black Sea. Sole in IIIa typically spawn in late May/early June, which is later than spawning times for sole in the southern North Sea (April–June) and the Mediterranean (February; (Muus and Nielsen, 1999)).

Interactions and exchanges between sole in IIIA and neighbouring stocks, or within IIIa (i. e., between Kattegat and Skagerrak) may occur but are poorly documented. The former stock boundary in the east (i.e. limit at border between Kattegat and Subdivisions 22–23) were biologically based on the scarcity beyond the Kattegat. The boundary to the west (i.e. between Skagerrak and the North Sea) is likely porous to some extent due to migration of adults and/or drift of sole eggs and larvae. However, neither the direction nor magnitudes of exchanges have been described. It is more likely that there is exchange within the stock (between Skagerrak and Kattegat) because hydrographic conditions influence drift of eggs and larvae of another flatfish species (plaice) from Skagerrak to Kattegat (Nielsen *et al.*, 1998). Muus and Nielsen (1999) state that sole in the Kattegat is separated from the North Sea and better adapted for hard winters. New genetic studies are helping to clarify the genetic and biological basis for population differences (Draisma *et al.*, 2003).

Sole for assessment purposes in IIIa are assumed to mature at age 3 although there is little empirical data and no time-series to support this assumption. A similar assumption is used for assessment of North Sea sole and is consistent with Muus and Nielsen (1999) who state that sole mature between ages 3–5 and at sizes of 25–35 cm. A new sampling scheme to collect maturity information for sole in the Kattegat was started by Denmark in May 2003.

Sole in IIIa is a small stock compared with other sole stocks in the ICES area (e.g. North Sea, Bay of Biscay). Sole are nocturnal predators (Muus and Nielsen, 1999) and therefore more susceptible to capture by fisheries at night than in daylight.

A.2. Fishery

The major part of the sole catches in Kattegat and Skagerrak are taken in the mixed species trawl fishery using mesh sizes 70–105 mm and with gillnets using mesh sizes of 90–120 mm. Minimum legal landing size is 24.5 cm.

Sole have been exploited in the Kattegat and Skagerrak since at least 1952. The fishery fluctuated between 200 and 500 t annually prior to the mid-1980s. Landings increased to a maximum of 1400 t in 1993 and since then have decreased almost every year to a level about 600 t by the end of the 1990s. In 2002–2005 the fishery has became increasingly limited by quota restrictions, which gave an incentive for substantial misreporting. A revision of the perception of the stock in 2005 resulted in higher TACs that no longer limited the fishery and the incentive for misreporting. In 2007 a Vessel Quota Share system was put in force for the Danish fishermen that replaced the weekly catch rations regulation. This change in regulation allows the fishermen to adjust effort to suitable seasons with regard to weather, prizes, catch rates, etc.

Denmark takes more than 90% of the total Kattegat-Skagerrak catch. Kattegat is traditionally the most important area accounting for 70–80% of the annual catches. Since 2004 the Belts accounts for an increasing part of the total catches (approx 20% of IIIa and 22+23 catches in 2007–2008). Sweden and Germany are the other nations participating in the fishery.

Sole has been one of the most important species in the late 1990s in the Danish Kattegat fisheries and accounted for about 25% of the total value of the human consumption fisheries. The economic importance of sole is more limited in Skagerrak where it accounts for less than 5% of the total value of the Danish human consumption fisheries.

For the period 1991–1993 the official catch statistics are disputable with a very significant amount of sole assumed landed without being properly recorded. For Kattegat, where most of the sole catches in 1994–2000 were taken under the effort regime, the official statistics are assumed fairly accurate as there are no catch constraints.

However in 2000 and 2001, some catches from the North Sea were reported as being caught in the Skagerrak. These reported landings have been subtracted from working group estimates for these years and assessments from 2003 and onwards are based on the revised landings and catch numbers-at-age. Substantial misreporting in 2002–2005 (respectively 50, 100, 100 and 20%) under the weekly rations fishery has been added to the official catches to obtain total landings (WG estimates).

Danish discard sampling at sea is carried out within EU programmes that began in 1995 in both Kattegat and Skagerrak. However, the data from this programme is still incomplete and not applied in the assessment.

Discard levels are in general believed to be only a few percent when measured relative to the sole landings, a.o. due to the high price of sole. However, analyses of private logbooks, survey data, and observer data indicate that in 2002–2004 there was considerable economic incentive to landing without reporting as the entire two week ration in many cases could be taken in just a few hauls. However, it is not known to what extend the catches are discarded or landed as black landings (i.e. without providing both catch and effort data to the official statistics), or distributed to and landed by vessels not having caught their rations. Based on information from the industry estimates of non-reporting and discarding at 50% in 2002 and 100% in both 2003 and 2004 was included in the assessment from 2005. In June 2005 a new regulation was put in force with total quotas and weekly rations that not any longer limited the fishery, and therefore it is assumed that since June 2005 there is no incentive to mis- or nonreport the catches. The total misreporting for 2005 was due to those circumstances assumed to be approximately 20% for the entire year. For 2006 an onwards no misreporting is assumed to occur.

Mean fishing mortality (ages 4–8) has usually been 0.3–0.5 for all years (ICES, 2003).

A.3. Ecosystem aspects

Both salinity and temperature probably influence sole distribution and production in IIIa because the species' geographical distribution is confined to relatively warm, saline water (Muus and Nielsen, 1999). Large variations in either factor will therefore influence stock productivity and therefore availability to the fishery.

The Kattegat has also been eutrophied over the past 50 years and eutrophication has influenced many aspects of the Kattegat ecosystem, including occasional severe anoxia periods (Pihl, 1994; Isaksson *et al.*, 1994), increased primary production and possibly a change in fish productivity and species composition (Nielsen and Richardson, 1996). The specific effects of eutrophication on sole have not been investigated.

The large increase in landings in the early 1990s compared with long-term historical levels (1950s–1980s) may represent both changes in environmental conditions and fishery developments (e. g., increased effort) but the relative importance of the two factors is not known.

B. Data

B.1. Commercial catch

Denmark collects biological information (lengths, weights, ages) on a quarterly basis from commercial fisheries which is used for stock assessment. Landings data are supplied by Sweden and Germany by quarter separately for Kattegat and Skagerrak.

Data files are available from ICES.

Representative commercial fishing vessels are also monitored by DIFRES fisheries observers. These data provide information on catch rates and locations, and discarding rates.

B.2. Biological

No weight-at-age in the stock is available and therefore assumed to be the same as weight-at-age in the catch.

A fixed natural mortality of 0.1 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (M_{prop}) and the proportion of fishing mortality before spawning (F_{prop}) have been historically set to 0.

No time-series of maturity information is available for sole in IIIA. Danish sampling started in 2004 will develop a new time-series. Therefore, until then knife-edge maturity-at-age 3 is used for this stock. This is the same assumption as used for the North Sea sole.

B.3. Surveys

Four surveys are being conducted. One survey samples in shallow coastal waters (RV Havkat) and the other three surveys sample in open waters of the Kattegat and Belt Sea (RV Havfisken; RV Argos-IBTS and Cooperative Fishermen-DTU Aqua sole survey).

Two research vessels (RV Argos and RV Havfisken) capture sole in the Kattegat-Skagerrak. Descriptions of the sampling design, gears used and results are available in WG Docs. 11 (Jørgensen, 2005) and 10 (MacKenzie *et al.*, 2005) from the 2005 Assessment Working Group meeting. The main features of the surveys and findings are summarized here.

RV Argos IBTS survey

The ICES database includes four IBTS survey series covering Subdivision 3A. The surveys have mainly been conducted by the Swedish vessel Argos, but (very) few hauls have been conducted by vessels from other countries. The first quarter survey series dates back to 1983, the second, third and fourth quarter series cover the periods 1991–1995, 1991–2003, and 1991–1996, respectively.

Mean catches were very low (<2.0 sole per hour) in the second and third quarter and the time-series from the fourth quarter was very short; only the time-series from the first quarter have been used previously (ICES, 2005; Jørgensen 2005).

There were very few soles in hauls at depth >110 m in the first quarter surveys. These hauls have been excluded from further analyses. The number of valid hauls (including hauls without sole) varied from 28–41 per year. Catches were low before 1990 (mean number of sole per hour <2.0; Figure 3.1). Since then mean catches have fluctuated between 1.0 (2001) and 23.1 (1993) sole per hour (ICES 2005; Jørgensen 2005).

None of the sole from the IBTS survey are aged using otoliths. Ages were estimated by applying age–length-keys from the commercial Danish fishery in Skagerrak and Kattegat for 1984–2004. In the pooled key there were no observations <17 cm and data from the Danish sole survey in autumn 2004 were applied (MacKenzie *et al.*, 2005). The age-specific abundance indices were used as an exploratory tuning fleet in XSA runs at the 2005 assessment meeting but not included in the final run. Presently, the Argos IBTS survey is not used in the assessment.

RV Havfisken survey description

The RV Havfisken typically visits 30–40 stations per year in the Kattegat and Belt Sea. The survey is designed for catching mainly cod and plaice in daytime hauls. The surveys started in October 1994 and since 1996, surveys are also conducted in March. Average abundances for the Kattegat have been calculated. All soles captured by the survey are length-measured. The Havfisken survey is a general survey of juvenile demersal fish abundances in the region, and is not designed specifically to estimate sole abundance.

In the early years of the survey, only a small non-representative part of the sole catches were aged using otoliths. It is therefore not possible to produce annual age–length keys for the spring or fall surveys. Age information from all years has been combined by quarter to increase sample size. Age-specific abundance indices from the surveys were then derived from length measurements converted into ages indices using the combined quarter specific age–length key.

The age-specific catch rates for the Kattegat (Subdivision 21) have been averaged across stations to produce annual abundance indices. Abundances in the Kattegat are higher in fall surveys than spring surveys, particularly among the younger age groups (ICES 2005; MacKenzie *et al.*, 2005).

Sole abundances increased from 2001–2004 and the spatial distribution has expanded during the same years (ICES 2005; MacKenzie *et al.*, 2005). However, in 2005, sole abundances decreased compared with 2004; the decrease was approximately 50% for the age; groups 2 and 3, which are the ages most commonly caught in this survey. Sole abundances appear to have decreased, relative to 2004, more in the Kattegat than in the Belt Sea.

The relative abundance of year classes within the survey demonstrates some consistency across years. Abundant year classes of particular age groups generally appear as abundant in the following year. This is particularly true for the younger age groups (2 and 3 year-olds).

The age-specific indices were used as a tuning fleet in the sole XSA assessment until 2009 assessment. The establishment of the cooperative Fisherman-DTU Aqua survey in 2004 has in 2010 lead to the use of this survey in the assessment instead of the Havfisken survey that was mainly designed for other species.

RV Havkat survey description

This survey is conducted in summer (ca. mid-July to early mid-August) along the Danish coast of the Kattegat. It has been conducted since the 1950s but with a large gap in sampling in the 1970s to 1985. Since 1985 the survey has been conducted almost annually. These data are reported here because the database for earlier years is still under preparation. Some additional details of the survey are given elsewhere (Nielsen *et al.*, 1998; MacKenzie *et al.*, 2005).

The survey typically captures several hundred juvenile sole annually, but abundances differ between areas along the coast. The frequency distribution of sole body lengths demonstrates that most sole captured are 10–14 cm long. For purposes of estimating year-class strength, the length range 7–16 cm was chosen to represent 1-group sole (MacKenzie *et al.*, 2005) applied in exploratory RCT3 runs by WGBFAS 2005.

The average abundance of 1-group sole at all sites along the Danish Kattegat coast was ca. 10/10 min. haul (MacKenzie *et al.*, 2005). However since 1997 there have been three years with somewhat higher abundances (15–20/10 min. haul). In 2004 the abundance was only about half the long-term average.

There are spatial differences in the abundance of 1-group sole along the Danish coast. Abundances are highest at area 2 (central-northern Kattegat) and lowest in area 7 (southern Kattegat). As expected therefore the time-trend at site 2 is most similar to the Kattegat-wide time-series. Site 7 (southern Kattegat) however has a large increase in 2003 and 2004 compared with previous years. This pattern is not present at site 2 or the Kattegat-wide time-series (MacKenzie *et al.*, 2005).

Presently, the Havkat survey is not used for recruitment estimation in the assessment.

Cooperative Fishermen–DTU Aqua Sole Survey

In 2004 National Institute of Aquatic Resources (DTU Aqua) (former DIFRES) initiated a survey-series targeting sole in Skagerrak and Kattegat in cooperation with The Danish Fishermen's Association. The purpose is to establish a time-series of catch and effort data independent of the commercial fishery in order to strengthen the scientific advice on the sole stock in ICES Division IIIa. However, data on all commercial species are recorded. In 2005 the survey design was changed slightly in order to allow estimation of trawlable biomass and abundance. Two commercial trawlers conduct the survey without any restrictions in the vessels quota and with dispensation from all bycatch regulations. Staff from DTU Aqua is on board the vessels during the surveys.

The survey was originally designed in order to establish fisheries independent cpue indices by means of annual fishing at 120 fixed stations. In 2005 the survey design was changed slightly: the number of stations selected by the fishermen was reduced by 10 from 60 to 50, while the number of stations selected randomly by DTU AQUA was increased to 70. These 70 randomly distributed stations allow an estimation of the trawlable biomass and abundance for the entire survey area. As there are no stations deeper than 90 m the biomass and abundance are estimated for depths between 10 and 90 m. The survey area is stratified by ICES squares and the area between 10 and 90 m is estimated. There is at least 5 mile between each station in order to spread out the stations (there are a few stations with lesser distance between, but then there is great difference in the depth).

From WGBFAS 2010 the survey abundance by age are used to calibrate the assessment as a tuning-series. The survey is documented in a WD to the WG each year.

B.4. Commercial cpue

Official logbooks

Prior to 2005 the sole assessment was calibrated by catch rate indices from two commercial trawl fisheries (using 70–90 mm and 90–104 mm mesh size respectively). However, ICES (ICES, 2004) considered that these cpue indices could be compromised due to lack of knowledge of fisherman targeting behaviour and the effect of misreporting, particularly in years with restricting quotas and TACs. This concern was confirmed by a study evaluating the impact of the ration system on the incentive to misreport (Hovgård, 2005, WD at WGBFAS 2005). The study concluded that since 2000 the rations (allocated as individual weekly or half monthly rations) have been increasingly restrictive in the sole fishing seasons as most vessels reached the ceiling of their rations due to the mismatch between the catch potential and the ration. During these periods the incentive to misreport was considered to have been high. Outside the peak seasons for sole fishery (i.e. April to August for trawlers and January to April for gillnetters) it was found that most often the sole rations were not entirely utilized and therefore not constraining the fishery.

Considering the limited incentive to misreport the catches of sole outside the peak seasons, in 2005 WGBFAS replaced the commercial tuning fleets with three new catch rate indices based on data from large trawlers, small trawlers and small gillnetters, all fishing outside the main sole seasons. In 2005 only large trawlers and gillnetters were kept as tuning fleets.

At the WGBFAS 2007 meeting the commercial gillnet fleet was rejected due to an abnormal increase in cpue since 2004, which could have been caused by a shift in the fishery pattern from June 2005 when non-restrictive quotas were introduced.

Regarding official logbook indices within and outside the sole season, it was noted by WKFLAT that the discrepancy between the two indices observed in the early 2000s indicates that the catch rates within the sole season indeed were biased as suggested by Hovgård (2005), supporting the decision by WGBFAS in 2005 to exclude them from the assessment.

Since 2007 only large trawlers outside the season have been used in the assessment among official logbook information.

Private logbooks

Due to the lack of unbiased catch rate indices, DIFRES, in collaboration with the Danish Fishermen Organisation, in 2004 established a database with data from private logbooks for calibration of the sole assessment.

The private logbooks covers the period from 1987 to 2008 and provides information on effort (number of hours trawling/number of nets) catches (kg by major species or species group) and location (name of fishing ground) from 7 trawlers and 3 gillnetters ranging in size from 15 BRT to 111 BRT and with an engine capacity of 150 to 450 HP.

Only data from the main sole fishing areas (Central Kattegat and Southern Kattegat) and the main seasons (October to January for trawlers and April to October for gillnetters) are applied in the assessment.

Catches from the private logbooks (by year, quarter, area and fleet) are distributed on age group in a two step procedure. First, the total catches are split into the two commercial size groups used by the industry assuming that they have the same size distribution as catches included in the official logbook database. Subsequently, the catch of each of the two commercial size groups are distributed into age groups assuming that the age structure of the private logbook catches is similar to the age structure of the official landings given by the Danish harbour sampling programme.

Further details on the private logbook programme were given by Christensen (2006).

Catch rate indices from the private logbooks were applied to calibrate the sole assessment from 2005. From 2005 to 2008 the database was updated annually. In addition to entering the new data, in some cases the data from former years was reevaluated; in particular information about fishing location were corrected or added if missing. However, sensitivity analysis indicated that updating the historical data had marginal implication on the assessment results only.

Assessment year	Gear	Area	Period
2005	Trawl (70–104 mm)	KC	October to January
	Trawl (70–104 mm)	KS	October to January
	Gillnet	KS	April to October
	Gillnet	KC	April to October
2006 onwards	Trawl (70–104 mm)	KC+KS combined	October to January
	Gillnet	KC+KS combined	April to October

In 2005 four tuning fleets based on the private logbook data were applied to calibrate the sole assessment (text table). Following the recommendation of the Assessment Review Group (ICES, 2005) in 2006 the number of private logbook tuning fleets was reduced to two by combining the areas. Sensitivity analysis indicated that aggregating the tuning fleets did not have a major impact on XSA result in the final run.

During the benchmark assessment in 2010, the consistency and reliability of private logbooks collected annually were discussed. Whereas WKFLAT considered the historical data likely to be unbiased the Group was concerned that given a future situation with incentive to misreport catches, also the private logbooks might be compromised. As, furthermore, the number of vessels participating in the voluntary logbook programme has declined over time, in 2010 WKFLAT concluded that the tuning-series should be maintained in the assessment without being updated in future.

B.5. Other relevant data

None.

C. Historical stock development

Model used until 2009 assessment: XSA under following conditions:

Software used: IFAP/Lowestoft VPA suite

Model Options chosen for the final assessment by WGBFAS since 2006:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 7

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

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

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Model agreed on WKFLAT 2010 to be implemented at WGBFAS 2010: A **S**tate-space **A**ssessment **M**odel (SAM) (reviewed at WGMG 2009 at http://www.ices.dk/reports/SSGSUE/2009/WGMG09.pdf) under the following conditions:

Software used: AD model-builder implemented into Internet user-interface (http://www.sole3a.stockassessment.org), requires password.

Model options are conceptually different from options in previous XSA and therefore not provided here, but available at Internet address above (see model.cfg file).

All input data equal to previous XSA apart from these changes adopted at WKFLAT 2010: i) inclusion of landings in Subdivision 22–24, ii) use of Fisherman-DTU Aqua survey and exclusion of Havfisken survey, iii) cessation of tuning-series Private logbooks trawlers.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1984–last data year	2–11+ [2–9+ since 2007]	Yes
Canum	Catch-at-age in numbers	1984–last data year	2–11+ [2–9+ since 2007]	Yes
Weca	Weight-at-age in the commercial catch	1984–last data year	2–11+ [2–9+ since 2007]	Yes
West	Weight-at-age of the spawning stock at spawning time.	1984–last data year	2–11+ [2–9+ since 2007]	Yes/No; assumed to be the same as weight-at-age in the catch
M_{prop}	Proportion of natural mortality before spawning	1984–last data year	2–11+ [2–9+ since 2007]	No; set to 0 for all ages in all years
F_{prop}	Proportion of fishing mortality before spawning	1984–last data year	2–11+ [2–9+ since 2007]	No; set to 0 for all ages in all years
Mat_{prop}	Proportion mature-at-age	1984–last data year	2–11+ [2–9+ since 2007]	No
Natmor	Natural mortality	1984–last data year	2–11+ [2–9+ since 2007]	No; set to 0.1 for all ages in all years

Tuning data of final SAM run WGBFAS since 2010

Type	Name	Source of data	Year range	Age range
Tuning fleet 1	6 trawlers	Private logbooks	1987–2008	2–6
Tuning fleet 2	3 gillnetters	Private logbooks	1994–2007	2–8
Tuning fleet 3	Trawlers	Official logbooks	1994–assess year	3–8
Tuning fleet 4	Fisherman-DTU Aqua	Scientific survey	2004–assess year	2–8
Not used since WG 2007	Gillnetters small	Official logbooks	1998–2005	3–10
Not used since WG 2009	Havfisken 4th quarter	Scientific survey	1994–assess year	2–6

D. Short-term projection

Model used: Age structured

Software used: ICES standard assessment tools with management option table and yield-per-recruit routines (MFDP1a). Since 2007 YR and short-term prediction were also run in the FLR environment for graphic presentation. SAM model will implement STF and provide results with uncertainty bounds.

Initial stock size. Taken from the SAM age 3 and older.

Recruitment: Age 2 (recruit) abundance in forecast years is the geometric mean from 1994 to recent years. Presently corresponding to a period when recruitment has been relatively low.

Natural mortality: Set to 0.1 for all ages in all years

Maturity: Knife-edge 3+ 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 of recent three years

Exploitation pattern: Average of recent three years, and rescaled if trend.

Intermediate year assumptions: Fsq, either scaled or unscaled depending on F trend and expected development in fishery.

Stock–recruitment model used: None, Age 2 (recruit) abundance in forecast years is the geometric mean from 1993–1994 up to recent years

Procedures used for splitting projected catches: Not relevant

E. Medium-term projections

Medium term analysis by WGBFAS 2006 indicate that in 2015 there is less that 5% probability that SSB would be below B_{pa} provided F_{pa} is applied every year. No medium-term analysis has been carried out since 2006 (no request).

The 2006 exercise was based on:

Model used: Age structured

Software used: @RISK for excel. The Study Group on Management Strategies for Baltic Fish Stocks (ICES CM 1998/ACFM:11) used a spreadsheet macro program for producing medium-term projections. This program was made available to the Working Group in the 1999 assessment and was modified (i.e. biological inputs) for application to sole in Division IIIA. The program allows the user to include stochastic variations in several input parameters and has been used in assessments of sole in IIIA since then, including this year's assessment.

Initial stock size: Recruit (age 2) abundance for all years in projection is geometric mean of the years 1993–2003 with random variability (sd of ln recruitment). Initial abundances for ages 3–11+ assume random variability based on log int. s.e. from XSA diagnostics.

Natural mortality: Set to 0.1 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: Weights-at-age were drawn randomly from mean and standard deviations based on those in the catch for the years 1998–2005.

Exploitation pattern: Average of the years 2003–2005, scaled by the F_{bar} (4–8) 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 geometric mean recruitment-at-age 2 for the years 1993–2003 with random variability (sd of ln recruitment) was used.

F. Long-term projections

Standard yield-per-recruit analyses are conducted as part of stock assessment using long-term average (15 yrs) as input and with MFYPR2a software. LTF will be implemented in SAM model.

G. Biological reference points

ICES has proposed the following reference points in 1999 in its stock summary:

ICES CONSIDERS THAT	ICES PROPOSES THAT
B_{lim} is 770 t	B_{pa} be set at 1060 t
F_{lim} is 0.47	F_{pa} be set at 0.30

These reference point definitions follow the guidelines given by the Study Group on the Precautionary Approach to Fishery Management (ICES CM 1998/ACFM:10).

Information was presented in 2008 on candidates for F_{MSY} (Vinther, 2008). Stochastic scenarios demonstrate that under realistic assumptions of assessment and implementation uncertainties, F_{MSY} is estimated to a value of around 0.35. The risk of SSB falling below the present precautionary biomass reference point is close to zero for a long-term F at 0.35. Even with biomass reference points twice as big as the present ones, the risk of a SSB below those is less than 5%. This estimated F_{MSY} is close to the present F_{pa} (0.30).

In 2009/2010 ICES is in a transition phase into MSY reference points. At WKFLAT 2010 the present biomass reference points was rejected; both B_{lim} and B_{pa} are based on two outlier observations in the first two years of the dataseries, and they were assessed to be far to low. A possible candidate for a $B_{trigger}$ (in accordance with the new MSY concept) is in the neighbourhood of SSB=2000 t. Preliminary estimates of a F_{msy} candidate was around 0.3. WKFLAT decided that final decisions of new MSY reference points should be made at the WGBFAS meeting 2010 based on guidelines from WKFRAME.

H. Other issues

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6 Sole in the North Sea

6.1 Current stock status and assessment issues

Fishing mortality was estimated at 0.34 in 2008 which is below F_{pa} (=0.4). The SSB in 2008 was estimated at about 40 000 t which is above both B_{lim} (25 000 t) and B_{pa} (35 000 t). Two weak year classes in 2003 and 2004 were followed by a strong year class in 2005, the impact of which is now being seen in the SSB estimations. Projected landings for 2010 at F_{sq} are 15 500 t, slightly lower than projected landings for 2009 (15 100 t).

Catch-at-age analysis was carried out with XSA using the settings given below.

YEAR	2008	2009
Catch-at-age	Landings	Landings
Fleets	BTS-Isis 1985–2007 SNS 1970–2007 NL-BT 1990–2007	BTS-Isis 1985–2008 SNS 1970–2008 NL-BT 1990–2008
Plus group	10	10
First tuning year	1970	1970
Last data year	2007	2008
Time-series weights	No taper	No taper
Catchability dependent on stock size for age <	2	2
Catchability independent of ages for ages >=	7	7
Survivor estimates shrunk towards the mean F	5 years/5 ages	5 years/5 ages
s.e. of the mean for shrinkage	2.0	2.0
Minimum standard error for population estimates	0.3	0.3
Prior weighting	Not applied	Not applied

The full diagnostics are presented in Table 6.1.1. The SSB in 2007 was estimated at around 19 kt (Table 6.1.2) which has increased to around 40 kt in 2008 due to the maturation and growth of the 2005 year class and a reduction in fishing effort. Mean F(2–6) in 2008 was estimated at 0.34 which is the lowest since the 1960s. Recruitment of the 2007 year class, in 2008 (age 1), was estimated at 91 million (Table 6.1.2).

Retrospective analyses done in 2009 suggested that F had been overestimated in the year before (2008) but underestimated over a series of previous years, while SSB was overestimated (Figure 6.1.1).

At WGNSSK 2009 it was recommended that during the current benchmark assessment, attention should be paid to the following issues:

- In 2003 the plus-group was set from age 15 to age 10. The choice of reducing the plus group to age 10 needs further attention, although the current WG thinks that the very small number of older fish currently present in the stock will lead to a limited impact...
- Follow changes in technical efficiency in the commercial fleets and look for external evidence.
    - Trends in mean weights and maturity and how that could affect the assessment and forecasts. In particular it would be in-

teresting to examine the impact of sex ratios and the faster growth and larger ultimate size of females.

- Explore the effects of including discards.
- Investigate the considerable differences in retrospective patterns of XSA results when run survey or commercial lpue series separately.
- Study the effects of using an un-scaled F in the forecast procedure.

6.2 Compilation of available data

6.2.1 Catch and landings data

Landings data by country and TACs are presented in Table 6.2.1. The majority of the landings come from the Netherlands, which has had 73% of the landings since 2000. The second most important fishery is that of Belgium, with approximately 9% of the landings. Discards-at-age estimates are only available for the Dutch 80 mm beam trawl fleet. Discards estimates derived from this sampling programme are presented in Table 6.2.2. These estimates are only available since 2000, when the discards sampling programme was started. The discards percentages observed in the Dutch discard sampling programme for beam trawl vessels fishing for sole with 80 mm mesh size are much lower for sole (for 2002–2008, between 10–17 % by weight, see Table 6.2.2) than for plaice. No trends in discard percentages were observed. Previously, these discards estimates have not been included in the assessment, the main reason for which was that the discarding of sole is relatively low in all periods for which observations are available. In addition, gaps in the discard sampling programmes result in incomplete time-series. Inclusion of a stable time-series of discards in the assessment will have minor effect on the relative trends in stock indicators (Kraak *et al.*, 2002; Van Keeken *et al.*, 2003). No other discards estimates were available for other countries. Figure 6.2.1 shows the landings, discards (Dutch data only), and catches in weight over time assuming the discarding by the fleets of other countries is negligible.

The age composition of the landings is presented in Table 6.2.3 (see also Figures 6.2.2, 6.2.3 and 6.2.4). Age compositions and mean weight-at-age in the landings were available over a range of different levels of aggregation (e.g. quarterly, annually, by age, or by sex and age). Overall, however, the samples were thought to be representative of the majority of the landings throughout the time-series. To calculate the landings by age, age compositions are combined separately by sex on a quarterly basis then raised to the annual international total.

The discards data (Tables 6.2.2 and 6.2.4, and Figure 6.2.5) were only available for the Netherlands, which has more than 70% of the landings of sole. The discarding-at-age data demonstrate that discarding occurs only on the younger ages, being indicative of minimum landing size (MLS) discarding.

During this Benchmark Assessment for North Sea sole we have explored separate stock assessments for female and male sole (see suggestions by the WGNSSK 2009 above). In order to estimate the landings data by sex, the raising procedure for the landings by country had to be revisited. In order to derive a landings estimate for each sex, the data were first raised to represent a landings-at-age table for the entire population, as described above. Subsequently, the landings-at-age were subdivided by using the proportionality in sexes-at-age for each country's data, weighted by their landings. The sum of the resulting landings-at-age for females (Table 6.2.5) and males (Table 6.2.6) is then equal to the unsexed landings-at-age. Females (Figure 6.2.6) appear in the landings at an earlier age than males (Figure 6.2.7). The main reason for this is the dimorphic growth of sole, whereby females grow faster than males.

6.2.2 Biological data

Weights-at-age in the landings for both sexes combined (Table 6.2.7) are measured weights from the various national market sampling programmes. Weights-at-age in the stock (stock weights) are the average weights from the second Quarter landings. Over the entire time-series, weights were higher between the mid-1970s and mid-1980s (Figure 6.2.8) for the younger age groups compared with time periods before and after (see Figures 6.2.8–6.2.11). Estimates of weights for the older ages fluctuate more because of smaller samples sizes due to decreasing numbers of older fish in the stock and hence landings.

The stock weights-at-age data for the two sexes separately were available from the different countries fishing for sole over different time-spans (Figure 6.2.12). The weighted averaging procedure for combining the data of the different countries to obtain North Sea wide estimates of stock weights by sex results in the same dome-shaped pattern in the two sexes separately as is observed when the sexes are combined. The stock weights of females (Table 6.2.8) and males (Table 6.2.9) show similar trends (Figures 6.2.13–6.2.16). As expected, the female weights are higher than the male weights. This is especially pronounced in the older ages, and caused by the differential growth rates.

In order to test whether the dome shaped pattern was caused by a bias due to differences in the protocols used by the contributing countries over time, a GAM model was fitted to the data. The model disentangles country, year and sex effects for each of the ages i on the stock weight W_i separately, by using:

$$W_i = \text{s(year)} + \text{s(year, by=sex)} + \text{sex} + \text{country},$$

where sex and country are factor variables , and s(year) is a smooth function of numeric ‘year’. The term s(year, by=sex) allows for testing whether the shape of the stock weight change over time is different for each sex.

The model results indicate that there has been a dome shaped pattern in the stock weights over time, independent of the difference in countries that have contributed to the data (Figure 6.2.17). Age 4 also demonstrates trends in time that are different for the two sexes. Finally, there was a significant difference in the level or *average stock weight* by age observed by the different countries. The stock weights observed in the UK, for example, were generally lower than those observed elsewhere (Figure 6.2.18a). On the other hand, the German stock weights-at-age are generally higher. Strikingly, the difference between the countries appears to increase with increasing age of the fish. The spatio-temporal patterns in sole weight-at-age clearly require some more investigation.

There has also been a substantial change in sex ratio in the sole in the larger market categories in the Dutch market data. Market category (MC) 5 represents the smallest/youngest fish and MC 1 the largest/oldest. In the mid-1980s, for example, there were *ca.* 50 times more females in MC 1 than males while by the late 2000s this had changed to *ca.* 500 times more females (see Figure 6.2.18b). We do not currently think that this is due to a sampling bias. It was suggested the observation might be related to a closure of the plaice box where sole spawn, but this can be rejected as an explanation because only boats >300 hp were used to plot the graph in Figure 6.2.18b. The Group agreed that this phenomenon required further investigation.

North Sea sole is assessed using a knife-edged maturity-ogive which assumes full maturation at age 3. This maturity-ogive was based on market samples of females from observations made in the 1960s and 1970s. Mollet *et al*. (2007) have, however, recently described the shift of age-at-maturity towards younger ages which may be important in stock assessment due to its potential impact on the calculation of spawning-stock biomass. This question was, therefore, considered during the current benchmark assessment. Dutch market sampling data 1957–2008 summarizing the state of sexual maturity of sole were gathered together and combined with data from the surveys. Considerable problems were encountered, however, when we attempted to estimate a long-term trend from these data. First the state of sexual maturity should be assessed from individuals caught during Quarter 1 due to the possibility of confusion between immature fish and post-spawners. Secondly the MLS for sole is 23 cm meaning that there are very few immature individuals available at all and we couldn't use the survey data because they are only available for Quarter 3. Third there is considerable doubt whether male sole can be staged at all due to their minute gonads (A. Rijnsdorp, pers.comm.). Ultimately a crude time-invariant ogive was estimated according to the following logistic regression model [P(mature) = age + sex] and its output is displayed graphically in Figure 6.2.25. According to this model 29% of age 1 female sole, 78% age 2 female sole and 97% of age 3 female sole are sexually mature. Males mature earlier and 50% of age 1s, 89% of age 2s and 99% of age 3s are mature. More work is required before reliable time-trends in these data can be derived and the question of the staging of male sole needs to be addressed.

Natural mortality in the period 1957−2008 has been assumed constant over all ages at 0.1, except for 1963 where a value of 0.9 was used to take into account the effect of the severe winter (1962−1963) (ICES-FWG 1979). The current winter (2009–2010) has also been cold and WKFLAT agreed that its potential influence on the sole stock should be carefully considered in future.

6.2.3 Survey tuning data

The following two survey-series have historically been used to tune the assessment of North Sea sole:

- BTS-ISIS (Beam Trawl Survey)
- SNS (Sole Net Survey)

The BTS (Beam Trawl Survey) is carried out in the southern and southeastern North Sea in August and September using an 8 m beam trawl (Table 6.2.10 and Figures 6.2.19, 6.2.20, 6.2.21). The SNS (Sole Net Survey) is a coastal survey with a 6 m beam trawl carried out in the third quarter. In 2003 the SNS survey was carried out during the second quarter and data from this year were omitted (Table 6.2.11 and Figures 6.2.20, 6.2.22). These two research vessel survey time-series were revised by WGBEAM in 2009 (ICES-WGBEAM, 2009).

The BTS survey consists of two components: (1) the southwestern region, which has been covered by RV Isis since 1985, and (2) the northwestern region, which has been covered by RV "Tridens" since 1996. As a tuning-series for sole, only the BTS-ISIS survey is currently considered to be important, because the RV-Tridens catches much less sole.

The BTS-ISIS index time-series was updated in 2009 for two reasons. First, the age data were updated. Secondly, the index-areas were re-evaluated. The age data are now included in IMARES' new Oracle database (hitherto the data were stored in text files) and this data transfer caused minor differences to the age–length keys by area, and hence in the age compositions (not in the total catches). The part of the total survey area covered by each vessel is defined as the 'index-area' based on temporal coverage, i.e. coverage in all or most of the survey years (Figure 6.2.19). These index-areas were defined in the past but were re-evaluated this year because shifts in the survey grid have occurred. Some ICES rectangles included in the index-area have not been sampled in the last 4–5 years because of re-occurring damage to the nets (e.g. in 43E9), whereas other rectangles, not historically included in the index-area have been sampled consistently since 1990 (e.g. 37F7 and 39F8). Therefore, new index-areas were proposed for both vessels (see Figure 6.2.19a). The change in index area had a small effect on the abundance indices but has had some impact on the assessment of sole resulting in slightly lower estimates of SSB and higher estimates of F. Overall the new indices tend to be higher (especially at younger ages due to the inclusion of coastal rectangles), but the pattern of relative year-class strength is not affected. The SNS was also revised for similar reasons. The SNS age data are now included in the Oracle database, a correction for the 2006 sole data, and improved age readings for catch year 1997. A comparison of the indices (plaice and sole) before and after these database corrections can be found in the ICES WGBEAM 2009 Report.

Both the BTS-ISIS and SNS survey tuning indices were also made available by IMARES for the two sexes separately (see Tables 6.2.14, 6.2.15, 6.2.17, and 6.2.18).

At a recent meeting concerning the Benchmark Assessment for sole, stakeholders questioned why BTS and SNS surveys were used for sole when there was such a large component of the stock on the western side of the North Sea (see Figure 6.2.19a). There are at least two trawl survey data indices available that cover this area: one done by the British (Corystes) and one done by the Belgians. These Dutch and UK indices are displayed in Tables 6.2.20 and 6.2.21. The Belgian index was unavailable.

6.2.4 Commercial tuning data

Two commercial indices have historically been available for use as tuning-series to the assessment.

- Dutch Commercial Beam Trawl Fleet lpue series/index
- Spatially Corrected Dutch Commercial Beam Trawl Fleet lpue series/index

The Dutch Commercial Beam Trawl Fleet lpue series consists of the total landings by the fleet divided by the total effort in HP hours. Data from market sampling are used to convert the weights caught to numbers-at-age. Effort nearly doubled between 1978 and 1994, has declined since 1996, and was <40% of the maximum (1994) in the series during 2008 (see Table 6.2.12).

The Spatially Corrected Dutch Commercial Beam Trawl Fleet lpue series (Table 6.2.13) was constructed because of spatial differences in lpue, and evidence of changes in catchability across the North Sea (Quirijns and Poos, 2009, WD). Fishers target concentrations of fish so dividing total landings by total effort, without accounting for targeting behaviour, may bias a commercial lpue index. Beam trawl fishers fishing in the southern area mainly target sole; in the central area they target a mixture of sole and plaice; and in the north they mainly target plaice.

There are, therefore, two main differences in the way this series is calculated cf. the Dutch Commercial Beam Trawl Fleet lpue series/index. First the data are spatially weighted. To do this the North Sea was split into three areas:

- • North: north of 55 degrees latitude;
- • Central: between 53 and 55 degrees latitude;
- • South: south of 53 degrees latitude;

Correction for targeting behaviour by beam trawlers on a North Sea scale was done using EU logbook data. Lpue was calculated per ICES rectangle, per year. Subsequently, the lpues of all ICES rectangles were averaged over the entire year and for each of the larger areas described above (North, South and Central). Within these areas average lpue and total effort was then calculated by year. Overall lpues were then obtained by averaging the lpue for each the three different areas. This removes the major effects of changes in spatial effort allocation due to for instance changing targeting behaviour. Again the weights of the landings were converted to numbers-at-age using market sampling data. Temporal trends by area are shown in Figure 6.2.23.

Secondly the 'effort' estimation used for the Spatially Corrected Dutch Commercial Beam Trawl Fleet lpue series/index was 'standardized' for engine power because engine power has an effect on landing rate. The majority of the Dutch beam trawl fleet consists of vessels with an engine power around 1471 kW (=2000 hp). The analyses have been restricted to the large cutters with engine powers above 221 kW. Data were standardized to a vessel of 1471 kW by applying the estimated relationship for this fleet from (Rijnsdorp *et al.*, 2006):

$$= \frac{}{\left(\quad * \quad ^{\beta} / 1471^{\beta} \right)}$$

where L is landings in kilograms; E is effort in days-at-sea; P is engine power in kW; and β is a constant with value 0.8089 for sole and 0.5162 for plaice. This means that all results can be expressed as for instance 2000 kg per day fishing with a 1471 kW vessel or 5000 days-at-sea by 1471 kW vessels.

The average lpue of a standardized NL beam trawler (1471 kW) over the period 1999 to 2007 was 266 kg day-1, and the data have a significant (P<0.01) temporal trend of -6.1 kg day-1 year-1. The lpue estimated for 2008 (313 kg day-1) was above the mean (266 kg day-1).

Collection of more comprehensive data on the catch-rate by individual tows in conjunction with the obligatory recording of fishing locations using VMS will be important to assess the way lpue time-series reflect stock biomass, and may in future provide data for correcting cpue time-series for variations in micro-scale targeting. Other factors that may cause bias in cpue: increasing efficiency of the fleet, and vessel interactions will need to be estimated separately.

At a recent meeting, the Dutch fishing industry provided another list of beam trawlers that are known to specifically target sole without any quota restrictions affecting their behaviour. The rationale was that the lpues estimated would then apply more directly to sole and not be 'clouded' by targeting activity on other species, which may happen more in other components of the fleet, e.g.. boats fishing primarily for plaice in the North. The list of boats supplied by the industry consisted of large (> 2000 HP) beam trawlers which were divided into the following three groups based on the spatial distributions of their fishing activities:

Group A. South of the 52.00° North (five vessels);

Group B. Between 52.00°–53.30° North (eight vessels);

Group C. Between 54.00°–55.00° North (four vessels);

Due to the short time period available and a problem with the availability of market category data in IMARES' database, VISSTAT, we were only able to calculate this index by age for 2001 onwards. The index for the three areas by total weight of sole caught is displayed (see Figure 6.2.26). The plot suggests a rise in lpue for the group of beamers fishing in the south (see black dots in Figure 6.2.27).

6.2.5 Industry/stakeholder data inputs

As described above, at a pre-WKFLAT 2010 meeting in The Hague attended by representatives from IMARES and the Fishing Industry, it was suggested that we should perhaps consider using a list of 'specialist' sole boats as a tuning fleet. The relevant data were supplied by the industry and have formed the subject of some of our investigations here.

6.3 Stock identity and migration issues

It is believed that North Sea sole is a reasonably homogeneous entity. In some years there are high concentrations of sole in the eastern English Channel and exchange of animals between VIId (English Channel) and the North Sea seems likely. However, because the North Sea stock is substantially larger than the English Channel stock, the effect on the assessment of this exchange is likely to be very small for North Sea sole.

6.4 Spatial changes in the fishery and stock distribution

The main fleet landing sole in the North Sea (the Dutch beam trawl fleet) has shifted its spatial fishing effort distribution southward since 1990 (Figure 6.2.24), caused by changes in targeting, resulting from the days-at-sea regulations, high oil prices, and different patterns in the history of changes in the TACs between plaice and sole.

A study on large cutters of the Dutch beam trawl fleet targeting sole and plaice revealed that targeting behaviour of the fleet was measurable at different spatial scales. The fleet targets sole on all scales examined, whereas it only targets plaice on the micro-scale (Quirijns *et al.*, 2008). The fleet can switch between target species, which can be concluded from the negative correlation between targeting indices of sole and plaice. The fleet increasingly targeted sole instead of plaice when fishing opportunities for sole were relatively high. The observed targeting on the different scales reflects different aspects of location choice by fishers. On the macroscale (>100 nmi), fishers have to choose between fishing areas where the abundance of target species will differ in a predictable manner as a consequence of differences in habitat choice and seasonal dynamics of the species. The choice of fishing areas may put particular constraints on the rigging of the gear (mesh size, number of tickler chains, and type of groundrope). On the medium- and micro-scale, fishers have the problem of how to find local concentrations of the target fish species. This paper estimated variations in targeting behaviour of the fleet, seasonal and spatial dynamics of the species as well as of the fishing fleets. Aggregating commercial catchrates at the level of ICES rectangles and in periods of a month means that changes in spatial patterns on the macro- and medium-scale are adequately accounted for and produce a time-series that is not affected by changes in the distribution of the fishing fleet relative to that of the fisheries resource. However, the fact that beam trawl fishers exploit local fishing grounds on the micro-scale within an ICES rectangle implies that high-resolution data (10×10 nmi, 1 week) are needed to quantify the interannual variations in targeting and its effect on cpue. In the period studied, the micro indices displayed only modest interannual variations that were not significantly related to quota constraints. This suggests that the bias introduced by ignoring the micro-scale targeting, will not have a significant effect on the lpue time-series. However, the small sample size of the fleet for which micro-scale data were available (<20% of the Dutch fleet) may have reduced the power of the statistical test. The wide range of potential index values on the micro-scale, suggest that scope for targeting (or avoidance) behaviour may be large. This implies that under different constraints variations in micro-scale targeting may bias the lpue index for stock biomass in future.

In recent years no changes in the spatial distribution of juvenile or adult soles have been observed (Grift *et al*., 2004, Verver *et al*., 2001). There are concentrations of sole on both the eastern and western sides of the southern North Sea and the relative importance of these areas fluctuates over time.

The proportion of undersized sole (<24 cm) inside the Plaice Box did not change after its closure to large beamers and remained stable at a level of 60–70% (Grift *et al.*, 2004). The different length groups revealed different patterns in abundance. Sole of around 5 cm demonstrated a decrease in abundance from 2000 onwards, while groups of 10 and 15 cm were stable. The largest groups indicated a declining trend in abundance, which had already set in years before the closure.

6.5 Environmental drivers of stock dynamics

Sole growth rates in relation to changes in environmental factors were analysed by Rijnsdorp *et al*. (2004). Based on market sampling data it was concluded that both length-at-age and condition factors of sole have increased since the mid-1960s to a high point in the mid-1970s (see Figure 6.2.17). Since the mid-1980s length-at-age and condition have been intermediate between the troughs (1960) and peaks (mid-1970s). Growth rates of the juvenile age groups were negatively affected by intraspecific competition. Length of 0-group fish in autumn demonstrated a positive relationship with sea temperature in the second and third quarters, but for the older fish no temperature effect was detected. The overall pattern of the increase in growth and the later decline correlated with temporal patterns in eutrophication; in particular the discharge of dissolved phosphates from the Rhine. Trends in the stock indicators e.g. SSB and recruitment, did not coincide, however, with observed patterns in eutrophication.

(Mollet, Kraak, and Rijnsdorp, 2007) used the reaction norm approach to investigate the change in maturation in North Sea sole and demonstrated that age and size-at-first maturity significantly shifted to younger ages and smaller sizes. These changes occurred from 1980 onwards. Size at 50% probability of maturation at age 3 decreased from 29 to 25 cm.

The 'nursery size hypothesis' (Iles and Beverton, 1998) suggests that recruitment variability of North Sea sole is tempered by strong density-dependent mechanisms occurring during the early juvenile stages on nursery grounds, i.e. environmental factors are capable of generating variability of the number of larvae settling but, due to the important density-dependence on the nursery grounds, there is much less variability of the actual number of recruits than in the number of juveniles that settle. Extreme environmental event, e.g. cold winters, (Rijnsdorp *et al.*, 1992) or variation of the nursery size (Le Pape *et al.*, 2003) can, however, contribute to survival on the nursery grounds.

6.6 Role of multispecies interactions

The WG was unable to comment given the time available.

6.6.1 Trophic interactions

The WG was unable to comment given the time available.

6.6.2 Fishery interactions

The WG was unable to comment given the time available.

6.7 Impacts on the ecosystem

The WG was unable to comment given the time available.

6.8 Stock assessment methods

6.8.1 Models

eXtended Survivors Analysis (XSA)

Currently the stock assessment of North Sea sole is done using XSA. XSA is a VPA type analysis, but also allows for the inclusion of different tuning indices (Shepherd, 1999). XSA is a commonly used stock assessment method for the assessment of demersal fish species, but it lacks some of the advantages described below. One of the advantages is that it assumes the catches-at-age are known without error.

Statistical Catch-at-Age model with time-varying fishing and discarding selectivity functions (AAP)

The conceptual complexity of the current reconstruction of the historical (<2000) discards data (ICES 2005; van Keeken *et al.*, 2004a), led to the development of a new statistical catch-at-age model, which explicitly incorporates the discard reconstruction into the assessment (Aarts and Poos, 2009). In short, a statistical catch-at-age model describes the biological processes in mathematical form and links several model components with existing data, such as data on landings, discards, and tuning indices. The link between model estimates and observations is made by means of a specification of a likelihood function which is maximized. The new aspect of the proposed method by (Aarts and Poos, 2009) is that it does not assume constant fishing and selectivity in time, but explicitly models the fishing and discard selectivity as a flexible function of time using spline smoothers. The proposed statistical catch-at-age model includes data on landings and discards separately, and therefore explicitly allows for observation errors on those, and other data sources. A major advantage of this statistical catch-at-age model is that it allows for the inclusion of additional biological processes, uses objective criteria (i.e. likelihood-based information criteria) to select the best model and explicitly estimates uncertainty in both the input data and the uncertainty in the stock summaries, such as SSB and fishing mortality F.

SAM model

This model is known as a 'state-space' model and a detailed description is currently available in the 2009 Methods WG report (ICES, 2009). State-space models are extensions to statistical models allowing *unobserved* random variables and were introduced to fisheries stock assessment by (Gudmundsson, 1994; Fryer, 2001; Fryer, Needle, and Reeves, 1999). The SAM configuration of the model is different from those used in the past and uses a more flexible computational approach. In the model the 'states' are the random variables that we don't observe, e.g. $N_{a,y}$ where N is the total population, and the 'observations' are the random variables that we do observe, e.g. $C_{a,y}$ where C is catch. Unlike XSA, SAM is a statistical model so the quantification of uncertainties is integral and it has all the standard statistical toolboxes for model validation, confidence interval estimation, and associated statistical tests. It allows 'noise' in catch-at-age' estimations, and has maximum likelihood estimation of model parameters. Survival of fish from one age group to the next is stochastic. Fishing mortality is modelled as a Random Walk while 'selectivity' can evolve over time. Prediction from the model is easy and it can also handle missing values sensibly. Furthermore the model is available on a web interface where Lowestoft VPA-format files can be uploaded, the model fitted and the output of different runs plotted and stored. During WKFLAT 2010 we were able to do an assessment for North Sea sole and the results are discussed below.

6.8.2 Sensitivity analysis

The WG did not do any sensitivity analysis on the effect of specific assessment model parameters on assessment results.

6.8.3 Retrospective patterns

The main problem in the North Sea sole stock assessment is a consistent bias in the retrospective pattern, particularly on fishing mortality (see Figure 6.1.1). When survey data (BTS-ISIS and SNS) were used alone in the assessment the retrospective pattern reverses, suggesting conversely that F estimates have been too low over the last few years. Hence survey data suggest higher Fs, and commercial data lower Fs (Figure 6.8.1), the different tuning-series thus conveying different information. This is the main problem we set out to address.

6.8.4 Evaluation of the models

After considerable experimentation WKFLAT 2010 has chosen to recommend an XSA model tuned with the uncorrected commercial fleet data cut off before 1997 which eliminates the retrospective bias problem. It does this because the smaller subset of the commercial data clearly has less of a problem with time-dependent or evolving catchabilities. This corroborates the finding of a breakpoint in the catchability estimates for the commercial tuning index in the mid-1990s, shown in Figure 6.8.2, taken from ICES (2005). The XSA settings from the 'old' model (WGNSSK, 2009) are shown in Table 6.1.1, the new (WKFLAT 2010) in Table 6.8.1.

Three different stock assessment models were tried on the North Sea sole stock during WKFLAT: XSA, SCAA, and SAM. These three models, together with the range of possible tuning fleets/indices gave an impossible number of potential assessment runs to try, see Table below:

Models	Indices	Biological data
XSA	NL Beam (uncorrected)	Weights-at-age

	NL Beam post-1997	Ogives (observed from data)
SCAA	NL Beam Corrected	Sex (Males, females, both)
SAM	NL Beam Specialist	
	BTS-ISIS (new)	
	SNS (new)	
	UK Corystes survey	

Many, but not all, of these potential assessments were run during the WG and the most important results are described below (e.g. sex separate, alternative indices, the SAM and AAP models).

Sex separated assessment

Output from an XSA assessments on female and male sole separately in terms of F_{bar}, SSB and R are shown in Figures 6.8.3 and 6.8.4. Here the uncorrected commercial (NL Beam) tuning index was used (Tables 6.2.16 and 6.2.19), spanning the full time-series for which it was available (1990–2008). In order to calculate the SSB, the stock weights-at-age needed to be estimated in some combinations of years and ages, because of missing data in the female stock weights-at-age matrix. SSB in 2008 was estimated to be 29 300 t while F_{bar} on the females was 0.37 (vs. 0.34 for the WGNSSK 2009 final assessment). For the males SSB in 2008 was 11 300 t while F_{bar} was considerably lower at 0.24. The combined SSB from the male and female components was thus 40 600 t. This assessment suggests that there were (in 2008) 2.6 times more female sole in the spawning-stock biomass than males. The retrospective biases were also rather similar to those seen in the final WGNSSK 2009 assessment with consistent underestimates of F_{bar} in both sexes. Selectivity patterns are displayed in Figures 6.8.5 and 6.8.6. The impact on selectivity by the fishery due to the differential growth rates is clear; females being caught at a younger age than males due to their faster growth rates.

Observed maturity ogives

Because of the considerable problems that were encountered in obtaining unbiased maturity-at-age estimates over the entire time span of the assessment, no analytical assessments were run using the empirical maturity ogives. If such analytical assessment were to be done, however, using the sex separated data would be most appropriate. Previous studies indicate that changes in the maturity ogive can substantially affect the spawning-stock biomass estimates. Bromley (2003) for example, also estimated maturity ogives for North Sea sole using English market data and demonstrated that when these 'observed' data were used instead, SSB fell (Bromley, 2003). The fall in perceived SSB happened because not all three- sole spawn which is assumed by the 'knife-edged' ogives used as 'standard'.

With discards

Discarding data for North Sea sole were prepared and are summarized in this report (see Figure 6.2.5) although there was no time to run any assessments incorporating these data. Discarding is not, however, thought to be a serious issue for North Sea sole. The minimum landing size (MLS) for sole is 23 cm and most fish below this size are not retained by the fishery. Even small sole have a considerable market value and are, therefore, unlikely to be discarded.

Alternative indices

XSA assessments were run with a range of alternative tuning indices. During WKFLAT 2010 three commercial indices and three survey indices were made available. As described above the commercial indices were all based on Dutch beam trawlers which take 70–80% of the total landings of North Sea sole. They comprise the uncorrected NL Beam trawl index (based on a simple division of total landings by total HP effort), a 'corrected' Beam trawl index (spatially weighted and effort standardized), and an index suggested by fishers comprising a group of 'specialist' sole boats (also spatially weighted and effort standardized).

Two of the trawl survey indices currently used in the assessment (BTS-ISIS and SNS) have been updated in 2009 (see WGBEAM Report). The updated survey tuning indices have a small effect on the stock assessment, reducing the SSB estimate in the most recent year, and increasing the F_{bar} estimate in the most recent year (Table 6.8.2 and Table 6.8.3). The perception of SSB in 2008 changed from around 40 000 t to around 38 000 t. The retrospective pattern that was observed by ICES WGNSSK 2009 did not substantially change by the update of the two survey tuning indices (Figure 6.8.8).

The other two potential survey tuning indices are collected by the UK and Belgium, but neither was published in the WG Beam report. The UK index was supplied to us by staff from Cefas but we were unable to locate the Belgian data. We recommend that in future these two potentially useful tuning indices be assessed with respect to North Sea sole and included and included in the WGBEAM Reports for potential use in the assessment.

The basic problem in the assessment of North Sea sole is the retrospective bias discussed above. Since the problem was thought to be due to a temporal change in catchability in the commercial tuning index we investigated the effect (on the retrospective bias) of using a more recent subset of those data, i.e. from 1997 onwards. The output of this assessment is displayed in Figure 6.8.9 and indeed has less retrospective bias. The retrospectivity estimates using "Mohn's ρ" (Mohn, 1999) also indicate that using commercial data from 1997 onwards substantially reduces the retrospectivity (Figure 6.8.10). For the calculation of "Mohn's ρ", the retrospective pattern of the last six years was used.

Various other combinations of indices were also tried. The impact of the tuning index suggested by the stakeholders (the 'Specialist' Sole Beam Trawlers) was also investigated. We ran an XSA assessment including this fleet, together with the two standard survey indices (updated BTS and SNS) and assessed the output (see Figure 6.8.11). In this scenario there is a positive retrospective bias, similar to the pattern observed when survey-series are used alone (see Figure 6.8.1).

SAM model

The SAM model was fitted with the help of DTU-Aqua and the output from a run, tuned with BTS, SNS and NL Corrected 1997–2008. The output is summarized, together with confidence bounds in Figures 6.8.12–6.8.16. The median results of the SAM model are very similar to those obtained via the standard XSA analyses, both in terms of the SSB estimates as in terms of F_{bar} estimates. The 95% confidence intervals in F (compared with the median F) are much larger than the confidence intervals in SSB.

ANP model

This model was run without discards and the results were essentially similar to those obtained from XSA and SAM. The outputs (SSB and F_{bar}) from a run using the uncorrected commercial cpue index 1997–2008 are displayed in Figures 6.8.17 and 6.8.18. It should be noted that the difference in confidence intervals for SSB and F_{bar} observed using SAM can also be found in the ANP model. The drawback of using the ANP model is that in its current formulation it cannot assess the stock status outside the time span for which tuning data are available for the full age range.

6.9 Stock assessments

The model we have selected reduces the retrospective bias but also reduces our perception of SSB (now 36 700 t in 2008, cf, 40 700) and increases our perception of F_{bar} (0.4 in 2008, cf 0.34). A full stock summary is found in Table 6.8.4. Some of this difference between the two assessments is due to the revised (ISIS and SNS) survey-series described above.

6.10 Recruitment estimation

The WG was unable to comment given the time available.

6.11 Short-term and medium-term forecasts

The WG was unable to comment given the time available.

6.12 Biological reference points

Given that the assessment results in terms of historical biomass estimates did not change substantially following the updates in assessment methodology in WKFLAT 2010, the estimates of these reference points are still valid. An estimation of yield-per-recruit type F reference points indicates that the assessment did not substantially the $F_{0.1}$ and F_{max} reference points. For these reference points, the selection patterns and weights-at-age are taken to be the average of the last three years. F_{max} is ill-defined by a very flat topped yield-per-recruit curve (Figure 6.12.1).

REFPT	FBAR 2-6	YIELD/R	SSB/R
$F_{0.1}$	0.10	0.14	1.03
F_{max}*	0.61	0.17	0.24

A time-series of the $F_{0.1}$ and F_{max} reference points using a three year moving window reveals that $F_{0.1}$ has been relatively constant over time, while F_{max} has been increasing since the mid-1990 (Figure 6.12.2). WKFLAT did not consider any reference points based on MSY calculations.

6.13 Recommended modifications to the Stock Annex

There was no Stock Annex, and it was written during the meeting

6.14 Recommendations on the procedure for assessment updates

On the basis of our work at WKFLAT 2010 we make the following recommendations:

- The problem of retrospective bias in the assessment should be eliminated by truncating the uncorrected cpue series at 1997.

- XSA is the model that should be used in preference to SAM. This decision was mainly steered by the potential issues with the expertise required. WKFLAT considers SAM to be a very sound approach for modelling North Sea sole. In particular the confidence bounds that the model is capable of providing will be useful for informing management. The SAM model should be run alongside the XSA model. The next benchmark dealing with Sole in Subarea IV should consider switching to SAM if sufficient experience is gained using it and interpreting its results.
- The temporal trends in the weight-at-age data should be further investigated. There was no significant interaction between sex and trend and the trend in the data seems to be a real function of changing growth. There was, however, a strong country effect identified, i.e. weights-at-age of soles collected by Germany were, for example, higher than those collected by the other countries (UK, Belgium and The Netherlands). WKFLAT suggested that this was a spatial effect, i.e. weights-at-age data collected by the Germans come (typically) from further North where fish are larger for a given age. Because the effort by the main fishery for this stock (Dutch Beam trawlers) has shifted south and west, WKFLAT recommends further analysis into the spatial trends in these input data.
- Sex ratios in the largest market sampling categories were much more female biased than they had been in the past. Explanations for this observation (sampling bias vs. real biological effects) should be explored in detail.
- There is no clear 'management' related reason why the sexes in sole should be modelled separately and lumping the sexes does not cause much bias. From a biological perspective (e.g. evolutionary effects of fishing) the sex dependent differences in selection patterns (mortality) due to growth, however, have the potential to inform management in future. The independent trajectories of the female and male parts of the sole stock should, therefore, be studied in more detail.
- The UK beam trawl and Belgian survey indices for sole (and plaice) should be published by WGBEAM whose members should discuss them in the context of patterns and differences observed in the Dutch BTS (ISIS and Tridens) and SNS data. We know that large spatial changes in the distribution of plaice in the North Sea have occurred, *viz*. the migration of juvenile plaice out of the Plaice Box. WGBEAM should investigate spatial changes in the distribution of sole.
- The data available had too few immature individuals for a reliable estimate of long-term trend in the proportion of mature fish in the population. Small individual sole sampled during the Belgian, German, Dutch, and British discarding programmes (Quarter 1) should be sexed and staged so that a reliable time-series can be constructed.
- The likely impact of the current cold winter (in 1963 natural mortality was set as 0.9) was not assessed but WKFLAT recommends that this should be monitored carefully.

6.15 Industry supplied data

The list of ships targeting sole was supplied by representatives from the fishing industry. The industry is also involved in the collection of discard data which have been presented here.

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Table 6.1.1. Sole in Subarea IV: XSA diagnostics from final assessment WGNSSK 2009.

```
cpue data from xsa.indices
Catch data for 52 years. 1957 to 2008. Ages 1 to 10.
          fleet first age last age first year last year alpha beta
1      BTS-ISIS         1        9       1985      2008  0.66 0.75
2           SNS         1        4       1970      2008  0.66 0.75
3 NL Beam Trawl         2        9       1990      2008     0    1

 Time series weights :
   Tapered time weighting not applied

Catchability analysis :
    Catchability independent of size for ages >   1
    Catchability independent of age for ages > =  7
Terminal population estimation :
    Survivor estimates shrunk towards the mean F
    of the final   5 years or the  5 oldest ages.
    S.E. of the mean to which the estimates are shrunk =   2
    Minimum standard error for population
    estimates derived from each fleet =  0.3
    prior weighting not applied

Regression weights
     year
age   1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  all    1    1    1    1    1    1    1    1    1    1

 Fishing mortalities (per year)
    year
age   1999  2000  2001  2002  2003  2004  2005  2006  2007  2008
  1  0.004 0.020 0.015 0.006 0.013 0.012 0.025 0.033 0.006 0.022
  2  0.175 0.239 0.284 0.230 0.225 0.230 0.207 0.263 0.243 0.126
  3  0.608 0.579 0.559 0.620 0.601 0.533 0.584 0.425 0.467 0.316
  4  0.710 0.790 0.748 0.637 0.625 0.685 0.651 0.436 0.467 0.382
  5  0.785 0.614 0.734 0.710 0.627 0.588 0.667 0.455 0.465 0.482
  6  0.575 0.763 0.522 0.618 0.783 0.444 0.632 0.489 0.400 0.382
  7  0.524 0.844 0.555 0.441 0.441 0.361 0.570 0.475 0.455 0.280
  8  0.485 0.691 0.691 0.886 0.453 0.277 0.398 0.498 0.385 0.586
  9  1.234 0.391 0.554 0.443 0.412 0.958 0.340 0.384 0.709 0.732
  10 1.234 0.391 0.554 0.443 0.412 0.958 0.340 0.384 0.709 0.732

 XSA population number ( thousands )
      age
year        1      2      3     4     5     6     7    8    9   10
  1999  82581 103065 167236 16936 11815  2913  1711 5431  491 1192
  2000 123824  74450  78264 82386  7536  4878  1483  916 3027 2313
  2001  63480 109804  53027 39674 33830  3691  2057  577  415 1781
  2002 187821  56599  74769 27439 16992 14697  1983 1068  262 1066
  2003  85663 168944  40699 36404 13137  7561  7165 1154  399 1399
  2004  46679  76515 122114 20181 17635  6351  3126 4171  664  658
  2005  49955  41746  55012 64863  9201  8863  3687 1971 2860 1456
  2006 221770  44101  30718 27765 30607  4271  4264 1887 1198 1769
  2007  60383 194184  30687 18179 16238 17573  2369 2400 1037 1119
  2008  90949  54335 137762 17411 10317  9232 10657 1360 1478 1344

Estimated population abundance at 1st Jan  2009
      age
year   1     2     3     4     5    6    7    8   9  10
  2009 0 80469 43345 90880 10752 5763 5701 7287 685 643

 Fleet:  BTS-ISIS
```

```
 Log catchability residuals.
   year
age  1985   1986   1987   1988   1989   1990   1991   1992   1993   1994
1995   1996
 1 -0.499 -0.458  0.022 -0.081 -0.132 -0.043 -0.250  0.039 -0.102  0.110
0.488 -0.035
 2  0.197 -0.623 -0.210  0.574  0.353  0.683  0.195  1.138 -0.267 -0.368
0.483 -0.336
 3 -0.056 -0.131 -0.450 -0.559  0.583  0.116  0.340  0.334 -1.027  0.210
0.990  0.234
 4  0.275 -0.430 -0.256  0.026  0.919 -0.433 -0.214  0.255  0.417 -2.079
0.438  0.636
 5 -0.085  0.211  0.059 -0.888  0.416  0.010 -1.247 -0.168  1.267  0.199
0.087  0.438
 6  0.201 -0.135  0.112 -0.457 -0.068  0.989 -0.837 -0.820  1.055 -0.802
0.624  0.710
 7     NA -0.084  0.390  0.110  0.454 -0.110 -0.454 -0.228 -0.984  0.110
1.186  0.453
 8     NA     NA  0.075  0.101     NA -0.404 -0.073  0.283 -0.019 -1.059
0.668  0.391
 9     NA -0.121     NA -0.416 -0.154 -1.043 -1.211 -0.107  1.015     NA
1.500  0.089
   year
age  1997   1998   1999   2000   2001   2002   2003   2004   2005   2006
2007   2008
 1  0.613  0.040  0.162  0.002  0.190 -0.094  0.113  0.026 -0.086 -0.321
0.063  0.231
 2  0.053  0.135  0.509 -0.202 -0.065 -0.384 -0.553 -0.632 -0.332 -0.647 -
0.041  0.339
 3  0.166  0.203  0.742  0.107 -0.107 -0.023  0.258 -0.522 -0.109 -1.708 -
0.061  0.470
 4  0.441  0.396  0.108 -0.492  0.268 -0.061  0.307 -0.083 -0.522 -0.386 -
0.168  0.639
 5  1.105 -0.858  1.881  0.225 -0.235 -0.291 -0.027  0.188 -0.663 -0.688 -
0.485 -0.448
 6 -0.368 -1.728  1.499  0.336 -0.192 -0.016  0.189 -0.380 -0.450  0.339
0.117  0.082
 7  0.287  0.310  1.476  0.591 -0.410 -1.051  0.393 -0.377 -0.315 -0.331 -
0.784 -0.629
 8 -1.026     NA  1.359 -1.115  0.669  0.884     NA -0.684 -0.338     NA -
2.071 -1.584
 9  1.393     NA -1.089  0.487     NA     NA  0.532     NA     NA -1.599
NA  0.288
   year

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

               2       3       4       5        6       7       8       9
Mean_Logq -8.9000 -9.4591 -9.7382 -9.9113 -10.0973 -9.9763 -9.9763 -9.9763
S.E_Logq   0.4708  0.5666  0.5972  0.7076   0.7017  0.6300  0.9034  0.9389

 Regression statistics
 Ages with q dependent on year-class strength
         slope intercept
Age 1 0.6799813  9.854946

 Fleet:  SNS

 Log catchability residuals.
   year
age 1970   1971   1972   1973   1974   1975   1976   1977  1978   1979
1980   1981
```

```
 1 0.268  0.164 -0.012  0.486 -0.021 -0.097 -0.321  0.056 0.374 -0.118
0.073  0.006
 2 0.762  0.815  0.018  0.628 -0.649  0.215 -1.348  0.094 0.422  0.290
0.093  0.391
 3 0.503  0.159 -0.281  0.256 -0.704 -0.124  0.243  0.271 0.461  0.308
0.283  0.777
 4 0.083 -2.578     NA -0.421     NA  0.244 -0.787 -0.200 0.131  0.365 -
0.048 -0.198
   year
age  1982   1983  1984   1985   1986   1987   1988   1989   1990   1991
1992   1993
 1  0.239 -0.150 0.336  0.440 -0.048  0.184 -0.219  0.091 -0.267 -0.034 -
0.039 -0.006
 2  0.179  0.207 0.228  0.517 -0.186 -0.077  0.247  0.463  0.409  0.699 -
1.224  0.374
 3 -0.011 -0.724 0.400 -0.193 -0.434 -0.873  0.105  0.497 -0.057  0.827 -
0.061  0.033
 4 -0.013 -0.406 0.067 -0.085 -0.545 -0.378  0.661 -0.260  0.924  0.689
0.941  0.564
   year
age  1994   1995   1996   1997  1998   1999   2000   2001   2002 2003
2004   2005
 1 -0.228 -0.197 -0.721  0.115 0.253 -0.001 -0.296 -0.091  0.219   NA
0.320 -0.201
 2  0.047 -0.429 -0.488 -0.778 0.621  0.243 -1.430 -0.139 -0.061   NA
0.134 -0.617
 3  0.324  0.011 -1.002  0.249 0.476  0.063 -0.208 -0.273  0.027   NA
0.183 -0.144
 4 -1.499  0.811  0.082  0.182 0.953 -0.866  0.077 -0.438     NA   NA
0.873     NA
   year
age   2006   2007   2008
  1 -0.215 -0.130 -0.211
  2  0.219 -0.408 -0.478
  3 -0.112 -0.967 -0.288
  4  0.799  0.278     NA

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

                2       3       4
Mean_Logq -4.7123 -5.4686 -5.9980
S.E_Logq   0.5633  0.4437  0.7432

 Regression statistics
 Ages with q dependent on year-class strength
          slope intercept
Age 1 0.7362234  5.812331

 Fleet:  NL Beam Trawl

 Log catchability residuals.

   year
age   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999
2000
  2 -0.509 -1.198 -0.673 -0.283 -0.717  0.166  0.273 -0.428  0.375 -0.222
0.215
  3 -0.263 -0.366 -0.258 -0.520 -0.250 -0.494 -0.111  0.033 -0.147  0.128
0.291
  4 -0.215 -0.136 -0.420 -0.213 -0.476  0.063  0.260 -0.142  0.197 -0.251
-0.102
  5 -0.193  0.078 -0.284  0.050 -0.211 -0.739  0.062  0.026 -0.225  0.182
-0.181
```

```
  6 -0.301 -0.477 -0.122 -0.017  0.004 -0.235 -0.210  0.300  0.052 -0.126
0.254
  7 -0.242 -0.325  0.183  0.220 -0.075 -0.204  0.208 -0.429  0.144 -0.302
0.324
  8  0.045 -0.253 -0.049 -0.135 -0.516 -0.116  0.240  0.502 -0.416  0.039
0.395
  9  0.065  0.102  0.188  0.037  0.149  0.106  0.073 -0.254 -0.162  0.318
-0.246
   year
age   2001   2002   2003   2004   2005  2006   2007   2008
  2  0.318  0.302  0.359  0.383  0.163 0.537  0.662  0.277
  3 -0.050  0.309  0.239  0.351  0.329 0.207  0.234  0.339
  4  0.288  0.053  0.309  0.203  0.318 0.035  0.097  0.133
  5  0.276  0.260  0.000  0.157  0.535 0.119 -0.025  0.113
  6 -0.307  0.386  0.629 -0.140  0.110 0.143  0.070 -0.013
  7  0.029 -0.083  0.259  0.002  0.275 0.219 -0.211  0.010
  8  0.046  0.631 -0.075 -0.492 -0.336 0.452 -0.284  0.228
  9 -0.065 -0.117 -0.320  0.256  0.027 0.191 -0.243  0.096


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

                2       3       4       5       6       7       8       9
Mean_Logq -6.0179 -5.1125 -4.9857 -4.9552 -5.1483 -5.2391 -5.2391 -5.2391
S.E_Logq   0.5031  0.2965  0.2437  0.2709  0.2690  0.2334  0.3419  0.1875

Terminal year survivor and F summaries:
Age 1 Year class = 2007
source   survivors N scaledWts
BTS-ISIS    112941 1     0.396
SNS          60395 1     0.493
fshk        103186 1     0.015
nshk         83433 1     0.096

Age 2 Year class = 2006
source        survivors N scaledWts
BTS-ISIS          52419 2     0.416
SNS               33464 2     0.430
NL Beam Trawl     57165 1     0.143
fshk              22081 1     0.011

Age 3 Year class = 2005
source        survivors N scaledWts
BTS-ISIS          82279 3     0.293
SNS               66613 3     0.349
NL Beam Trawl    136670 2     0.350
fshk              49059 1     0.009

Age 4 Year class = 2004
source        survivors N scaledWts
BTS-ISIS          10612 4     0.253
SNS                6909 3     0.221
NL Beam Trawl     13198 3     0.516
fshk               6435 1     0.010

Age 5 Year class = 2003
source        survivors N scaledWts
BTS-ISIS           3742 5     0.213
SNS                6335 4     0.176
NL Beam Trawl      6554 4     0.601
fshk               4730 1     0.010
```

```
Age 6 Year class = 2002
source        survivors N scaledWts
BTS-ISIS           4784 6     0.195
SNS                6977 3     0.067
NL Beam Trawl      5904 5     0.727
fshk               3602 1     0.010

Age 7 Year class = 2001
source        survivors N scaledWts
BTS-ISIS           4796 7     0.185
SNS                9335 2     0.041
NL Beam Trawl      8013 6     0.765
fshk               4013 1     0.009

Age 8 Year class = 2000
source        survivors N scaledWts
BTS-ISIS            369 8     0.159
SNS                 796 3     0.023
NL Beam Trawl       764 7     0.803
fshk               1098 1     0.015

Age 9 Year class = 1999
source        survivors N scaledWts
BTS-ISIS            427 9     0.130
SNS                 527 3     0.015
NL Beam Trawl       678 8     0.839
fshk               1315 1     0.016
```

Table 6.1.2. Sole in Subarea IV: Stock assessment summary as in WGNSSK 2009.

year	recruitment	ssb	catch	landings	tsb	fbar2-6	Y/ssb
1957	128909	55107	11601	12067	63402	0.178	0.22
1958	128643	60919	14216	14287	72300	0.207	0.23
1959	488757	65580	13702	13832	85947	0.171	0.21
1960	61714	73398	18740	18620	105898	0.204	0.25
1961	99488	117099	23246	23566	123495	0.190	0.20
1962	22895	116830	27039	26877	123703	0.213	0.23
1963	20420	113628	26380	26164	115588	0.313	0.23
1964	539075	37127	11740	11342	51185	0.289	0.31
1965	121959	30029	17767	17043	101359	0.317	0.57
1966	39901	84243	33705	33340	92965	0.325	0.40
1967	75135	82958	32704	33439	91227	0.406	0.40
1968	99262	72306	33285	33179	83081	0.490	0.46
1969	50787	55267	27014	27559	68707	0.546	0.50
1970	137795	50680	19683	19685	60369	0.399	0.39
1971	42148	43742	23374	23652	63445	0.511	0.54
1972	76525	47437	21320	21086	56194	0.462	0.44
1973	104859	36775	18950	19309	51131	0.504	0.53
1974	109939	36110	18237	17989	53712	0.489	0.50
1975	40816	38365	20559	20773	54502	0.497	0.54
1976	113311	38944	16959	17326	48118	0.423	0.44
1977	140375	34623	17672	18003	54463	0.459	0.52
1978	47256	36195	20370	20280	55274	0.479	0.56
1979	11723	44954	22321	22598	51806	0.492	0.50
1980	151694	33584	15496	15807	41164	0.453	0.47
1981	149346	22921	15009	15403	49109	0.496	0.67
1982	152751	32855	21286	21579	58007	0.541	0.66
1983	142179	39956	24828	24927	66061	0.486	0.62
1984	70791	43464	26747	26839	64065	0.613	0.62
1985	80833	41082	24497	24248	53235	0.595	0.59
1986	159654	34554	18316	18201	52243	0.573	0.53
1987	72553	29658	17462	17368	55478	0.489	0.59
1988	454627	38765	21612	21590	70216	0.567	0.56
1989	108296	34075	22156	21805	94200	0.447	0.64
1990	177757	89643	35485	35120	113017	0.454	0.39
1991	70476	77479	34096	33513	103246	0.448	0.43
1992	354171	76772	29787	29341	104411	0.427	0.38
1993	69289	54752	31858	31491	99117	0.511	0.58
1994	57057	74337	33405	33002	86148	0.562	0.44
1995	96104	58934	30690	30467	71432	0.532	0.52
1996	49508	38310	22913	22651	52897	0.698	0.59
1997	271749	28071	15050	14901	48354	0.596	0.53
1998	114161	20882	21049	20868	60803	0.636	1.00
1999	82581	41918	23717	23475	59548	0.571	0.56
2000	123824	39217	22859	22641	55756	0.597	0.58
2001	63480	30762	20582	19944	49748	0.569	0.65
2002	187821	31412	17092	16945	49010	0.563	0.54
2003	85663	25758	17940	17920	54707	0.572	0.70
2004	46679	38402	18744	18757	51218	0.496	0.49
2005	49955	33520	16722	16355	42280	0.548	0.49
2006	221770	25778	12246	12594	43393	0.414	0.49
2007	60383	19585	14725	14635	52120	0.408	0.75
2008	90949	40676	13924	14144	53592	0.338	0.35

Table 6.2.1. Sole in Subarea IV: Official landings and landings estimated by ICES WGNSSK 2009 (tonnes).

YEAR	BE	DK	FR	GE	NL	UK	OTHER	TOTAL	UNALLOC	WG	TAC
						(E/W/NI)	countries	reported	landings	Total	
1982	1900	524	686	266	17686	403	2	21467	112	21579	21000
1983	1740	730	332	619	16101	435		19957	4970	24927	20000
1984	1771	818	400	1034	14330	586	1	18940	7899	26839	20000
1985	2390	692	875	303	14897	774	3	19934	4314	24248	22000
1986	1833	443	296	155	9558	647	2	12934	5266	18200	20000
1987	1644	342	318	210	10635	676	4	13829	3539	17368	14000
1988	1199	616	487	452	9841	740	28	13363	8227	21590	14000
1989	1596	1020	312	864	9620	1033	50	14495	7311	21806	14000
1990	2389	1427	352	2296	18202	1614	263	26543	8577	35120	25000
1991	2977	1307	465	2107	18758	1723	271	27608	5905	33513	27000
1992	2058	1359	548	1880	18601	1281	277	26004	3337	29341	25000
1993	2783	1661	490	1379	22015	1149	298	29775	1716	31491	32000
1994	2935	1804	499	1744	22874	1137	298	31291	1711	33002	32000
1995	2624	1673	640	1564	20927	1040	312	28780	1687	30467	28000
1996	2555	1018	535	670	15344	848	229	21199	1452	22651	23000
1997	1519	689	99	510	10241	479	204	13741	1160	14901	18000
1998	1844	520	510	782	15198	549	339	19742	1126	20868	19100
1999	1919	828		1458	16283	645	501	21634	1841	23475	22000
2000	1806	1069	362	1280	15273	600	539	20929	1603	22532	22000
2001	1874	772	411	958	13345	597	394	18351	1593	19944	19000
2002	1437	644	266	759	12120	451	292	15969	976	16945	16000
2003	1605	703	728	749	12469	521	363	17138	782	17920	15850
2004	1477	808	655	949	12860	535	544	17828	-681	17147	17000
2005	1374	831	676	756	10917	667	357	15579	776	16355	18600
2006	980	585	648	475	8299	910		11933	667	12600	17670
2007	955	413	401	458	10365	1203	5	13800	835	14635	15000
2008	1379	507	714	513	9456	851	15	13435	710	14145	12800

Table 6.2.2. Sole in Subarea IV: Overview of landings and discards numbers and weights per hour and percentages in the Dutch discards sampling.

		NUMBERS			WEIGHT		
Period	trips	Landings	Discards	%D	Landings	Discards	%D
	n	n·h-1	n·h-1		kg·h-1	kg·h-1	
1976–1979	21	116	8	6%	38	1	3%
1980–1983	22	84	23	21%	27	3	9%
1989–1990	6	286	83	22%	72	11	13%
1999–2001	20	92	21	19%	22	2	8%
2002	6	124	37	24%	18	3	13%
2003	9	95	32	25%	20	3	14%
2004	8	174	58	25%	28	5	17%
2005	9	99	29	23%	20	2	11%
2006	9	64	26	29%	16	2	13%
2007	10	94	27	23%	22	2	10%

Table 6.2.3. Sole in Subarea IV: sexes combined landing numbers-at-age.

2010-02-24 15:23:56 units= NA

	age														
year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	0	1415	10148	12642	3762	2924	6518	1733	509	5379	166	266	34	79	364
1958	0	1854	8440	14169	9500	3484	3008	4439	2253	727	5215	111	207	35	262
1959	0	3659	12025	10401	8975	5768	1206	2025	2574	1366	736	2875	101	128	409
1960	0	12042	14133	16798	9308	8367	4846	1593	1056	2800	992	515	3135	133	326
1961	0	959	49786	19140	12404	4695	3944	4279	836	990	1711	1154	444	2539	416
1962	0	1594	6210	59191	15346	10541	4826	4112	2087	900	1539	977	1161	389	2528
1963	0	676	8339	8555	46201	8490	6658	2423	3393	1566	1002	764	1778	413	2861
1964	55	155	2113	5712	3809	17337	3126	1810	818	872	495	217	474	336	621
1965	0	47100	1089	1599	5002	2482	12500	1557	1525	389	627	475	322	200	1195
1966	0	12278	133617	990	1181	3689	744	6324	702	767	287	473	120	87	716
1967	0	3686	25683	85127	1954	536	1919	760	5047	538	610	455	348	277	685
1968	1037	17148	13896	24973	48571	462	245	1644	324	4407	254	820	82	396	564
1969	396	23922	21451	5326	12388	25139	331	244	1190	289	2961	291	538	151	1042
1970	1299	6140	25993	8235	1784	3231	11960	246	140	686	169	2416	238	582	1143
1971	420	33369	14425	12757	4485	1442	2327	7214	192	232	826	291	1413	466	1366
1972	358	7594	36759	7075	4965	1565	523	1232	4706	120	100	492	119	922	1048
1973	703	12228	12783	16187	4025	2324	994	765	1218	3337	221	297	499	110	1326
1974	101	15380	21540	5487	7061	1922	1585	658	401	609	2363	104	32	305	1401
1975	264	22954	28535	11717	2088	3830	790	907	508	234	252	1905	25	84	945
1976	1041	3542	27966	14013	4819	966	1909	550	425	204	195	132	1320	39	773
1977	1747	22328	12073	15306	7440	1779	319	1112	256	211	93	122	108	852	729
1978	27	25031	29292	6129	6639	4250	1738	611	646	191	235	123	106	68	879
1979	9	8179	41170	16060	2996	3222	1747	816	241	393	154	117	103	73	687
1980	637	1209	12511	17781	7297	1450	2197	1409	367	54	415	52	52	32	598
1981	423	29217	3259	6866	8223	3661	948	886	766	197	107	160	92	21	331
1982	2660	26435	45746	1843	3535	4789	1678	615	605	527	149	74	201	12	315
1983	389	34408	41386	21189	624	1378	1950	978	386	301	423	31	14	177	230
1984	191	30734	43931	22554	8791	741	854	1043	524	242	209	146	30	24	243
1985	165	16618	43213	20286	9403	3556	209	379	637	200	192	189	94	33	267
1986	374	9363	18497	17702	7747	5515	2270	110	283	620	355	172	126	105	304
1987	94	29053	22046	8899	6512	3119	1567	903	81	103	165	144	62	55	165
1988	10	13219	47182	15232	4381	3882	1551	891	524	38	34	85	42	10	108
1989	117	46387	18263	22654	4624	1653	1437	647	458	227	45	35	44	35	82
1990	863	11939	104454	9767	9194	3349	1043	1198	554	225	291	58	26	44	201
1991	120	13163	25420	77913	6724	3675	1736	719	730	304	281	340	14	15	136
1992	980	6832	44378	16204	38319	2477	3041	741	399	454	162	224	116	6	218
1993	54	50451	16768	31409	13869	24035	1489	1184	461	172	293	101	75	108	93
1994	718	7804	87403	13550	18739	5711	11310	464	916	265	73	211	76	41	242
1995	4801	12767	16822	68571	6308	7307	1995	6015	295	331	58	67	48	20	144
1996	172	18824	16190	16964	27257	3858	4780	943	3305	239	287	149	50	100	163
1997	1590	6047	23651	7325	5108	12793	1201	2326	333	1437	31	114	20	23	63
1998	244	56648	15141	14934	3496	1941	4768	794	1031	238	410	43	59	12	84
1999	287	15762	72470	8187	6111	1212	664	1984	331	492	43	175	8	35	59
2000	2351	15073	32738	42803	3288	2477	804	435	931	303	219	49	102	8	33
2001	884	25846	21595	19876	16730	1427	834	274	168	508	61	60	11	52	32

2002	1055	11053	32852	12290	8215	6448	673	597	89	91	153	40	36	6	38
2003	1048	32330	17498	16090	5820	3906	2430	400	128	144	89	90	58	38	32
2004	516	14950	47970	9524	7457	2165	901	961	389	117	95	28	51	46	52
2005	1156	7417	23141	29523	4262	3948	1524	616	785	169	55	30	19	82	46
2006	6814	9690	10109	9340	10640	1572	1533	704	363	241	138	32	10	9	108
2007	317	39888	10887	6447	5741	5513	824	729	501	186	104	163	39	11	41
2008	1919	6118	35504	5258	3755	2788	2477	574	730	270	186	118	66	16	12

Table 6.2.4. Sole in Subarea IV: Sexes combined Dutch discards numbers-at-age.

2010-02-24 15:36:42 units= NA

year \ age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1958	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1959	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1960	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1961	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1962	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1963	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1964	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1965	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1966	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1967	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1968	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1969	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1970	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1971	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1972	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1973	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1974	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1975	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1976	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1977	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1978	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1979	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1980	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1981	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1982	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1991	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1992	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1993	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1994	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1995	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1996	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1997	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

1998	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1999	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2000	2278	5074	3875	936	38	28	6	1	3	2	0	0	0	0	0
2001	713	4207	2056	897	340	28	0	0	0	0	0	0	0	0	0
2002	18302	1866	3512	174	360	0	0	0	0	0	0	0	0	0	0
2003	430	12949	1660	335	37	32	7	0	0	0	0	0	0	0	0
2004	2370	14271	4103	671	603	0	0	0	0	0	0	0	0	0	0
2005	1903	3891	4309	1610	137	126	48	49	38	0	0	0	0	0	0
2006	9714	2117	682	731	211	235	28	0	0	33	0	0	0	0	0
2007	849	5660	647	220	28	43	29	0	0	0	0	0	0	0	0
2008	2073	816	859	88	26	30	8	4	0	1	0	0	0	0	0

Table 6.2.5. Female Sole in Subarea IV: female landing numbers-at-age.

2010-02-24 15:49:03 units= NA

year	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	0	1197	7198	9168	2340	1500	3104	768	346	2504	63	153	35	26	170
1958	0	1565	6417	8684	5813	1744	1381	1663	925	300	2388	111	54	35	57
1959	0	3432	9181	7962	4982	3293	764	772	1335	709	355	1309	90	30	242
1960	0	10105	9612	11087	5121	3504	2245	527	495	1187	432	202	1240	46	223
1961	0	672	36571	13653	7074	2951	1882	1900	496	551	792	736	204	1228	210
1962	0	1594	4064	34907	9052	5123	2401	2028	949	326	567	461	671	89	1272
1963	0	649	6876	6174	28282	6249	4258	1672	2064	974	468	274	926	281	1900
1964	53	76	1207	3386	2110	9637	1898	1009	515	624	335	137	242	179	292
1965	0	29238	924	703	2600	1219	6115	966	863	163	472	201	175	40	571
1966	0	8376	78675	578	619	1494	527	3447	447	457	224	269	53	53	135
1967	0	2068	13072	45873	1096	404	1219	280	2578	519	428	165	299	83	416
1968	721	10311	7175	11963	26082	338	82	852	192	2332	214	371	69	189	459
1969	396	11870	10190	2030	5501	14055	326	125	782	227	1754	231	322	109	335
1970	690	3881	13216	4758	1063	1959	6904	143	87	414	101	1373	86	364	62
1971	130	17908	8126	6857	2191	871	1226	4100	119	97	410	90	872	240	424
1972	256	4568	17515	3454	2567	719	330	638	2761	63	60	234	82	592	344
1973	586	6818	6765	8683	2428	1113	623	515	582	1884	178	110	251	68	715
1974	61	7069	10765	2901	4173	954	846	280	223	308	1612	80	13	148	71
1975	46	13463	14463	6313	1136	2079	503	569	306	110	189	1244	19	57	87
1976	658	2253	13876	7482	2494	562	1095	392	309	156	80	100	889	26	37
1977	1006	13519	7103	7964	3659	901	148	630	154	136	76	76	61	492	14
1978	1	13753	15597	3150	3212	2114	753	270	390	65	147	86	61	64	370
1979	8	4986	21070	8829	1649	1587	1073	468	151	275	116	91	72	62	48
1980	442	604	6691	8984	3428	708	1146	806	206	40	208	30	23	8	23
1981	244	14484	1521	3367	3919	1804	395	461	360	94	38	98	32	16	45
1982	2098	16596	23584	1020	1527	2104	822	332	326	277	94	36	113	10	33
1983	52	22254	23166	12251	429	709	1074	590	188	179	229	28	4	73	29
1984	191	18759	21600	10744	4810	420	469	626	304	94	130	98	28	24	49
1985	77	9520	22838	9565	4908	2002	114	224	372	145	79	115	70	29	24
1986	272	6261	9572	10024	3690	2673	1339	78	115	305	180	85	65	74	50
1987	92	18919	13450	4858	3759	1353	762	475	33	64	118	87	43	40	43
1988	9	8482	25546	7897	2362	2306	849	513	321	29	20	55	37	10	18
1989	115	32274	11186	11431	2191	757	865	320	166	102	45	18	35	16	28
1990	544	9614	72014	5630	5367	1729	523	735	209	168	132	28	25	23	33
1991	120	10350	16728	43160	2735	2431	892	400	404	146	112	128	10	13	32
1992	801	4792	29997	8772	17975	1307	1682	446	183	221	81	150	84	5	66
1993	0	44401	11934	17172	5722	9366	504	563	254	155	148	67	69	54	34
1994	526	6624	69349	9541	9345	2432	4080	252	446	138	53	121	57	29	78
1995	3365	9671	12601	41216	3472	3408	909	2156	135	223	51	33	34	20	20
1996	112	13134	10965	9539	14309	1826	1858	428	1177	133	167	66	48	79	73
1997	1361	3778	14880	4673	2841	5450	622	741	176	558	25	105	20	12	40
1998	128	41686	10046	8802	1837	853	1932	271	276	117	205	10	43	5	35
1999	287	13305	51388	5701	3417	654	385	924	215	164	33	92	8	19	31

2000	2232	12159	22944	24167	1992	1056	407	202	412	72	126	7	61	8	19
2001	719	20690	15493	11329	7592	901	464	186	85	208	54	58	11	23	17
2002	946	8652	24977	8530	3920	2795	404	223	79	90	104	40	36	0	34
2003	930	27616	13003	9522	2551	1554	1134	152	128	69	11	46	38	26	11
2004	527	13211	38248	6363	3624	1067	527	543	204	120	55	0	49	47	24
2005	1025	5957	18182	19430	2148	1806	482	262	283	42	48	30	19	36	26
2006	6026	8438	7393	5749	6279	763	454	350	130	142	22	19	10	9	23
2007	238	35505	8191	3711	3067	2364	455	308	275	58	58	22	4	1	0
2008	1618	5708	28480	3435	1661	1667	1106	206	310	69	41	53	65	8	0

Table 6.2.6. Male Sole in Subarea IV : landing numbers-at-age.

2010-02-24 15:56:59 units= NA

age

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	0	218	2951	3474	1422	1424	3414	965	163	2876	103	113	0	53	184
1958	0	289	2023	5485	3688	1740	1627	2776	1328	426	2828	0	153	0	89
1959	0	227	2844	2439	3993	2475	442	1254	1239	657	381	1566	11	98	11
1960	0	1937	4520	5710	4187	4863	2601	1066	561	1613	560	312	1895	87	0
1961	0	287	13215	5487	5330	1744	2062	2380	340	439	918	418	240	1311	34
1962	0	0	2146	24285	6295	5419	2425	2085	1138	574	973	516	490	300	1128
1963	0	27	1463	2381	17918	2241	2400	751	1329	593	535	491	853	131	371
1964	1	79	907	2327	1699	7700	1228	801	303	248	160	80	232	157	63
1965	0	17862	165	895	2402	1263	6386	592	662	226	155	274	147	160	127
1966	0	3903	54942	412	561	2195	217	2877	255	310	64	203	67	34	68
1967	0	1617	12612	39254	859	133	700	479	2469	19	182	290	48	194	47
1968	316	6837	6721	13010	22489	124	163	792	132	2075	40	449	12	206	38
1969	0	12052	11261	3296	6887	11084	6	119	408	63	1207	59	215	43	101
1970	609	2259	12777	3477	721	1272	5057	103	53	272	67	1043	152	218	22
1971	290	15461	6299	5900	2294	572	1101	3114	72	135	417	201	541	226	121
1972	101	3026	19244	3621	2399	846	194	594	1945	57	40	258	37	330	85
1973	117	5410	6018	7505	1596	1212	371	250	635	1454	43	186	248	41	232
1974	40	8311	10775	2586	2888	969	739	377	177	301	752	24	19	157	39
1975	218	9492	14072	5404	952	1751	287	338	202	124	62	660	6	27	43
1976	383	1289	14090	6531	2325	404	815	159	115	47	115	32	431	14	24
1977	740	8809	4970	7343	3781	878	170	482	102	75	17	45	47	360	8
1978	26	11279	13695	2979	3427	2136	984	341	255	127	88	37	46	4	165
1979	1	3193	20100	7231	1347	1635	674	348	91	118	38	25	31	11	26
1980	186	587	5635	8533	3761	721	1018	582	156	13	201	21	28	24	5
1981	179	14732	1738	3499	4304	1857	553	425	407	104	69	62	60	4	22
1982	562	9839	22162	822	2008	2686	856	283	279	251	55	38	88	2	15
1983	337	12154	18220	8938	196	669	876	388	198	123	193	3	11	104	13
1984	0	11975	22331	11811	3982	321	385	417	220	149	80	48	2	0	20
1985	88	6603	20384	10726	4500	1555	95	155	265	64	113	74	25	4	56
1986	102	3092	8924	7681	4056	2849	933	32	167	315	175	88	61	31	8
1987	0	9548	8183	3885	2633	1709	777	414	46	37	45	55	18	14	23
1988	1	4705	21594	7351	2038	1584	705	384	205	9	15	31	5	0	42
1989	0	13834	7012	11136	2506	937	589	334	301	138	0	18	14	11	23
1990	319	2326	32440	4137	3827	1620	519	462	345	57	159	30	1	22	20
1991	0	2813	8692	34753	3989	1244	844	318	327	158	169	212	4	2	38
1992	179	2040	14381	7433	20344	1170	1359	296	215	232	81	74	32	2	31
1993	0	6050	4834	14237	8147	14669	984	621	207	17	146	34	6	54	39
1994	179	1078	17018	4091	9308	3251	7107	210	473	141	33	93	27	15	109
1995	1436	3097	4221	27355	2836	4499	1086	3859	161	108	7	34	14	0	13
1996	60	5690	5226	7426	12948	2032	2922	515	2128	106	119	83	3	21	14
1997	215	2238	8635	2653	2280	7285	632	1590	172	878	8	13	1	14	11
1998	115	14962	5095	6132	1659	1088	2836	524	755	120	205	33	16	7	15
1999	0	2457	21082	2486	2694	558	279	1059	116	328	9	82	1	16	3

2000	83	2683	9294	17982	1246	1383	384	226	504	226	90	42	40	0	0
2001	161	5033	5998	8452	9059	519	366	87	82	297	6	1	0	28	0
2002	98	2291	7549	3638	4214	3589	262	368	9	0	47	0	0	0	0
2003	118	4715	4495	6568	3269	2352	1296	248	0	76	78	44	20	11	0
2004	0	2043	10695	3355	3985	1142	392	437	193	0	41	29	3	0	24
2005	131	1460	4959	10094	2115	2142	1042	355	502	126	7	0	0	46	0
2006	788	1252	2716	3591	4361	809	1079	354	233	99	116	13	0	0	51
2007	79	4383	2696	2736	2675	3150	369	422	227	128	47	130	19	16	44
2008	301	410	7024	1823	2094	1121	1372	368	420	201	145	65	0	8	0

Table 6.2.7. Sole in Subarea IV : landing weights-at-age.

2010-02-26 17:48:37 units= kg

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	0.000	0.154	0.177	0.204	0.248	0.279	0.290	0.335	0.436	0.394	0.432	0.471	0.631	0.437	0.533
1958	0.000	0.145	0.178	0.220	0.254	0.273	0.314	0.323	0.388	0.401	0.409	0.502	0.287	0.578	0.577
1959	0.000	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.391	0.438	0.417	0.437	0.412	0.589
1960	0.000	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.363	0.436	0.428	0.442	0.427	0.578
1961	0.000	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.372	0.369	0.397	0.478	0.450	0.551
1962	0.000	0.155	0.165	0.208	0.241	0.295	0.320	0.321	0.334	0.349	0.347	0.394	0.435	0.373	0.476
1963	0.000	0.163	0.171	0.219	0.258	0.309	0.323	0.387	0.376	0.440	0.397	0.433	0.444	0.490	0.578
1964	0.153	0.175	0.213	0.252	0.274	0.309	0.327	0.346	0.388	0.444	0.439	0.475	0.403	0.447	0.644
1965	0.000	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.425	0.459	0.480	0.458	0.397	0.528
1966	0.000	0.177	0.190	0.180	0.301	0.332	0.429	0.399	0.449	0.472	0.541	0.526	0.521	0.491	0.499
1967	0.000	0.192	0.201	0.252	0.277	0.389	0.419	0.339	0.424	0.498	0.456	0.389	0.519	0.442	0.591
1968	0.157	0.189	0.207	0.267	0.327	0.342	0.354	0.455	0.465	0.475	0.674	0.524	0.656	0.495	0.650
1969	0.152	0.191	0.196	0.255	0.311	0.373	0.553	0.398	0.468	0.499	0.496	0.538	0.474	0.613	0.613
1970	0.154	0.212	0.218	0.285	0.350	0.404	0.441	0.463	0.443	0.511	0.512	0.541	0.456	0.542	0.542
1971	0.145	0.193	0.237	0.322	0.358	0.425	0.420	0.490	0.534	0.425	0.489	0.466	0.578	0.563	0.583
1972	0.169	0.204	0.252	0.334	0.434	0.425	0.532	0.485	0.558	0.481	0.472	0.577	0.597	0.677	0.647
1973	0.146	0.208	0.238	0.346	0.404	0.448	0.552	0.567	0.509	0.569	0.644	0.399	0.547	0.642	0.670
1974	0.164	0.192	0.233	0.338	0.418	0.448	0.520	0.559	0.609	0.602	0.661	0.678	0.532	0.582	0.679
1975	0.129	0.182	0.225	0.320	0.406	0.456	0.529	0.595	0.629	0.560	0.648	0.683	0.620	0.645	0.678
1976	0.143	0.190	0.222	0.306	0.389	0.441	0.512	0.562	0.667	0.658	0.538	0.736	0.668	0.598	0.684
1977	0.147	0.188	0.236	0.307	0.369	0.424	0.430	0.520	0.562	0.622	0.731	0.607	0.605	0.643	0.581
1978	0.152	0.196	0.231	0.314	0.370	0.426	0.466	0.417	0.572	0.471	0.604	0.711	0.588	0.830	0.716
1979	0.137	0.208	0.246	0.323	0.391	0.448	0.534	0.544	0.609	0.657	0.728	0.774	0.806	0.839	0.815
1980	0.141	0.199	0.244	0.331	0.371	0.418	0.499	0.550	0.598	0.544	0.658	0.684	0.674	0.661	0.717
1981	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.553	0.403	0.665	0.565	0.721	0.745
1982	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.580	0.556	0.628	0.591	0.771	0.898	0.768
1983	0.134	0.182	0.217	0.301	0.389	0.416	0.467	0.489	0.505	0.609	0.622	0.600	0.334	0.631	0.756
1984	0.153	0.171	0.221	0.286	0.361	0.386	0.465	0.555	0.575	0.512	0.655	0.631	0.722	0.845	0.707
1985	0.122	0.187	0.216	0.288	0.357	0.427	0.447	0.544	0.612	0.634	0.509	0.656	0.767	0.801	0.680
1986	0.135	0.179	0.213	0.299	0.357	0.407	0.485	0.543	0.568	0.536	0.575	0.634	0.632	0.789	0.715
1987	0.139	0.185	0.205	0.277	0.356	0.378	0.428	0.481	0.393	0.608	0.646	0.615	0.697	0.728	0.696
1988	0.127	0.175	0.217	0.270	0.354	0.428	0.484	0.521	0.559	0.594	0.808	0.717	0.756	0.771	0.698
1989	0.118	0.173	0.216	0.288	0.336	0.375	0.456	0.492	0.470	0.512	0.683	0.630	0.737	0.649	0.754
1990	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.602	0.661	0.522	0.583	0.510	0.637
1991	0.127	0.186	0.210	0.263	0.315	0.436	0.443	0.467	0.507	0.567	0.548	0.530	0.949	0.738	0.568
1992	0.146	0.178	0.213	0.258	0.298	0.380	0.409	0.460	0.487	0.531	0.590	0.468	0.630	0.779	0.626
1993	0.097	0.167	0.196	0.239	0.264	0.300	0.338	0.441	0.496	0.636	0.564	0.583	0.651	0.610	0.641
1994	0.143	0.180	0.202	0.228	0.257	0.300	0.317	0.432	0.409	0.415	0.544	0.478	0.702	0.614	0.554
1995	0.151	0.186	0.196	0.247	0.265	0.319	0.344	0.356	0.444	0.511	0.792	0.564	0.764	0.940	0.602
1996	0.163	0.177	0.202	0.234	0.274	0.285	0.318	0.370	0.390	0.516	0.546	0.555	0.601	0.700	0.763
1997	0.151	0.180	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.406	0.579	0.605	0.668	0.450	0.762
1998	0.128	0.182	0.189	0.252	0.262	0.289	0.336	0.292	0.335	0.397	0.504	0.433	0.649	0.541	0.735
1999	0.163	0.179	0.212	0.229	0.287	0.324	0.354	0.372	0.372	0.365	0.533	0.561	0.708	0.577	0.696
2000	0.145	0.170	0.200	0.248	0.290	0.299	0.323	0.368	0.402	0.294	0.447	0.409	0.642	1.031	0.740
2001	0.143	0.185	0.202	0.270	0.275	0.333	0.391	0.414	0.433	0.438	0.523	0.646	0.600	0.595	0.830
2002	0.140	0.183	0.211	0.243	0.281	0.312	0.366	0.319	0.571	0.413	0.556	0.456	0.606	0.356	0.797
2003	0.136	0.182	0.214	0.256	0.273	0.317	0.340	0.344	0.503	0.388	0.316	0.498	0.404	0.577	0.625

2004	0.127	0.180	0.209	0.252	0.263	0.284	0.378	0.367	0.327	0.348	0.397	0.387	0.560	0.493	0.474
2005	0.172	0.185	0.207	0.243	0.241	0.282	0.265	0.377	0.318	0.321	0.525	0.578	0.433	0.346	0.512
2006	0.156	0.190	0.220	0.263	0.291	0.322	0.293	0.358	0.397	0.464	0.251	0.450	0.637	0.814	0.359
2007	0.154	0.180	0.205	0.237	0.253	0.273	0.295	0.299	0.281	0.351	0.410	0.230	0.457	0.254	0.282
2008	0.150	0.182	0.225	0.245	0.260	0.311	0.314	0.283	0.280	0.373	0.343	0.302	0.650	0.572	0.459

Table 6.2.8. Female Sole in Subarea IV : stock weights-at-age.

2010-02-24 17:52:13 units= kg

year	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	NA	NA	0.150	0.207	0.239	0.318	0.349	0.469	0.445	0.528	0.602	0.589	0.587	0.876	0.449
1958	NA	NA	0.175	0.223	0.298	0.356	0.379	0.444	0.527	0.515	0.566	0.610	0.433	0.566	0.766
1959	NA	NA	0.163	0.216	0.305	0.362	0.415	0.382	0.454	0.508	0.589	0.570	0.413	0.598	0.777
1960	NA	NA	0.172	0.237	0.290	0.359	0.389	0.507	0.616	0.530	0.552	0.517	0.670	0.466	0.629
1961	NA	NA	0.151	0.217	0.271	0.281	0.325	0.396	0.321	0.445	0.484	0.450	0.785	0.506	0.667
1962	NA	NA	0.147	0.233	0.328	0.374	0.390	0.406	0.488	0.581	0.506	0.647	0.556	0.688	0.708
1963	NA	NA	0.150	0.207	0.290	0.324	0.377	0.437	0.421	0.483	0.570	0.616	0.635	0.654	0.693
1964	NA	NA	0.157	0.258	0.333	0.361	0.374	0.419	0.459	0.506	0.458	0.565	0.502	0.547	0.675
1965	NA	0.142	0.219	0.228	0.299	0.336	0.419	0.422	0.578	0.594	0.464	0.746	0.462	NA	0.724
1966	NA	NA	0.171	0.143	0.409	0.448	0.473	0.468	0.479	0.529	0.770	0.655	0.785	0.555	0.714
1967	NA	0.177	0.187	0.288	0.272	0.469	0.495	0.482	0.517	0.464	0.496	0.531	0.582	0.688	0.642
1968	NA	0.125	0.198	0.318	0.385	0.342	0.629	0.571	0.560	0.591	0.753	0.669	0.676	0.712	0.784
1969	NA	0.137	0.196	0.312	0.397	0.451	0.579	0.568	0.584	0.582	0.606	0.595	0.710	0.746	0.799
1970	NA	0.138	0.223	0.333	0.402	0.462	0.511	0.573	0.476	0.611	0.561	0.658	0.763	0.721	0.733
1971	NA	0.147	0.234	0.365	0.422	0.514	0.515	0.573	0.592	0.540	0.585	0.716	0.705	0.669	0.675
1972	NA	0.156	0.250	0.380	0.508	0.528	0.580	0.568	0.658	0.528	0.502	0.690	0.758	0.771	0.733
1973	NA	0.152	0.264	0.396	0.469	0.555	0.578	0.614	0.639	0.671	0.644	0.545	0.711	0.704	0.794
1974	NA	0.149	0.260	0.406	0.507	0.546	0.611	0.785	0.697	0.793	0.743	0.647	0.676	0.623	0.793
1975	NA	0.153	0.240	0.393	0.488	0.549	0.625	0.675	0.756	0.815	0.684	0.789	0.775	0.831	0.782
1976	NA	0.145	0.229	0.365	0.467	0.541	0.610	0.609	0.723	0.841	0.745	0.854	0.744	0.737	0.699
1977	NA	0.152	0.235	0.346	0.470	0.525	0.587	0.606	0.651	0.729	0.681	0.818	0.715	0.760	0.702
1978	NA	0.143	0.250	0.349	0.446	0.530	0.592	0.601	0.694	0.778	0.808	0.901	0.693	0.885	0.859
1979	NA	0.143	0.250	0.366	0.463	0.551	0.619	0.700	0.739	0.779	0.937	0.815	0.975	0.948	0.903
1980	NA	0.172	0.225	0.375	0.457	0.559	0.610	0.650	0.755	0.566	0.873	0.754	0.909	1.212	0.857
1981	NA	0.139	0.220	0.371	0.462	0.505	0.588	0.664	0.693	0.689	0.620	0.778	0.741	0.856	0.736
1982	NA	0.131	0.221	0.340	0.495	0.567	0.587	0.662	0.751	0.767	0.748	0.679	0.898	0.747	0.851
1983	NA	0.142	0.227	0.334	0.428	0.540	0.607	0.615	0.719	0.757	0.821	0.773	0.741	0.838	0.822
1984	NA	0.133	0.241	0.356	0.444	0.484	0.584	0.689	0.724	0.816	0.807	0.918	0.873	0.952	0.968
1985	NA	0.125	0.211	0.344	0.429	0.494	0.497	0.700	0.769	0.723	0.765	0.803	0.843	0.947	0.892
1986	NA	0.134	0.223	0.362	0.489	0.563	0.620	0.525	0.806	0.837	0.820	0.792	0.936	1.026	0.979
1987	0.144	0.159	0.209	0.326	0.441	0.531	0.543	0.624	0.401	0.692	0.720	0.721	0.796	0.847	1.025
1988	NA	0.135	0.227	0.318	0.414	0.510	0.629	0.645	0.646	0.483	1.040	0.883	0.707	0.847	0.804
1989	NA	0.135	0.208	0.334	0.358	0.440	0.510	0.618	0.609	0.658	0.669	0.841	0.801	0.734	0.722
1990	NA	0.146	0.216	0.315	0.406	0.400	0.433	0.536	0.655	0.544	0.823	0.644	0.803	0.651	0.873
1991	NA	0.140	0.202	0.303	0.409	0.479	0.499	0.568	0.570	0.738	0.743	0.752	NA	1.367	0.706
1992	NA	0.165	0.217	0.279	0.372	0.466	0.517	0.548	0.572	0.675	0.686	0.745	0.750	NA	0.671
1993	NA	0.125	0.202	0.282	0.342	0.411	0.520	0.604	0.583	0.708	0.815	0.895	0.710	0.734	0.678
1994	NA	0.150	0.181	0.229	0.324	0.394	0.450	0.563	0.559	0.562	0.568	0.715	0.706	0.722	0.706
1995	NA	0.165	0.192	0.281	0.281	0.425	0.417	0.526	0.531	0.599	0.533	0.580	0.782	0.584	0.632
1996	0.139	0.156	0.200	0.255	0.353	0.379	0.502	0.578	0.623	0.661	0.798	0.888	0.733	0.750	0.927
1997	NA	0.138	0.210	0.256	0.311	0.421	0.420	0.489	0.507	0.633	0.642	0.740	0.729	0.752	0.688
1998	NA	0.142	0.194	0.292	0.311	0.365	0.495	0.421	0.517	0.499	0.692	0.498	0.638	0.707	0.627
1999	NA	0.133	0.204	0.255	0.338	0.379	0.440	0.492	0.444	0.436	0.530	0.779	0.567	0.869	0.714
2000	NA	0.149	0.197	0.277	0.332	0.408	0.392	0.576	0.523	0.335	0.331	0.685	0.790	1.372	0.960
2001	NA	0.144	0.202	0.269	0.371	0.394	0.465	0.421	0.510	0.711	0.515	0.731	0.616	0.913	0.955
2002	NA	0.152	0.216	0.280	0.361	0.410	0.475	0.596	0.618	NA	0.704	0.775	0.665	NA	0.806
2003	NA	0.150	0.214	0.295	0.390	0.477	0.521	0.553	0.618	0.790	0.916	0.602	0.495	0.597	0.681

2004	NA	0.137	0.208	0.281	0.357	0.424	0.489	0.540	0.507	0.625	0.531	NA	0.677	NA	0.711
2005	NA	0.115	0.195	0.278	0.345	0.457	0.507	0.579	0.594	0.710	0.478	0.837	1.212	0.757	NA
2006	NA	0.150	0.218	0.267	0.329	0.381	0.485	0.440	0.518	0.595	0.697	0.618	0.801	0.542	0.490
2007	NA	0.153	0.193	0.262	0.323	0.373	0.426	0.443	0.434	0.554	0.631	0.586	0.624	NA	NA
2008	NA	0.159	0.214	0.252	0.369	0.431	0.486	0.458	0.619	0.668	0.644	0.764	0.693	0.594	NA

Table 6.2.9. Male Sole in Subarea IV : stock weights-at-age.

2010-02-24 17:52:14 units= kg

year	age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	NA	NA	0.137	0.145	0.167	0.206	0.197	0.220	0.327	0.267	NA	0.299	NA	0.555	0.144
1958	NA	NA	0.151	0.170	0.174	0.193	0.224	0.249	0.290	0.287	0.295	NA	NA	NA	0.388
1959	NA	NA	0.143	0.157	0.165	0.191	0.211	0.237	0.236	0.205	0.251	0.280	NA	NA	NA
1960	NA	NA	0.144	0.158	0.161	0.179	0.209	0.210	0.258	0.246	0.435	0.262	0.343	NA	NA
1961	NA	NA	0.137	0.166	0.175	0.179	0.226	0.195	0.225	0.207	0.271	0.287	0.384	0.307	NA
1962	NA	NA	0.148	0.146	0.185	0.233	0.217	0.215	0.195	0.277	0.233	0.244	0.325	0.360	0.376
1963	NA	NA	0.141	0.162	0.173	0.191	0.215	0.229	0.239	0.274	0.276	0.333	0.344	0.282	0.350
1964	NA	NA	0.162	0.164	0.174	0.210	0.208	0.229	0.262	0.291	0.282	0.385	0.414	0.259	0.334
1965	NA	0.122	0.132	0.221	0.196	0.223	0.256	0.219	0.368	0.317	NA	0.308	0.379	0.339	0.399
1966	NA	NA	0.144	0.160	0.244	0.199	0.287	0.272	0.252	0.304	0.401	0.329	0.283	0.322	0.411
1967	NA	NA	0.141	0.184	0.214	0.353	0.268	0.224	0.273	NA	0.271	0.273	0.380	0.325	NA
1968	NA	0.119	0.151	0.188	0.224	0.218	NA	0.286	0.339	0.307	NA	0.332	0.521	0.325	NA
1969	NA	0.136	0.152	0.193	0.233	0.254	NA	0.255	0.293	0.325	0.354	0.422	0.340	0.339	0.360
1970	NA	0.135	0.178	0.217	0.253	0.277	0.312	0.352	0.348	0.369	0.404	0.365	0.388	0.375	0.508
1971	NA	0.149	0.188	0.250	0.297	0.274	0.323	0.338	0.375	0.335	0.382	0.319	0.415	0.353	0.416
1972	NA	0.154	0.196	0.250	0.319	0.334	0.324	0.335	0.380	0.364	0.416	0.382	0.392	0.453	0.374
1973	NA	0.145	0.195	0.251	0.274	0.324	0.324	0.323	0.301	0.348	0.472	0.415	0.344	0.483	0.391
1974	NA	0.142	0.186	0.253	0.292	0.321	0.376	0.362	0.401	0.365	0.400	0.426	0.487	0.420	0.486
1975	NA	0.142	0.180	0.229	0.285	0.318	0.361	0.397	0.372	0.368	0.383	0.405	0.466	0.356	0.468
1976	NA	0.140	0.174	0.226	0.260	0.334	0.345	0.345	0.384	0.425	0.426	0.443	0.395	0.406	0.441
1977	NA	0.137	0.179	0.229	0.267	0.296	0.362	0.352	0.374	0.381	0.585	0.466	0.512	0.432	0.366
1978	NA	0.132	0.169	0.225	0.273	0.306	0.306	0.219	0.350	0.288	0.303	0.360	0.407	0.370	0.436
1979	NA	0.152	0.175	0.218	0.263	0.297	0.342	0.346	0.341	0.368	0.381	0.504	0.474	0.477	0.603
1980	NA	0.139	0.178	0.240	0.281	0.293	0.374	0.404	0.386	0.598	0.403	0.479	0.458	0.447	0.585
1981	NA	0.134	0.185	0.247	0.274	0.308	0.346	0.357	0.435	0.426	0.283	0.536	0.458	0.616	0.348
1982	NA	0.129	0.169	0.233	0.265	0.302	0.314	0.317	0.405	0.367	0.373	0.461	0.523	0.430	0.547
1983	NA	0.132	0.163	0.215	0.240	0.322	0.330	0.341	0.332	0.380	0.389	0.301	NA	0.490	0.428
1984	NA	0.132	0.167	0.206	0.248	0.251	0.327	0.398	0.369	0.390	0.359	0.434	NA	NA	0.325
1985	NA	0.133	0.160	0.190	0.229	0.267	0.303	0.399	0.379	0.309	0.343	0.412	0.434	0.449	0.266
1986	NA	0.129	0.156	0.192	0.224	0.279	0.322	0.366	0.447	0.301	0.400	0.488	0.436	0.587	0.513
1987	NA	0.143	0.155	0.198	0.238	0.263	0.275	0.272	0.292	0.313	0.310	0.385	0.361	0.445	0.420
1988	NA	0.123	0.162	0.192	0.243	0.272	0.254	0.304	0.321	0.376	0.458	0.426	0.448	NA	0.398
1989	NA	0.128	0.160	0.199	0.228	0.270	0.276	0.314	0.344	0.327	NA	0.491	0.509	0.415	0.494
1990	NA	0.137	0.167	0.199	0.248	0.231	0.293	0.316	0.322	0.383	0.329	0.441	0.456	0.374	0.365
1991	NA	0.128	0.158	0.181	0.214	0.242	0.227	0.260	0.418	0.348	0.274	0.392	0.348	0.593	0.472
1992	NA	0.126	0.151	0.177	0.198	0.196	0.278	0.246	0.253	0.315	0.387	0.323	0.483	0.591	0.510
1993	NA	0.140	0.144	0.163	0.173	0.201	0.203	0.302	0.319	0.358	0.286	0.362	0.431	0.439	0.300
1994	NA	0.102	0.140	0.150	0.175	0.196	0.205	0.233	0.308	0.213	0.276	0.342	0.310	0.404	0.294
1995	NA	0.131	0.148	0.152	0.171	0.203	0.220	0.226	0.399	0.289	0.162	0.274	0.509	NA	0.453
1996	NA	0.132	0.144	0.152	0.169	0.179	0.199	0.227	0.258	0.253	0.298	0.312	0.284	0.414	0.345
1997	NA	0.172	0.144	0.159	0.169	0.184	0.207	0.222	0.261	0.240	0.294	0.311	0.274	0.274	0.449
1998	NA	0.128	0.146	0.165	0.186	0.192	0.208	0.178	0.233	0.207	0.285	0.265	0.302	0.342	0.306
1999	NA	0.106	0.137	0.164	0.166	0.201	0.213	0.210	0.187	0.309	0.230	0.308	0.434	0.254	0.354
2000	NA	0.123	0.141	0.154	0.144	0.180	0.188	0.164	0.243	NA	0.548	0.256	0.512	NA	NA
2001	NA	0.132	0.129	0.151	0.175	0.207	0.212	0.349	0.296	0.281	NA	0.508	NA	0.308	NA
2002	NA	0.131	0.142	0.166	0.169	0.184	0.180	0.198	0.384	NA	0.274	NA	NA	NA	NA
2003	NA	0.120	0.131	0.151	0.160	0.181	0.175	0.218	NA	NA	0.193	0.206	0.292	NA	NA

2004	NA	0.131	0.143	0.155	0.147	0.156	0.199	0.221	0.238	NA	NA	0.376	0.531	NA	NA
2005	NA	NA	0.129	0.142	0.146	0.166	0.152	0.200	0.215	0.165	0.323	NA	NA	0.294	NA
2006	NA	0.129	0.139	0.149	0.155	0.180	0.187	0.198	0.252	0.291	NA	0.367	NA	NA	0.188
2007	NA	0.129	0.135	0.146	0.153	0.170	0.177	0.164	0.181	0.212	NA	0.349	NA	NA	0.272
2008	NA	0.140	0.134	0.138	0.159	0.178	0.183	0.199	0.230	NA	0.365	NA	NA	NA	NA

Table 6.2.10. Sole in Subarea IV. BTS-ISIS survey index (updated by WGBEAM in 2009).

2010-02-24 18:02:27[1] BTS-ISIS units= NA

		1	2	3	4	5	6	7	8	9
1985	1	7.03	7.12	3.695	1.654	0.688	0.276	0.000	0.000	0.000
1986	1	7.17	5.18	1.596	0.987	0.623	0.171	0.158	0.000	0.018
1987	1	6.97	12.55	1.834	0.563	0.583	0.222	0.228	0.058	0.000
1988	1	83.11	12.51	2.684	1.032	0.123	0.149	0.132	0.103	0.014
1989	1	9.02	68.08	4.191	4.096	0.677	0.128	0.242	0.000	0.051
1990	1	37.84	24.49	21.789	0.778	1.081	0.770	0.120	0.115	0.025
1991	1	4.04	28.84	6.872	6.453	0.136	0.135	0.063	0.045	0.013
1992	1	81.62	22.28	10.449	2.529	3.018	0.090	0.162	0.078	0.020
1993	1	6.35	42.34	1.338	5.516	3.371	6.199	0.023	0.084	0.053
1994	1	7.66	7.12	19.743	0.124	1.636	0.088	0.983	0.009	0.000
1995	1	28.12	8.46	6.268	5.129	0.363	0.805	0.316	0.734	0.039
1996	1	3.98	7.63	1.955	1.785	2.586	0.326	0.393	0.052	0.264
1997	1	169.34	4.92	2.985	0.739	0.710	0.380	0.096	0.035	0.042
1998	1	17.11	27.42	1.862	1.242	0.073	0.015	0.391	0.000	0.000
1999	1	11.96	18.36	15.783	0.584	1.920	0.310	0.218	0.604	0.003
2000	1	14.59	6.14	4.045	1.483	0.263	0.141	0.060	0.007	0.150
2001	1	8.00	9.96	2.156	1.564	0.684	0.074	0.037	0.028	0.000
2002	1	20.99	4.18	3.428	0.886	0.363	0.361	0.032	0.069	0.000
2003	1	10.51	9.95	2.459	1.670	0.360	0.187	0.319	0.000	0.020
2004	1	4.19	4.35	3.553	0.644	0.626	0.118	0.070	0.073	0.000
2005	1	5.53	3.40	2.377	1.303	0.167	0.171	0.077	0.047	0.000
2006	1	17.09	2.33	0.278	0.709	0.479	0.151	0.088	0.000	0.007
2007	1	7.50	19.50	1.464	0.565	0.315	0.537	0.031	0.009	0.000
2008	1	15.25	9.06	12.298	1.313	0.222	0.279	0.202	0.028	0.047

Table 6.2.11. Sole in Subarea IV. SNS survey index.

2010-02-24 18:04:35[1] SNS units= NA

		1	2	3	4
1970	1	5410	734	238	35
1971	1	903	1831	113	3
1972	1	1455	272	149	0
1973	1	5587	935	84	37
1974	1	2348	361	65	0
1975	1	525	865	177	18
1976	1	1399	74	229	27
1977	1	3743	776	104	43
1978	1	1548	1355	294	28
1979	1	94	408	301	78
1980	1	4313	89	109	61
1981	1	3737	1413	50	20
1982	1	5857	1146	228	7
1983	1	2621	1123	121	40
1984	1	2493	1100	318	74
1985	1	3619	716	167	49
1986	1	3705	458	69	31
1987	1	1948	944	65	21
1988	1	11227	594	282	82
1989	1	2831	5005	208	53
1990	1	2856	1120	914	100
1991	1	1254	2529	514	624
1992	1	11114	144	360	195
1993	1	1291	3420	154	213
1994	1	652	498	934	10
1995	1	1362	224	143	411
1996	1	218	349	30	36
1997	1	10279	154	190	27
1998	1	4095	3126	142	99
1999	1	1649	972	456	10
2000	1	1639	126	166	118
2001	1	970	655	107	36
2002	1	7548	379	195	0
2003	1	NA	NA	NA	NA
2004	1	1370	624	393	69
2005	1	568	163	124	0
2006	1	2726	117	25	30
2007	1	849	911	33	40
2008	1	1259	259	325	0

Table 6.2.12. Sole in Subarea IV. NL Beam Trawl Commercial cpue index.

2010-02-24 22:10:02[1] NL Beam Trawl units= NA

		2	3	4	5	6	7	8	9	10	11	12	13	14	15
1990	71.1	128	1190	102	92.6	23.5	8.93	11.52	5.288	1.941	1.885	0.605	0.141	0.183	1.940
1991	68.5	107	251	872	67.7	31.2	9.97	4.55	5.723	2.292	1.431	2.642	0.088	0.088	0.701
1992	71.1	71	477	157	419.6	20.5	29.27	6.27	3.080	3.868	1.069	2.307	0.928	0.056	1.533
1993	76.9	511	142	314	125.2	242.2	11.53	10.56	3.069	0.858	2.419	0.650	0.546	0.767	0.286
1994	81.4	66	858	91	159.8	38.1	109.74	2.33	6.437	2.162	0.319	1.953	0.307	0.246	1.843
1995	81.2	120	140	659	35.0	63.2	11.05	57.66	1.810	2.525	0.296	0.271	0.431	0.074	1.342
1996	72.1	220	126	155	294.2	21.8	44.01	6.55	38.474	2.219	2.649	1.193	0.319	0.860	1.387
1997	72.0	63	256	63	46.2	135.7	6.90	25.00	1.319	16.04	0.083	1.069	0.153	0.194	0.611
1998	70.2	720	129	158	26.0	16.3	48.36	3.01	4.801	0.299	4.088	0.071	0.527	0.071	0.613
1999	67.3	176	820	62	66.3	10.8	4.99	22.69	1.976	5.394	0.089	1.887	0.030	0.327	0.446
2000	64.6	191	458	337	31.7	24.5	7.04	4.98	9.923	3.251	1.780	0.356	0.836	0.046	0.681
2001	61.4	305	222	244	213.0	11.7	8.24	2.21	1.515	6.010	0.130	0.554	0.114	0.652	0.277
2002	56.7	159	437	140	106.4	89.6	7.48	6.77	0.952	0.423	1.799	0.212	0.300	0.000	0.370
2003	51.6	503	224	241	65.8	54.7	38.02	4.36	1.202	1.143	1.182	1.260	0.446	0.504	0.019
2004	48.1	233	774	117	105.2	24.7	13.31	11.27	2.807	0.541	0.707	0.333	0.374	0.208	0.312
2005	49.1	103	333	428	77.3	40.8	18.76	5.89	12.607	1.772	0.672	0.122	0.041	1.263	0.041
2006	44.1	154	177	152	186.5	21.6	21.43	11.84	6.100	3.741	2.676	0.181	0.068	0.023	1.043
2007	42.9	776	178	105	85.3	86.2	7.81	7.60	2.960	0.839	2.098	0.420	0.000	0.000	1.072
2008	30.2	156	952	108	61.7	42.0	47.52	6.56	5.861	2.550	1.060	0.563	0.133	0.232	0.000

Table 6.2.13. Sole in Subarea IV. NL Beam Trawl Commercial cpue index (corrected for spatial change in fleet targeting).

2010-02-24 22:10:02[1] NL Beam Trawl Corrected units= NA

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1997	1	4.3	18.1	84.2	23.4	18.9	60.3	3.3	11.5	0.8	9.7	0.1	1.0	0.1	0.1	0.4
1998	1	0.3	152.0	31.9	51.8	9.4	6.2	22.0	1.3	2.6	0.3	2.5	0.0	0.4	0.0	0.1
1999	1	0.6	39.0	230.2	20.5	25.7	4.9	2.7	12.0	1.0	2.6	0.1	1.6	0.0	0.3	0.0
2000	1	4.9	36.6	96.0	162.9	12.2	11.4	3.7	2.3	6.1	1.0	1.4	0.2	1.0	0.0	0.1
2001	1	2.0	65.8	54.3	72.0	70.3	4.8	3.9	1.0	0.8	3.0	0.1	0.4	0.1	0.4	0.0
2002	1	2.2	33.0	114.2	43.0	35.6	33.8	3.3	2.8	0.7	0.3	1.2	0.1	0.3	0.0	0.3
2003	1	1.7	95.1	50.4	63.9	18.2	17.0	13.5	1.6	0.8	0.5	0.3	0.5	0.2	0.2	0.0
2004	1	0.7	42.9	165.8	30.0	28.9	7.3	5.2	4.5	1.0	0.3	0.3	0.1	0.2	0.1	0.2
2005	1	3.3	20.4	69.9	104.4	13.7	12.7	4.0	2.7	3.6	0.3	0.1	0.0	0.5	0.0	0.0
2006	1	18.2	30.9	40.6	39.8	54.4	6.8	7.0	4.0	2.1	1.8	0.7	0.1	0.1	0.0	0.4
2007	1	0.7	135.7	38.6	26.4	24.1	26.1	2.8	2.8	1.0	1.2	0.6	0.2	0.0	0.1	0.0
2008	1	10.3	32.8	249.0	32.5	20.0	16.3	18.7	2.4	2.5	0.9	0.5	0.4	0.1	0.1	0.0

Table 6.2.14. Sole in Subarea IV. North Sea Sole BTS-ISIS survey index for females.

2010-02-24 23:01:32[1] BTS-ISIS Females units= NA

		1	2	3	4	5	6	7	8	9
1985	1	2.84	2.23	1.467	0.971	0.217	0.054	0.000	0.000	0.000
1986	1	3.38	2.37	0.486	0.438	0.396	0.101	0.099	0.000	0.018
1987	1	2.30	6.99	0.890	0.394	0.583	0.120	0.085	0.058	0.000
1988	1	14.10	3.11	1.457	0.701	0.062	0.029	0.077	0.000	0.000
1989	1	5.21	30.55	0.943	0.824	0.223	0.067	0.124	0.000	0.051
1990	1	12.27	10.92	10.282	0.489	1.004	0.373	0.090	0.115	0.025
1991	1	1.68	16.24	2.450	4.102	0.098	0.109	0.025	0.045	0.013
1992	1	42.16	13.66	4.364	1.207	1.260	0.020	0.124	0.048	0.020
1993	1	3.92	19.08	0.277	1.265	0.244	0.505	0.023	0.006	0.018
1994	1	2.92	4.07	7.185	0.124	0.282	0.005	0.471	0.009	0.000
1995	1	14.42	1.95	1.311	2.412	0.225	0.272	0.097	0.162	0.039
1996	1	1.59	3.00	0.754	0.594	0.682	0.050	0.069	0.011	0.092
1997	1	56.71	1.65	1.047	0.179	0.218	0.249	0.017	0.007	0.000
1998	1	6.52	12.66	0.459	0.525	0.003	0.000	0.218	0.000	0.000
1999	1	5.57	9.23	8.109	0.326	0.480	0.167	0.136	0.322	0.003
2000	1	5.94	2.91	2.004	0.800	0.075	0.047	0.030	0.007	0.036
2001	1	3.20	4.55	0.826	0.603	0.334	0.074	0.000	0.005	0.000
2002	1	8.70	1.43	1.106	0.351	0.156	0.088	0.012	0.016	0.000
2003	1	5.27	3.74	0.866	0.574	0.312	0.026	0.038	0.000	0.000
2004	1	2.21	2.23	1.641	0.285	0.322	0.066	0.018	0.032	0.000
2005	1	2.59	1.07	0.834	0.913	0.088	0.073	0.065	0.000	0.000
2006	1	8.73	1.02	0.166	0.364	0.275	0.090	0.047	0.000	0.000
2007	1	3.09	8.63	0.545	0.346	0.083	0.132	0.014	0.009	0.000
2008	1	6.04	4.04	5.295	0.700	0.137	0.000	0.047	0.000	0.000

Table 6.2.15. Sole in Subarea IV. SNS survey index females.

2010-02-24 23:01:32[1] SNS Females units= NA

		1	2	3	4
1970	1	2288	375	133	21
1971	1	339	804	94	0
1972	1	773	122	98	0
1973	1	2589	401	36	20
1974	1	1250	184	18	0
1975	1	247	402	50	0
1976	1	675	20	113	13
1977	1	1740	367	9	27
1978	1	732	588	152	0
1979	1	48	178	158	56
1980	1	2261	41	53	15
1981	1	1526	669	26	0
1982	1	2585	687	113	7
1983	1	1419	525	36	23
1984	1	973	493	132	19
1985	1	1743	344	105	16
1986	1	1504	204	15	13
1987	1	784	406	20	15
1988	1	4184	217	49	45
1989	1	1075	1952	60	37
1990	1	1245	416	253	17
1991	1	468	858	203	272
1992	1	4804	65	79	70
1993	1	488	1712	45	12
1994	1	251	152	346	2
1995	1	522	64	63	139
1996	1	100	98	2	5
1997	1	4067	43	67	0
1998	1	1252	694	33	11
1999	1	748	495	186	10
2000	1	630	55	58	12
2001	1	378	306	36	15
2002	1	3027	126	95	0
2003	1	NA	NA	NA	NA
2004	1	310	195	201	49
2005	1	176	50	20	0
2006	1	1201	99	25	30
2007	1	330	231	33	15
2008	1	614	96	78	0

Table 6.2.16. Sole in Subarea IV. NL Beam Trawl index females.

2010-02-24 23:09:45[1] NL Beam Trawl Females units= NA

		2	3	4	5	6	7	8	9	10	11	12	13	14	15
1990	71.1	104.2	823.2	60.1	52.9	11.52	4.25	7.41	2.096	1.646	0.844	0.281	0.141	0.155	0.169
1991	68.5	90.0	175.2	498.3	28.6	22.51	5.81	3.65	3.401	1.066	0.861	1.183	0.088	0.073	0.088
1992	71.1	50.0	326.0	85.0	196.4	11.76	16.26	3.66	1.181	1.786	0.563	1.463	0.675	0.042	0.014
1993	76.9	449.8	100.5	167.4	49.8	92.16	3.60	5.51	2.003	0.780	1.469	0.390	0.546	0.520	0.000
1994	81.4	58.6	693.2	66.9	75.2	14.62	38.86	1.24	4.005	0.958	0.233	1.044	0.307	0.135	0.479
1995	81.2	90.5	103.9	394.5	17.5	26.06	5.18	20.49	0.788	1.576	0.296	0.074	0.296	0.074	0.025
1996	72.1	155.3	91.1	88.6	152.6	10.61	15.56	2.57	12.968	1.262	1.512	0.444	0.319	0.638	0.388
1997	72.0	40.9	164.1	39.9	24.9	57.31	3.69	7.42	0.625	6.042	0.083	0.986	0.153	0.042	0.292
1998	70.2	529.8	82.6	88.1	12.2	6.71	20.74	1.25	1.795	0.299	1.895	0.014	0.399	0.014	0.185
1999	67.3	151.8	590.9	43.4	36.6	5.75	2.81	10.07	1.263	1.545	0.089	0.966	0.030	0.163	0.134
2000	64.6	126.4	257.0	277.8	19.9	11.56	3.95	1.92	4.892	0.526	1.347	0.062	0.697	0.016	0.077
2001	61.4	251.9	166.6	138.7	95.0	7.18	4.53	1.42	0.717	2.394	0.130	0.538	0.114	0.293	0.049
2002	56.7	125.6	338.3	98.1	51.3	39.24	4.53	2.56	0.847	0.423	1.235	0.212	0.300	0.000	0.370
2003	51.6	429.5	166.2	142.7	28.8	21.78	17.73	1.67	1.202	0.543	0.155	0.640	0.291	0.349	0.019
2004	48.1	201.5	604.7	76.7	50.1	11.95	7.63	6.24	1.435	0.541	0.416	0.000	0.353	0.208	0.146
2005	49.1	91.5	269.6	280.4	27.2	19.37	4.36	3.30	4.155	0.367	0.570	0.122	0.041	0.550	0.041
2006	44.1	133.2	129.7	96.2	109.3	11.20	7.71	5.78	2.177	2.177	0.431	0.113	0.068	0.023	0.318
2007	42.9	687.2	132.0	59.4	41.5	33.66	4.69	3.57	1.399	1.049	0.816	0.163	0.070	0.023	0.000
2008	30.2	145.7	763.9	70.5	27.3	25.10	21.23	2.35	2.483	0.662	0.232	0.265	0.133	0.133	0.000

Table 6.2.17. Sole in Subarea IV. BTS-ISIS survey index males.

2010-02-24 23:28:44[1] BTS-ISIS male units= NA

		1	2	3	4	5	6	7	8	9
1985	1	4.19	4.89	2.227	0.683	0.471	0.222	0.000	0.000	0.000
1986	1	3.79	2.81	1.111	0.549	0.226	0.070	0.059	0.000	0.000
1987	1	4.67	5.55	0.944	0.169	0.000	0.101	0.143	0.000	0.000
1988	1	69.02	9.40	1.227	0.331	0.061	0.120	0.054	0.103	0.014
1989	1	3.80	37.53	3.248	3.272	0.454	0.061	0.118	0.000	0.000
1990	1	25.57	13.56	11.508	0.289	0.077	0.397	0.030	0.000	0.000
1991	1	2.35	12.60	4.422	2.351	0.039	0.026	0.039	0.000	0.000
1992	1	39.46	8.63	6.084	1.322	1.759	0.070	0.038	0.031	0.000
1993	1	2.43	23.26	1.061	4.251	3.127	5.694	0.000	0.078	0.035
1994	1	4.74	3.05	12.558	0.000	1.354	0.083	0.512	0.000	0.000
1995	1	13.70	6.50	4.957	2.717	0.138	0.533	0.218	0.572	0.000
1996	1	2.38	4.63	1.200	1.191	1.904	0.275	0.324	0.041	0.172
1997	1	112.63	3.27	1.938	0.560	0.492	0.131	0.079	0.028	0.042
1998	1	10.58	14.76	1.403	0.718	0.070	0.015	0.173	0.000	0.000
1999	1	6.39	9.14	7.673	0.258	1.441	0.143	0.082	0.282	0.000
2000	1	8.66	3.23	2.041	0.682	0.188	0.094	0.030	0.000	0.114
2001	1	4.80	5.41	1.330	0.960	0.350	0.000	0.037	0.023	0.000
2002	1	12.29	2.75	2.322	0.536	0.207	0.273	0.020	0.053	0.000
2003	1	5.24	6.20	1.592	1.096	0.047	0.161	0.281	0.000	0.020
2004	1	1.99	2.12	1.912	0.359	0.304	0.052	0.053	0.041	0.000
2005	1	2.95	2.32	1.543	0.390	0.078	0.098	0.012	0.047	0.000
2006	1	8.36	1.31	0.113	0.345	0.204	0.061	0.041	0.000	0.007
2007	1	4.41	10.88	0.920	0.219	0.232	0.405	0.018	0.000	0.000
2008	1	9.21	5.02	7.003	0.613	0.085	0.279	0.155	0.028	0.047

Table 6.2.18. Sole in Subarea IV. SNS survey index males.

2010-02-24 23:28:45[1] SNS male units= NA

		1	2	3	4
1970	1	3122	359	105	14
1971	1	564	1027	20	3
1972	1	681	150	51	0
1973	1	2998	535	48	18
1974	1	1098	177	47	0
1975	1	279	462	127	18
1976	1	725	54	116	13
1977	1	2003	409	95	16
1978	1	816	767	142	28
1979	1	46	230	142	21
1980	1	2052	48	56	47
1981	1	2211	745	24	20
1982	1	3272	459	115	0
1983	1	1202	598	85	17
1984	1	1520	607	186	55
1985	1	1877	372	62	33
1986	1	2201	254	54	18
1987	1	1163	537	45	7
1988	1	7043	377	233	36
1989	1	1756	3053	148	16
1990	1	1611	703	662	84
1991	1	785	1672	311	352
1992	1	6310	80	281	125
1993	1	803	1707	109	200
1994	1	401	346	588	8
1995	1	840	159	80	272
1996	1	118	251	28	31
1997	1	6212	110	122	26
1998	1	2843	2432	108	88
1999	1	901	477	269	0
2000	1	1009	71	108	106
2001	1	592	349	71	20
2002	1	4521	253	101	0
2003	1	NA	NA	NA	NA
2004	1	1060	429	192	20
2005	1	392	113	104	0
2006	1	1526	18	0	0
2007	1	518	680	0	25
2008	1	645	163	247	0

Table 6.2.19. Sole in Subarea IV. NL Beam Trawl index males.

2010-02-24 23:28:45[1] NL Beam Trawl male units= NA

		2	3	4	5	6	7	8	9	10	11	12	13	14
1990	71.1	23.35	367.0	41.7	39.8	11.95	4.68	4.107	3.193	0.295	1.041	0.324	0.000	0.028
1991	68.5	17.12	75.7	374.0	39.1	8.70	4.16	0.905	2.321	1.212	0.584	1.445	0.000	0.015
1992	71.1	20.94	150.5	71.5	223.2	8.75	13.01	2.616	1.899	2.082	0.506	0.844	0.267	0.014
1993	76.9	61.09	41.8	146.4	75.4	150.03	7.93	5.033	1.079	0.091	0.949	0.260	0.000	0.247
1994	81.4	7.64	165.3	24.1	84.6	23.53	70.88	1.093	2.432	1.204	0.086	0.909	0.000	0.123
1995	81.2	29.90	35.7	264.3	17.5	37.11	5.86	37.180	1.034	0.936	0.000	0.197	0.123	0.000
1996	72.1	64.45	35.0	66.4	141.7	11.17	28.46	3.967	25.506	0.957	1.137	0.749	0.000	0.222
1997	72.0	21.71	91.8	22.7	21.4	78.40	3.22	17.583	0.694	10.000	0.000	0.083	0.000	0.153
1998	70.2	190.56	45.9	70.4	13.8	9.62	27.62	1.752	3.020	0.000	2.194	0.057	0.128	0.057
1999	67.3	23.89	229.0	18.3	29.7	5.10	2.18	12.615	0.713	3.848	0.000	0.921	0.000	0.149
2000	64.6	26.27	96.3	209.4	10.5	15.53	4.18	2.461	5.882	1.904	0.960	0.356	0.464	0.000
2001	61.4	53.03	55.9	105.1	118.0	4.56	3.71	0.798	0.798	3.616	0.000	0.016	0.000	0.358
2002	56.7	33.26	102.3	41.9	55.1	50.39	2.93	4.215	0.106	0.000	0.564	0.000	0.000	0.000
2003	51.6	73.31	57.4	98.4	37.0	32.95	20.27	2.713	0.000	0.601	1.027	0.620	0.155	0.155
2004	48.1	31.16	169.1	40.4	55.1	12.79	5.68	5.031	1.372	0.000	0.312	0.333	0.021	0.000
2005	49.1	22.61	73.3	150.8	26.5	23.87	9.84	5.173	6.640	0.407	0.102	0.000	0.000	0.733
2006	44.1	20.86	47.3	55.9	77.2	10.45	13.72	6.032	3.923	1.587	2.268	0.068	0.000	0.000
2007	42.9	88.39	46.3	45.2	43.8	52.52	3.12	4.056	1.562	1.935	0.023	0.303	0.000	0.117
2008	30.2	10.46	188.4	37.4	34.4	16.89	26.32	4.205	3.377	1.921	0.828	0.331	0.000	0.099

Table 6.2.20. Sole in Subarea IV. NL Beam Specialist Sole Boats.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2001	1.0	49.3	1067.6	734.2	795.4	668.7	42.7	29.9	12.6	6.8	19.8	0.9	4.2	0.2	3.5	0.6
2002	1.0	59.5	596.8	1458.3	455.0	330.8	282.4	23.5	20.5	2.6	1.3	5.0	0.6	0.8	NA	0.9
2003	1.0	57.3	1492.4	646.7	704.7	204.0	169.7	125.7	10.8	3.0	3.3	4.0	3.1	0.9	1.2	0.2
2004	1.0	16.1	756.3	1638.6	280.2	266.5	64.3	43.4	28.8	7.8	1.9	1.5	0.5	1.9	0.1	1.0
2005	1.0	103.5	481.4	1184.5	1325.4	169.4	147.1	44.4	31.3	35.1	1.9	1.6	0.4	0.1	4.2	0.2
2006	1.0	257.6	587.7	735.5	633.5	771.2	87.0	95.0	56.4	24.4	16.4	12.3	0.6	0.3	0.1	7.0
2007	1.0	26.8	2682.5	596.3	368.5	295.2	288.1	25.3	25.4	9.2	10.4	2.8	1.4	0.2	0.4	0.2
2008	1.0	265.5	603.3	3100.7	353.2	195.1	135.1	148.0	17.9	17.8	11.8	4.4	2.9	0.3	0.7	NA

Table 6.2.21. Sole in Subarea IV. Corystes Southern North Sea Beam Trawl Survey.

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1995	1	0.5	41.6	86.4	17.1	16.1	9.8	5.2	0.9	0.8	0.0	0.0	0.2	0.2	0.0	0.0	0.0
1996	1	3.3	75.5	52.5	22.9	9.0	8.3	8.8	1.3	1.8	0.7	0.0	1.7	0.0	0.0	0.2	0.3
1997	1	4.5	70.5	63.2	19.8	9.3	5.6	3.5	7.1	1.8	1.8	0.5	0.0	0.0	0.0	0.0	0.5
1998	1	7.9	10.6	63.3	15.7	1.8	0.9	0.9	0.0	0.4	0.0	0.0	0.0	0.0	0.2	0.0	0.0
1999	1	9.0	103.7	18.5	24.5	9.4	0.9	0.3	1.1	0.6	1.6	0.0	0.4	0.0	0.0	0.0	0.5
2000	1	3.2	192.5	157.9	15.0	14.1	7.0	2.6	0.7	0.4	0.9	2.1	0.8	0.1	0.1	0.0	0.0
2001	1	5.9	91.4	174.9	45.7	3.0	4.6	1.8	0.8	0.6	0.2	0.2	0.5	0.1	0.2	0.0	0.0
2002	1	2.2	125.8	47.3	33.3	22.0	3.6	4.4	1.8	0.9	1.1	0.3	0.7	0.0	0.7	0.3	0.3
2003	1	0.9	69.9	129.3	16.3	23.6	14.7	0.8	6.4	1.5	0.9	0.4	0.2	0.4	1.1	0.0	0.3
2004	1	24.6	58.6	57.8	50.2	12.5	10.1	8.6	0.7	2.2	1.1	0.5	0.0	0.0	0.2	1.7	0.6
2005	1	37.6	107.0	55.5	19.8	37.7	3.3	10.4	5.6	0.6	1.2	2.6	1.3	0.0	0.7	0.0	0.0
2006	1	7.0	202.5	82.2	20.6	14.0	35.2	6.7	9.2	5.3	0.4	2.2	0.7	0.4	0.0	0.0	0.5
2007	1	9.4	40.7	77.3	19.2	4.4	2.8	11.4	0.9	2.2	1.1	0.2	0.3	0.4	0.0	0.0	0.0
2008	1	1.0	105.3	59.8	43.5	13.3	0.8	4.0	10.5	2.3	1.8	0.3	0.8	0.3	0.0	0.0	0.0

Table 6.8.1. Sole in Subarea IV. XSA diagnostics for XSA with updated survey indices, and uncorrected commercial indices cut-off in 1997 (WKFLAT recommended model).

```
Cpue data from xsa.indices.oldcom
Catch data for 52 years. 1957 to 2008. Ages 1 to 10.

          fleet first age last age first year last year alpha beta
1      BTS-ISIS         1        9       1985      2008  0.66 0.75
2           SNS         1        4       1970      2008  0.66 0.75
3 NL Beam Trawl         2        9       1997      2008     0    1

Time-series weights :
   Tapered time weighting not applied

Catchability analysis :
    Catchability independent of size for ages >   1
    Catchability independent of age for ages >   7

Terminal population estimation :
    Survivor estimates shrunk towards the mean F
    of the final   5 years or the  5 oldest ages.
    S.E. of the mean to which the estimates are shrunk =   2
    Minimum standard error for population
    estimates derived from each fleet =  0.3
    prior weighting not applied

Regression weights
     year
age   1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
  all    1    1    1    1    1    1    1    1    1    1

 Fishing mortalities (per year)
    year
age   1999  2000  2001  2002  2003  2004  2005  2006  2007  2008
  1  0.004 0.020 0.015 0.006 0.013 0.012 0.026 0.035 0.006 0.023
  2  0.176 0.240 0.285 0.231 0.228 0.238 0.221 0.279 0.261 0.128
  3  0.610 0.582 0.562 0.622 0.605 0.546 0.617 0.467 0.509 0.348
  4  0.714 0.796 0.755 0.643 0.629 0.694 0.680 0.480 0.544 0.437
  5  0.791 0.621 0.745 0.724 0.639 0.596 0.684 0.491 0.542 0.627
  6  0.584 0.777 0.533 0.637 0.818 0.459 0.647 0.512 0.451 0.487
  7  0.546 0.872 0.575 0.457 0.463 0.389 0.603 0.495 0.489 0.333
  8  0.517 0.747 0.742 0.954 0.478 0.298 0.446 0.549 0.411 0.666
  9  1.293 0.432 0.643 0.503 0.475 1.076 0.376 0.456 0.856 0.826
  10 1.293 0.432 0.643 0.503 0.475 1.076 0.376 0.456 0.856 0.826

 XSA population number (thousands)
      age
```

year	1	2	3	4	5	6	7	8	9	10
1999	82311	102752	166825	16865	11751	2880	1658	5170	480	1164
2000	123572	74205	77981	82014	7472	4820	1453	869	2790	2132
2001	63241	109576	52805	39419	33493	3633	2005	550	372	1596
2002	185151	56382	74563	27238	16761	14392	1930	1021	237	964
2003	82972	166528	40502	36218	12956	7351	6889	1106	356	1249
2004	43932	74079	119927	20003	17466	6187	2936	3922	620	615
2005	47517	39261	52809	62884	9040	8711	3539	1800	2635	1341
2006	208705	41895	28469	25771	28817	4126	4126	1752	1043	1539
2007	59380	182363	28691	16144	14434	15954	2238	2275	916	987
2008	88461	53427	127066	15605	8475	7599	9191	1241	1365	1240

Estimated population abundance at 1st Jan 2009

age										
year	1	2	3	4	5	6	7	8	9	10
2009	0	78217	42523	81202	9118	4097	4224	5961	577	541

Fleet: BTS-ISIS

Log catchability residuals.

year												
age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	-0.165	-0.647	-0.084	-0.090	-0.238	0.180	-0.358	0.090	-0.098	0.152	0.491	-0.104
2	0.043	-0.543	-0.258	0.522	0.299	0.724	0.365	1.048	0.122	-0.061	0.434	-0.171
3	-0.029	-0.240	-0.497	-0.582	0.551	0.164	0.476	0.365	-0.749	0.433	0.849	0.233
4	0.255	-0.252	-0.285	-0.035	0.905	-0.222	-0.176	0.314	0.631	-2.170	0.151	0.801
5	-0.030	0.222	0.032	-0.963	0.286	0.419	-1.051	-0.211	1.553	0.288	-0.247	0.421
6	0.157	-0.401	0.108	-0.431	-0.128	1.245	-0.872	-0.505	1.350	-0.918	0.468	0.730
7	1.000	0.256	0.387	0.118	0.504	0.236	-0.734	-0.113	-1.154	-0.021	1.141	0.387
8	1.000	1.000	0.050	0.125	1.000	0.469	-0.064	0.054	-0.075	-1.357	0.253	0.365
9	1.000	-0.082	1.000	-0.396	-0.096	-0.265	-0.647	-0.056	0.231	1.000	0.907	-0.227

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.684	0.075	0.120	-0.065	0.099	-0.171	0.047	0.015	0.114	-0.361	0.107	0.206
2	-0.082	0.025	0.415	-0.309	-0.184	-0.426	-0.644	-0.653	-0.279	-0.679	-0.038	0.329
3	0.062	0.109	0.667	0.047	-0.207	-0.046	0.220	-0.539	-0.070	-1.704	-0.021	0.505
4	0.344	0.298	0.019	-0.573	0.184	-0.094	0.246	-0.068	-0.518	-0.376	-0.090	0.712
5	0.973	-0.992	1.756	0.101	-0.357	-0.312	-0.123	0.101	-0.499	-0.741	-0.433	-0.191
6	-0.445	-1.807	1.402	0.235	-0.299	-0.018	0.124	-0.417	-0.255	0.272	0.146	0.258
7	0.150	0.216	1.440	0.511	-0.504	-0.694	0.338	-0.378	-0.319	-0.415	-0.851	-0.499
8	-1.114	0.000	1.301	-1.211	0.629	1.061	1.000	-0.690	-0.247	NA	-2.160	-0.239
9	1.298	0.000	-1.080	0.465	1.000	1.000	0.539	1.000	NA	-1.599	NA	0.296

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

	2	3	4	5	6	7	8	9
Mean_Logq	-8.8503	-9.4326	-9.7162	-9.8469	-10.0564	-9.9208	-9.9208	-9.9208
S.E_Logq	0.4519	0.5466	0.6097	0.7045	0.7334	0.6419	0.8897	0.7660

Regression statistics

Ages with q dependent on year-class strength

	slope	intercept
Age 1	0.738052	9.59503

Fleet: SNS

Log catchability residuals.

age \ year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	-0.041	0.185	-0.209	0.097	-0.267	-0.037	-0.023	-0.008	-0.240	-0.202	-0.750	0.133	0.267
2	-0.176	-0.052	0.267	0.481	0.432	0.723	-1.201	0.398	0.072	-0.404	-0.464	-0.753	0.646
3	-0.420	-0.876	0.126	0.509	-0.047	0.844	-0.042	0.050	0.343	0.030	-0.983	0.268	0.497
4	-0.469	-0.330	0.676	-0.199	0.970	0.732	0.995	0.621	-1.444	0.871	0.141	0.278	1.012

age \ year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.001	-0.300	-0.095	0.246	NA	0.370	-0.176	-0.402	-0.126	-0.197
2	0.269	-1.403	-0.113	-0.034	NA	0.197	-0.522	-0.879	-0.309	-0.433
3	0.084	-0.186	-0.249	0.048	NA	0.220	-0.063	-1.152	-0.853	-0.168
4	-0.805	0.139	-0.344	NA	NA	0.942	NA	-0.295	0.506	NA

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

	2	3	4
Mean_Logq	-4.7353	-5.4855	-6.0521
S.E_Logq	0.5774	0.4772	0.7407

Regression statistics

Ages with q dependent on year-class strength

	slope	intercept
Age 1	0.7479843	5.723333

Fleet: NL Beam Trawl

Log catchability residuals.

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2	-0.694	0.108	-0.488	-0.050	0.051	0.038	0.106	0.150	-0.037	0.326	0.464	0.026
3	-0.186	-0.365	-0.090	0.075	-0.265	0.093	0.025	0.154	0.164	0.081	0.100	0.214
4	-0.274	0.065	-0.381	-0.231	0.162	-0.072	0.181	0.081	0.226	-0.006	0.116	0.132
5	-0.119	-0.372	0.035	-0.324	0.136	0.125	-0.135	0.016	0.405	0.041	-0.028	0.220
6	0.153	-0.092	-0.276	0.106	-0.452	0.250	0.506	-0.273	-0.032	0.022	0.024	0.063
7	-0.497	0.106	-0.335	0.283	-0.011	-0.123	0.234	0.003	0.256	0.188	-0.213	0.109
8	0.468	-0.475	0.029	0.398	0.042	0.630	-0.096	-0.495	-0.297	0.475	-0.292	0.280
9	-0.307	-0.133	0.290	-0.220	0.009	-0.065	-0.252	0.298	0.051	0.289	-0.129	0.142

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

```
                2       3       4       5       6       7       8       9
Mean_Logq -5.7491 -4.8918 -4.8504 -4.8004 -4.9827 -5.1650 -5.1650 -5.1650
S.E_Logq   0.3157  0.1844  0.1977  0.2187  0.2564  0.2482  0.3929  0.2182

Terminal year survivor and F summaries:
Age 1 Year class = 2007
source        survivors N scaledWts
BTS-ISIS         103438 1     0.411
SNS               60134 1     0.473
fshk              97968 1     0.016
nshk              83018 1     0.100

Age 2 Year class = 2006
source        survivors N scaledWts
BTS-ISIS          53070 2     0.361
SNS               33394 2     0.335
NL Beam Trawl     43636 1     0.295
fshk              20853 1     0.009

Age 3 Year class = 2005
source        survivors N scaledWts
BTS-ISIS          74871 3     0.277
SNS               56248 3     0.288
NL Beam Trawl    110897 2     0.427
fshk              45944 1     0.008

Age 4 Year class = 2004
source        survivors N scaledWts
BTS-ISIS           9908 4     0.244
SNS                5139 3     0.185
NL Beam Trawl     10698 3     0.562
fshk               5977 1     0.010

 Age 5 Year class = 2003
source        survivors N scaledWts
BTS-ISIS           2849 5     0.204
SNS                3678 4     0.148
NL Beam Trawl      4715 4     0.635
fshk               4415 1     0.012

 Age 6 Year class = 2002
source        survivors N scaledWts
BTS-ISIS           3697 6     0.184
SNS                3901 3     0.057
NL Beam Trawl      4408 5     0.747
```

```
fshk               3377 1     0.012

 Age 7 Year class = 2001
source         survivors N scaledWts
BTS-ISIS           3997 7     0.181
SNS                7911 2     0.034
NL Beam Trawl      6504 6     0.775
fshk               3728 1     0.010

Age 8 Year class = 2000
source         survivors N scaledWts
BTS-ISIS            407 8     0.173
SNS                 698 3     0.022
NL Beam Trawl       612 7     0.786
fshk                994 1     0.018

Age 9 Year class = 1999
source         survivors N scaledWts
BTS-ISIS            377 9     0.155
SNS                 446 3     0.014
NL Beam Trawl       573 8     0.812
fshk               1039 1     0.019
```

Table 6.8.2. Sole in Subarea IV. XSA diagnostics for XSA with updated survey indices, and full uncorrected commercial indices.

cpue data from xsa.indices.oldcom

Catch data for 52 years. 1957 to 2008. Ages 1 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	BTS-ISIS	1	9	1985	2008	0.66	0.75
2	SNS	1	4	1970	2008	0.66	0.75
3	NL Beam Trawl	2	9	1990	2008	0	1

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for ages > 1

Catchability independent of age for ages > 7

Terminal population estimation :

Survivor estimates shrunk towards the mean F

of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population

estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

year										
age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities (per year)

year										
age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.004	0.020	0.015	0.006	0.013	0.012	0.025	0.034	0.005	0.023
2	0.175	0.239	0.284	0.229	0.225	0.232	0.213	0.267	0.257	0.123
3	0.608	0.580	0.559	0.620	0.600	0.535	0.594	0.442	0.479	0.339
4	0.709	0.791	0.750	0.637	0.626	0.682	0.656	0.449	0.497	0.398
5	0.785	0.613	0.736	0.714	0.627	0.590	0.660	0.461	0.486	0.534
6	0.576	0.764	0.521	0.622	0.792	0.444	0.635	0.480	0.409	0.409
7	0.525	0.846	0.556	0.441	0.446	0.368	0.572	0.480	0.441	0.289
8	0.487	0.694	0.696	0.888	0.452	0.282	0.410	0.500	0.391	0.557
9	1.266	0.394	0.558	0.448	0.414	0.953	0.347	0.401	0.714	0.754
10	1.266	0.394	0.558	0.448	0.414	0.953	0.347	0.401	0.714	0.754

XSA population number (thousands)

age

year	1	2	3	4	5	6	7	8	9	10
1999	82569	102980	167147	16939	11813	2910	1708	5410	485	1176
2000	123760	74438	78187	82306	7539	4876	1480	914	3008	2299
2001	63586	109747	53017	39605	33758	3694	2056	574	413	1771
2002	187330	56694	74717	27430	16930	14631	1985	1067	259	1056
2003	84838	168500	40785	36357	13129	7504	7105	1156	397	1394
2004	45515	75768	121712	20259	17592	6343	3075	4118	666	660
2005	49196	40693	54337	64499	9272	8825	3680	1925	2812	1432
2006	211961	43415	29765	27154	30278	4335	4230	1880	1156	1707
2007	61648	185309	30066	17317	15685	17275	2428	2369	1032	1113
2008	89215	55480	129732	16849	9536	8731	10387	1413	1450	1318

Estimated population abundance at 1st Jan 2009

year \ age	1	2	3	4	5	6	7	8	9	10
2009	0	78900	44381	83614	10244	5057	5249	7043	732	618

Fleet: BTS-ISIS

Log catchability residuals.

age \ year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	-0.148	-0.635	-0.073	-0.089	-0.229	0.178	-0.344	0.085	-0.090	0.158	0.488	-0.093
2	0.052	-0.522	-0.252	0.533	0.312	0.732	0.371	1.056	0.128	-0.054	0.441	-0.164
3	-0.030	-0.227	-0.467	-0.575	0.567	0.182	0.486	0.374	-0.738	0.441	0.858	0.242
4	0.258	-0.259	-0.264	0.020	0.914	-0.197	-0.147	0.330	0.645	-2.155	0.163	0.812
5	-0.016	0.218	0.014	-0.933	0.372	0.428	-1.011	-0.169	1.574	0.304	-0.226	0.432
6	0.171	-0.393	0.087	-0.479	-0.090	1.381	-0.868	-0.446	1.411	-0.896	0.482	0.753
7	NA	0.262	0.385	0.065	0.418	0.284	-0.503	-0.124	-1.052	0.066	1.162	0.393
8	NA	NA	0.036	0.108	NA	0.292	0.001	0.428	-0.116	-1.188	0.378	0.376
9	NA	-0.105	NA	-0.469	-0.132	-0.461	-1.099	0.054	0.896	NA	1.257	-0.043

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.671	0.077	0.122	-0.061	0.102	-0.175	0.036	0.000	0.096	-0.365	0.087	0.203
2	-0.076	0.031	0.421	-0.305	-0.178	-0.424	-0.650	-0.672	-0.313	-0.715	-0.049	0.296
3	0.070	0.116	0.675	0.053	-0.203	-0.039	0.220	-0.551	-0.105	-1.757	-0.079	0.489
4	0.356	0.309	0.028	-0.564	0.192	-0.089	0.256	-0.073	-0.544	-0.434	-0.178	0.623
5	0.983	-0.979	1.768	0.108	-0.349	-0.308	-0.123	0.111	-0.520	-0.790	-0.534	-0.352
6	-0.441	-1.807	1.410	0.239	-0.299	-0.020	0.110	-0.427	-0.252	0.225	0.061	0.089
7	0.173	0.203	1.422	0.501	-0.515	-0.707	0.321	-0.412	-0.354	-0.424	-0.939	-0.626
8	-1.135	NA	1.261	-1.272	0.580	0.998	NA	-0.724	-0.313	NA	-2.187	-0.418
9	1.279	NA	-1.083	0.389	NA	NA	0.413	NA	NA	-1.714	NA	0.212

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

	2	3	4	5	6	7	8	9
Mean_Logq	-8.8583	-9.4429	-9.7323	-9.8687	-10.0811	-9.9478	-9.9478	-9.9478
S.E_Logq	0.4573	0.5547	0.6084	0.7135	0.7459	0.6151	0.8722	0.8512

Regression statistics

Ages with q dependent on year-class strength

	slope	intercept
Age 1	0.7317385	9.618934

Fleet: SNS

Log catchability residuals.

age \ year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	0.254	-0.146	0.346	0.455	-0.040	0.190	-0.204	0.099	-0.264	-0.033	-0.023	-0.005	-0.235
2	0.208	0.234	0.256	0.545	-0.158	-0.049	0.275	0.492	0.437	0.727	-1.196	0.402	0.075
3	0.012	-0.699	0.422	-0.170	-0.411	-0.850	0.129	0.521	-0.032	0.850	-0.037	0.057	0.347
4	0.056	-0.345	0.133	-0.026	-0.485	-0.318	0.722	-0.199	0.986	0.752	1.002	0.625	-1.437

age \ year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	-0.198	-0.744	0.133	0.267	0.002	-0.297	-0.095	0.238	NA	0.346	-0.197	-0.410	-0.149	-0.199
2	-0.400	-0.460	-0.750	0.649	0.272	-1.402	-0.110	-0.035	NA	0.175	-0.559	-0.917	-0.324	-0.469
3	0.034	-0.978	0.273	0.500	0.087	-0.183	-0.249	0.051	NA	0.204	-0.102	-1.208	-0.914	-0.188
4	0.873	0.143	0.282	1.015	-0.805	0.140	-0.345	NA	NA	0.928	0.000	-0.362	0.410	0.000

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

	2	3	4
Mean_Logq	-4.7404	-5.4923	-6.0596
S.E_Logq	0.5814	0.4839	0.7191

Regression statistics

Ages with q dependent on year-class strength

	slope	intercept
Age 1	0.7462669	5.740802

Fleet: NL Beam Trawl

Log catchability residuals.

age \ year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
2	0.268	-0.433	0.371	-0.226	0.210	0.313	0.296	0.357	0.389	0.187	0.550	0.710	0.250
3	-0.119	0.024	-0.156	0.120	0.284	-0.058	0.302	0.228	0.347	0.337	0.238	0.252	0.401
4	0.253	-0.149	0.189	-0.259	-0.108	0.283	0.046	0.303	0.190	0.318	0.056	0.152	0.165
5	0.054	0.018	-0.233	0.173	-0.191	0.270	0.256	-0.008	0.152	0.516	0.124	0.010	0.207
6	-0.213	0.296	0.047	-0.130	0.249	-0.314	0.387	0.635	-0.144	0.110	0.118	0.086	0.049
7	0.206	-0.428	0.144	-0.302	0.325	0.027	-0.087	0.266	0.019	0.274	0.227	-0.244	0.037
8	0.233	0.501	-0.411	0.041	0.396	0.050	0.631	-0.080	-0.480	-0.310	0.454	-0.270	0.174
9	0.089	-0.270	-0.159	0.341	-0.241	-0.061	-0.108	-0.319	0.248	0.045	0.232	-0.238	0.122

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

                2       3       4       5       6       7       8       9
Mean_Logq -6.0131 -5.1042 -4.9783 -4.9464 -5.1429 -5.2365 -5.2365 -5.2365
S.E_Logq   0.5086  0.3054  0.2476  0.2736  0.2712  0.2373  0.3370  0.1901

 Terminal year survivor and F summaries:

Age 1 Year class = 2007
source        survivors N scaledWts
BTS-ISIS         104087 1     0.417
SNS               60444 1     0.468
fshk             100587 1     0.015
nshk              83302 1     0.099

Age 2 Year class = 2006
source        survivors N scaledWts
BTS-ISIS          53668 2     0.441
SNS               33742 2     0.406
NL Beam Trawl     56971 1     0.142
fshk              21516 1     0.011

Age 3 Year class = 2005
source        survivors N scaledWts
BTS-ISIS          75410 3     0.316
SNS               56917 3     0.326
NL Beam Trawl    133610 2     0.348
fshk              48107 1     0.009

Age 4 Year class = 2004
source        survivors N scaledWts
BTS-ISIS          10582 4     0.267
SNS                5562 3     0.202
NL Beam Trawl     12879 3     0.521
fshk               6304 1     0.010

Age 5 Year class = 2003
source        survivors N scaledWts
BTS-ISIS           3280 5     0.217
SNS                4349 4     0.160
NL Beam Trawl      6145 4     0.611
fshk               4681 1     0.011

Age 6 Year class = 2002
source        survivors N scaledWts
```

BTS-ISIS	4204	6	0.191
SNS	4645	3	0.061
NL Beam Trawl	5650	5	0.736
fshk	3581	1	0.011

Age 7 Year class = 2001

source	survivors	N	scaledWts
BTS-ISIS	4376	7	0.186
SNS	9242	2	0.036
NL Beam Trawl	7856	6	0.768
fshk	4003	1	0.009

Age 8 Year class = 2000

source	survivors	N	scaledWts
BTS-ISIS	475	8	0.162
SNS	882	3	0.022
NL Beam Trawl	789	7	0.802
fshk	1083	1	0.015

Age 9 Year class = 1999

source	survivors	N	scaledWts
BTS-ISIS	388	9	0.137
SNS	510	3	0.013
NL Beam Trawl	659	8	0.832
fshk	1261	1	0.017

Table 6.8.3. Sole in Subarea IV: Stock assessment summary for stock assessment with updated tuning indices and full uncorrected commercial index.

	recruitment	ssb	catch	landings	tsb	fbar2-6	Y/ssb
1957	128911	55108	11601	12067	63402	0.178	0.22
1958	128645	60920	14216	14287	72301	0.207	0.23
1959	488770	65581	13702	13832	85949	0.171	0.21
1960	61715	73400	18740	18620	105901	0.204	0.25
1961	99494	117101	23246	23566	123498	0.190	0.20
1962	22898	116833	27039	26877	123707	0.213	0.23
1963	20422	113632	26380	26164	115593	0.313	0.23
1964	539120	37129	11740	11342	51188	0.289	0.31
1965	121971	30032	17767	17043	101368	0.317	0.57
1966	39905	84252	33705	33340	92975	0.325	0.40
1967	75182	82970	32704	33439	91240	0.406	0.40
1968	99255	72321	33285	33179	83102	0.489	0.46
1969	50807	55291	27014	27559	68730	0.546	0.50
1970	137858	50712	19683	19685	60405	0.399	0.39
1971	42098	43776	23374	23652	63486	0.511	0.54
1972	76403	47484	21320	21086	56229	0.462	0.44
1973	105034	36812	18950	19309	51158	0.504	0.52
1974	109988	36120	18237	17989	53748	0.489	0.50
1975	40843	38478	20559	20773	54622	0.498	0.54
1976	113327	38953	16959	17326	48132	0.424	0.44
1977	140373	34706	17672	18003	54547	0.459	0.52
1978	47212	36284	20370	20280	55361	0.477	0.56
1979	11694	44874	22321	22598	51719	0.492	0.50
1980	151719	33499	15496	15807	41076	0.452	0.47
1981	149195	23031	15009	15403	49215	0.497	0.67
1982	152831	32895	21286	21579	58033	0.543	0.66
1983	142228	39952	24828	24927	66069	0.487	0.62
1984	70821	43446	26747	26839	64054	0.615	0.62
1985	80851	41056	24497	24248	53214	0.595	0.59
1986	159652	34455	18316	18201	52147	0.574	0.53
1987	72545	29593	17462	17368	55412	0.487	0.59
1988	454340	38780	21612	21590	70216	0.566	0.56
1989	108305	34044	22156	21805	94135	0.446	0.64
1990	177745	89670	35485	35120	113045	0.454	0.39
1991	70463	77468	34096	33513	103232	0.448	0.43
1992	354130	76743	29787	29341	104377	0.427	0.38
1993	69284	54709	31858	31491	99068	0.512	0.58
1994	57052	74271	33405	33002	86081	0.562	0.44
1995	96101	58867	30690	30467	71364	0.532	0.52
1996	49513	38225	22913	22651	52812	0.698	0.59
1997	271641	28067	15050	14901	48345	0.596	0.53
1998	114068	20868	21049	20868	60770	0.636	1.00
1999	82569	41884	23717	23475	59502	0.571	0.56

2000	123760	39171	22859	22641	55706	0.598	0.58
2001	63586	30719	20582	19944	49702	0.570	0.65
2002	187330	31361	17092	16945	48948	0.564	0.54
2003	84838	25723	17940	17920	54566	0.574	0.70
2004	45515	38291	18744	18757	50947	0.497	0.49
2005	49196	33266	16722	16355	41829	0.552	0.49
2006	211961	25311	12246	12594	42335	0.420	0.50
2007	61648	19085	14725	14635	50335	0.425	0.77
2008	89215	38537	13924	14144	51542	0.361	0.37

Table 6.8.4. Sole in subarea IV: Stock assessment summary for stock assessment with updated tuning indices and uncorrected commercial index cut-off in 1997 (WKFLAT recommended model).

	recruitment	ssb	catch	landings	tsb	fbar2-6	Y/ssb
1957	128911	55108	11601	12067	63402	0.178	0.22
1958	128644	60920	14216	14287	72301	0.207	0.23
1959	488767	65581	13702	13832	85948	0.171	0.21
1960	61715	73399	18740	18620	105900	0.204	0.25
1961	99492	117101	23246	23566	123497	0.190	0.20
1962	22897	116832	27039	26877	123706	0.213	0.23
1963	20422	113631	26380	26164	115592	0.313	0.23
1964	539108	37129	11740	11342	51187	0.289	0.31
1965	121967	30031	17767	17043	101366	0.317	0.57
1966	39903	84249	33705	33340	92972	0.325	0.40
1967	75173	82967	32704	33439	91237	0.406	0.40
1968	99253	72317	33285	33179	83097	0.489	0.46
1969	50803	55285	27014	27559	68723	0.546	0.50
1970	137829	50703	19683	19685	60395	0.399	0.39
1971	42083	43767	23374	23652	63473	0.511	0.54
1972	76392	47469	21320	21086	56212	0.462	0.44
1973	104991	36793	18950	19309	51137	0.504	0.52
1974	109963	36096	18237	17989	53717	0.489	0.50
1975	40827	38435	20559	20773	54575	0.498	0.54
1976	113302	38919	16959	17326	48095	0.425	0.45
1977	140302	34664	17672	18003	54500	0.460	0.52
1978	47165	36226	20370	20280	55292	0.478	0.56
1979	11674	44796	22321	22598	51633	0.492	0.50
1980	151620	33434	15496	15807	41004	0.453	0.47
1981	149020	22958	15009	15403	49121	0.498	0.67
1982	152451	32814	21286	21579	57914	0.545	0.66
1983	141538	39844	24828	24927	65879	0.489	0.63
1984	70898	43268	26747	26839	63797	0.619	0.62
1985	81781	40749	24497	24248	52962	0.600	0.60
1986	159380	34063	18316	18201	51853	0.581	0.53
1987	72743	29389	17462	17368	55181	0.493	0.59
1988	456626	38596	21612	21590	70169	0.568	0.56
1989	108281	33926	22156	21805	94290	0.440	0.64
1990	177532	89876	35485	35120	113236	0.443	0.39
1991	70451	77678	34096	33513	103415	0.446	0.43
1992	353645	77453	29787	29341	105062	0.422	0.38
1993	69193	55673	31858	31491	99972	0.509	0.57
1994	57002	74521	33405	33002	86316	0.563	0.44
1995	96009	59283	30690	30467	71768	0.534	0.51
1996	49413	38652	22913	22651	53221	0.701	0.59
1997	271247	27877	15050	14901	48121	0.601	0.53
1998	113815	20656	21049	20868	60496	0.641	1.01

1999	82311	41680	23717	23475	59256	0.575	0.56
2000	123572	38862	22859	22641	55355	0.603	0.58
2001	63241	30413	20582	19944	49354	0.576	0.66
2002	185151	31094	17092	16945	48527	0.571	0.54
2003	82972	25370	17940	17920	53832	0.584	0.71
2004	43932	37628	18744	18757	49974	0.507	0.50
2005	47517	32322	16722	16355	40587	0.570	0.51
2006	208705	24053	12246	12594	40689	0.446	0.52
2007	59380	17808	14725	14635	48496	0.462	0.82
2008	88461	36723	13924	14144	49374	0.406	0.39

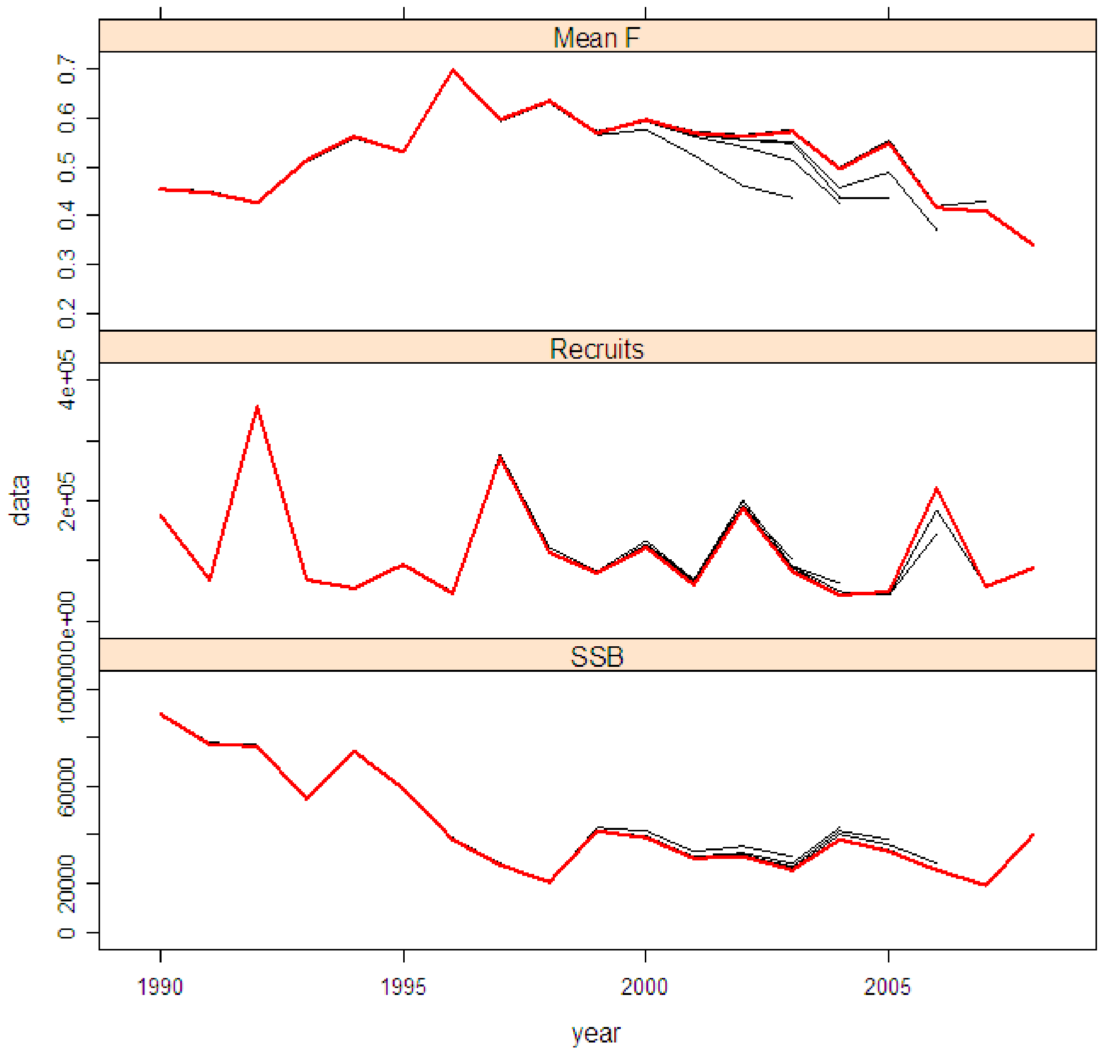


Figure 6.1.1. Sole in Subarea IV. Retrospective analysis of F, Recruitment and SSB (ylab Recruits = numbers, ylab SSB = tons).

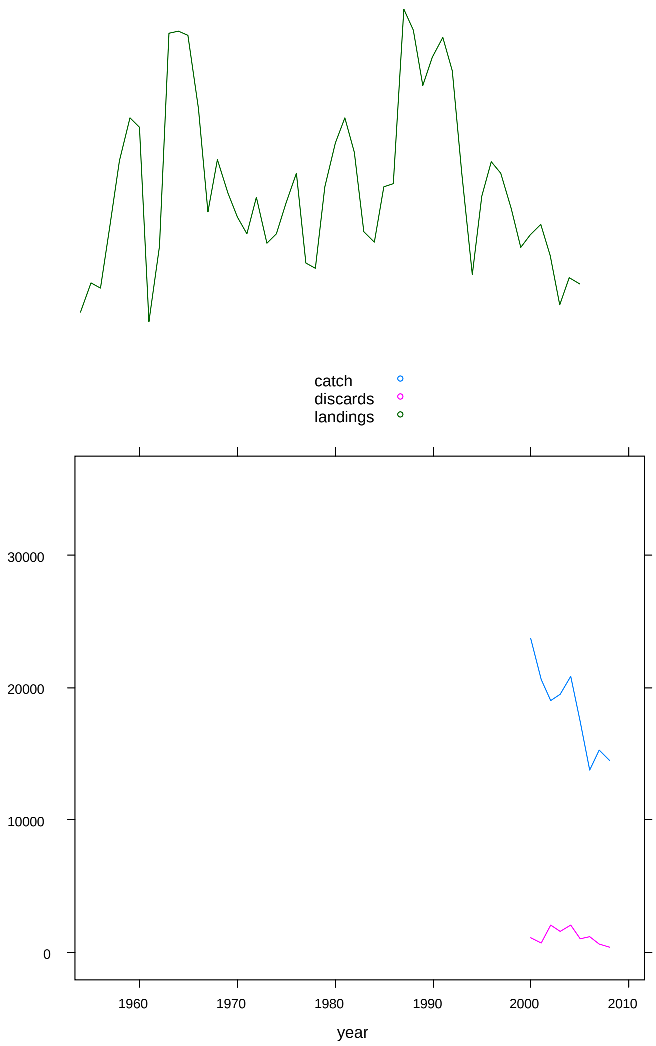


Figure 6.2.1. Sole in Subarea IV. Landings, discards and catches. Note that only the Dutch discards estimates are included. (ylab=tons).

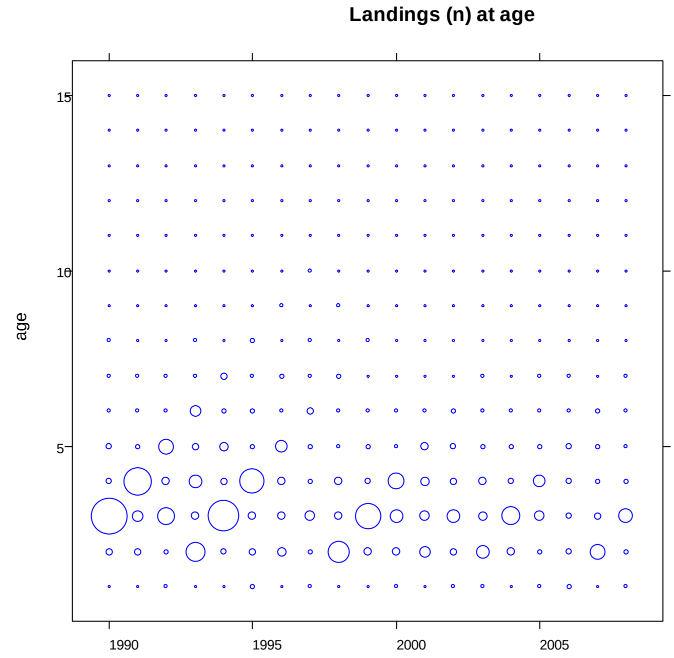


Figure 6.2.2. Sole in Subarea IV. Landings-at-age (unsexed) for ages 1–15, years 1990–2008.

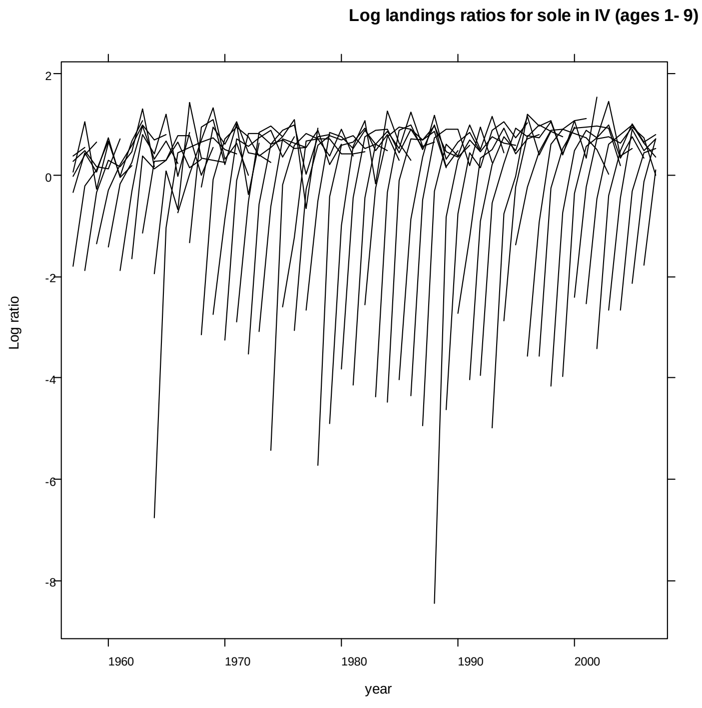


Figure 6.2.3. Sole in Subarea IV. Log landings (sexes combined) ratios for ages 2–9.

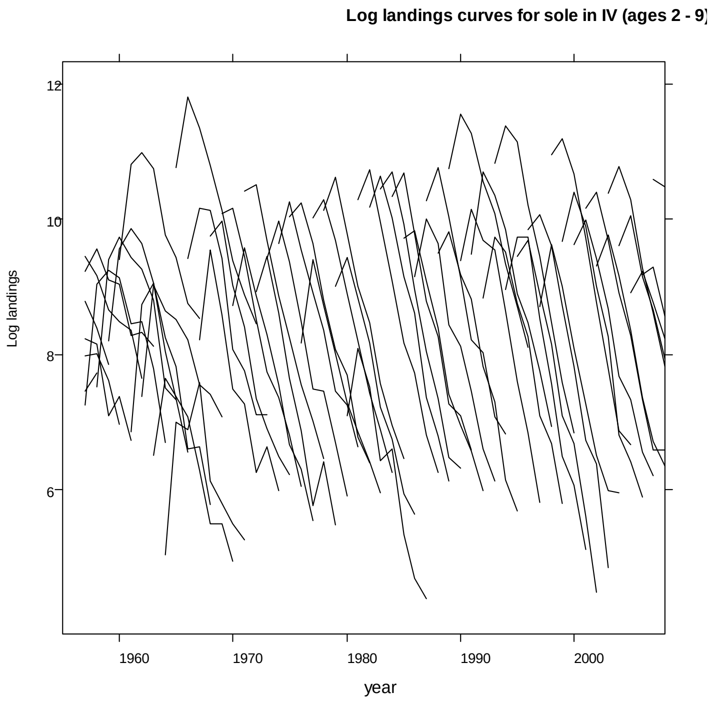


Figure 6.2.4. Sole in Subarea IV. Log landings (sexes combined) curves.

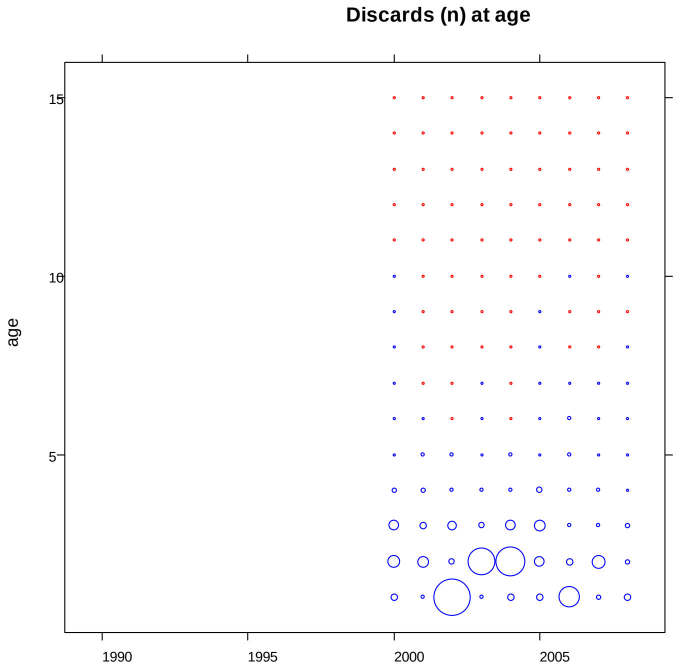


Figure 6.2.5. Sole in Subarea IV. Discards-at-age (sexes combined) for ages 1–15, years 1990–2008. Note that data are available since 2000.

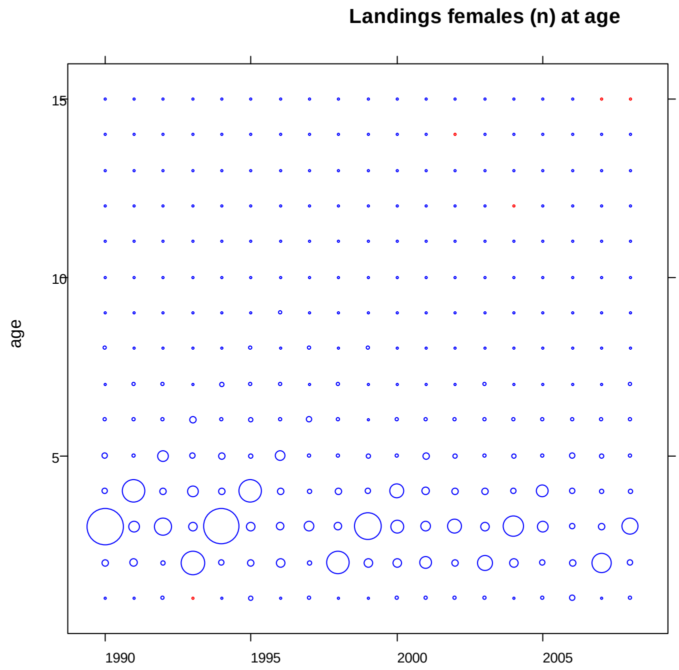


Figure 6.2.6. Sole in Subarea IV. Landings-at-age for females for ages 1–15, years 1990–2008.

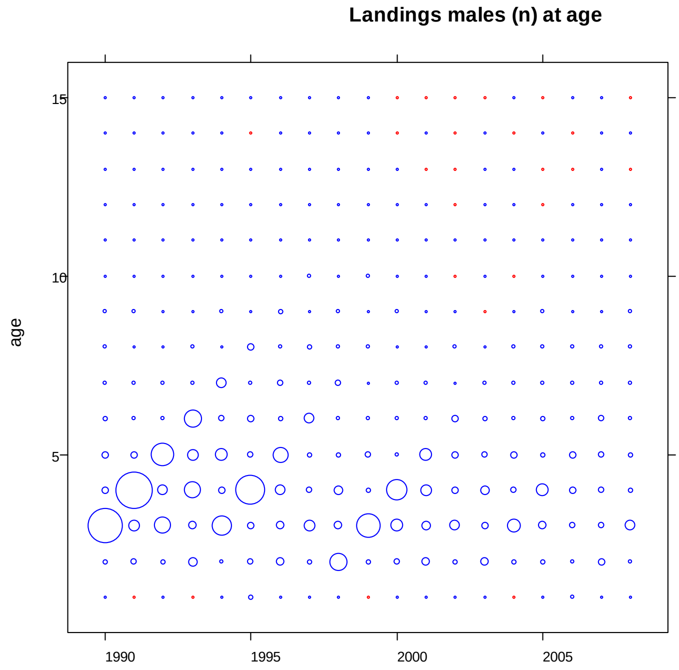
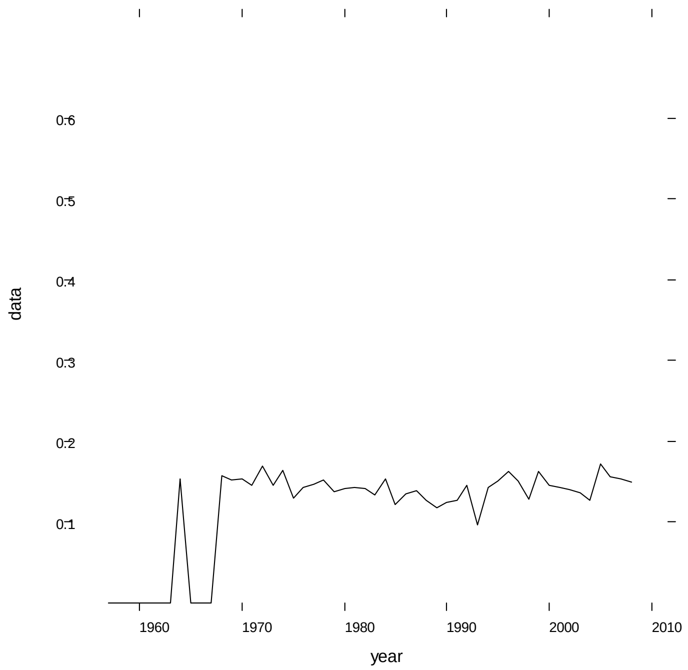


Figure 6.2.7. Sole in Subarea IV. Landings-at-age for males for ages 1–15, years 1990–2008.



data
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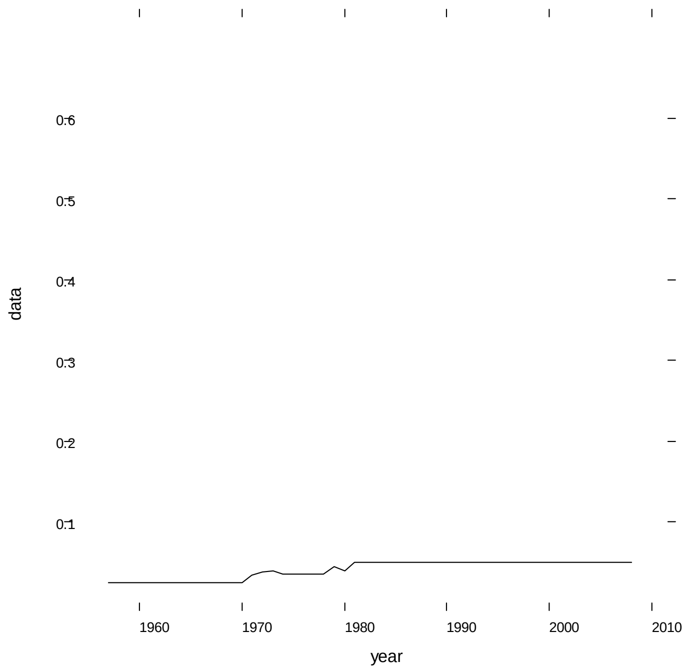
0.5
0.4
0.3
0.2
0.1
1960
1970
1980
1990
2000
2010
year



0.6
0.5
0.4
0.3
0.2
0.1
data
1960
1970
1980
1990
2000
2010
year

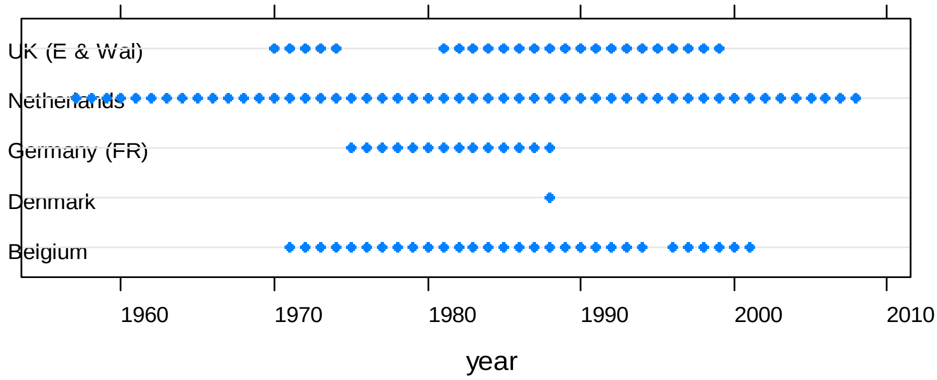
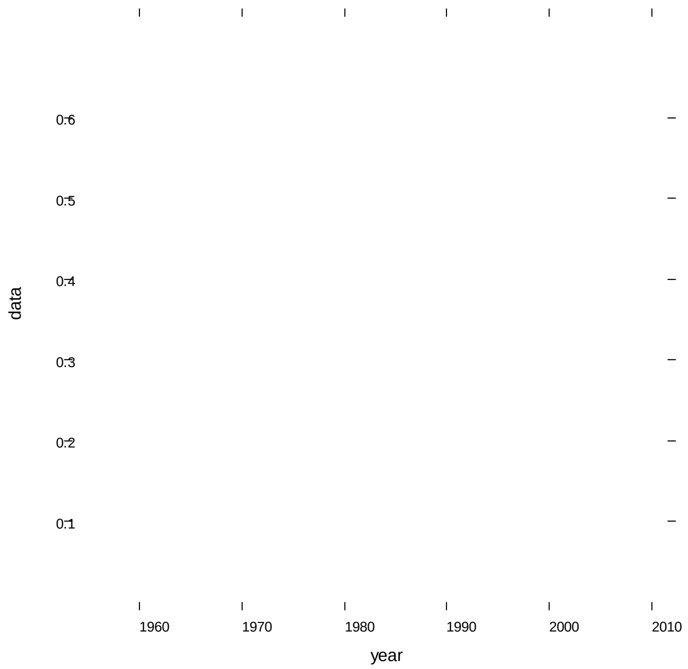
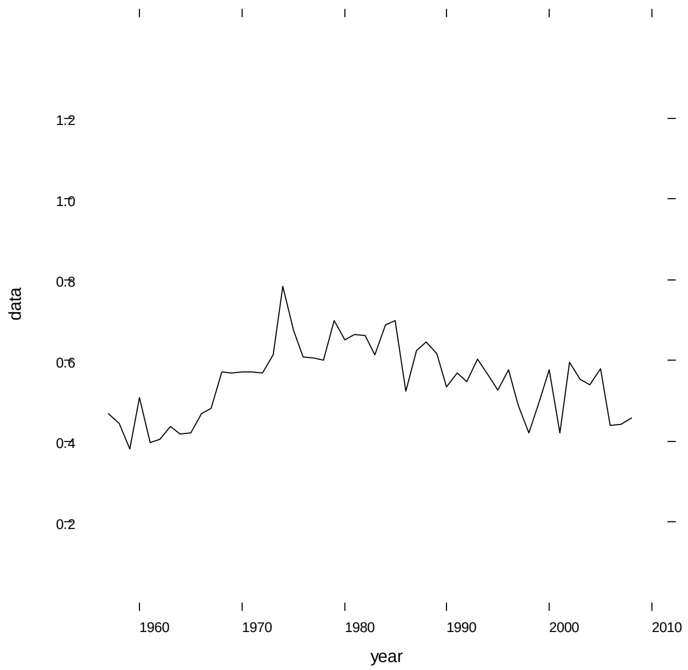
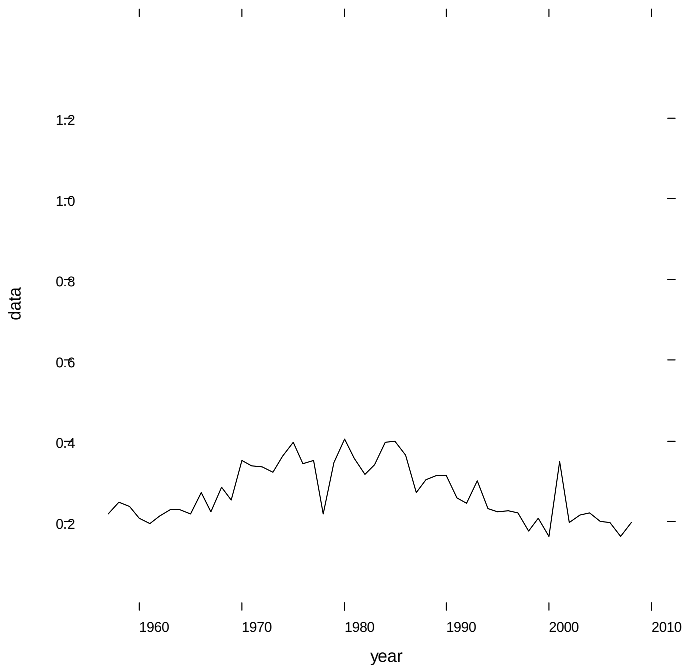


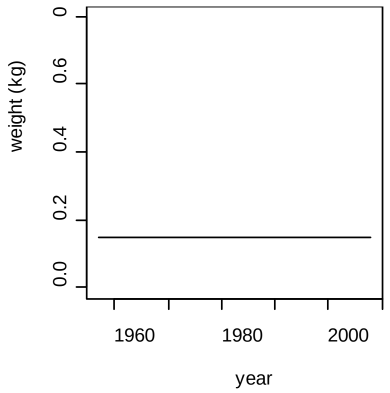
Figure 6.2.12. Sole in Subarea IV. Availability of stock weights-by-sex for the different countries contributing to the age structured landings data.




1.2
1.0
0.8
0.6
0.4
0.2
data
1960
1970
1980
1990
2000
2010
year



data
1.2
1.0
0.8
0.6
0.4
0.2
1960
1970
1980
1990
2000
2010
year


weight (kg)
0
0.6
0.4
0.2
0.0
1960
1980
2000
year

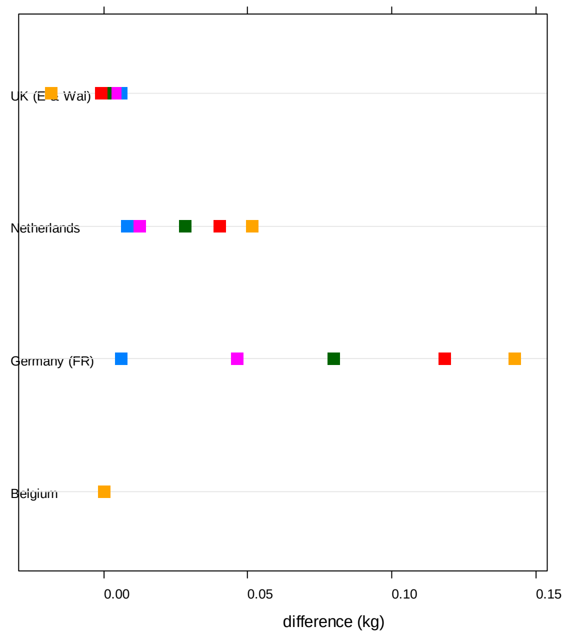


Figure 6.2.18a. Sole in Subarea IV. Predicted differences in stock weights for the different countries. Each dot represents an age (blue: age 2, purple: age 3, brown: age 4, red: age 5, orange: age 6). Belgium is the baseline.

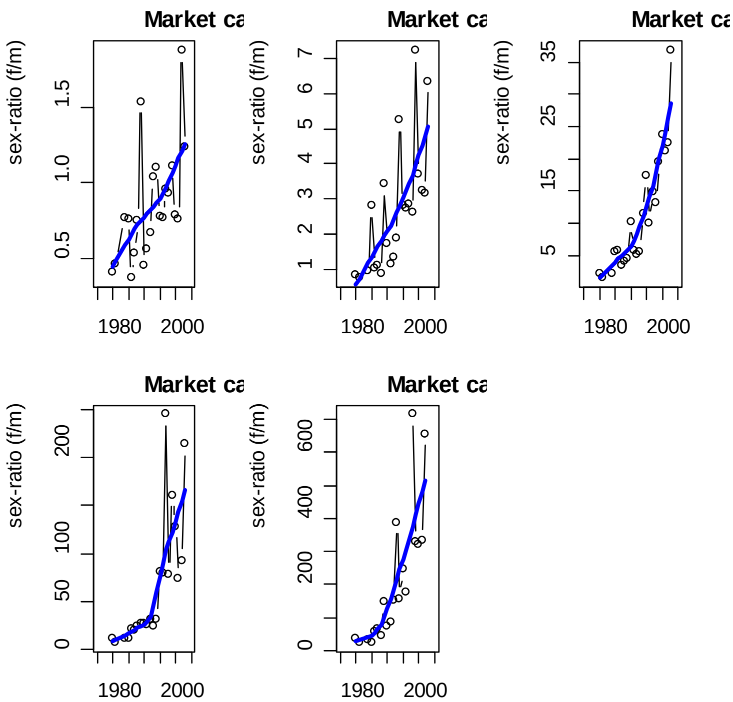


Figure 6.2.18b. Sole IV. Sex ratios in landings by boats >300 hp between 1985 and 2008 in Dutch market sampling data.

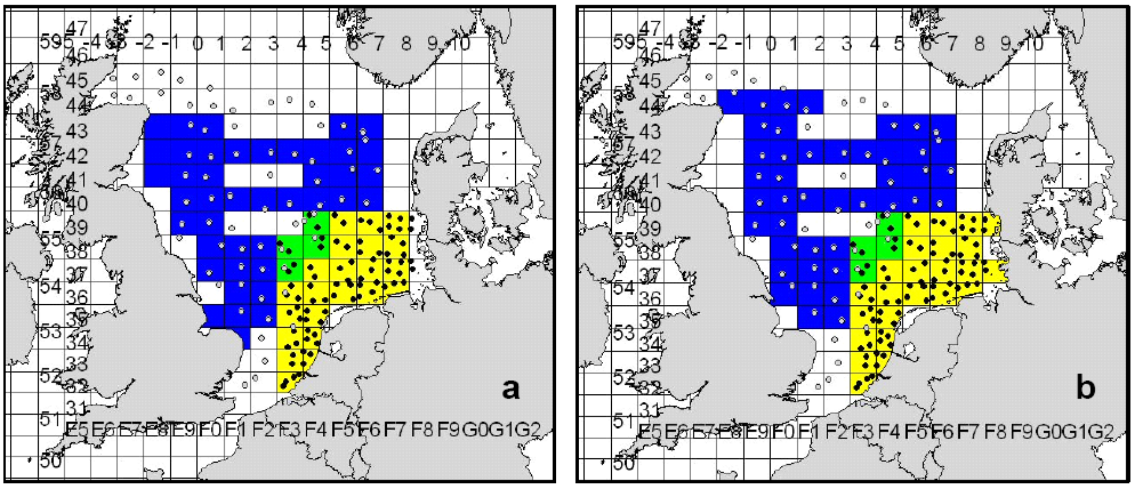


Figure 6.2.19a. Sole in Subarea IV. Survey area of the Dutch offshore survey (BTS) showing the spatial coverage of the 2007 survey by the RV "Tridens" (grey dots) and the RV Isis (black dots). Also presented are the previous index areas (a) of "Tridens" (blue + green shading) and Isis (yellow + green shading) and the new index areas (b). Taken from ICES WGBEAM 2009.

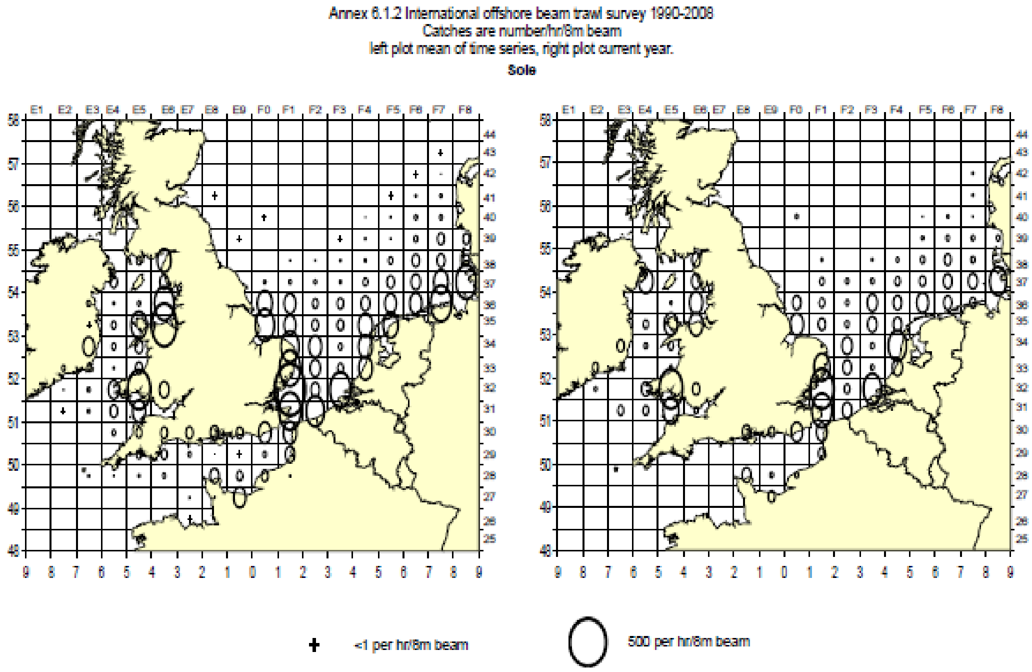


Figure 6.2.19b. Sole in Subarea IV International beam trawl survey Quarter 3. Average abundance 1990–2008 (left) vs. abundance in 2009 (right) see WGBEAM Report 2009.

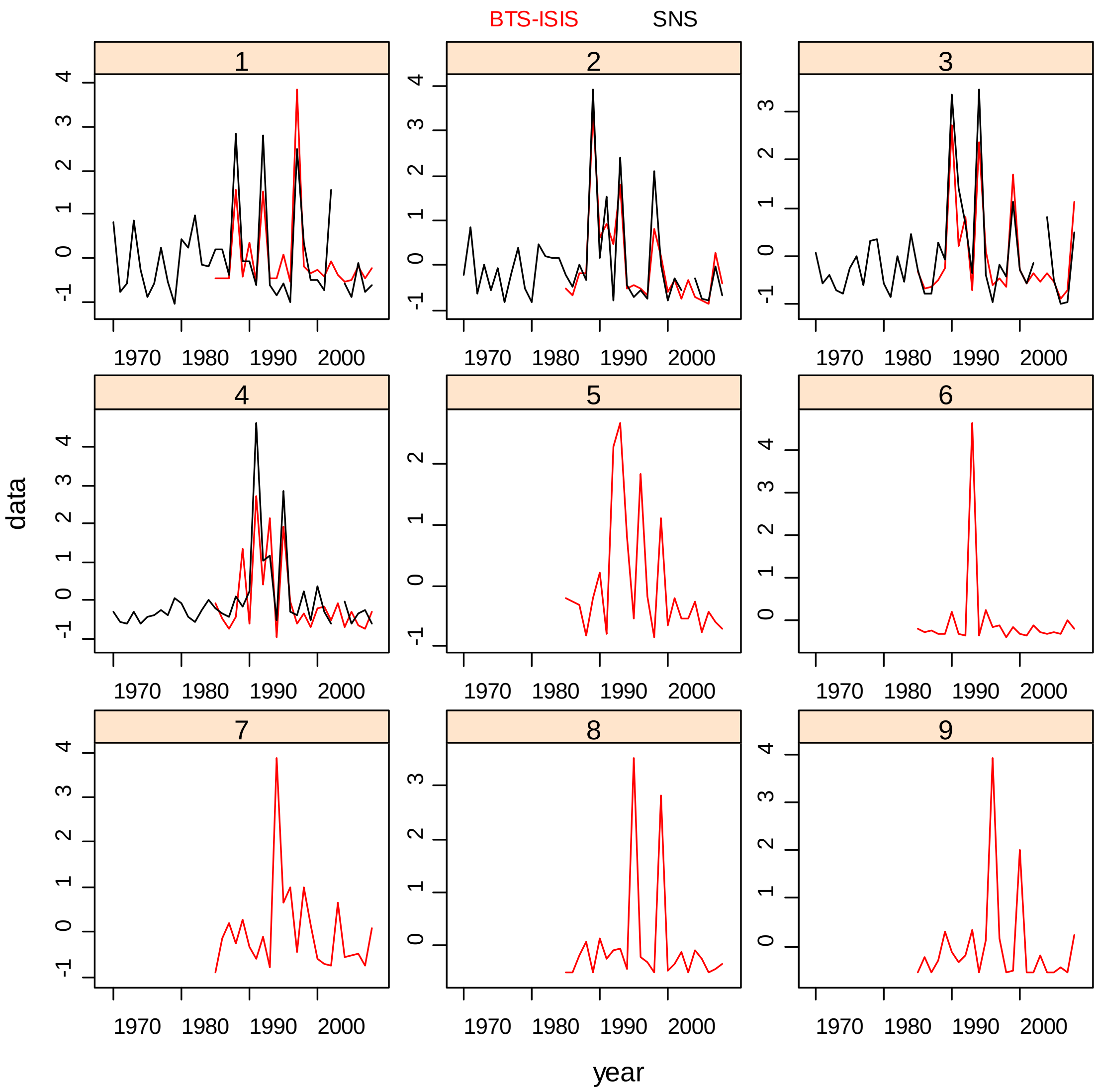


Figure 6.2.20. Sole in Subarea IV. Time-series of centered BTS-ISIS (red lines) and SNS (black lines) index tuning-series for ages 1 to 9. These data have been changed by WGBEAM 2009 since WGNSSK 2009 (see text). (ylab=log index).

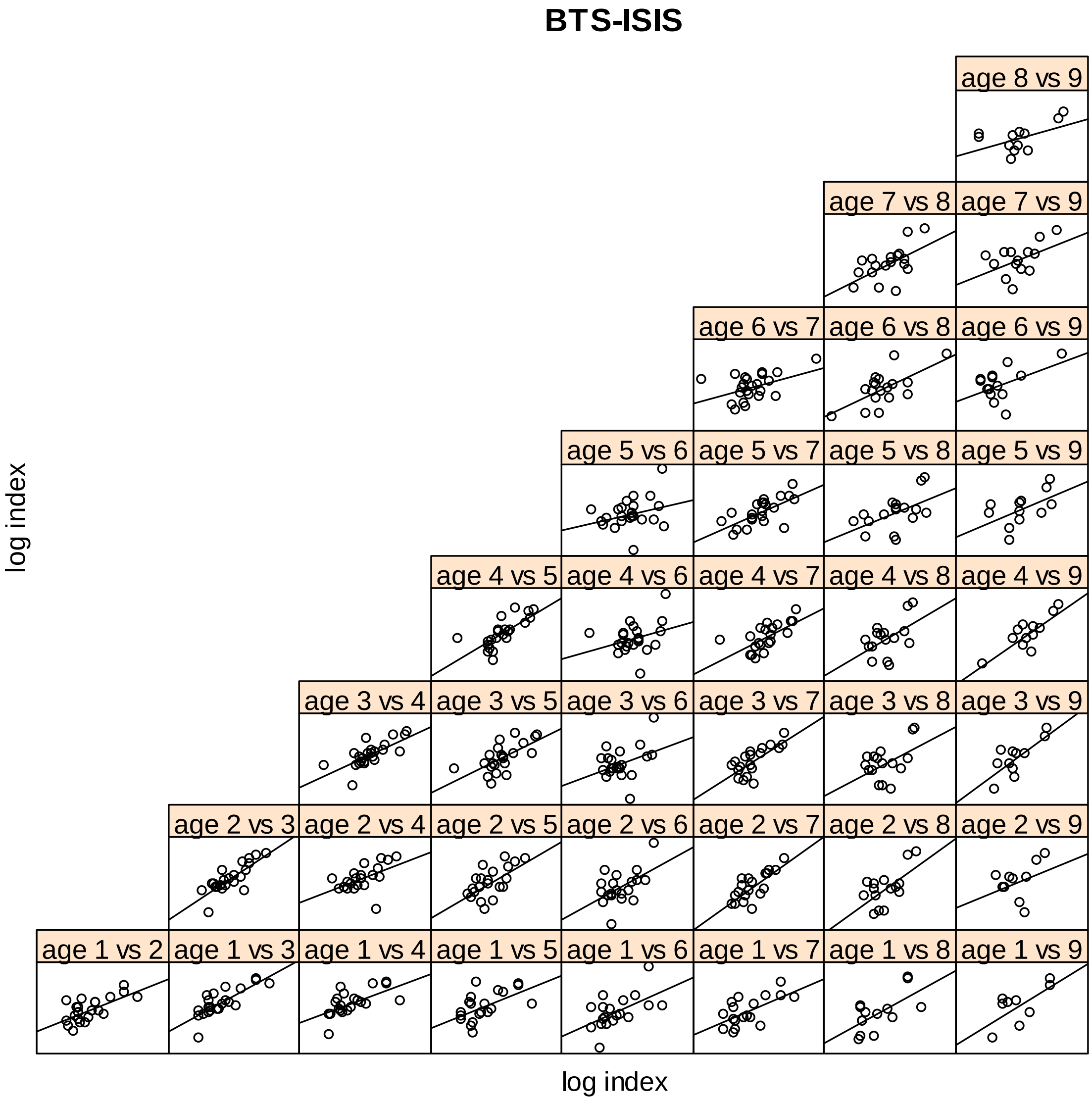


Figure 6.2.21. Sole in Subarea IV. Internal consistency plot for the BTS-ISIS index tuning-series for ages 1 to 9. These data have been changed by WGBEAM 2009 since WGNSSK 2009 (see text).

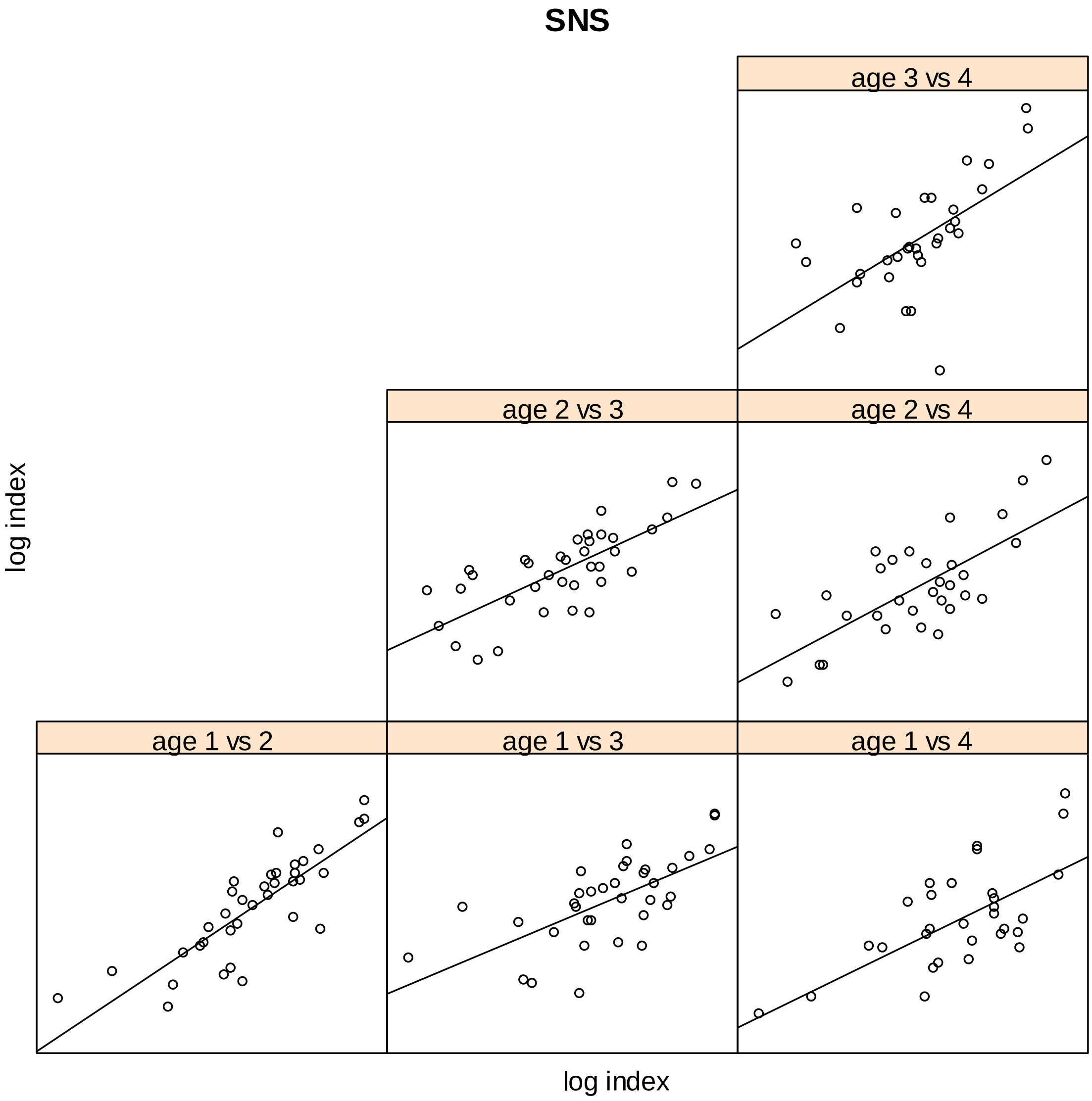


Figure 6.2.22. Sole in Subarea IV. Internal consistency plot for the SNS index tuning-series for ages 1 to 4. These data have been changed since WGNSSK 2009 (see text).

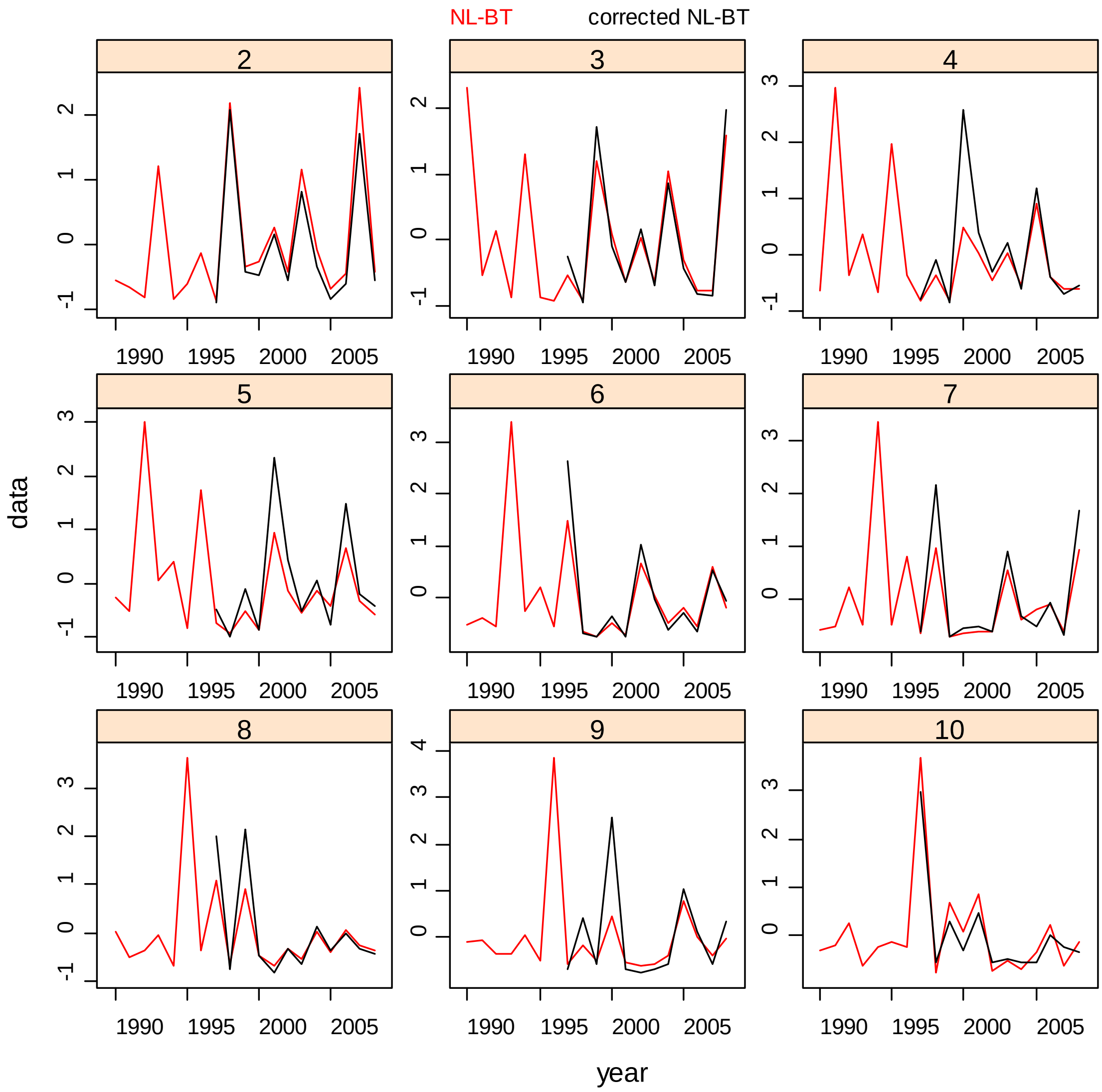


Figure 6.2.23a. Sole in Subarea IV. Time-series of centered NL beam trawl fleet tuning-series (red lines) and the corrected NL beam trawl fleet tuning-series (black lines) for ages 2 to 10. (ylab=log index).

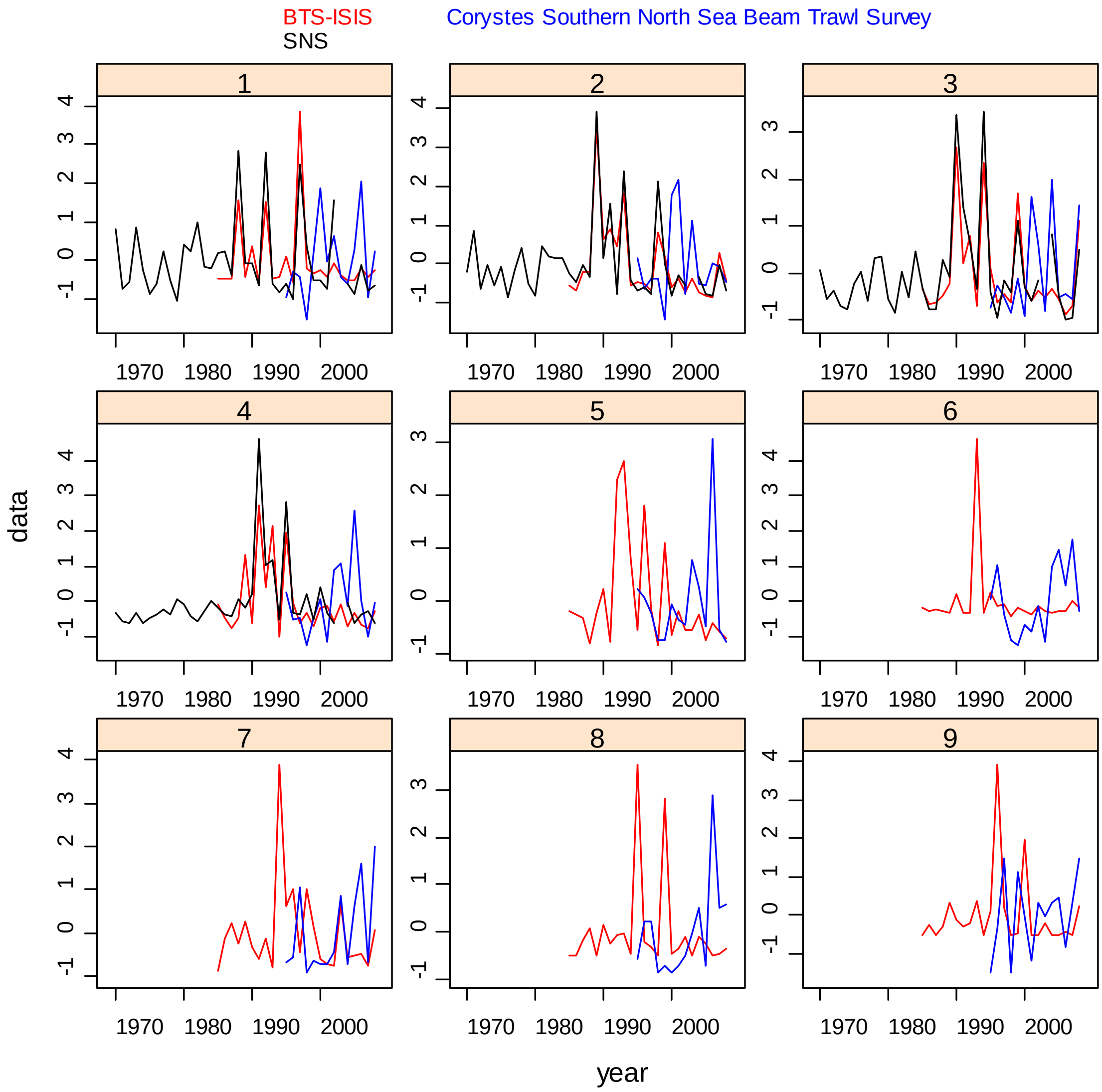


Figure 6.2.23b. Sole in Subarea IV. Time-series of centered Dutch BTS-ISIS (red lines), the Dutch SNS (black lines) and the UK Corystes (blue) tuning-series for ages 2 to 10. (ylab=log index).

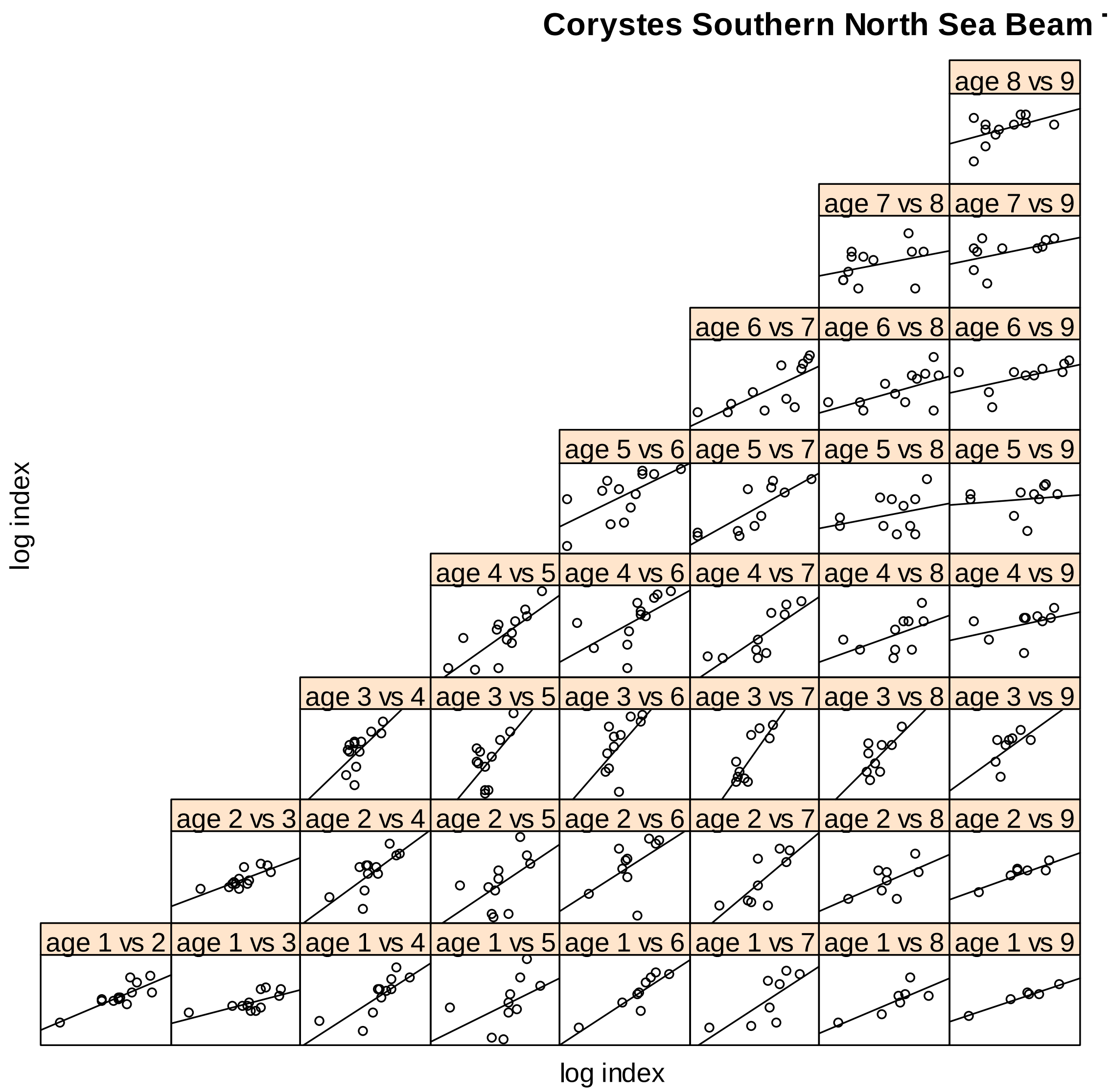


Figure 6.2.23c. Sole in Subarea IV. Internal consistency plot for the UK Corystes Beam trawl index tuning-series for ages 1 to 9.

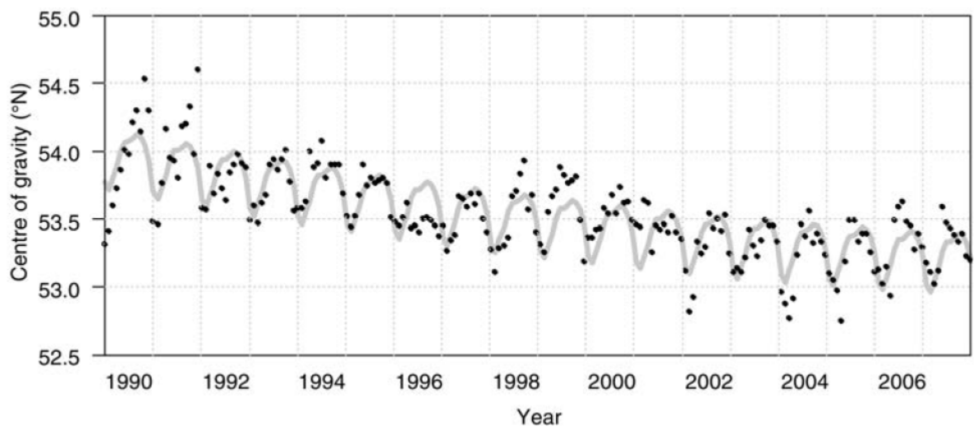


Figure 6.2.24. Sole in Subarea IV. Time-series of the monthly centre of gravity of the Dutch beam trawl fleet latitudinally. Each dot represents the centre of gravity in a single month, calculated from the mandatory logbook data. The grey line represents monthly predictions of the centre of gravity, using a simple generalized linear model. From Poos *et al.*, 2010.

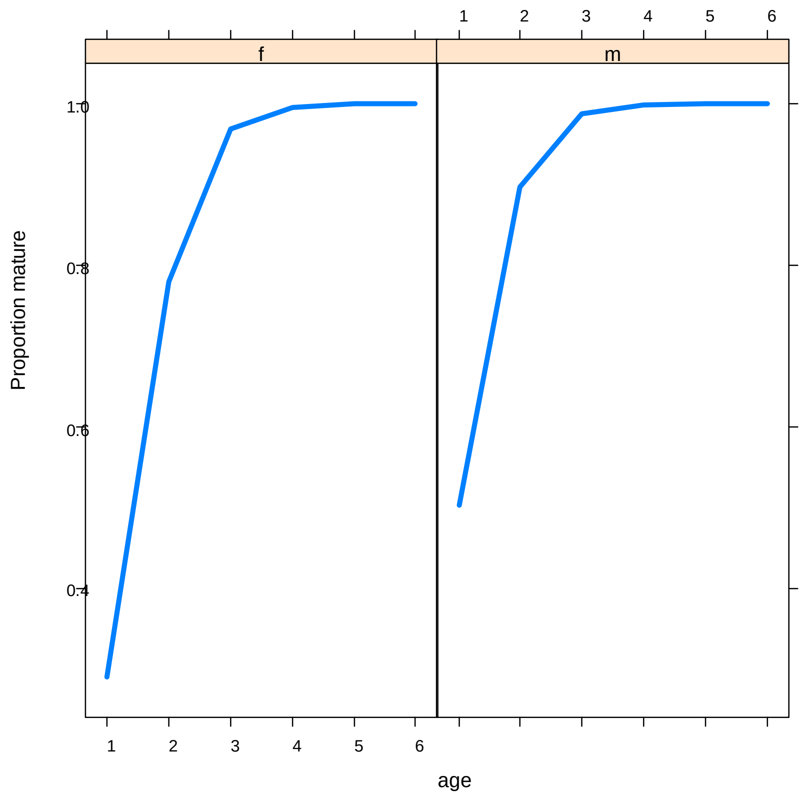
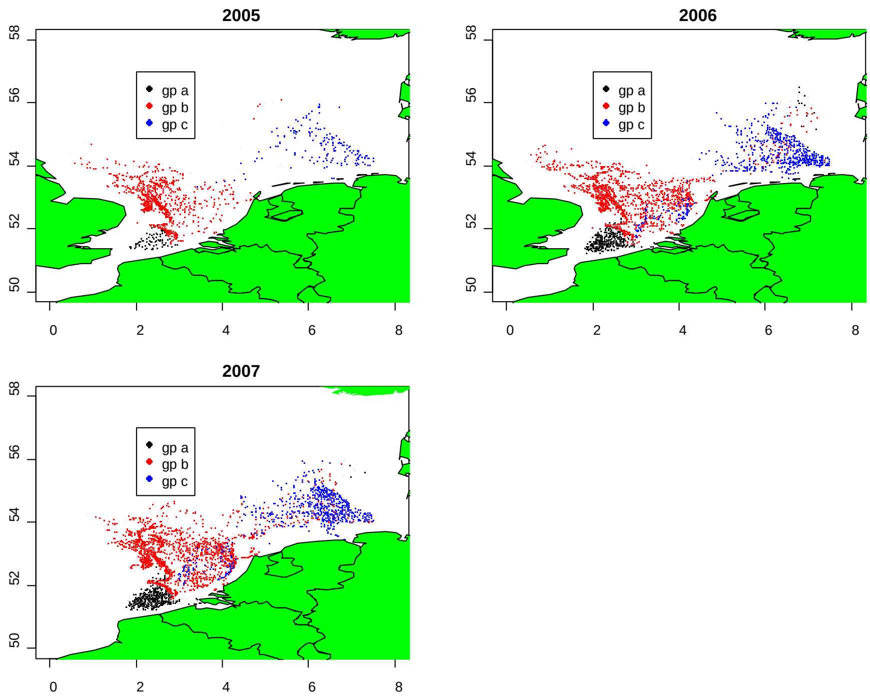


Figure 6.2.25. Sole in Subarea IV. Proportion mature by sex estimated from Dutch market sampling data.


2005
2006
2007
gp a
gp b
gp c
58
56
54
52
50
0
2
4
6
8

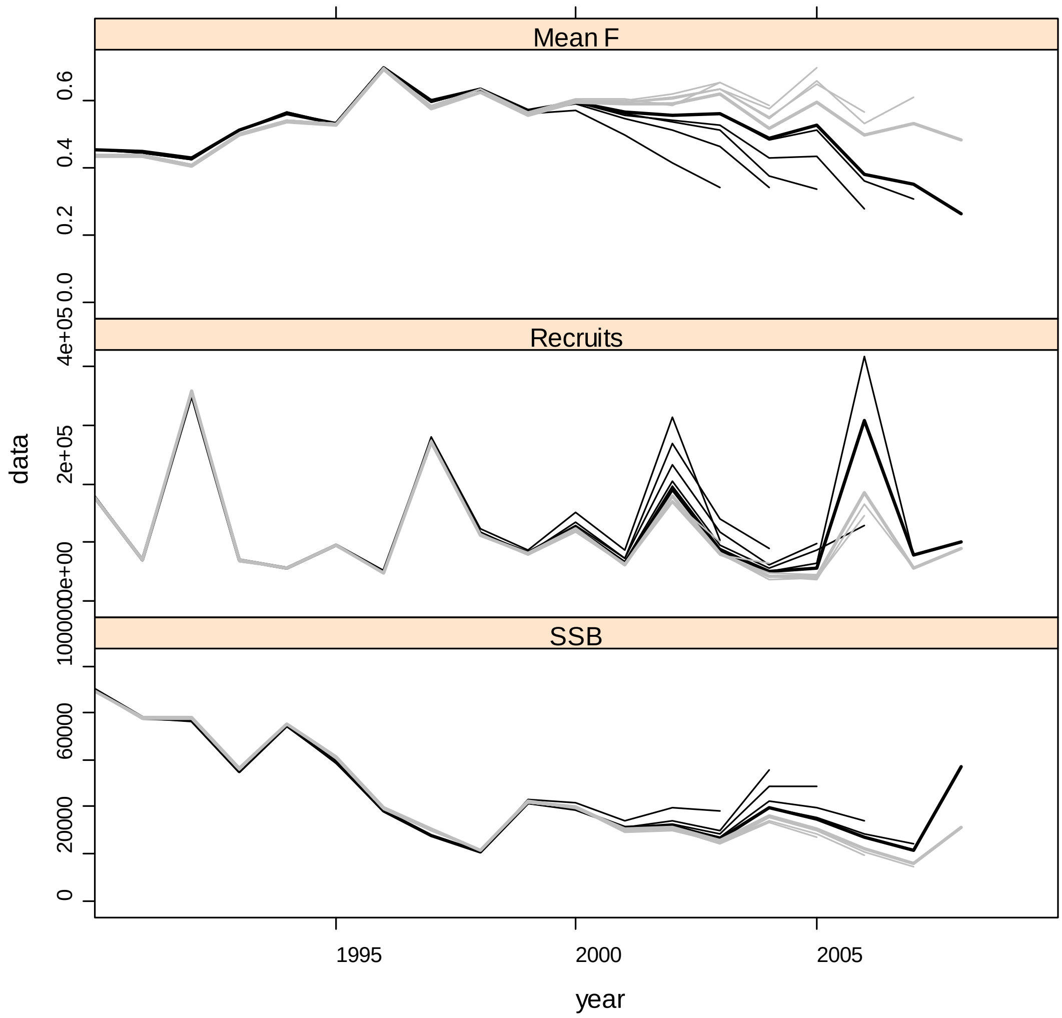


Figure 6.8.1. Sole in Subarea IV. XSA retrospective analysis of assessment estimates of fishing mortality, SSB, and recruitment using different combinations of indices. Grey lines: using survey indices only. Black lines: using commercial indices only. (ylab recruits = numbers, ylab SSB = tonnes).

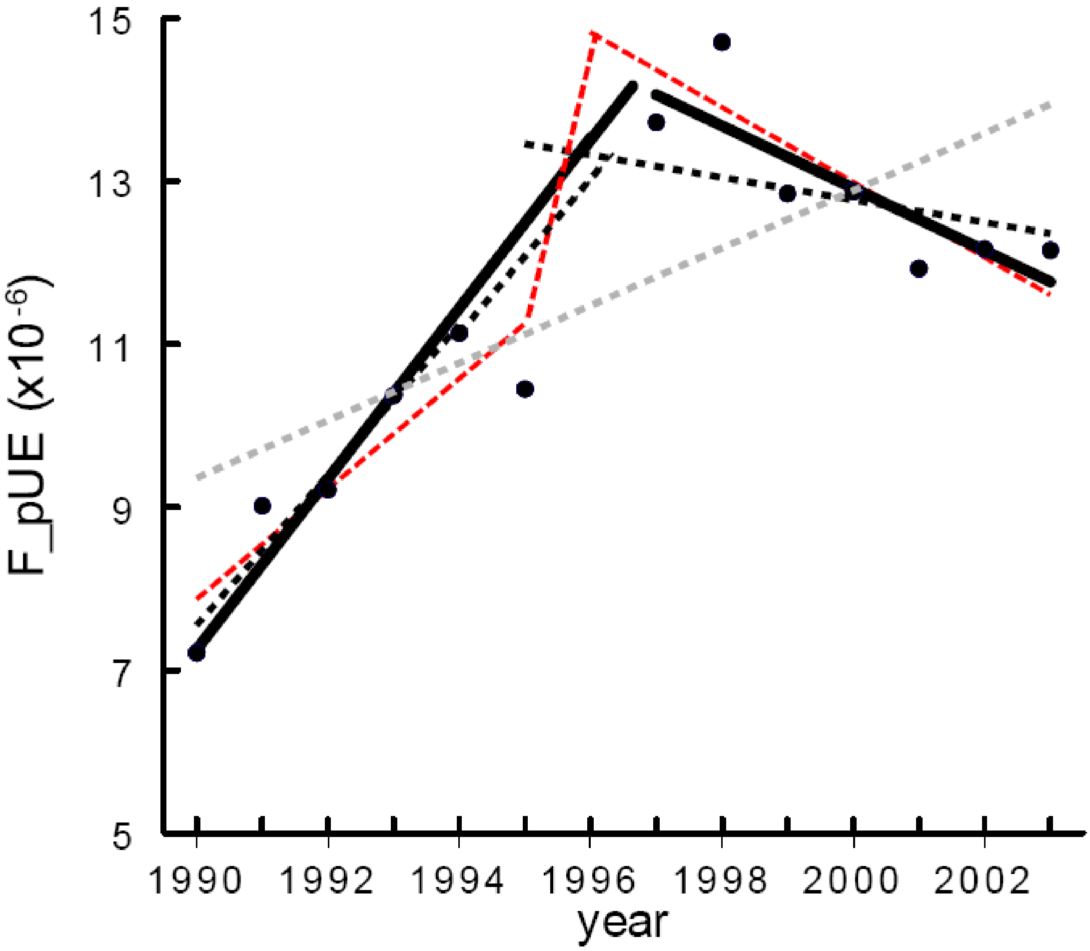


Figure 6.8.2. Sole in Subarea IV: Time-series of F_{pUE} in the Dutch beam trawl. Grey dotted line is the linear trend line with 2.8% increase per year. The thick black line represents segmented trend with a regression break in 1996 or 1997. The black dashed line shows segmented trend with a regression break in 1994. A regression break in 1995 is shown as thin dashed line. Please note the two regression lines are connected by a step line from 1995 to 1996. Taken from WGNSSK 2006 (ICES 2006).

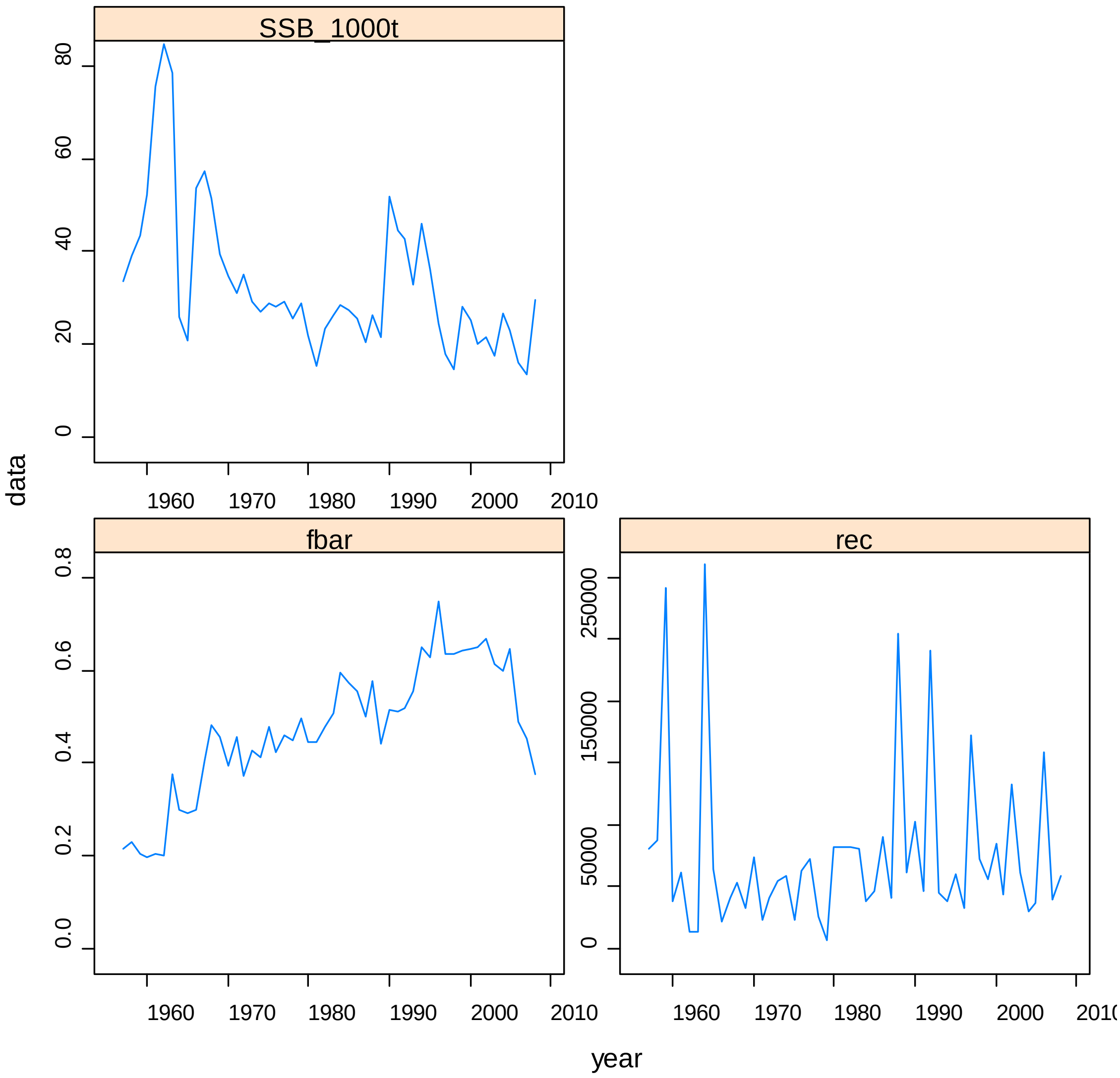


Figure 6.8.3. Sole in Subarea IV females only. Standard stock assessment output showing F, SSB and recruitment. The uncorrected commercial tuning index was used, together with the SNS and BTS; ISIS indices. (ylab recruits = numbers).

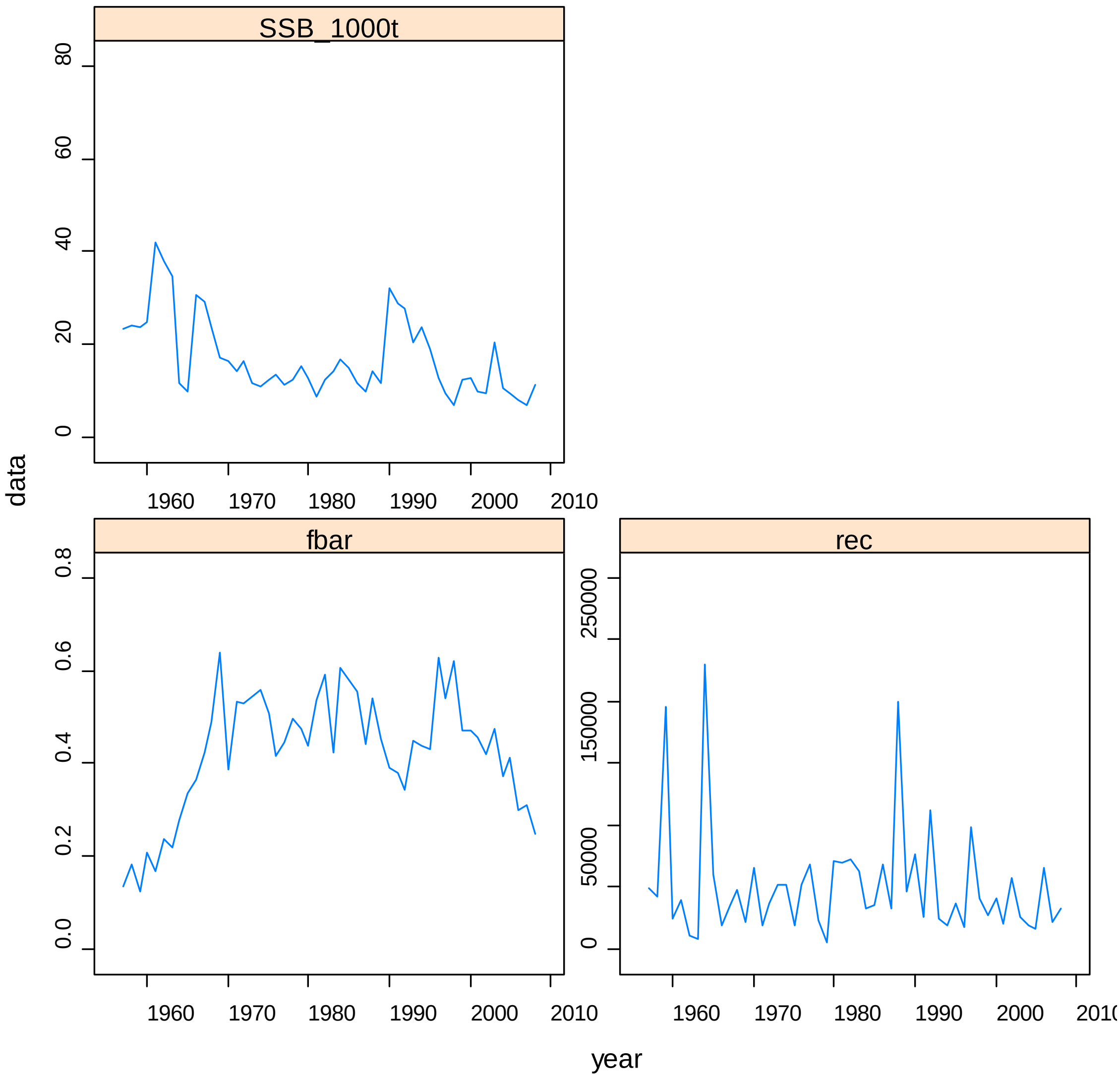
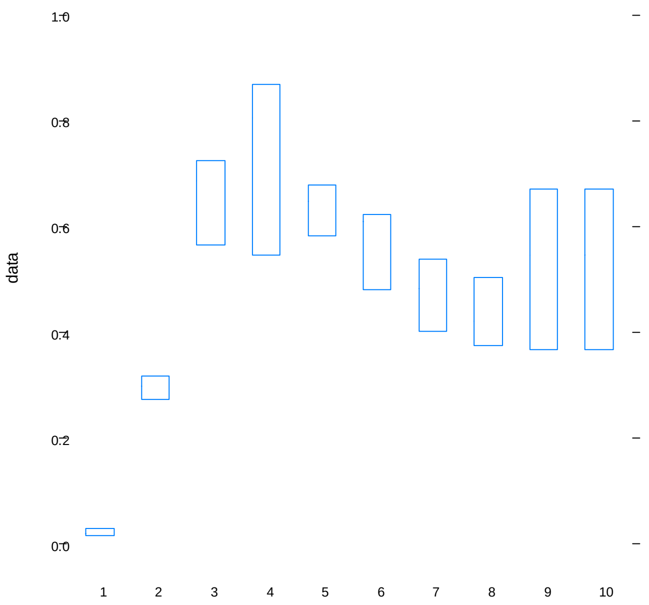


Figure 6.8.4. Sole in Subarea IV males only. Standard stock assessment plot showing F, SSB and recruitment. The uncorrected commercial tuning index was used, together with the SNS and BTS; ISIS indices. (ylab recruits = numbers).



1.0
0.8
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data
1
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10

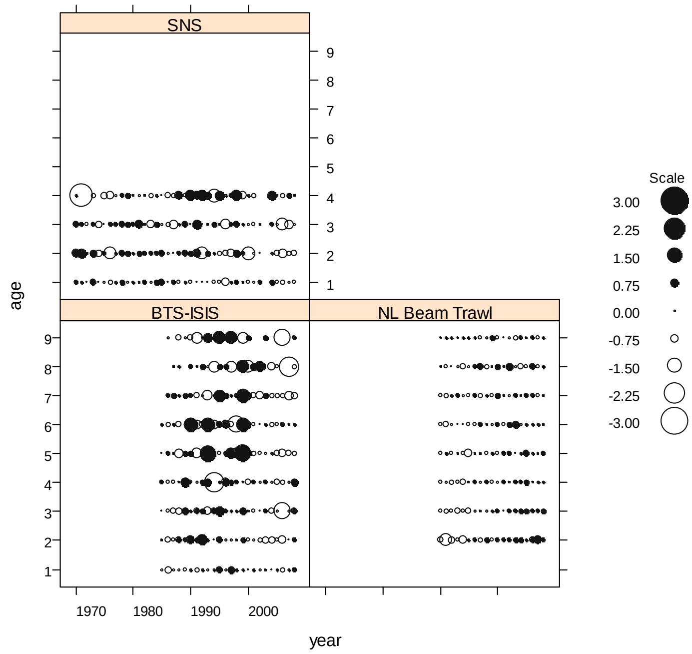

Figure 6.8.7. Sole in Subarea IV. Log catchability residuals for the tuning fleets, updated BTS, updated SNS and complete time-series of uncorrected NL beam trawl. Closed and dark- circles indicate positive residuals, Open circles indicate negative residuals.

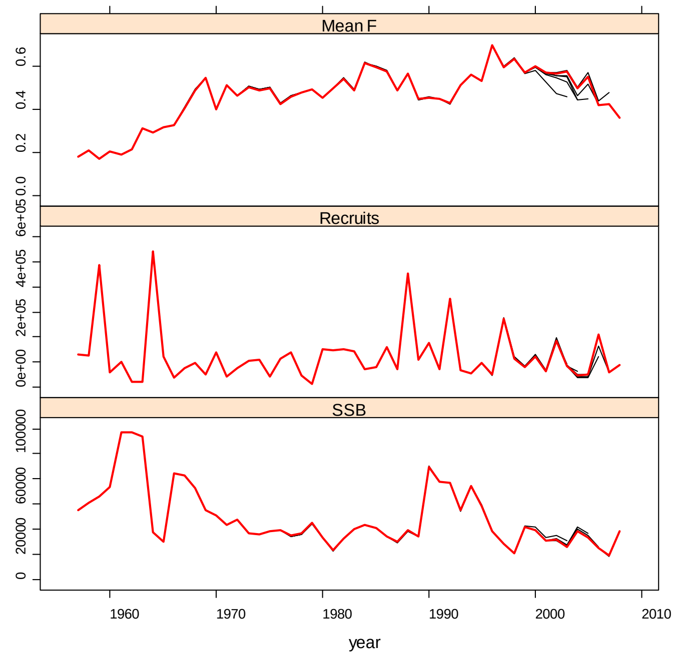

Figure 6.8.8. Sole in Subarea IV. XSA assessment. Retrospective analysis using 'new' commercial index (specialist sole boats) which was available from 2001. (ylab Recruits = numbers, ylab SSB = tonnes).

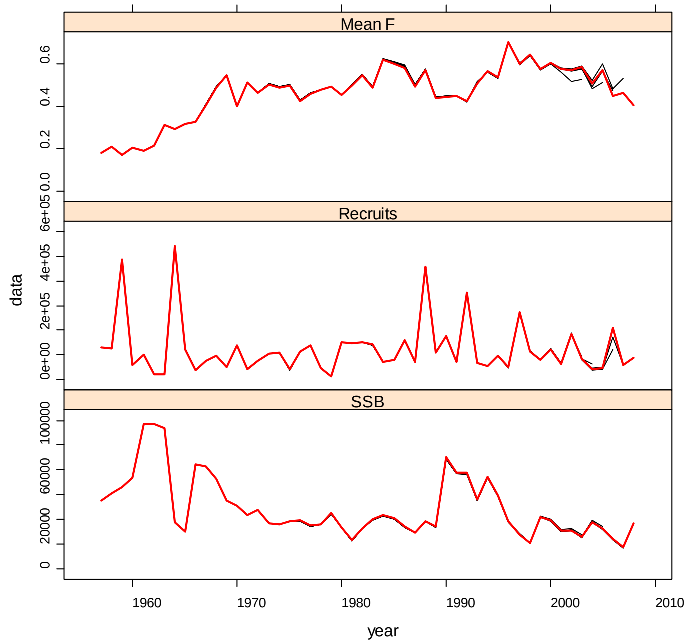

Figure 6.8.9. Sole in Subarea IV. XSA assessment. Retrospective analysis using uncorrected commercial index cut off pre-1997. (ylab Recruits = numbers, ylab SSB = tonnes).

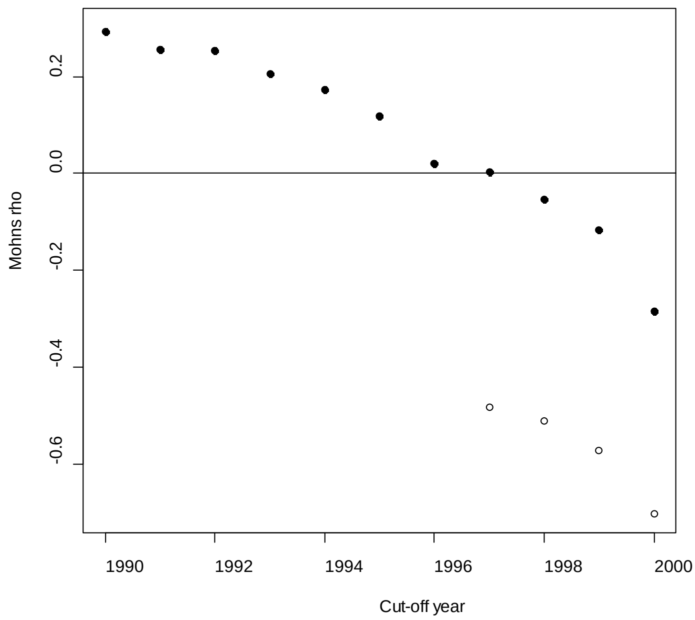

Figure 6.8.10. Sole in Subarea IV. Mohn's ρ as a function of different cut-off points for the commercial tuning indices. Black dots indicate the uncorrected NL beam trawl cpue series. Open dots indicate the spatially corrected NL beam trawl cpue series.

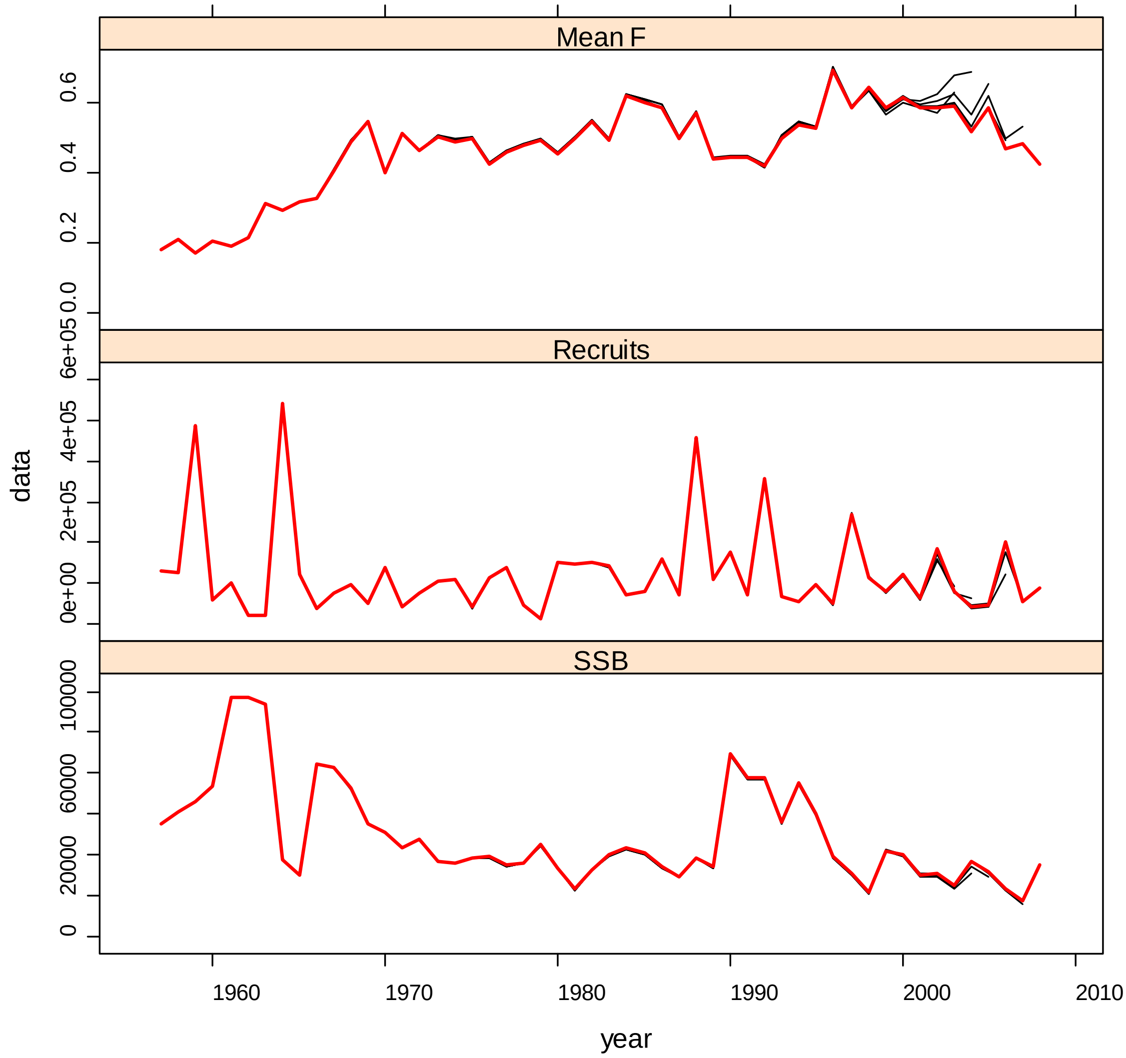

Figure 6.8.11. Sole in Subarea IV. XSA assessment. Retrospective analysis using 'new' commercial index (specialist sole boats) which was available from 2001. (ylab Recruits = numbers, ylab SSB = tonnes).

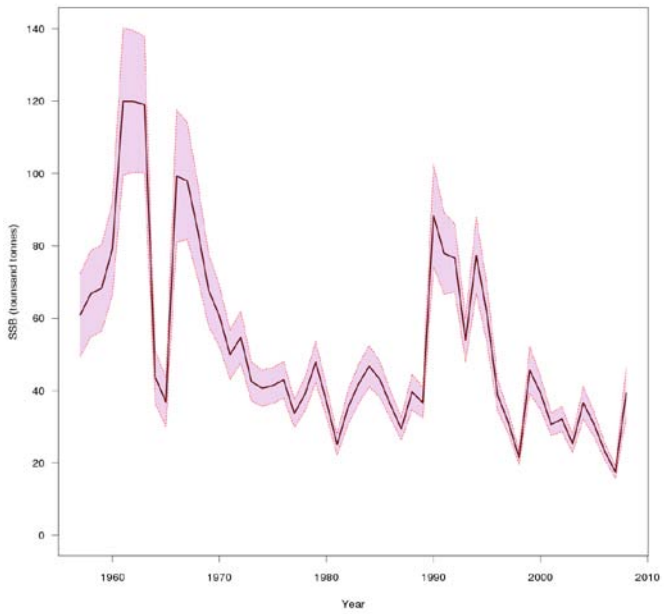

Figure 6.8.12. Sole in Subarea IV. SSB estimated using SAM assessment (tuned with BTS, SNS and NL Beam Corrected 1997–2008).

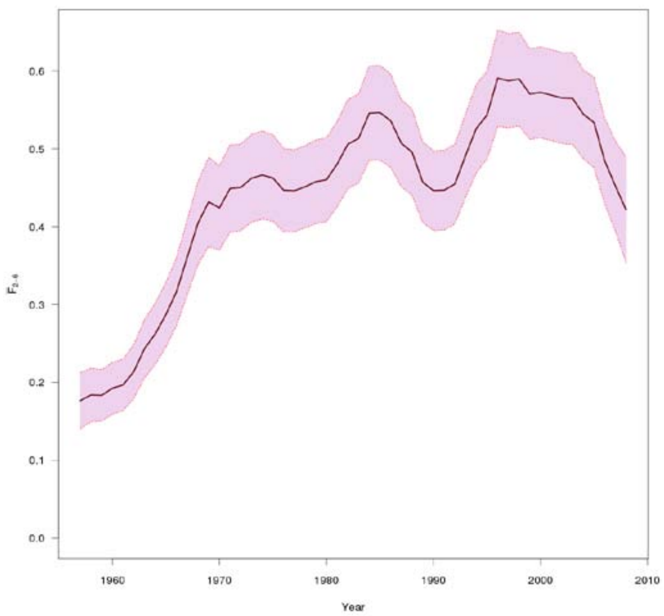

Figure 6.8.13. Sole in Subarea IV. Fbar estimated using SAM assessment (tuned with BTS, SNS and NL Beam Corrected 1997–2008).

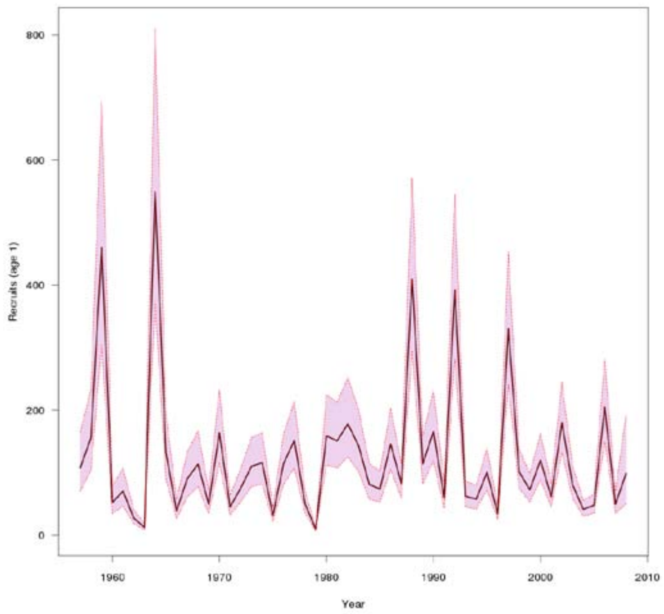

Figure 6.8.14. Sole in Subarea IV. Recruitment estimated using SAM assessment (tuned with BTS, SNS and NL Beam Corrected 1997–2008).

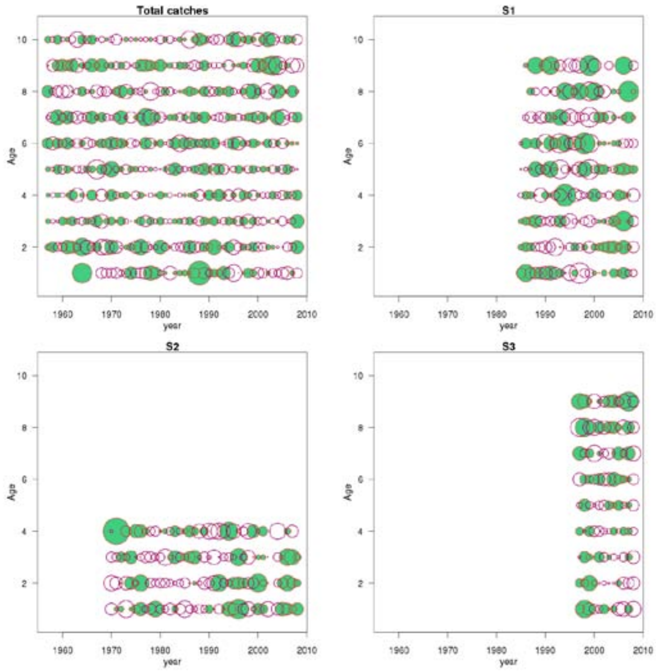

Figure 6.8.15. Sole in Subarea IV. SAM assessment. Residuals on catches and tuning indices (S1=BTS, S2=SNS, and S3 = NL corrected 1997–2008).

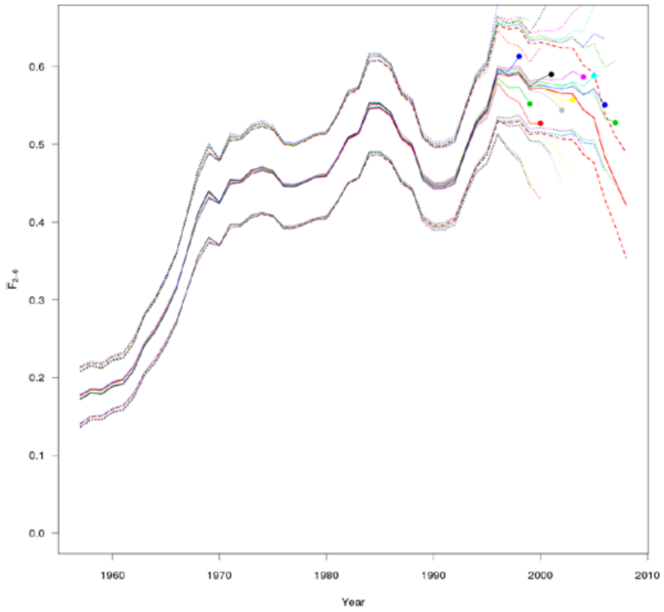

Figure 6.8.16. Sole in Subarea IV. SAM retrospective assessments (F_{bar}) tuned with BTS, SNS, and NL corrected 1997–2008.

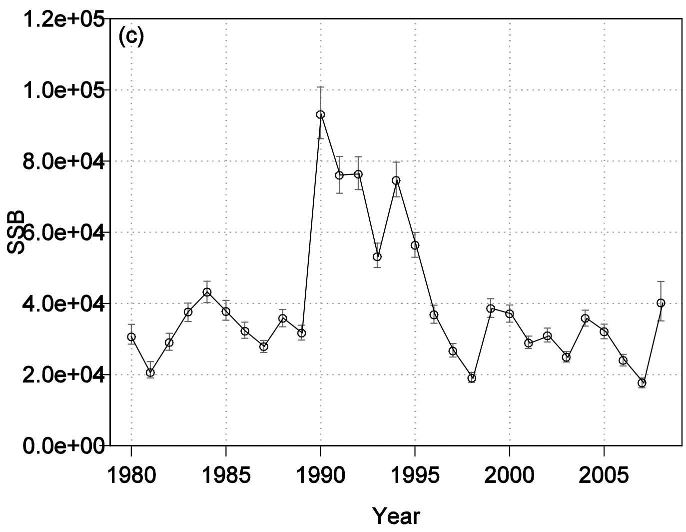

Figure 6.8.17. Sole in Subarea IV. ANP assessment SSB estimated using uncorrected commercial tuning index 1997–2008, BTS and SNS.

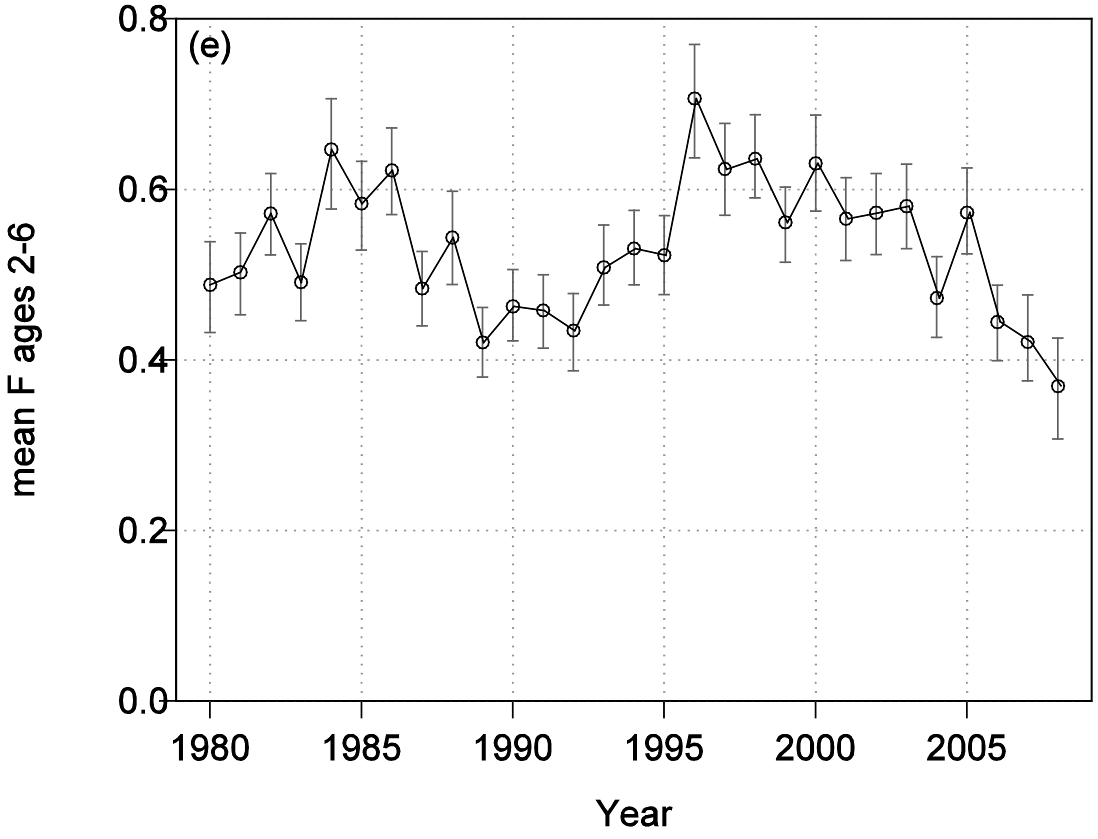

Figure 6.8.18. Sole in Subarea IV. ANP assessment Fbar estimated using uncorrected commercial tuning index 1997–2008, BTS and SNS.

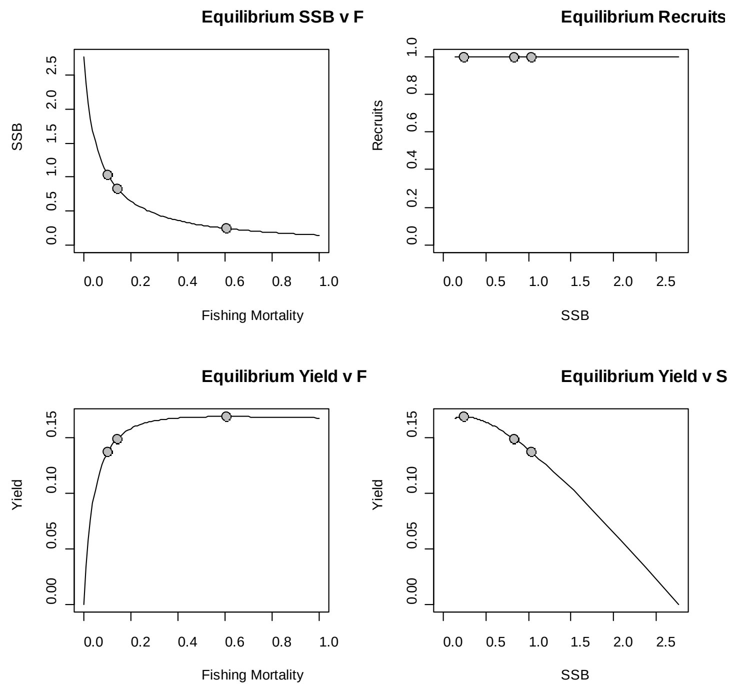

Figure 6.12.1. Sole in Subarea IV. Yield-per-recruit curve analysis results.

Stock Annex: North Sea sole

Stock specific documentation of standard assessment procedures used by ICES.

Stock	North Sea sole
Working Group	WGNSSK
Date	3 March 2010
By	Jan Jaap Poos

A. General

A.1 Stock definition

The North Sea sole is defined to be a single stock in ICES Area IV. The stock assessment is done accordingly, assuming sole in the North Sea is a closed stock.

A.2 Fishery

North Sea sole is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and southeastern North Sea. Directed fisheries are also carried out with seines, gillnets, and twin trawls, and by beam trawlers in the central North Sea. The minimum mesh sizes enforced in these fisheries (80 mm in the mixed beam trawl fishery) are chosen such that they correspond to the Minimum Landing Size for sole. Due to the minimum mesh size, large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea sole have generally decreased in number of vessels in the last ten years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000 HP (the maximum engine power allowed) and 300 HP (the maximum engine power for vessels that are allowed to fish within the 12 mile coastal zone and the plaice box).

In recent times the days-at-sea regulations, high oil prices, and different patterns in the history of changes in the TACs of plaice and sole have led to a transfer of effort from the northern to the southern North Sea. Here, sole and juvenile plaice tend to be more abundant leading to an increase in discarding of small plaice. A change in efficiency of the commercial Dutch beam trawl fleet has been described by Rijnsdorp *et al.* (2006). This change in efficiency is related to changes in targeting and the change in spatial distribution (Quirijns *et al.*, 2008; Poos *et al.*, 2010). An analysis of the changes in efficiency by the 2006 North Sea Demersal Assessment Working Group demonstrated that the increase in efficiency was especially pronounced between 1990 (the beginning of the time-series for which data were available) to 1996–1998, after which the efficiency seemed to decrease slightly. The data for which this could be analysed spanned 1990 to 2002, so the efficiency changes since 2002 could not be estimated.

Conservation schemes and technical conservation measures

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

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

Mesh size regulations for towed trawl gears require that vessels fishing North of 55°N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the sole fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100 mm is required.

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

A.3 Ecosystem aspects

Sole growth rates in relation to changes in environmental factors were analysed by Rijnsdorp *et al.* (2004). Based on market sampling data it was concluded that both length-at-age and condition factors of sole increased since the mid-1960s to a high point in the mid-1970s. Since the mid-1980s length-at-age and conditions have been intermediate between the troughs (1960) and peaks (mid-1970s). Growth rates of the juvenile age groups were negatively affected by intraspecific competition. Length of 0-group fish in autumn demonstrated a positive relationship with sea temperature in the second and third quarters, but for the older fish no temperature effect was detected. The overall pattern of the increase in growth and the later decline correlated with temporal patterns in eutrophication; in particular the discharge of dissolved phosphates from the Rhine. Trends in the stock indicators e.g. SSB and recruitment, did not coincide, however, with observed patterns in eutrophication.

In recent years no changes in the spatial distribution of juvenile and adult soles have been observed (Grift *et al.*, 2004; Verver *et al.*, 2001). The proportion of undersized sole (<24 cm) inside the Plaice Box did not change after its closure to large beamers and remained stable at a level of 60–70% (Grift *et al.*, 2004). The different length groups demonstrated different patterns in abundance. Sole of around 5 cm revealed a decrease in abundance from 2000 onwards, while groups of 10 and 15 cm were stable. The largest groups displayed a declining trend in abundance, which had already set in years before the closure.

Mollet *et al.* (2007) used the reaction norm approach to investigate the change in maturation in North Sea sole and demonstrated that age and size-at-first maturity significantly shifted to younger ages and smaller sizes. These changes occurred from 1980 onwards. Size at 50% probability of maturation at age 3 decreased from 29 to 25 cm.

B. Data

B.1 Commercial catch

Landings data by country and TACs are available since 1957. The Netherlands has the largest proportion of the landings, followed by Belgium. Discards data are only available from the Netherlands, where a discards sampling programme has been carried out on board 80 mm beam trawl vessels fishing for sole since 2000. The discards percentages observed in the Dutch discard sampling programme were much lower for sole (for 2002–2008, between 10–17% by weight) than for plaice. No significant trends in discard percentages have been observed since the start of the programme. Inclusion of a stable time-series of discards in the assessment will have minor effect on the relative trends in stock indicators (Kraak *et al.*, 2002; Van Keeken *et al.*, 2003). The main reason for not including discards in the assessment is that the discarding is relatively low in all periods for which observations are available. In addition, the time-series of sampling data is short and gaps in the discard sampling programmes render them incomplete.

Age and sex compositions and mean weight-at-age in the landings have been available for different countries for different years. In the more recent years, age compositions and mean weight-at-age in the landings have been available on a quarterly basis from Denmark, France, Germany (sexes combined) and The Netherlands (by sex). Age compositions on an annual basis were previously available from Belgium (by sex). Overall, the samples are thought to be representative of around 85% of the total landings. For the final assessment, the age compositions are combined separately by sex on a quarterly basis then raised to the annual international total. Alternatively, sex separated landings-at-age and weights-at-age can be calculated from the data. Since the mid-1990s, annual Sole catches have been dominated by single strong year classes (e.g. the 2005 year class).

B.2 Biological

Weight-at-age

Weights-at-age in the landings are measured weights from the various national market sampling programmes. Weights-at-age in the stock are the second quarter landings weights, as estimated by the Fishbase database computer program used for raising North Sea sole data. Over the entire time-series, weights were higher during the 1980s compared with time periods before and after. Estimates of weights for older ages fluctuate more because of smaller samples sizes due to decreasing numbers of older fish in the stock and landings.

Natural mortality

Natural mortality in the period 1957–2008 has been assumed constant over all ages at 0.1, except for 1963 where a value of 0.9 was used to take into account the effect of the severe winter (1962–1963; ICES-FWG 1979).

Maturity

The maturity-ogive is based on market samples of females from observations in the sixties and seventies. Mollet *et al*. (2007) described the shift of the age-at-maturity towards younger ages. A knife-edged maturity-ogive is used, assuming no maturation at ages 1 and 2, and full maturation at age 3.

B.3 Surveys

There are three trawl surveys that could potentially be used as tuning indices for the assessment of North Sea sole.

- The BTS-ISIS (Beam Trawl Survey);

- The SNS (Sole Net Survey);
- The UK Corystes survey.

The BTS-ISIS (Beam Trawl Survey) is carried out in the southern and southeastern North Sea in August and September using an 8 m beam trawl. The SNS (Sole Net Survey) is a coastal survey with a 6 m beam trawl carried out in the third quarter. In 2003 the SNS survey was carried out during the second quarter and data from this year were. The research vessel survey time-series have been revised by WGBEAM (ICES-WGBEAM, 2009). WKFLAT 2010 decided to use only the BTS-ISIS and the SNS surveys as tuning-series, because of lack of information on the raising procedure and spatial coverage of the UK Corystes series. In the assessment, the BTS-ISIS and SNS indices, calculated by WGBEAM, are used for tuning the stock assessment.

B.4 Commercial lpue

There is one commercial fleet available that can be used as a tuning-series for the stock assessment, being the Dutch beam trawl fleet. This fleet takes more than 70% of the landings, and is relatively homogeneous in terms of size and engine power. The data from this commercial fleet can be estimated using two different methods. The first method uses the total landings, and creates the age distribution for these landings by segregating the total landings into market categories, with age distributions being known within market categories through market sampling. Effort for the Dutch commercial beam trawl fleet is expressed as total HP effort days. Effort nearly doubled between 1978 and 1994 and has declined since 1996. Effort during 2008 was <40% of the maximum (1994) in the series. A decline of ca. 25% was recorded in 2008 following the decommissioning that took place during 2008.

Alternatively, the data for the Dutch beam trawl fleet can be raised as described by (WGNSSK 2008, WD1). This allows reviewing the lpue trends in different areas of the North Sea. The data are based on various sources (WGNSSK 2008, WD1). There is a clear separation in lpue between areas, with the southern area producing a substantially higher lpue than the northern area. Average lpue of a standardized NL beam trawler (1471 kW) over the period 1999 to 2007 was 266 kg day$_{-1}$, and the data have a significant (P<0.01) temporal trend of -6.1 kg day^{-1} year^{-1}.

The stock assessment uses the tuning index resulting from using the first method to calculate the commercial index. Owing to the strong changes in catchability in the in the first part of the time-series, only the data from 1997 onwards is to be used in the assessment.

C. Historical stock development

WKFLAT 2010 decided that XSA should be used for providing advice, while also using the SAM models concurrently. There are currently three methods that could be used to provide an assessment of North Sea sole, being XSA, the ANP model (Aarts and Poos, 2009), and the SAM model (WKROUND 2009, WD14). The XSA assumes the catch-at-age matrix is complete and without error. The Aarts and Poos method is a variety of statistical catch-at-age model that uses splines to estimate the selectivity patterns in the surveys and for the catch-at-age matrix. WKFLAT tested an adaptation of the original ANP model, where the discards estimation procedures were not incorporated. The SAM model is a state-space assessment model, similar to TSA. The advantage of using ANP and SAM would be that they take into account (and demonstrate) the uncertainty of the assessment inputs and outputs. The disadvantage of using ANP is that it can only assess the stock status for those years where survey data are available. Once a new benchmark group decides that there is no problem with the operational aspects of using SAM for North Sea sole, we recommend replacing the use of XSA with SAM.

Model used as a basis for advice

The North Sea sole Advice is based on the XSA stock assessment. Settings for the final assessment are given below:

SETTING/DATA	VALUES/SOURCE	
Catch-at-age	Landings (since 1957, ages 1–10).	
Tuning indices	BTS Isis 1985 assessment year 1–9 SNS 1982 assessment year 1 4 NL-beam trawl index 1997-assessment year 2–9	
Plus group		10
First tuning year		1982
Time-series weights	No taper	
Catchability dependent on stock size for age <		2
Catchability independent of ages for ages >=		7
Survivor estimates shrunk towards the mean F	5 ages/5 years	
s.e. of the mean for shrinkage		2.0
Minimum standard error for population estimates		0.3
Prior weighting	Not applied	

The SAM model

SETTING/DATA	VALUES/SOURCE	
Catch at-age	Landings (since 1957, ages 1–10)	
Tuning indices	BTS Isis 1985 assessment year 1–9 SNS 1982 assessment year 1 4 NL-beam trawl index 1997-assessment year 2–9	
Plus group		10
First tuning survey year		1982
Catchability independent of ages for ages >=		7
Prior weighting	Not applied	

D. Short-term projection

Because the assessment on which the Advice is based is currently a fully deterministic XSA, the short-term projection can be done in FLR using FLSTF. Weight-at-age in the stock and weight-at-age in the catch are taken to be the mean of the last three years. The exploitation pattern is taken to be the mean value of the last three years, scaled to the last years F. Population numbers-at-ages 2 and older are XSA survivor estimates, unless there is consistent indication from the most recent recruitment surveys of a stronger or weaker year class. Numbers at age 1 and recruitment (age 0) are taken from the long-term geometric mean.

Management options are given for three different assumptions on the F values in the "intermediate" year; (A) F in the "intermediate" year is assumed to be equal to the average estimate for F of the last three assessment years scaled to the last years F; (B)

F_{2009} is 0.9 times the average estimate for F of the last three assessment years scaled to the last years F; and (C) F in the "intermediate" year is set such that the landings in the intermediate year equal the TAC of that year. ACOM in 2009 has decided to use option (A).

E. Medium-term projections

Generally, no medium-term projections are done for this stock.

F. Long-term projections

Generally, no long- term projections are done for this stock.

G. Biological reference points

The current reference points were established by the WGNSSK in 1998. The current reference points are $\mathbf{B_{lim}}$= $\mathbf{B_{loss}}$= 25 000 t and $\mathbf{B_{pa}}$ is set at 35 000 t using the default multiplier of 1.4. $\mathbf{F_{pa}}$ was proposed to be set at 0.4 which is the fifth percentile of $\mathbf{F_{loss}}$ and gave a 50% probability that SSB is around $\mathbf{B_{pa}}$ in the medium term. Equilibrium analysis suggests that F of 0.4 is consistent with an SSB of around 35 000 t. Given that the assessment results in terms of historical biomass estimates did not change substantially following the updates in assessment methodology in WKFLAT 2010, the estimates of these reference points are still valid.

	TYPE	VALUE	TECHNICAL BASIS
Precautionary approach	B_{lim}	25 000 t	B_{loss}
	B_{pa}	35 000 t	B_{pa} 1.4 * B_{lim}
	F_{lim}	Not defined	
	F_{pa}	0.40	F_{pa} = 0.4 implies B_{eq} > B_{pa} and P(SSB_{MT} < B_{pa}) < 10%.
Targets	F_{mgt}	0.2	EU management plan

(unchanged since 1998, target added in 2008).

H. Other issues

None identified.

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Annex 2: List of Recommendations from the WKFLAT 2010 plenary discussions

- General recommendations:
  - Procedural
  - General data/assessment issues relevant to all stocks
  - Other recommendations for ICES
- Species specific recommendation in terms of:
  - Data
  - Assessment
  - Reference Points
  - Other relevant issues unique to the stock

GENERAL RECOMMENDATIONS	TO WHOM
Clarification of expected outputs from the Benchmark Working Groups Despite the best efforts of the attending researchers, WKFLAT still encountered a number of difficulties in addressing its terms of reference. This was in part from a lack of additional work to address the terms of reference prior to the meeting, but in some cases it is not possible to avoid as issues arising during the meeting can not be adequately addressed due to the time available. This can result in it not being possible to recommend a candidate assessment method without further research/analysis into the issues identified. Should recommendations be made with a proviso that further work be done?	ACOM?
Further examination of stock identity issues for Plaice in Areas VII and IV WKFLAT recommends that ICES set up a study group similar to SGHERWAY to explore the potential for performing a combined assessment of plaice in the North Sea and English Channel, and apportioning quota between them. Such a SG could also explore the possibility of modelling/assessing the three different “subpopulations” and trying to estimate migration factors between the areas, using tagging studies to ground-truth these results. (see stand-alone section on the plaice mixing issue).	
Structure of Benchmark Report Duplication of sections was noted as a potential issue. There was some misunderstanding among members of the Benchmark Working Group as to exactly what was required in each section of the Report and the Stock Annex. WKFLAT recommends that the structure of benchmark reports be formalized as far as possible; i.e. what needs to be presented, what goes where, what level of detail is required in each section, inclusion of tables and figures, background material, etc.	ICES Secretariat Future benchmarks
Formal list of working documents A lot of the information considered in the Benchmark is laid out in working documents. Does this then need to be incorporated within the Report or can a formal list of working documents be produced then referred to in the Report? This is dependant on future availability and accessibility of these working documents from ICES (there is some concern that these documents may be lost over time).	
STOCK SPECIFIC RECOMMENDATIONS	
Plaice VIId (Eastern Channel)	
Discards Thought to be important for this species, but short time-series of data (four years of data) make it difficult to incorporate in the assessment (as well as raising problems?). Need time to explore further possibility of using Aarts and Poos model to reconstruct historical discard	

estimates based of current sampled data.	
Influence of missing UK Young Fish Survey indices The UK component of the YFS index is not available for 2007 onwards, resulting in the unavailability of the combined YFS-index. This combined index has been estimating the incoming year-class strength very consistently, thereby providing reliable estimates to the forecasts. Using the YFS-France index separately for the recent period is questionable (too short, lack of spatial coverage confidently pick up trends in recruits i.e. need north and south surveys). WKFLAT recommends (1) that the UK survey should continue and (2) that the most recent years of the French YFS should not be included in the assessment.	WGNSSK, Cefas, Ifremer
Use of current models to provide management advice WKFLAT 2010 recommends the use of a model taking account migration patterns with adjacent plaice stocks. The proposed final XSA-based model is useful in determining recent trends in F and SSB, and in providing a short-term forecast and advice on relative changes in F. However, WKFLAT does not recommend this as an analytical assessment, as it will not be useful for calculation of reference points.	
Biological reference points	
WKFLAT does not recommend that the current assessment be used as the basis for calculation of reference points.	
Other: Until the further work on including the discard estimates, and sensitivity of the assessment to the 65% adjustment to the Q1 catch-at-age has been examined, an analytical assessment cannot be defined. Further review of this work should be conducted, but an analytical assessment will not be available in time for the next assessment of this stock.	
Plaice VIIe (Western Channel)	
Data? The catch data needed for the migration model proposed by WKFLAT reassigns 15% of the first quarter Belgian, French and UK catch-at-age in VIId to the VIIe catch-at-age matrix used previously, to account for spawning migrations of VIIe fish into VIId.	
Use of current models to provide management advice	
WKFLAT 2010 concluded that the “migration” model provides the most robust assessment and that this model should form the basis of future ICES advice. However, WKFLAT acknowledges that such a change to the Advice implies more complicated management actions, and further work for the assessment in IVbc with regards to the changes adopted for the VIId in order to remain consistent with the approach for VIIe (removal of quarter one catches attributable for the stocks resident in VIIe and IVbc). Should it not be possible to effect appropriate management for the three individual stocks (VIIe, VIId and IVbc) using the Advice provided by the migration models, advice should be provided for VIIe on the basis of the “truncated model”.	
Biological reference points. Based on results of the migration model proposed, WKFLAT recommended using 2200 t as a $B_{trigger}$ in the new Advisory Framework based on MSY based management targets, provided that the management intervention at this level of SSB was sufficient to move the stock away from this level of SSB with considerable certainty. This is in contrast to the precautionary approach that would aim to maintain the stock above B_{pa}, but not necessarily intervene further beyond that. In any case it is deemed unlikely that low levels of SSB near $B_{trigger}$ would be reached if long-term management aimed to attain F levels near an appropriate proxy of F_{msy}. No appropriate proxy was developed for F_{msy} given the current uncertainty over the basis for such advice, however WKFLAT 2010 commented that because plaice are taken largely in conjunction with sole in Area VIIe it is important that the target levels between the stock are consistent especially because a management plan has been agreed for sole VIIe.	

If the "truncation model" is accepted to provide advice, reference points should be revisited.	
Sole IIIa (Kattegat-Skagerrak)	
Problems with age–length key (ALK). Small sampling size results in what is considered to be an unreliable disaggregation of ages in data. WKFLAT noted that improvements are possible, but did not make any specific recommendations.	
Incorporation of landings from the Belts area WKFLAT recommended that catches from the Belts be included within the management area of Sole IIIa. Inclusion is mainly for fishery reasons, as there is scarce biological information restock structure.	
Use of private logbook data No longer available for gillnets (last year 2007). Original justification for use of these sources (i.e. lack of confidence in official logbook data during the low TAC period from 2002–2004) no longer necessarily holds. Therefore WKFLAT recommends to keep these in the assessment for historical period (up to 2007 and 2008 for gillnets and trawlers, respectively) but these series will not be updated going forward.	
Surveys Replace KASU survey (not targeting sole, more for cod and plaice) with Fisherman's survey (specifically designed as a fisheries independent survey for sole in the region).	
Use of current models to provide management advice Scarce sampling and poor age estimation means there is a lack of confidence in the catch-at-age matrix. WKFLAT therefore recommends a change to the SAM model, while continuing with XSA for comparison purposes.	
Biological reference points. A potential candidate for F_{msy} equals 0.3, because yield above this level only increases insignificantly and the associated risk of exceeding the defined $B_{trigger}$ is less than 5%. A potential $B_{trigger}$ is 2000 t, which is lowest observed SSB apart from the first two observations in the time-series. Stock production dynamics below this SSB are therefore considered uncertain. WKFLAT considered the scenarios and concluded that WGBFAS 2010 should make a final evaluation of this based on guidelines adopted by WKFRAME in March 2010.	WGBFAS,WKFRAME
Sole IV (North Sea)	
Tuning indices Keep current, but truncate commercial beam trawl survey to start at 1997 due to suspected more notable changes in the catchability within this survey prior to 1997. While fisheries-independent surveys do not cover the full extend of the stock (i.e. southwest corner near channel not covered), there is not enough confidence in alternative surveys of this area (Belgian and UK) and it is thought that the inclusion of these surveys will only add noise to the assessment. The commercial tuning-series is thought to capture the trends in this are and of the older ages adequately. It is recommended that WGBEAM evaluates the Belgian and UK (Carystes) surveys in terms of their potential use in assessing the Sole IV stock. Also examine possibility of extending BTS survey for sole to cover this area or explain why this area is not currently included.	WGBEAM
Use of current models to provide management advice Keep current model with shortened cpue index. It is also recommended that the SAM model be run for exploration purposes.	
Biological reference points	
Given that the assessment results in terms of historical biomass estimates did not change substantially following the updates in assessment methodology in WKFLAT2010, the existing reference points are still valid. WKFLAT did not consider any reference points based on MSY calculations for this stock.	

General points and questions raised during Workshop discussions

These are issues that are not direct recommendations that have arisen, but may highlight points to be considered in future.

Benchmark TORs

This Benchmark has seen a step forward in the preparation of work going into the benchmark meeting (i.e. previous recommendations taken on board). But extra demand arises on top of expected issues, so will always be busy and hence TOR could be ambitious.

Ecosystem/environment/mixed fisheries TOR are too vague. The meeting is dominated by stock assessment scientists, often not even involved in preparation/raising of data so obviously the focus of the work lies on the assessment methods and analysis.

Either the attendance of ecologists/data specialists is required or, rather, for more specific recommendations are needed from other ICES groups as to what could be considered for inclusion within the assessments.

i.e. benchmark process should be taking on board recommendations from many ICES groups, not only the working group dealing with the assessment of the stock.

The work load is high and a clear list of specific tasks should be examined, rather than trying to innovate and do all the work at the same time. E.g. the establishment of reference points (and what ref pts to consider) should be clear going in so that these can be calculated from the outputs of the new assessment rather than the group having to reconsider exactly what the ref pts should be and how they are defined.

Consideration should also be made for what are the desired outcomes of the assessment are? Is it purely managerial or are outcomes for biological/ecological studies required too? E.g. separate sex assessments may not provide a better assessment for management purposes, but could provide useful information for further studies.

Biological reference points

The timing of WKFRAME was not ideal for provision pof MSY-based reference points by WKFLAT.

In general there was a problem with a lack of direction for new MSY ref points, particularly a large degree of uncertainty over $B_{trigger}$. The lower bound of B_{msy} is scientifically tricky to define given that F_{msy} is an equilibrium value.

Stocks considered at benchmark working groups

There is a need for synchronization of stocks considered at each benchmark meeting (i.e. fisheries/biologically/geographically related stocks). These stocks may have joint issues that are best examined with experts from all stocks. However, obviously there are practical issues and work load issues for combining all experts (e.g. one may be the expert for two of the stocks...)

Assignment of stocks among working groups

Recognizing the practical limitations, WKFLAT recommended that assessments of Plaice VIId and e be done in the same group as plaice in IV (i.e. WGNSSK), because of stock identity issues.

Evaluation of candidate assessment methods

There was some indication that a full suite of diagnostics of candidate stock assessment methods could not be adequately considered, and is ome cases were only given brief examinations. Decisions can often be outcome-based rather than examining the true best model and input data. There are no specific recommendations of what to check, as this expected to be within the expertise of those present in the WG.

Assessment methods

How important is the availability of expertise to perform the assessment in making a decision on choosing a benchmark procedure (e.g. SAM issue). Is lack assessor's ability/familiarity with the model a valid reason to exclude its use?

ICES to examine procedures for standardization of cpue data for use as tuning indices in assessment

Despite frequent use of commercial tuning indices in ICES stock assessments, there is currently variation between stocks in how this is dealt with. Should ICES provide a toolbox of recommended methods?

Is this already looked at within WGBEAM/PGCCD... ?

Formalise measurement of retrospective problems A common issue from assessments is the existence of a retrospective pattern. The reasons for this could vary from stock to stock, but methods for calculating/measuring the extent of the retrospective pattern and recommendations on the time frame to consider could be standardized (e.g. Mohn's rho). Also methods to display it. Lack of info/recommendations for identifying severity of retrospective error and displaying it. E.g. Mohn's rho, by age, year class?	WGMG
WKACCU sheets Provided, but perhaps not targeted to this group; more important from the collection side. Various issues with completing the forms, mainly due to a lack of intimate knowledge of the data provided for use in the assessments.	WKACCU

Annex 3: External's Comments on WKFLAT 2010

My background

In order to put my following comments in context, it is important to know my professional background. I am a Canadian academic who teaches fish biology, population, and quantitative ecology at the undergraduate level and quantitative analysis at the graduate level. My research programme is centred on the incorporation of quantitative behavioural principles to the analysis and interpretation of data from commercial fisheries. I have published articles on topics including the bias in cpue series that can be created by vessel movement (Gillis, 2003), highgrading behaviour (Gillis *et al*., 1995), and the identification of targeting behaviour within the catch records of a fleet or fleet component (Gillis *et al*., 2008). I often work with assessment biologists in my research and I have prepared many fisheries lectures for my courses. However, I have never performed a stock assessment using XSA, SCA, or any related methods. Thus, my background could be summarized as general population and quantitative ecology with a specialization in studying the impact of fishing behaviour on trends in catch and effort data.

Background material and workshop preparation

The initial presentation of the Benchmark made its role within the assessment and advisory process clear, but I was less certain of the process and my role in it before I arrived at ICES. Future external reviewers would benefit from more detail in this area prior to arrival. An ICES glossary of terms and abbreviations (ACOM, Benchmark, Stock Annex, WG and WK prefixes, etc.) would also be helpful if distributed in advance. For me, the biological and methodological background was more important than the contents of the previous Stock Annex in following and contributing to discussions regarding the choice of methods for future stock assessments.

Many of the technical issues related to XSA and the local biology of the populations under examination were outside my direct experience. I found the preliminary 'virtual' meetings critical to directing my preparation and contributing to the benchmark process. In addition, the background materials made available through the SharePoint site were indispensible. However, some important background material was only identified after the meeting began. This is inevitable in dynamic meetings like this one, but can be built upon. Background SharePoint folders with biological references (life history, migration studies, etc.) should be maintained between Benchmarks to avoid duplication of effort in future. The background SharePoint folders could contain a general methodological section. The methodological section would contain folders for references on the specific methods being considered, in this case XSA (ICES, 2006; 2007), SAM (ICES, 2010), and SCA model with discard estimates (Aarts and Poos, 2009). Specific biology folders within each stock folder would help bring outsiders up to speed with local species issues through internal reports and publications (this was done for one stock at the beginning of the Workshop and was very helpful).

I found myself referring to several reports from the Working Group on Methods of Fish Stock Assessments (ICES, 2006; ICES, 2007; ICES, 2010) in order to follow the development of quantitative methods within ICES, particularly regarding the current use and evaluation of XSA. Links to the full WGMG series within the SharePoint site would help external reviewers see the context in which current practices have developed.

Model comparison and selection

This is the key function of the Benchmark Workshop, according to my understanding of the current ICES assessment process. One of the reoccurring concerns was that any decisions made at the Benchmark Workshop would be "locked in" for 3–5 years even if compelling evidence of revision became apparent in the immediate future. Also, the upcoming change in ICES reference points to an MSY framework from a PA framework generated considerable discussion around the impact of different models on references and triggers under the new regime. Though apparently discordant to an outsider, I believe that these discussions are a necessary part of a policy shift and reflect the consideration and commitment of the biologists involved rather than a resistance to change.

The decisions made at this Benchmark Workshop occurred at several levels: the choice of the general structural and statistical forms of assessment models, and the choice of parameters or their limits, and the choice of the appropriate data to represent the processes being considered. In plenary, the discussion of sole assessments spent much time comparing the new, recommended (ICES, 2010) state space model (SAM) in place of the traditional XSA assessment. There were two main areas of concern in its adoption: 1) expertise within working groups that would perform annual assessments and 2) its unknown performance relative to XSA *in situ* rather than in simulation studies or with sample datasets. The prudent approach of continuing XSA and SAM in parallel until the next benchmark was favoured for sole stocks. The adoption of SAM as the primary assessment tool was contingent upon expertise within the stock assessment working groups that would be applying the technique. The plaice assessments favoured remaining with XSA over other methods until expertise, experience, and supporting data improved.

My time out of plenary was spent with the plaice assessment groups where the conceptual model of stock biology was the most critical issue. The impact of movement among plaice management areas on current and potential future assessments occupied much of the discussion. The Group was well aware of the risk of common exploitation levels on "stocks" consisting of several distinct reproductive components (Paulik *et al.*, 1967; Hilborn and Walters, 1992) as well as recent work on management implications for plaice in the English Channel (Kell *et al.*, 2004). Their final recommendations reflect careful consideration of these factors and their impact on the assessment methods employed.

In the examination of XSA diagnostics there was discussion of the utility of summary indices in the examination of diagnostics, in particular Mohn's ρ (Mohn, 1999; ICES, 2006). Ultimately, decisions were made based upon visual inspection of the retrospective patterns and residuals. However, the discussions left me with the impression that benefits in clarity and communication could be gained by presenting summaries of different assessment options with indices reflecting the criteria being applied. This should not replace examination of the original retrospective or residual patterns but supplement it in the same manner that a trendline supplements a scatterplot.

Improving model performance through parameter and data selection

I observed two different but concurrent approaches to improving the performance of the XSA: selection of parameters such as "shrinkage" and selection or modification of the tuning dataseries that supplemented the catch-at-age matrix in the analyses. There is little I can say about the choice of shrinkage estimates; this value reflected the confidence of the stock experts in the patterns and time-series reconstructions. However, the selection of tuning-series is close to my personal research interests in the behavioural impacts on the analysis of commercial fisheries data. I enjoyed the discussions of sources of bias in the commercial tuning-series, and comparisons among different datasubsets in commercial fleets (such as private and public log-books, on and off season in IIIa sole). The potential for hyperstability (Hilborn and Walters, 1992) will be higher in fleets that are able to successfully target the species of interest. This could generate uninformative tuning-series during early declines in abundance or even during times of extremely high abundance. Members of the Working Group were clearly aware of this issue. It would be interesting to see such behavioural considerations developed into guidelines for examining potential tuning-series. This should probably be performed outside the constraints of a benchmark meeting, possibly as an agenda item for a future methods working group.

Discarding: behavioural impacts on the catch-at-age matrix

The issue of discarding played a role in the development of benchmark stock annexes for both plaice and sole. Much of this work focused on the biases in the catch-at-age matrix, potentially represented statistically by the Aarts and Poos (2009) catch-at-age model. The initial impact of discards on tuning-series was a particular problem for IVd plaice. Strong year classes appeared to result in differences between commercial and index series as a result of young fish that were either not fully appearing in the commercial fishery, most likely due to discarding. However, it was also pointed out that among the southern stocks plaice is primarily a bycatch species and that sole is the more common target species. Following the same logic as age based discarding, it seems that fluctuations in sole abundance could also result in discards of plaice through highgrading (Gillis *et al*., 1995). This could appear as interannual differences in the discard selectivity curve fitted by the Aarts and Poos (2009) catch-at-age model. Under this scenario variation in sole catch could also be used as a qualitative consideration in selecting plaice trips or vessels for use in a tuning-series. This is not an ecological multispecies approach, but rather a technological one resulting from the interaction of gear deployment and catch composition. Guidelines for the consideration of such technological multispecies interactions could be as important as ecological ones in interpreting catch and effort data for stock assessment.

Closing remarks

I have greatly enjoyed the opportunity to learn and contribute through the ICES benchmark process. I can see that the importance of fleet dynamics is recognized within ICES and that the datasets being assembled across national fleets will allow these factors to be investigated more fully in future. Though perhaps premature for inclusion in a stock annex at this time, I believe that ICES will ultimately be able to explicitly incorporate vessel behaviour into their assessments by continuing their methodological development, integration of national datasets, and linkages to the fishing industry. I look forward to following the evolution of assessment methodology in the coming years.

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