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Report of the Benchmark and Data Compilation Workshop for Flatfish (WKFLAT 2009)

6–13 February 2009

Copenhagen, Denmark

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 Executive Summary

WKFLAT 2009 is the second benchmark workshop held under new ACOM procedures for assessment review. The meeting was held at ICES HQ, Copenhagen, Denmark from 6–13 February 2009. The meeting was chaired by Tony Smith (Australia) and the ICES Coordinator was Jan Jaap Poos (Netherlands). Mauricio Ortiz (USA) and Jim Ianelli (USA) participated in the meeting as invited external experts. There were 16 participants in the meeting representing seven nations. The main objective for the meeting was to review data inputs and assessment methods for several flatfish stocks in the North Sea and English Channel (IV plaice, VIId sole, VIIe sole) and to update Stock Annexes for these stocks (the recipes for conducting assessments to be applied by working groups over the next three to five years). The meeting started with a data workshop, to which stakeholders were invited to bring new data for consideration for use in assessments. Four stakeholders attended the meeting-two from the Netherlands, one from the UK and one from Belgium. The meeting agreed on a set of priority issues for each stock (related to data quality, data analysis, and assessment methods). A subgroup was set up for each stock to address stock-specific issues, with a daily plenary to report on and review progress, and to discuss generic issues. The full report of the meeting includes a set of generic issues identified during the workshop and associated recommendations, followed by detailed stock-specific reports and recommendations. A key output of the Workshop was an updated Stock Annex for each stock.

The workshop faced some problems in fully addressing its terms of reference. These arose from too short notice and inadequate allocation of resources ahead of the meeting to fully prepare material (data, key issues, additional analyses) for review at the meeting. In particular there was very limited ability for the meeting to review primary data inputs to assessments. Nevertheless progress was made on several important issues for each stock:

Western Channel sole

a) Preliminary analysis of the stock data using a statistical catch-at-age model failed to eliminate the retrospective pattern in *F* and *B* observed in recent assessments that used the XSA modelling approach. This could indicate conflicts in the data or that remaining assumptions common in both model approaches (e.g. constant natural mortality) are the cause.

b) Further study will be required to determine the cause of the retrospective bias, but in the mean time the workshop agreed that the current assessment approach provides an unreliable basis for short-term stock projections for management advice. The statistical approach may provide a more flexible way to evaluate data and model uncertainties and was encouraged.

Eastern Channel sole

a) An improved method for horsepower correction for the commercial Belgian beam trawl fleet was developed and applied during the workshop.

b) The recent loss of the UK component of the Young Fish Survey is of major concern for the assessment. Analyses conducted at the workshop demonstrated that the French component of the survey can continue to be used in the assessment, though this will result in much more variable estimates of recent recruitment resulting in more noise (though no detectable bias) in short-term stock forecasts.

North Sea plaice

a) The workshop explored several methods to combine the three survey tuning series currently available that cover different parts of the North Sea. Adoption of a combined index should be checked by WGBEAM.

b) The workshop evaluated the appropriateness of the use of commercial lpue series in the assessment. Advantages include wider spatial and temporal coverage and a better measure of larger fish. However, concerns remain about changes in fleet efficiency and unrecorded discarding. Monitoring proposals by the Dutch industry could help overcome these concerns.

c) The workshop appreciated the recent assessment of the stock that used a statistical catch-at-age model. Although the stock will continue for the moment to be assessed using XSA, the workshop endorsed parallel development of the statistical catch-at-age model so that it may be more fully evaluated and accepted if desired.

Of the more general issues identified and discussed at the meeting, the key recommendations include:

1) That ICES databases should include all data needed for assessments.

2) That general linear models and related methods be used to improve the standardization of LPUE series used in assessments.

3) That statistical catch-at-age models continue to be developed and applied to assess flatfish species.

4) That biological reference points be based on the latest assessment models and data where information and/or accepted model results indicate a significant change.

2 Introduction

The requirements for benchmark workshops were detailed by ACOM in 2008 (ACOM December 2008 22/12/2008 FINAL document). This Flatfish Workshop is the second such Benchmark Workshop (the first was for Roundfish in January 2009). The Terms of Reference are at Annex 1. The key aspects of the Terms of Reference are:

(i) to compile and evaluate data sources for stock assessments,

(ii) to solicit relevant data from industry and other stakeholders,

(iii) to review current methods used to assess stock status and outlook, and

(iv) to update the relevant Stock Annexes to include what benchmark participants identify as current best practice assessment inputs and methods, providing sufficient detail to ensure that assessment scientists can readily replicate assessments without the need to have been previously involved in such assessments.

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 for the week. The next six days then focused on resolving the assessment issues to the extent possible, with a view to revising the Stock Annexes for adoption for the following 3–5 years.

The workshop was chaired by Tony Smith (Australia) with ICES Coordinator Jan Jaap Poos (Netherlands). Mauricio Ortiz (USA) and Jim Ianelli (USA) were invited 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.

3 Sole in Division VIIe (Western Channel)

3.1 Current stock status and assessment issues

Sole in division VIIe has been deemed to be in poor condition as a result of fishing mortalities above Flim and a consummate decline of SSB to levels below Bpa in recent years. In 2007 a recovery plan was implemented by the commission to relying on stepped F reductions to a long-term management target of F=0.27 in an attempt to rebuild SSB to levels above Bpa. The plan called for fishing mortalities in 2007-2009 to be limited to 80% of those experienced by the stock in the period 2003-2005, furthermore the effect of these reductions is to be limited to a maximum annual TAC decrease of 15%. Following this the recovery plan is set to change to a management plan in 2010 with fishing mortalities reduced to 85% of those experienced in the years 2007–2009.

The evaluation of the status of the stock is based on an XSA assessment using four commercial tuning series (two historical, 1979–1987, two current 1988–2007) and a spatially limited beam trawl survey carried out on a chartered vessel by CEFAS (UK-BTS). Shrinkage is set to medium levels (1.0), but has virtually no weighting for ages greater than two. Weighting for ages two and greater is largely determined initially by the surveys with the commercial fleets increasingly taking overestimation of the abundance of older ages.

Recent assessments have indicated an increase in F in the recent period as well as downward revisions of F's over the period 2003–2005. The combined effects of this on the management plan calculations have been to call for a decrease in the TAC of 15% annually, rather than the planned stepped reductions. Consequently the anticipated stability of catches for the fleet has not materialized, despite recent decommissioning in the UK beam trawl fleet.

In the past misreporting to area VIId, underreporting and overshoots of the TAC have plagued this fishery. The assessment has accounted for the area misreporting and the overshoot of the TAC, but not the underreporting although this is thought to have declined to very low levels since 2003. In 2008 the UK established single area licences for the UK beam trawl fleet so that area misreporting is no longer possible. In addition the fleet has applied for marine stewardship council certification in 2007 to be taken forwards to a complete assessment in 2009. A number of modifications to gear of this multispecies fishery have been made to minimize the impact of the fleet on non-target species of fish and benthos in preparation for certification. However given the new single area licence, and the restrictive sole TAC set for 2009 discarding is anticipated in 2009. Up to now this has not been a problem for this fishery, and all efforts will be made to monitor the situation to ensure that this change does not bias the data for future assessments.

WGSSDS has in the past indicated that the stock is not in imminent danger of collapse despite the apparent relationship of the most recent estimates of SBB with the precautionary reference points. The conclusion was based on the relatively low F's compared with other sole stocks and the extended age structure of the catches with a sizeable proportion of the fish 12 years and older regularly extending to older than 30 years. In addition there was no indication of a decline in recruitment with decreasing stock size. This has been underlined by revisions of the 2003 SSB estimated by the 2004 WG to have been below Blim, estimated to have been above Bpa by the 2008 WG, suggesting that a recovery plan at that time was unnecessary.

In summary the biggest problem for this assessment and the management of the stock is the worsening retrospective pattern observed in conjunction with a management plan relying on annually changing target reference points in relation to persistent overestimates in F in the most recent years.

WKFLAT will aim to examine the reasons for the retrospective patterns in F and attempt to develop a more consistent assessment methodology for the stock, recalculate the management target reference points, and re-evaluate the precautionary reference points.

3.2 Compilation of available data

3.2.1 Catch and landings data

UK (>60%) and France (>30%) together provide almost all the catches for this stock. UK Landings data are based on EU logbook data for 7e catches. In 2002 the UK industry indicated that there had been substantial misreporting of landings to two rectangles in area VIId. It was possible to identify the misreported landings spatially and by reported lpue. Having identified misreported landings, data were corrected back to 1985 by the 2002 WG. This method of correction is ongoing. French official landings statistics have been poor since 1997, but since 1997 landings data have been calculated much more accurately using buyer and sellers notes. France has provided corrected landings information to the working group since 2002.

Numbers-at-age prior to 1994 are calculated by raising the UK age composition to UK and Channel Island Catches, adding the French age composition data, and finally raising the resulting age composition to the total international landings. From 1995WG to 2005WG the International landings for the stock were based entirely on English quarterly sampling effort then raised to quarterly international landings, since 2006WG French age data from 2003 onwards has been included.

Numbers-at-age 1 in the catch are low or zero in most years and most likely reflect variation in the sampling, rather than variation in the stock itself. Therefore, these were not considered to add useful information and are replaced by zeros.

3.2.2 Biological data

3.2.2.1 Weights-at-age

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:

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

where catch weights-at-age are mid-year values, and stock weights-at-age are 1 January values. Catch weights-at-age have been scaled to give a SOP of 100%, and the same scaling has been applied to the stock weights-at-age. Catch numbers at age 1 are replaced by zeros, but the catch weights-at-age 1 were retained because they are part of the smoothing procedure and do not affect the assessment. They are also essential to the medium-term forecast.

A smoother is applied to sampled catch weights-at-age to adjust for variation in the weight-at-age that may result from low levels of sampling rather than differences in growth rate between cohorts. It also allows estimation of the stock weights-at-age by extrapolation of the curve rather than by using quarter 1 samples, which may be sparse.

Although in year smoothing may have a tendency to smooth out the density-dependent effects on growth this was not thought to be a major problem for the assessment in this stock because of the limited variability in cohort size. The current methodology for in year smoothing includes smoothing through the 15+ group which is inappropriate because of the large numbers of year classes represented in the catches in this group. This should be addressed in future assessments.

3.2.2.2 Maturity-at-age

The maturity ogive applied to all years is, a combined sex maturity ogive taken from area VIIfg attributed to Pawson and Harley, WD presented to WGSSDS in 1997. Prior to 1997 maturity was taken to be knife-edge at age three.

Age	1	2	3	4	5	6,7, ...12+
Prop. Mature	0.00	0.14	0.45	0.88	0.98	1.00

Proportion of F and M before spawning have both been set to zero to reflect the SSB calculation date of 1 January. No new information on maturity in this stock was available to WKFLAT 2009.

3.2.2.3 Natural mortality-at-age

Natural mortality is assumed constant over ages and years at 0.1. This is consistent with the natural mortality estimates used for sole by other ICES working groups (WGNSSK: IV, VIId, WGNSDS: VIIa, WGSSDS: VIIfg, VIIIa,b) and consistent with estimates of M reported in Horwood, 1993 for VIIfg sole as well as other stocks and papers cited therein. No new information on natural mortality for this stock was available to WKFLAT 2009, however the estimate in M is very important to the evaluation of the historical stock trend and as such would have major impacts as to the evaluation of reference points.

3.2.3 Survey tuning data

Currently the only available survey for this stock is the Western Channel Beam trawl Survey conducted by the UK in late September, early October. The survey covers an relatively small area of VIIe from Start Point through to the middle of Lyme Bay and out to the edges of the Hurd Deep covering the immediate area of fishing for the Brixham fleet, but omitting Start Bay which these days contributes significantly to the landings of sole in VIIe. Sampling started originally in 1984 on the chartered commercial fishing vessel 'Bogey One', replaced in 1988 by the 'Carhelmar' and moved to the research vessel 'Corystes' in 2002 to 2004. Concerns were raised regarding differences in catchability between the Carhelmar and Corystes, and in 2003 the survey was carried out on the original vessel in addition to the Corystes. From 2005 onwards the survey has been moved back to the original vessel, and as a result of intersessional investigations the 2003 data were replaced with those collected on the Carhelmar. Therefore the time has only 2002 and 2004 data being collected on the Corystes.

The survey cpue demonstrates a decline from 1986 to 1995 in line with the commercial data. The abundance indices at ages 1 and 2 demonstrate little overall trend, but ages 3 to 6 indicate a decline over the series, despite intermittent peaks and troughs. The 1989 year class is indicated to be strong at all ages and this year class can also be traced through the catch-at-age matrix.

3.2.3.1 Evaluation of the quality of the survey data

The survey was examined for indications of trends in stock dynamics and for internal consistency. Figure 3.2.1 shows the means standardized cpue of the survey-at-age over time. The effects of the survey vessel change in 2003 and 2005 can be seen if one is looking for them but from the figure it seems small enough to ignore. Figure 3.2.2 however, shows plots of Z estimates calculated as the log-ratio of the survey abundance divided by the survey abundance the following year at the subsequent age. Here the effects of the vessel change become much more apparent, but apart from this there seems little indication of a persistent trend in F over time. In addition log abundance means standardized plots by year class demonstrate the internal consistency of the survey (Figure 3.2.3). The 1989 year class is tracked very consistently to age 9. Weaker year classes are tracked more poorly, but demonstrate reasonable correlation between most year classes. This suggests the survey is capable of tracking cohorts and should be reliable indicator of trends over time, although year-to-year variation may be more of a problem.

A more elaborate evaluation of the Z-trends indicated by the survey was carried out using a SURBA analysis. Estimation of survey catchability was not carried out so that F trends are only relevant on the relative scale, nevertheless resultant F estimates indicate no long-term trends in Z, but give the picture of relatively stable F's over the period of the survey from 1988–2007 (Figure 3.2.4).

FSP survey data

WKFLAT 2009 was presented with a new survey tuning series. The survey covers a larger area than the current survey and should provide improved coverage of the older ages. There is no doubt that additional information is a welcomed contribution and as such should be applauded. However there were a number of issues with regards to a full evaluation of the survey. Insufficient information on the aggregation of the data was presented in the report on the survey (WD) in order to evaluate the consistencies of the survey from a methodological perspective. Examination of the available data raised some concerns which further investigation should be aimed to resolve.

- The SSB indices for the western survey demonstrate a general decline over time and the value in 2008 demonstrates a further decline of a sufficient magnitude to be causing an apparent year-effect in the combined east and west indices.
- In 2008 the vessel used to cover the eastern part of the survey could only cover part of the survey at the usual time, and the Carhelmar was chosen to replace her. The survey was then completed in full, but using a smaller beam and significantly later in the year than was usual. The data as provided did not allow WKFLAT to inter-calibrate the data. It is recommended that such an analysis is carried out to improve the surveys performance.
- Year class tracking is weaker in some age classes than would be hoped and the effects of including such a short period in an assessment are very difficult to predict. More information on how the data were aggregated would be helpful.
- Estimates of the log catch ratios (Figure 3.2.5) indicate a substantial disruption to the overall pattern for the 2004 data (the ratio of the 2003 to 2004 data). This is probably associated with an otolith sampling issue at the beginning of the time-series in 2003. It is recommended a better description of the data collected and some remedial measures are investigated to overcome these difficulties. The effects can also be seen in the means standardized plots (Figures 3.2.6 and 3.2.7).

- The number of 6, 10 and 12 year old fish in 2006 is exactly the mean abundance of those ages across all years of sampling. Given the low probability of such an occurrence it is recommended that the calculations are checked again.

In the absence of the necessary data to examine these inconsistencies and the lack of a benchmark assessment this tuning series was not further evaluated other than within the framework of the AM model. If this time-series is to be more fully evaluated in the next benchmark procedure it is vital that these inconsistencies are explained.

3.2.4 Commercial tuning data

In the early part of the century the fishery for VIIe sole was largely prosecuted by otter trawlers and inshore netters. During the mid to late 1970s landings sharply increased with a considerable increase in nominal effort as the beam trawl fleet developed. Otter trawl effort declined with levels in 2002 being about half that of effort found in the late seventies. Beam trawl effort in terms of hours fished has continued to rise since 1988, but at a slower rate than previously as a consequence of licensing and quota restrictions, but boat size and power as well as beam sizes have also increased suggesting that the effective effort has continued to rise more sharply than suggested by the effort data alone.

Lpue has declined since the late eighties in both the otter and beam trawl fleets suggesting a marked decline in the SSB of this stock. Interestingly the catch-at-age information for these fleets does not suggest a marked decline in the age structure over this time suggesting the decline may be associated with environmental impacts rather than fishing, but given the uncertainty in current landings data it is difficult to distinguish between the potential causes of the discrepancy between the lpue and catch-at-age data. Little information is currently available regarding the development of the French fishery on this stock on the southern side of the Channel.

The UK beam trawl fleet in recent years has been landing large quantities of cuttlefish during winter. Investigations of the landings data indicated that misreporting was particularly high during the period of the cuttlefish fishery indicating that lpue was unlikely to be substantially lower than during the remainder of the year, justifying the inclusion of all trips in the lpue time-series. Similarly, there was no indication of differences in lpue for those trips split between divisions (misreporting to VIId) so that trips reporting to VIIe as well as those reporting to the two adjacent rectangles in VIId were included in the derivation of the tuning fleets.

UK beam trawl effort has climbed markedly since 1992. Otter trawl effort has stabilized following its decline during the 1980s and early 1990s.

Effort data for the whole fleet as used in tuning the assessment is calculated by an effort correction for horsepower based on lpue data for specific rectangle groupings. For the calculation of lpue, landings misreported to VIId (see catch data section) are corrected in the same manner as the catch data. No corrections are made to the effort statistics, as the time spent in VIId for the purposes of misreporting has been negligible.

3.2.4.1 Evaluation of the quality of the commercial tuning data

Consistency and trends in the commercial beam trawl tuning information were examined in the same way as the survey tuning information. Cohort estimation/the recruitment signal is strong in the beam trawl commercial tuning data, and this is highly consistent with the catch data as in general it represents roughly 65% of the catch data. However year-class estimation is also mostly consistent with the estimations from the entirely independent survey tuning series.

Estimates of F averaged over different groups of ages do not indicate much of a trend in fishing mortality over the tuning period (Figure 3.2.8) or a clear sign of a decline of numbers-at-age for the younger ages, although older ones seem to be rarer more recently (Figure 3.2.9). SURBA runs of the same data also do not indicate a rise in F as suggested by the latest assessment (Figure 3.2.10). The internal consistency of the data is generally good in terms of the age composition (Figure 3.2.11), however there is an indication that the effort calculations may be inappropriate, giving the series a trend in residuals within the XSA analysis of historical assessments. The log catch ratios and the SURBA trends do not display a good correlation with the estimated effort, which one might have expect given the large proportion of the catches taken by this tuning fleet. Reasons for this could be a poor signal to noise ratio or a change in the relative proportion of catches taken by the various fleets.

The otter trawl fleet also does not indicate a change in F (Figure 3.2.12) or unlike the UK-CBT fleet, abundance-at-age over the tuning period (Figure 3.2.13). The effort correction for this fleet is very different from that used for the beam trawl fleet, and the fleet has not changed substantially in recent times, so this may in fact be a better representation of lpue. Unfortunately it is also considerably more variable with particularly strong year effects of unknown origin in 1991 and 2005. Year class tracking for this fleet is less consistent as a consequence of the greater variability (Figure 3.2.14).

3.2.5 Industry/stakeholder data inputs

3.3 Stock identity and migration issues

In spite of some mixing, it is generally accepted that the stock in the western English Channel is discrete and constitutes a separate unit, certainly once mature. As in other stocks of sole, random longshore movement accompanies a seasonal onshore offshore migration associated with spawning. The closed population assumption for prerecruits and immature sole is less certain and historical tagging information seems to suggest that there is some net movement of juveniles into VIIe from area VIId, particularly in years of large recruitment in the latter area.

Given the limited movement of the stock and the spatial constriction of the fisheries, which leave part of the stock unexploited there is the potential for the stock to be poorly mixed, which may violate the assumptions of some assessment methods.

3.4 Spatial changes in the fishery and stock distribution

Investigations at WKFLAT 2009 regarding the spatial distribution of the fishery have been limited to the UK trawl fleets, because VMS data for the French fleets are not available as a consequence of those fisheries being prosecuted by gillnetters (and small number of otter trawlers) <20 m not monitored by VMS data and a lack of appropriate effort statistics (the only information available being days at sea and horse power, but no information on net length which is known to have changed over time).

UK beam trawl fleet

This fleet takes the largest proportion of landings. Its area of operation is largely restricted to the near coastal areas around Start Point on the UK coast extending east into Lyme Bay and west to Plymouth and occasionally south to the middle of the channel. VMS plots of the distribution of the fleet were examined for both inter annual and intra annual changes in the pattern for the period 2000–2007 (Figure 3.4.1 '2005', Figure 3.4.2 'July'). Data in the early part of this series is limited to vessels greater than 25 m so that effort may appear to be increasing. However the data suggests that there are no changes in the spatial extent over which the fishery has operated in the last seven years, and no apparent relative shifts of effort within the area between years or seasons, despite the industry claims of targeting cuttlefish and monkfish at different times of the year.

To the southwest of the usual operation of the SW beam trawl fleet VMS data also indicates the operation of beam trawlers. The boats operating in this area mostly use the homeport of Newlyn, targeting monkfish and megrim mostly. They take sole only as a bycatch while fishing in VIIe. They are not considered a significant contribution to the fishing mortality of sole and are not part of the beam trawl tuning fleet.

Because of the substantial sampling of the UK beam trawl fleet it was possible to split the annual fleet into monthly tuning fleets using quarterly ALKs in order to investigate if incomplete mixing may be affecting the understanding of stock dynamics (Figure 3.4.3). The analysis indicted different F patterns for the various monthly fleets mostly driven by the quarterly ALKs. It was inconclusive if these differences were associated with an increase in variability of the smaller ALKs or associated with real differences in the dynamics of the fleet or seasonal migration of the stock.

UK otter trawl fleet

Few boats in the fleet were covered by the VMS data even in the period where VMS monitoring was compulsory for boats greater than 15 m. The fleet taking sole largely operates inshore on small, multipurpose vessels not covered by VMS. The general area of operation is similar to that of the beam trawl fleet targeting sole, but generally further in-shore given the relative size of the vessels. VMS tracks examined for the larger otter trawlers were found to be unrepresentative of the activities of the otter trawl tuning fleet.

Although no French VMS data were available, discussions with the French representative at WKFLAT 2009 indicated that the French fleet was also largely coastal on the French side, prosecuted by netters and otter trawlers. Netters and otter trawlers operating on or near the spawning grounds take a significant proportion of the annual French landings during the first quarter. Consequently, the first quarter landings contain a larger proportion of larger fish than catches later on in the year. The majority of 2nd–4th quarter catches are taken by otter trawlers and represent a significant proportion of newly recruited sole.

The activities of UK and French fleets in VIIe are discrete. An area in the central channel and the western part of the division are rarely exploited for the targeting of sole. However sole are found relatively ubiquitously in most of the division, all be it in lesser abundances compared with the areas extensively fished (Figure 3.4.4). There is little evidence of how this distribution may have changed over time.

There also is little information on the historical spatial distribution of sole in the division, current knowledge indicates that sole are wide spread in the division, with most areas outside the western part of the central channel containing at least some sole (Figure 18). Two discontinuous areas of higher concentrations are located on the UK and French coasts in the eastern part of the region and indeed these are the spatially distinct areas of operation of the UK and French fleets. There are significant portions of the stock that remain unfished entirely. The effects of this on the assessment assumptions of completely mixed populations are unknown. But this pattern has been consistent for at least the last decade and probably longer.

3.5 Environmental drivers of stock dynamics

Little is known about the effects of the environment on the stock dynamics of VIIe sole. Certainly the division is on the convergence between the Celtic Sea proper and the Channel/North Sea ecosystem. If predicted increases in temperature were to materialize, changes to the stock dynamics of this and other species in the division would be expected. To date there is good evidence of a sizeable increase in the abundance of bass in the area, a species with a similar pan European distribution as sole. In addition there is some anecdotal evidence of changes in the range of some species such as langoustine, triggerfish, and black sea bream from warmer parts of the Atlantic. In the North Sea it has also been suggested that cold periods immediately prior to spawning have a tendency to increase year-class strength and there is some indication of this for this stock, however no statistical analysis has been carried out to date.

3.6 Role of multispecies 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

Three assessment models were investigated during the workshop for this stock.

XSA

XSA (implemented in FLR) as the currently used model was implemented in a variety of ways. The investigation of this model was largely carried out at WGSSDS 2008 as at the time ICES scheduled this to be a benchmark assessment every year because it was the subject of a recovery/management plan. The XSA method is well known to ICES so its assumptions are not further elaborated on here.

AM

AM (a model), developed by Jim Ianelli and tested during the workshop is developed in ADModel Builder. It is a highly flexible implementation of a statistical catch-at-age model used for a number of North American fisheries assessments. The model has not been extensively reviewed by ICES and is used here mainly to understand the data sources, their conflicts and how this results in the observed retrospective pattern.

SURBA

Surba (V2.2) provides trends only information on the fishery using survey or commercial tuning information. A more recent version of the model implementing simultaneous multi survey approach is available, but the code has been found to be 'buggy' in certain circumstances so its implementation was avoided. A more detailed description of the model can be found in the background documents to the workshop. The model was used to evaluate the internal consistency of both survey and commercial tuning data so its results are described under those sections. However the model was unable to converge using the FSP tuning information so this could not be evaluated.

3.8.2 Sensitivity analysis

Not investigated.

3.8.3 Retrospective patterns

No analytical assessment is presented because of the strong retrospective pattern in the previously employed methodology. These issues were thoroughly investigated during the workshop but could not be resolved.

3.8.4 Evaluation of the models

XSA

This stock has been assessed using XSA routinely. A few years ago the quality of the assessment declined with a tendency to underestimate SSB and overestimate F in the most recent years. This was made worse by the inclusion of French age data in the catches from 2003 onwards The preliminary analysis of tuning and catch data at WKFLAT 2009 failed to shed light on the reasons for this retrospective bias, so the aim was to see if different choices in the XSA settings could at least indicate reasons for this. Different shrinkage options, assumptions about the age of constant catchability, and population shrinkage (not currently used in this assessment) were examined. Although by trial and error it was possible to develop an assessment that did not display the retrospective bias, diagnostics indicated that these in general were poor representations of the available data.

A number of plots are represented indicating that the uncertainty in terms of the model settings is mainly concentrated in the historical part of the time-series. In general all model implementations assume a rise in historical SSB followed by a sharp decline in SSB following some of the greatest landings from this fishery in the late 1980s. Invariably the models indicate a commensurate increase in F's with the increase in landings having been variable but roughly stable since then. Estimates of F in the most recent assessments indicate a further increase in the last five years or so. The slope of these increases and the length of the period of increase varied dependent on the basis of the model parameter choice, but the actual values were invariably revised downwards in a retrospective analysis in subsequent years.

When using only the most recent data and when splitting the commercial beam trawl fleet into two periods, the retrospective pattern persisted. Using only the UK-BTS survey for tuning in the same period improved the degree of bias, but F estimates remain very variable and a significant portion of the SSB is not monitored, as the survey provides no information for ages >9.

It was concluded that there were irreconcilable differences in the data sources used in the assessment (model bias). Consequently, it was concluded that it is not possible to produce an analytical assessment indicative of the stock trends in recent years until these data conflicts are resolved.

AM

The main benefit of the model for this stock is that it treats uncertainty explicitly so that it was possible to investigate the effects of the FSP series, both in terms of the mean abundance estimate and the uncertainty surrounding it. It was found to increase uncertainty in recent estimates suggesting that it conflicted with other data sources. Because insufficient data were available to examine whether these differences were real or resulted from inconsistencies in the data aggregation, WKFLAT

2009 recommends that the procedure is described in more detail and analyses, particularly with regard to the effects of boat changes, be provided.

Despite the more realistic modelling of the fisheries and stock dynamics, the model suffered from the same difficulties as the XSA in explaining data conflicts and produced a similar retrospective pattern in F and SSB.

3.9 Stock assessment

A full analytical assessment of this stock using XSA is currently not possible because of the conflict of the catch-at-age information with the tuning data. As this conflict remains when commercial tuning information (65% of landings) is used, it may well be a case that the estimation of effort for the commercial series needs to be revised as it is based on historical estimates of the relationship between horsepower and catchability. However this is certainly not the only cause as an assessment tuned to surveys only still has problems. While the historical development of the stock seems more certain, recent estimates of F are inappropriate for management. The current implementation of the assessment method cannot be seen as indicative of recent stock trends and therefore should not be applied until the issues have been resolved.

A method able to take account of all available data sources as well as accurately estimating their uncertainty should be developed. The AM model examined at WKFLAT 2009 is a step in the right direction, but further work is required to include historical age data from France, better estimation of effort in commercial tuning data, model based estimation of the level of under reporting for the period 1989 to 2000, and an examination of the FSP survey data and the effects of changing vessels. In addition, a better understanding of ICES scientists as to the assumptions in the model and how representative these are in terms of the fisheries and stock dynamics will be needed.

In the interim management will be difficult and in many ways will be subjective. Nevertheless, there are some things that are relatively certain regarding the status of the stock. The stock is overfished with regards to the long-term management target, the stock is not in imminent danger of collapse and any reduction in F will serve to at least improve stock levels. Movement of SSB outside the observed range where stock dynamics become uncertain must be avoided at all costs.

3.10 Recruitment estimation

Estimation of recruitment in the final year of the assessment has been found to be variable. This is based on a single data point in a variable survey index, so the WG has routinely replaced this value with GM recruitment discounted for natural mortality, following a substantial overestimate of the incoming year class. This methodology should continue until the reasons for the survey variability at that age can be established or corrected.

Past recruitment estimates are very consistent between the three methods, but historical SSB estimates differ substantially as a consequence of differences in the starting assumptions between the XSA and AM models. Consequently, the interpretations of a stock recruit relationship differ substantially between the models. The historical method of using GM recruitment for future year classes should be maintained as this seems to be independent of model choice.

3.11 Short term and medium term forecasts

Given the strong retrospective pattern in the current assessment short-term forecasts are likely to be similarly biased. The source of the current bias could not be systematically isolated or corrected so short-term forecasts for this stock should not be used in management.

Until a more robust analytical assessment is available management of this stock could be based on the scrutinized survey data, but it needs to be born in mind that the survey is representative only of a spatially restrictive portion of the stock and does not monitor older ages (>9).

3.12 Biological reference points

Biological reference points in this stock were set in 1998 as described in the table below along with the reasoning. Reference points needed to be amended in 2001, as a consequence of a change in the assessment method. Increasing the plus group led to an increase in the absolute levels of SSB for which reference points needed to be recalculated.

	WG(1998)/ACFM(1998)	SINCE WG(2001)/ACFM (2001)
		Age range extended from 1–10+ to 1–12+
Flim	0.36 (Floss WG98)	0.28 (Floss WG01)
Fpa	0.26 (Flim*0.72)	0.20 (Flim*0.72)
Blim	1800 t (Bloss= B73 WG98)	2000 t (Bloss= B00 WG01)
Bpa	2500 t (Blim*1.4)	2800 t (Historical development)

Since then WG has suggested further changes to the reference points as a consequence of further changes to the assessment method which changed the perceived status of the stock, but these recommendations have not been adopted by ACF/ACOM, nor were reasons given for the rejection of the reference point amendments. Investigations with respect to the management plan developed by the WG first in 2003 and repetitions of the exercise in subsequent years indicated fishing mortalities of 0.27 have a less than 5% probability of driving the stock down to levels of SSB where stock dynamics are uncertain (outside the observed range of SSB), while maintaining catches within 90% of MSY. These conclusions were drawn from stochastic evaluations of the stock dynamics using CS5. The commission accepted this value as the long-term management target of the stock, but ICES till now has failed to accept adjusted F reference points commensurate with these levels. Consequently the official classification of the management plan is to imply that current Fs are not precautionary.

WKFLAT 2009 recommends that the current reference points be reviewed once a new analytical assessment has been accepted. Until such time, these reference points should not be used in management.

3.13 Recommended modifications to the stock annex

The current assessment methodology should not be used for a short-term forecast or to assess recent levels of SSB because of the consistent retrospective patterns in F and SSB. Nevertheless there is information to provide some advice on stock trends, and a suitable method to do this should be sought in the interim.

The UK-CBT tuning fleet indicates a gradient in the assessment residuals and some indication of a decline in the abundance of older ages in recent years. This is not obvious from the other fleets and may in part be the result of an old effort correction method. This should be investigated and updated if necessary.

The FSP survey needs to be investigated further in terms of its consistency and data and methods provided as to how this was derived.

Reference points should be revised once a new analytical assessment is accepted by a future Benchmark Workshop.

Estimation of weights-at-age should be revised to not include in-year smoothing through the plus group.

3.14 Recommendations on the procedure for assessment updates

It is not possible to perform an analytical assessment on this stock at this point. New assessment methods, particularly fully statistical models, should be investigated with further scrutiny of the data sources.

3.15 Industry supplied data

A survey of western Channel sole and plaice has been carried out each autumn since 2003 as part of the UK Fisheries Science Partnership (www.cefas.co.uk/fsp). A full report of the 2003–2008 surveys is available on the website. This survey has been used by ICES for tuning the VIIe plaice assessment. Equivalent abundance indices at age for VIIe sole are available for 2003–2008. The survey is confined to UK waters and is divided into eastern and western areas, each surveyed by a different vessel. The western survey uses twin 4 m beam trawls, the eastern survey twin 12 m beam trawls except in 2008 when the same vessel fished both areas using 4 m beams. A comparative set of tows carried out in 2008 in the east, using the same vessel and 12 m beams as used in 2003–2007, indicated very similar catch rates of sole by length class after standardizing as numbers-per-metre beam length-per-hour towed.

The SSB index for the survey follows the same trend as the 2008 ICES XSA assessment except for 2008 when the FSP index declines compared with the XSA values. The age-based indices from the survey do not demonstrate any marked year-effects, and the internal consistency in tracking year classes appears reasonable. Although the time-series is only six years long, the survey indices contain information on trends in abundance and appear suitable for evaluation within a catch-at-age assessment framework.

WKFLAT 2009 recommends that the western Channel sole and plaice autumn survey be investigated further with a view to its incorporation in future assessments. (See also section on survey information).

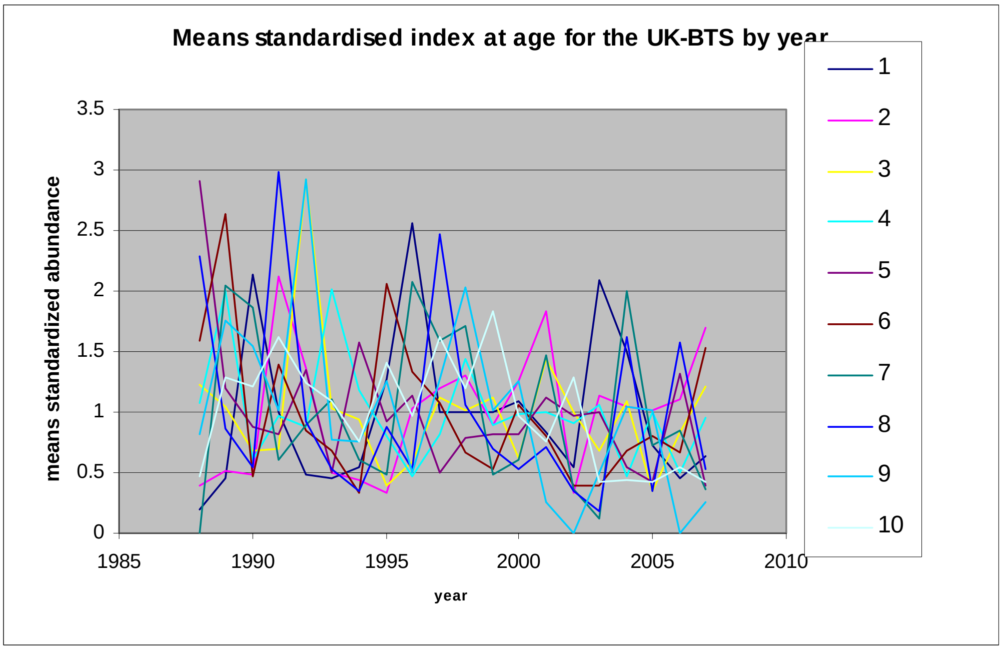


Figure 3.2.1. Sole in VIIe. means standardized index for the UK-BTS by year.

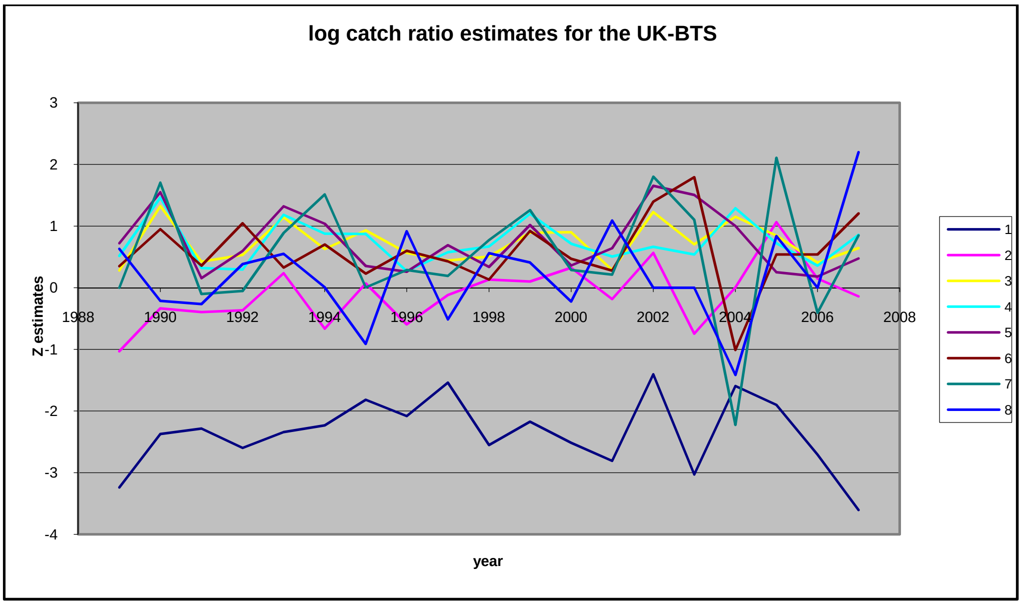


Figure 3.2.2. Sole in VIIe. log catch rations by age for the period 1988–2007 for the UK_BTS survey.

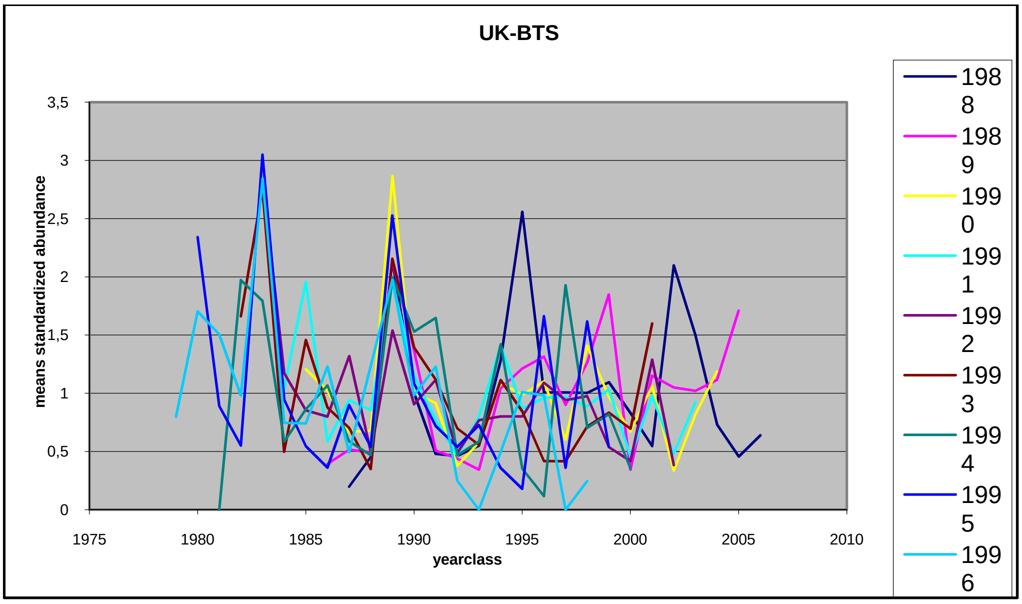


Figure 3.2.3. Sole in VIIe. Means standardized abundance index by year class for the UK_BTS survey.

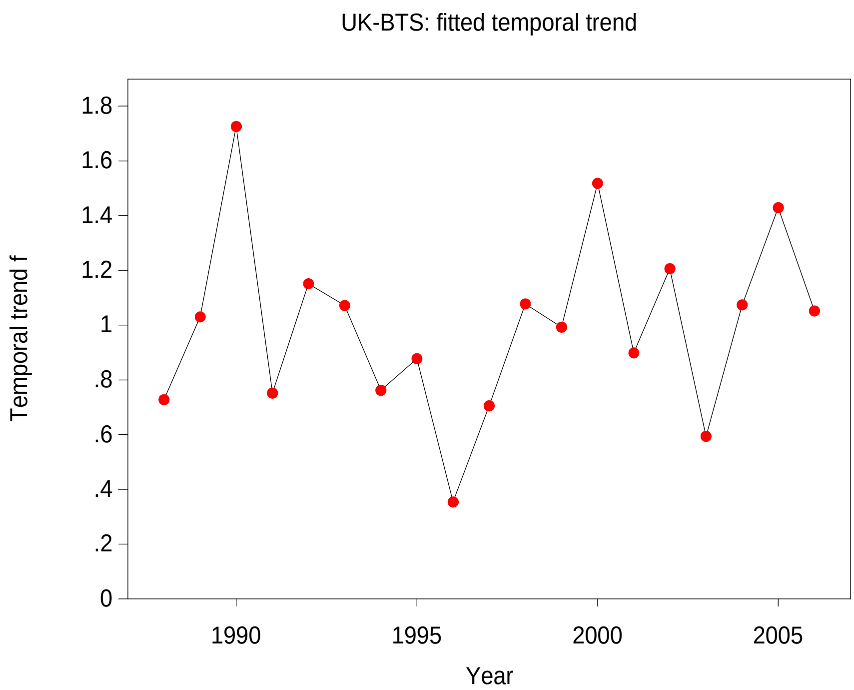


Figure 3.2.4. Sole in VIIe. Z estimates over time as modelled by SURBA.

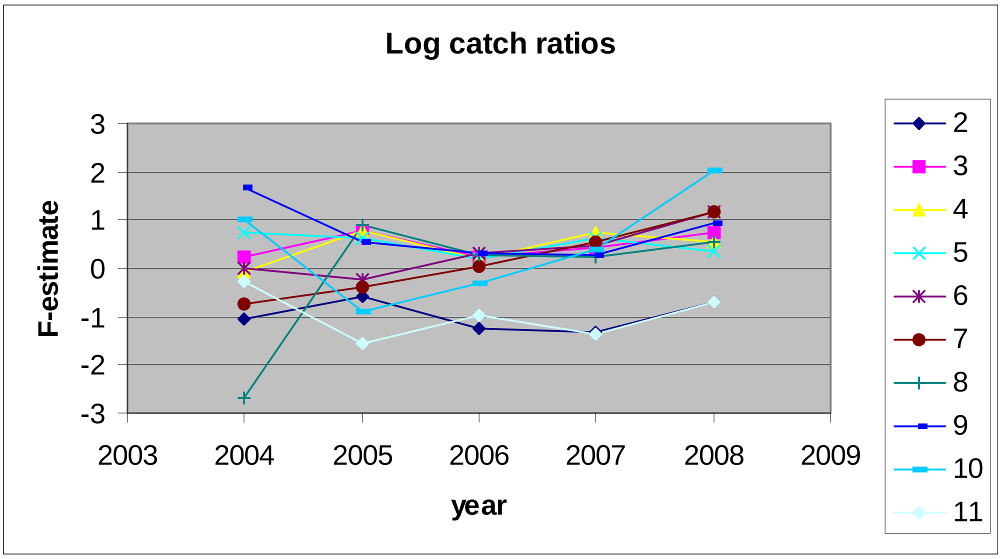


Figure 3.2.5. Sole in VIIe. Log catch ratios for the FSP-survey.

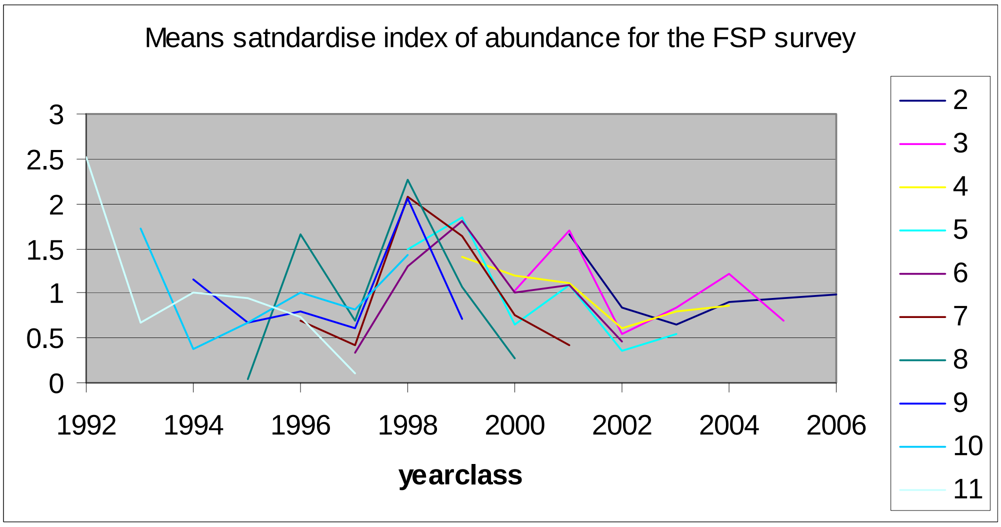


Figure 3.2.6. Sole in VIIe. Age specific abundance indices plotted by year class for the FSP survey.

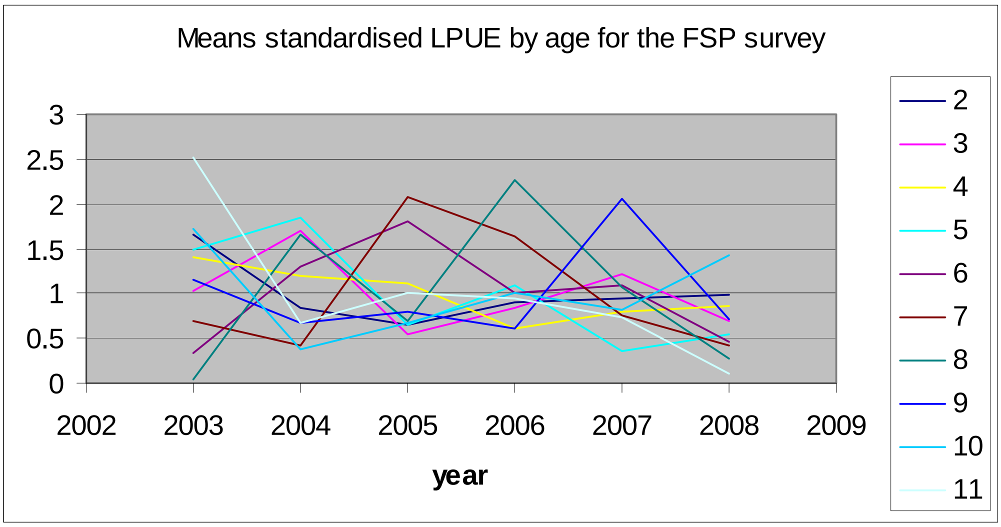


Figure 3.2.7. Sole in VIIe. age specific abundance indices plotted by year for the FSP survey.

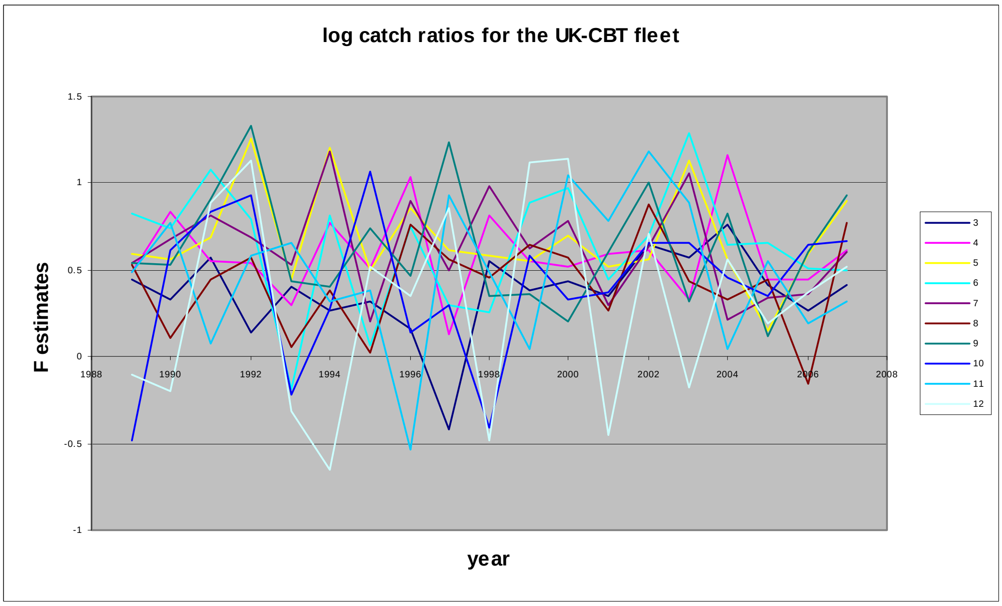


Figure 3.2.8. Sole in VIIe. log catch ratios-by-age for the UK-commercial beam trawl tuning fleet.

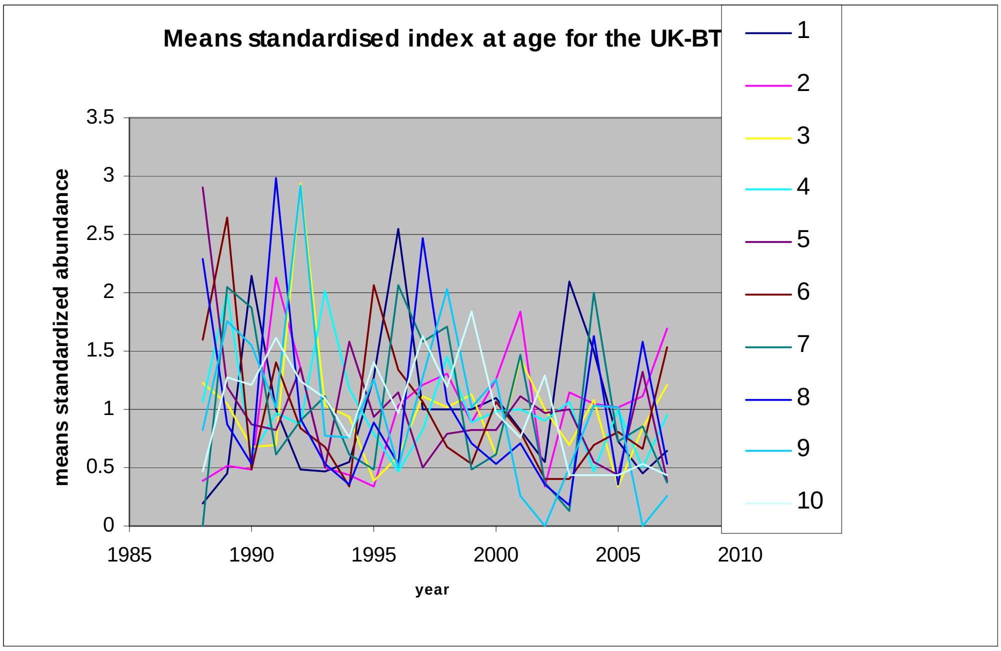


Figure 3.2.9. Sole in VIIe. means standardized index for the UK-CBT tuning fleet by year.

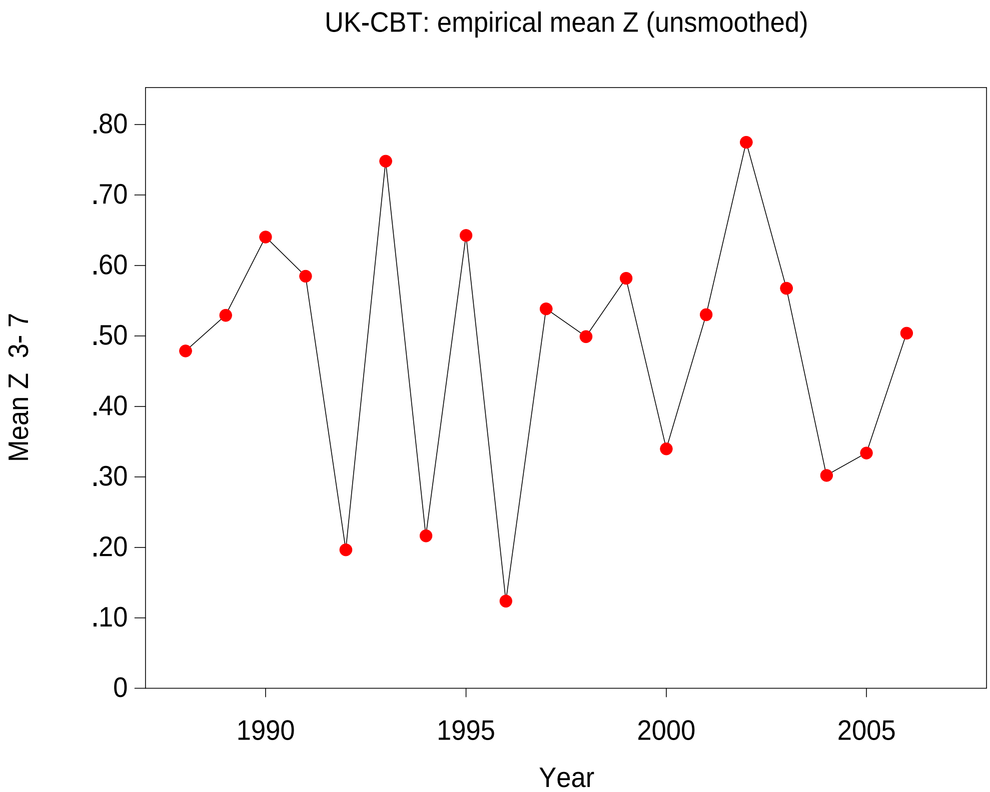


Figure 3.2.10. Sole in VIIe. SURBA estimates of Z based on UK-CBT data.

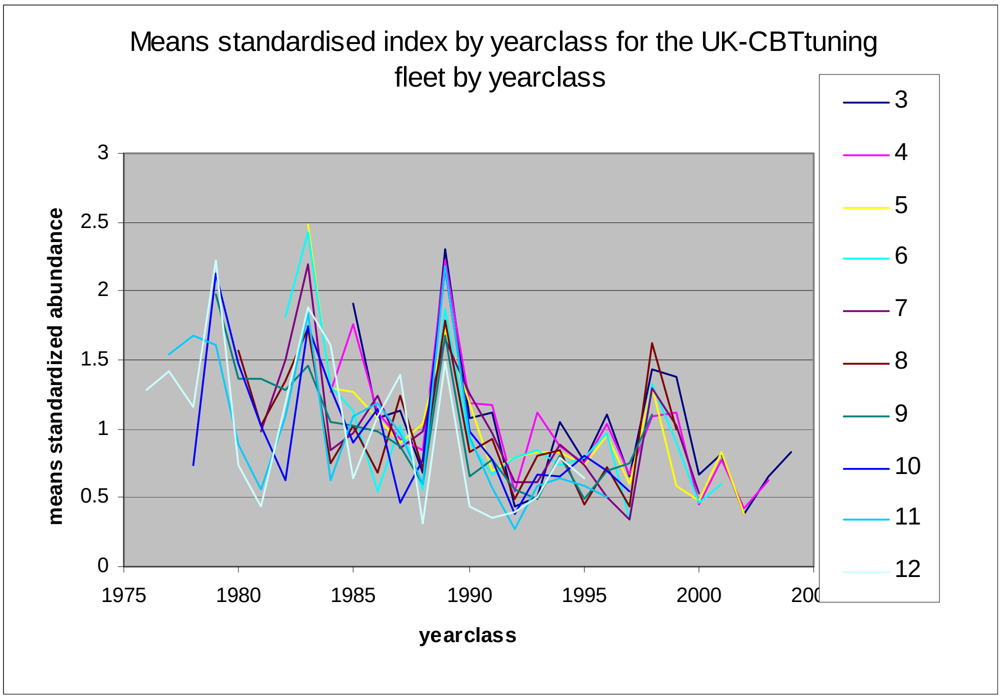


Figure 3.2.11. Sole in VIIe. Means standardized abundance of the UK-CBT tuning fleet by year class.

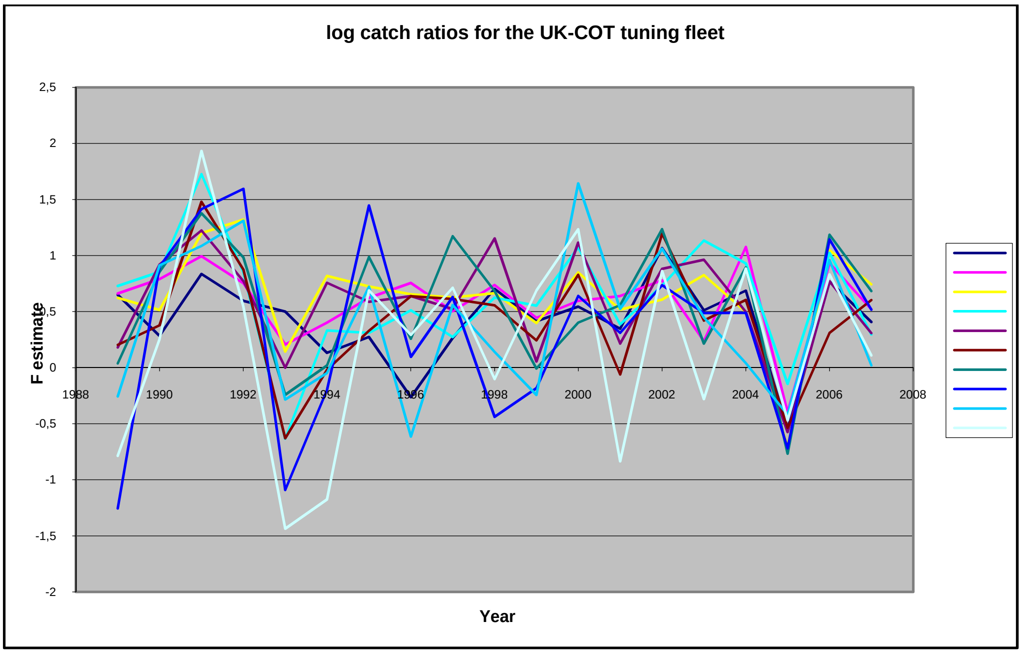


Figure 3.2.12. Sole in VIIe. Log catch ratios-by-age for the UK-COT tuning fleet by year.

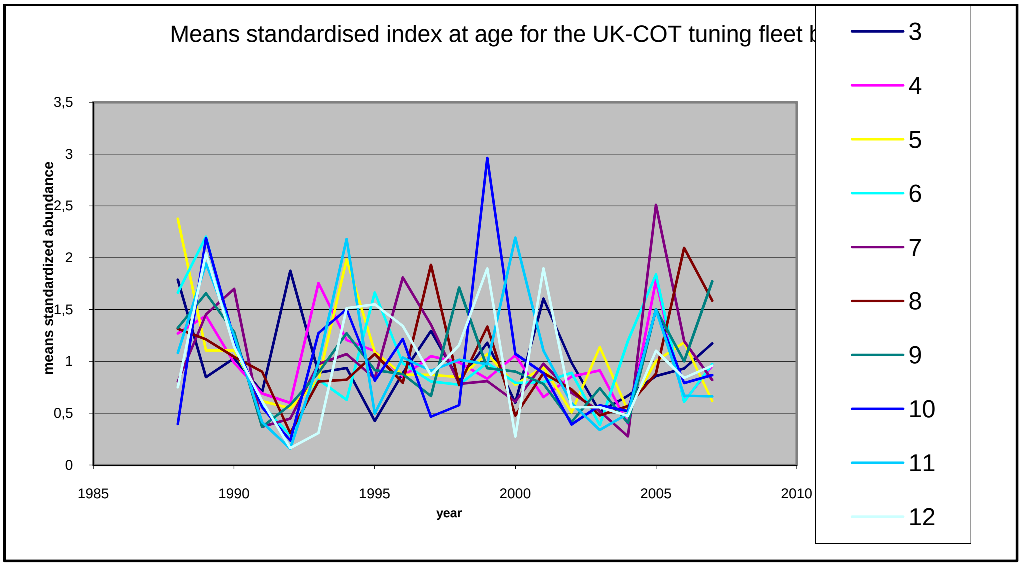


Figure 3.2.13. Sole in VIIe. Means standardized index for the UK-COT tuning fleet by year.

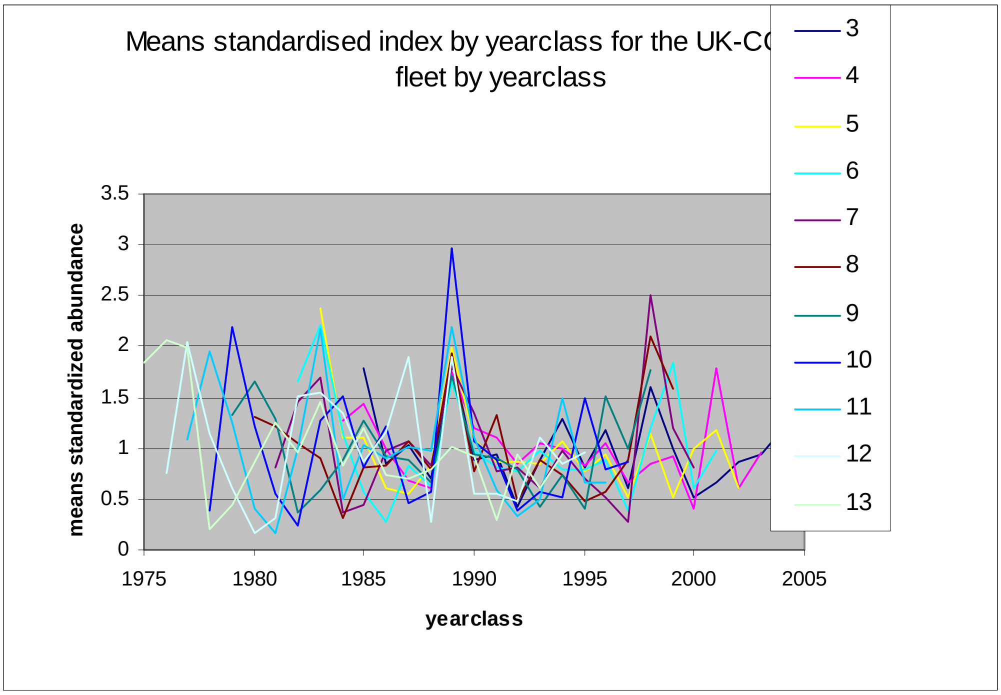


Figure 3.2.14. Sole in VIIe. means standardized index for the UK-COT tuning fleet by year class.

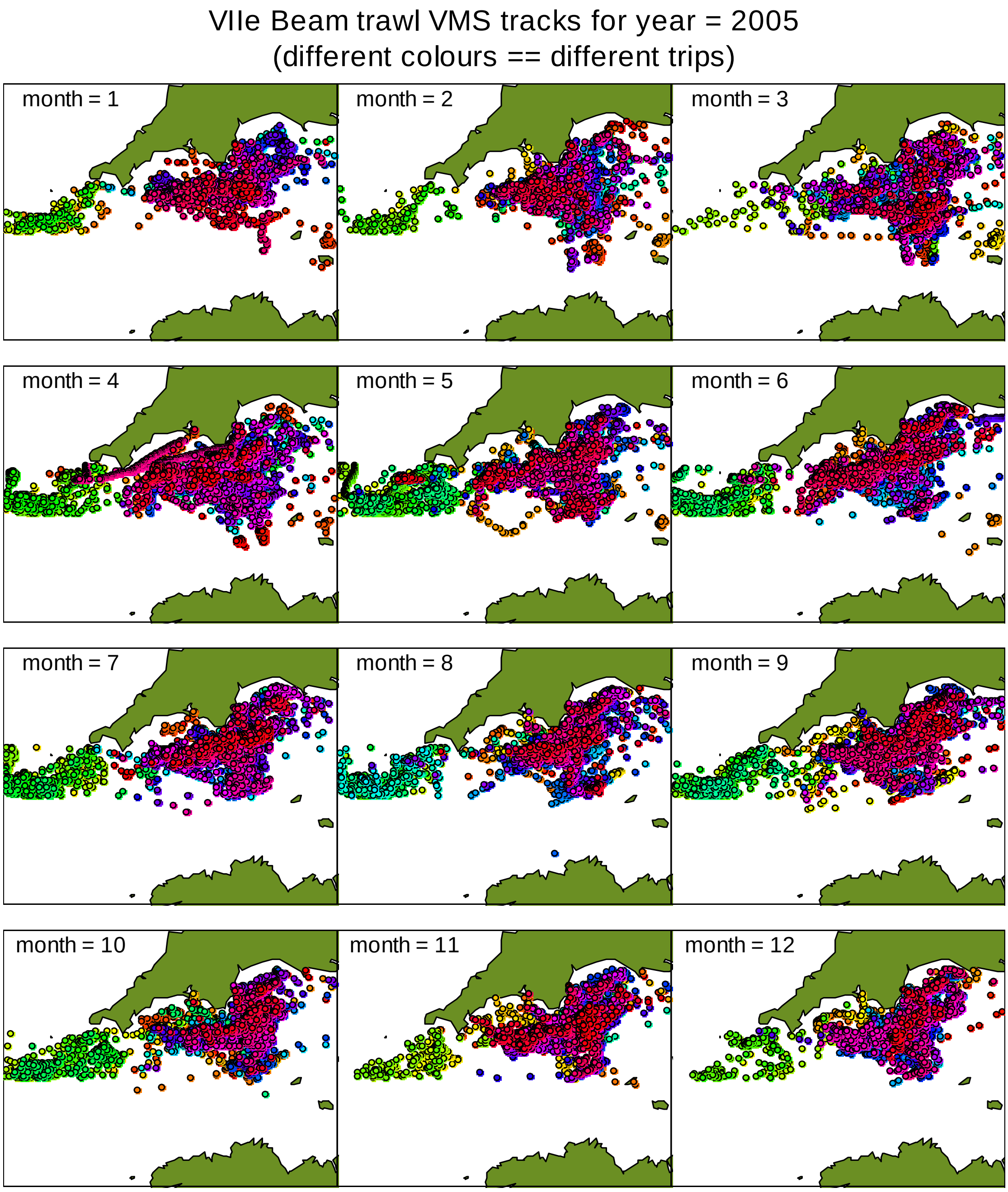


Figure 3.4.1. Sole in VIIe. VMS data for UK beam trawlers in 2005 showing little seasonal change in distribution. Points in the western part of the area represent mainly beam trawlers from Newlyn that target monkfish and megrim mostly.

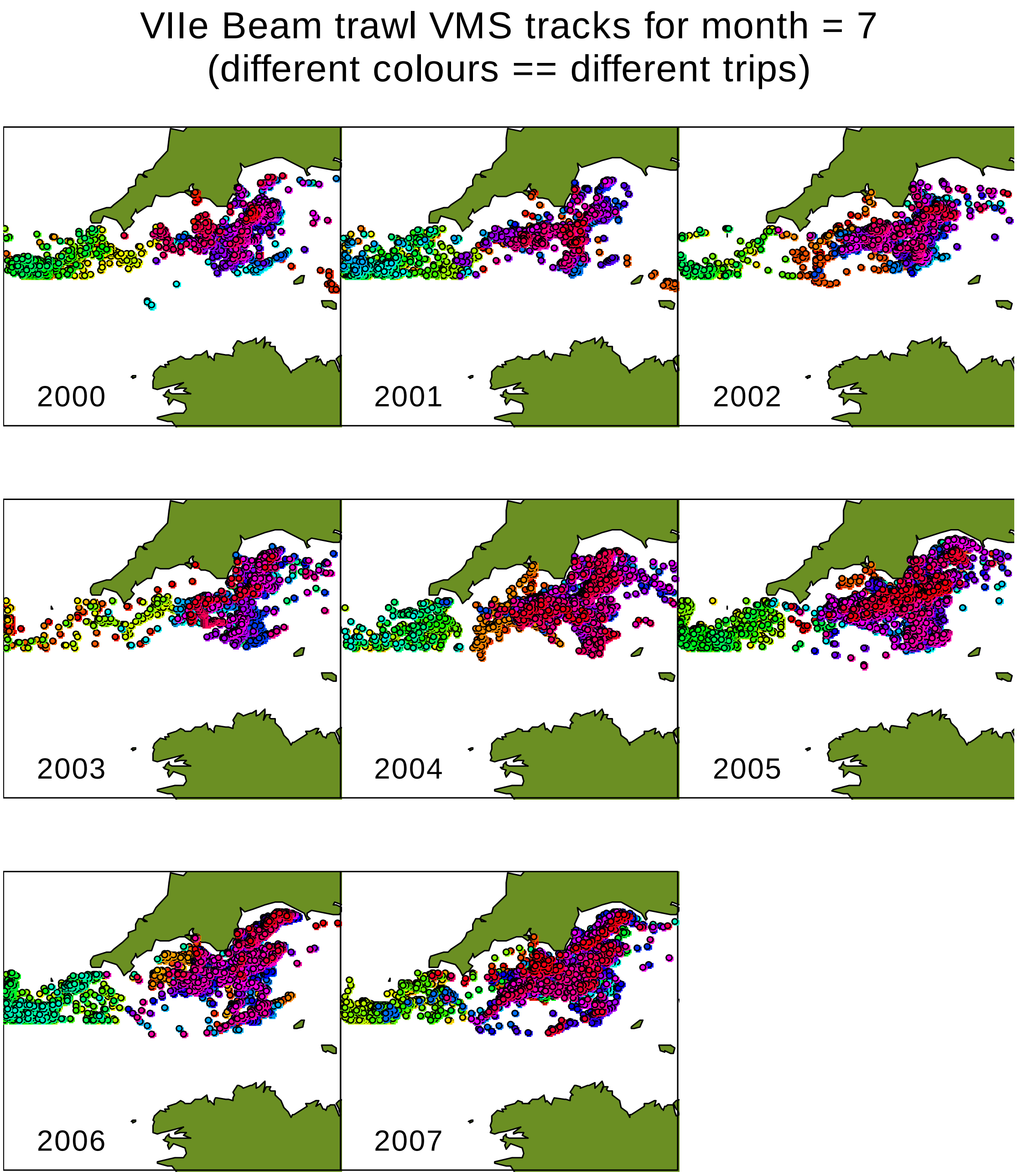


Figure 3.4.2. Sole in VIIe.VMS data for UK beam trawlers in July demonstrating little interannual variation in distribution. The apparent increase in the early years is ascribable to an increase in the use of VMS, rather than an increase in the number of boats in the fleet. Points in the western part of the area represent mainly beam trawlers from Newlyn that target monkfish and megrim mostly.

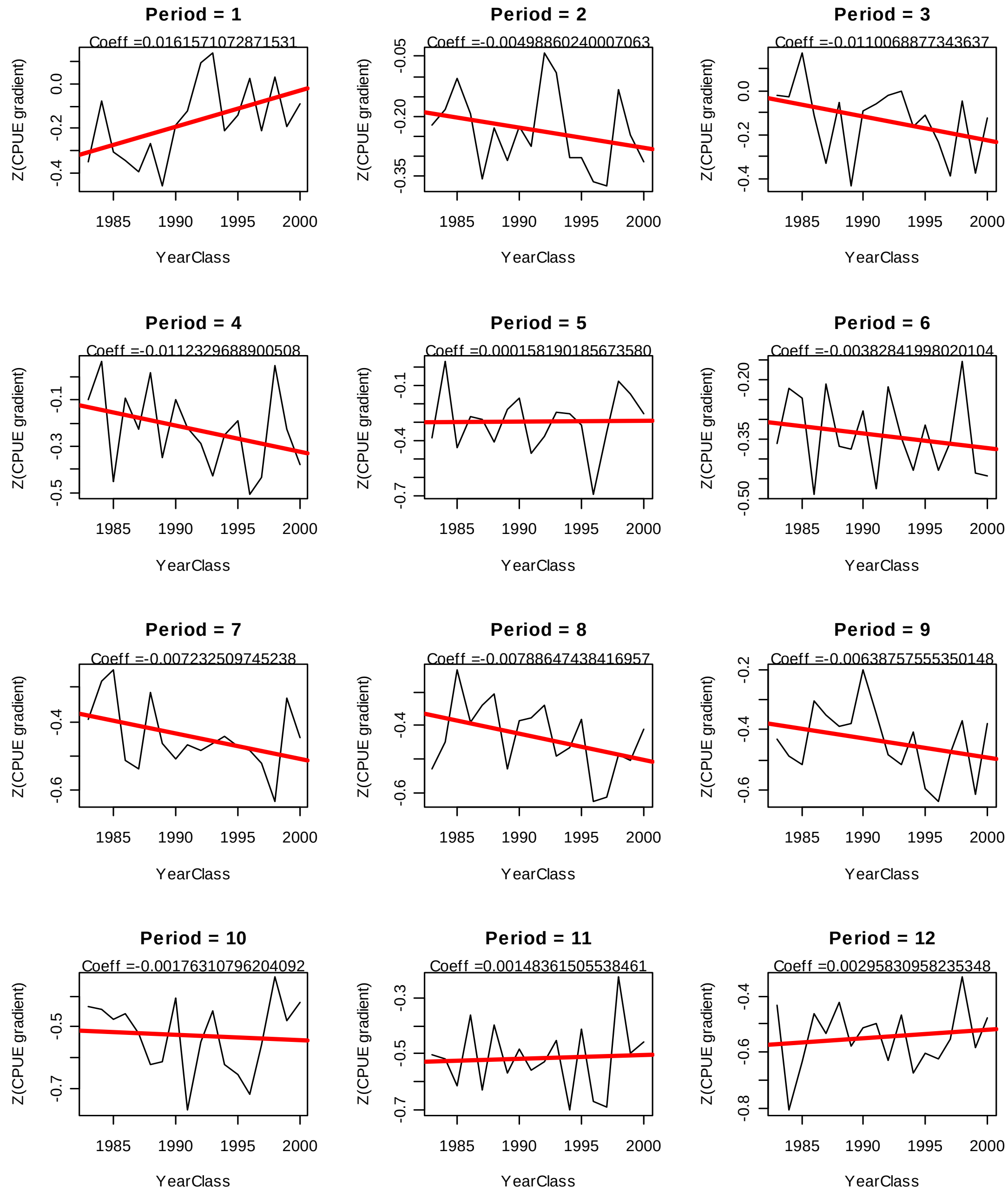


Figure 3.4.3. Sole in VIIe. Estimates of average yearly F's (ages 3–7) calculated from monthly lpue estimates in consecutive years with the red line indicating the overall trend over the period 1982–2000 for ages.

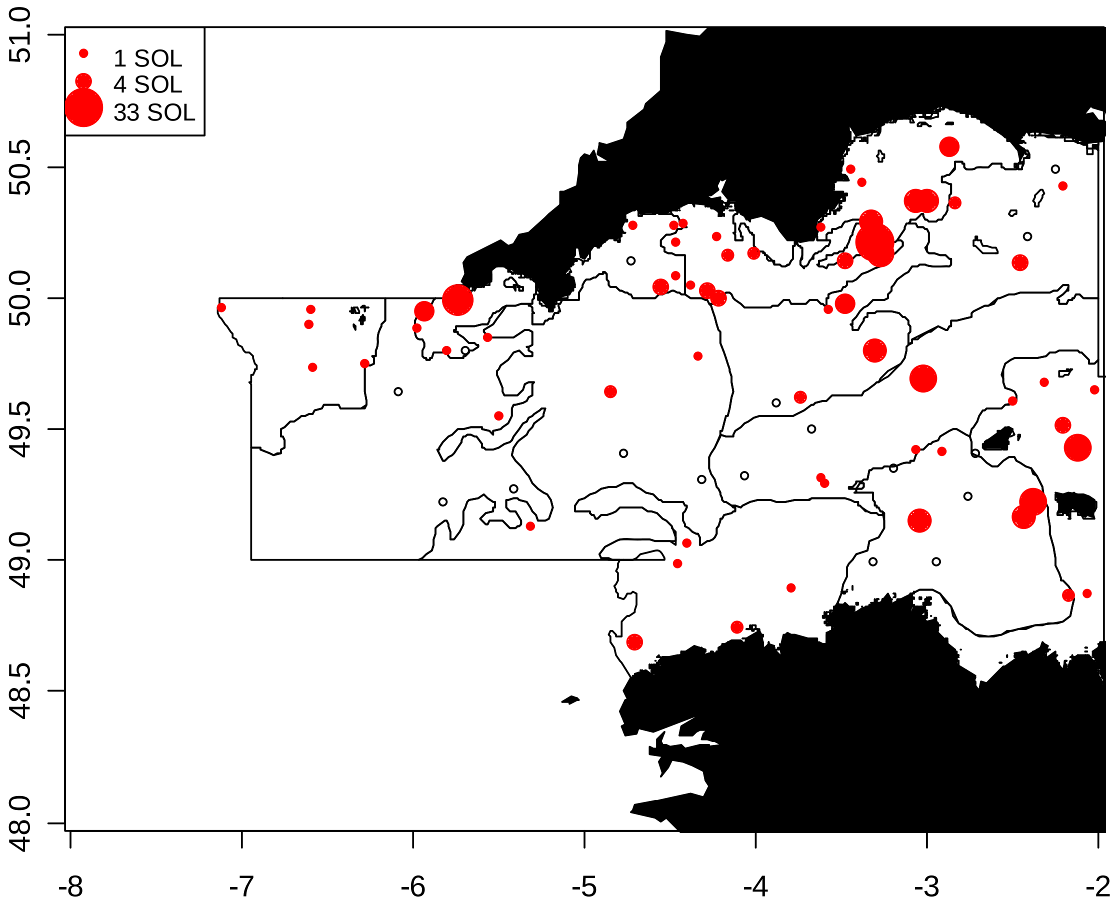


Figure 3.4.4: Sole in VIIe. Sole distribution as part of a beam trawl survey carried out in 2006 to investigate the extent of the distribution of sole in the division as a whole. Greater than 80% of hauls contained sole, and the distribution was relatively even. The areas of the highest concentrations observed were those that are known to be exploited by the UK and French fleets.

4 Sole in Division VIId (Eastern Channel)

4.1 Current stock status and assessment issues

The assessment model used is XSA. The assessment has been accepted by ICES as an analytic assessment. Overall the quality of the assessment is estimated to be good because there is very little retrospective pattern in fishing mortality, SSB and recruitment, however recruitment estimates in recent years are highly variable impairing the short-term forecast. Based on the most recent estimate of SSB and fishing mortality, ICES classifies the stock as having full reproductive capacity and at risk of being harvested unsustainably. The spawning-stock biomass has been fluctuating around a mean of about 10 000 t since 1982, and is currently above B_{pa} which is currently set at 8000 t. The fishing mortality has decreased since 1999 and has been around F_{pa} since 2001. Recent recruitment has been strong, with the 2001 and 2004 year classes being the two highest of the time-series (1982–2007). The estimates of the incoming year class are entirely based on two surveys, the International Young Fish Survey (YFS) and the UK beam trawl survey (UK-BTS). The International YFS index is a combined French-UK survey index. Since 2007, the UK part of the survey has not been conducted. Therefore the combined index was not used in last years' assessment and may not be available in future. The impact of the missing UK YFS survey data on the assessment was investigated during this bench mark working group (see Section 4.2.3.1.).

4.2 Compilation of available data

4.2.1 Catch/landings data

Data on landings is available since 1982. More detailed information is available in the stock annex.

The landings are taken by three countries: France (50%), Belgium (30%) and England (20%). Age sampling for the period before 1980 was poor, but between 1981 and 1984 quarterly samples were provided by both Belgium and England. Since 1985, quarterly catch and weight-at-age compositions were available from Belgium, France, and England.

Although discard information has been collected since 2003 by all three countries for the major fleets, this information has not been incorporated in the assessment. However, preliminary results suggest that discards are not a substantial part of the catch for this high valued species (around 5% by weight and around 10% by numbers). Therefore, it was concluded that not incorporating discards in the sole VIId assessment is unlikely to have a major impact. Nevertheless, the working group decided that future information on sole discards should be monitored.

4.2.1.1 Evaluation of the quality of the catch data

Black landings are not considered a problem in this stock. Allocation of landings from adjacent areas (VIIe into VIId) has occurred in the past, particularly by UK vessels from ICES rectangle 29E7 into 29E8. Correction for this area misreporting has been taken into account in the assessment.

4.2.2 Biological data

No new biological data were examined during the benchmark working group (more detailed information is available in the stock annex).

4.2.3 Survey tuning data

Relative abundance survey indices available and used in the assessment are the following:

- UK beam trawl survey (UK-BTS)-1988–present, for ages 1 to 6.
- International Young Fish Survey (combined index of UK and French YFS)-1987–2006, for age 1.

Note: Combined index only available until 2006 (since UK-YFS was halted in 2006). French YFS available until present.

4.2.3.1 Evaluation of the quality of the survey data

Two survey indices are available for the assessment: the UK beam trawl survey from 1988 until present and the International YFS (as a combined index) from 1987 until 2006.

As the UK index of the International YFS is not available for 2007 and will not be available for 2008, the Working Group decided to investigate possible consequences for the assessment in future. Since 2002, both indices (UK and FR) have been used in the assessment as a combined index, providing better diagnostics than the indices separately. Single fleet XSA runs for the separate indices reveal worse diagnostics than using the combined series. Retrospective analysis using the combined series and using the UK and French indices as separate series demonstrate very little change in retrospective pattern (Figures 4.2.1 and 4.2.2).

To investigate the impact of missing the UK series in future, an arbitrary five years of the UK series was omitted and the assessment rerun. The retrospective patterns of fishing mortality, SSB and recruitment hardly changed compared with the use of the whole available time-series of the UK index (Figure 4.2.3).

Figure 4.2.4 shows that there is almost no difference between the assessments using two commercial tuning fleets, the UK-BTS survey and (a) the combined YFS index, (b) the separate YFS indices from UK and France and (c) only the French YFS index.

4.2.4 Commercial tuning data

4.2.4.1 Evaluation of the quality of the commercial tuning data

Horse Power correction Belgian Beam trawl tuning fleet

One of the commercial tuning fleets in the assessment is the Belgian beam trawl fleet. The effort is corrected for horse power, based on a study carried out by IMARES and CEFAS in the mid 1990s (no reference available). The study calculated an effort correction for HP applicable to sole and plaice effort in the beam trawls fisheries. The corresponding equations for sole is P = 0.000204 BHP^1.23. This equation was estimated some 20 years ago, when the horse power deployed was substantially less than at present time. Therefore the Working Group decided to investigate a more realistic horse power correction for the Belgian beam trawl fleet.

Objective: to estimate of a conversion factor for horse-power (HP) for the Belgium beam Trawl vessels to convert nominal fishing effort to effective effort.

Data provided: Belgium vessel catch rates as kilograms of sole per hour with year, month, day, and vessel_ID. Data from 1996 to 2006 (9511 records). Preliminary analysis indicated 161 different vessels of which about 44 have HP between [216–225] HP, accounting for about 60% of records, and 117 vessels, most with HP between 500 to

1000 HP (Figure 4.2.5). Belgium scientist indicated that this group of about 221 HP is likely a group that misreporting HP. Thus it was suggested classifying the vessels into 2 classes; class 1 vessel with HP [216–225] HP, and class 0 the rest of the vessels. A plot of the nominal catch rates against HP demonstrates an increasing trend with HP, especially if the class 1 vessels are excluded (Figure 4.2.6 a–b). A plot of log transformed catch rates by year and class vessel also demonstrates an increasing trend with years, but different by vessel class, where class 1 demonstrates a lower overall nominal catch rates (Figure 4.2.7). However the data also demonstrates a wide range on catch rates for all vessels. The increase of HP with year is apparent once the vessel class 1 was excluded (Figure 4.2.8). Thus it is apparent the HP has a potential impact in the sole catch rates and standardization of nominal rates should be done. Sole catch rates were also different by month, indicating a seasonality effect (Figure 4.2.9).

The standardization of the nominal log transformed catch rates was performed using a generalized linear model, including the Year, month, vessel class and HP factors. Year, month and vessel class were treated as class factors, while HP was included as a continuous linear variable. The model fit indicated that all factors were significant (Table 4.2.1). Because the vessel class demonstrated different trends on catch rates, an interaction of HP and vessel class was included in the model. The model fit demonstrated a large residual variability. Plots of nominal catch rates by vessel_ID demonstrates that this variability is mainly among vessels of the same class (Figure 4.2.10). Because not all vessels are operating all years/month combinations, an approach for accounting for this vessel variability is to consider each vessel as a sampling unit and that their catch rates in a year-month are likely to be auto correlated. Therefore a second model was developed, assuming vessel as subject with an autocorrelation (AR-1) variance-covariance matrix. AIC information criteria indicated that this model fitted better the observed data (Table 4.2.2).

Figure 4.2.11 shows the predicted catch rates vs. the nominal ones by vessel class, the model predicted lower catch rates for the class 1 vessel overall. Figure 4.2.12 shows that predicted catch rates by HP, where for the class 1 it effectively remove the effect HP while for the class 0 vessels it predicted a linear increase in catch rates with HP. Table 4.2.3 shows the horse power factor predictions. Table 4.2.4 shows the estimates of fixed effects to the final model standardization cpue rates as function of HP and other variables. Figure 4.2.13 shows a residual diagnostic plot. Figure 4.2.14 shows the distribution studentized residuals.

In conclusion, sole catch rates for the Belgium beam trawlers have increased with increases in HP, once the vessels that misreport HP are accounted for. The model indicates approximately a 0.05 slope increase with HP in 1996–2007. However this is only applicable to vessel of class 0, not for the class 1 vessels clearly. Therefore the estimation of a single conversion factor for HP for the whole fleet is not advisable. Standardization of effort should at least take into account to which vessel class it belongs. And the effects of seasonality within a year (month effect) should be also considered. The proposal is therefore that a standardization of nominal lpue procedure be carry out including the factors mention above and predict catch rates for an lpue index instead of correcting only effort values.

The expected corrected values for standard HP and month/vessel class can be estimated as:

$$LPUE = \beta_0 + \beta_1 Year + \beta_2 Month + \beta_3 VessK + \beta_4 HP + \beta_5 HP * VessK$$

where the β's are the estimated GLM parameters given in Table 4.2.1. The model likelihood estimation is presented below:

Response: lgcpue, Distribution: Normal, Link: Identity, Observations (or Sum Wgts) = 9511

Whole Model Test

Model	-LogLikelihood	L-R ChiSquare	DF	Prob>ChiSq
Difference	1775.03976	3550.080	25	0.0000
Full	8138.08865			
Reduced	9913.12841			

Goodness Of Fit Statistic	ChiSquare	DF	Prob>ChiSq	Overdispersion
Pearson	6165.810	9485	1.0000	0.6483
Deviance	6165.810	9485	1.0000	

Effect Tests

Source	DF	L-R ChiSquare	Prob>ChiSq
Year	11	1728.385	0.0000
Month	11	118.68776	<.0001
HP	1	19.773625	<.0001
VessK	1	18.207051	<.0001
HP*VessK	1	17.61884	<.0001

Attempt to create a French effort series for trammelnets

In recent years, on average half of the landings of sole in VIId were realized by France, predominantly by the trammelnet and demersal trawl fisheries. However, no French commercial tuning data were available for these fisheries up till now. A first attempt to create an effort series for the French trammelnets is presented below.

Tables 4.2.6–4.2.8 give an overview of information available on the French trammelnet fishery in VIId. The absolute information in these tables is reliable from 2002 onwards. It should be noted that the dataset for 2008 is incomplete and therefore not fully comparable with previous years. The percentage of trips where the dimension of the gear is available increases over time, topping at almost 96% in 2007. Nevertheless, the use of the actual information is impossible without some reconstruction of the time-series.

The assumption that the time spent at sea (for trammelnets, time spent at sea equals effort) is proportional to the length of the nets, does not stand (Figure 4.2.15). The reason for this is certainly that Channel harbours are subject to high tides, meaning that vessels may go at sea and come back only during high tides. With that configuration, no relationship can be found between the time spent at sea and the length of the net, thus it is impossible to reconstruct a time-series.

From there, there are several alternatives

- As there are more than 75% of the trips with gear length information, it may be possible to adjust a General Linear Model with harbour, vessel length, year, month and maybe mesh size on the variable net length. If the explained variance is ok, this will constitute the series of effort.
- One might also try to investigate the consistency within vessels to see if the gaps are vessels we don’t know or just trips we don’t know. In the latter

case, it would be easy to fill the gaps with the information of that same vessel's surrounding trips.

In any case, an lpue time-series can be built with the information that is available. There is a risk to be evaluated on any bias if the improvement of the information by time is not random (more and more small vessels report their length nets …).

The lpue calculated by the sum of the landings over area and year divided by the sum of the effort (length of the nets * soaking time [days]) over area and year is given in Table 4.2.9. The unit of the table is kilos-per-km*days [soaking time].

4.2.5 Industry/stakeholder data inputs

No industry/stakeholder data were provided to the flatfish bench mark working group.

4.3 Stock identity and migration issues

The sole in the eastern English Channel (VIId) are considered to represent a separate stock from the larger North Sea stock to the east and the smaller geographically separate stock to the west in VIIe. No new information on stock identity and migration patterns has been provided to the working group. However, the influence of migration between stocks (in this case from the Thames estuary into VIId and the other way around) and their potential influence on the assessment should be investigated. See Stock Annex for more detailed information.

4.4 Spatial changes in the fishery and stock distribution

Effort and landings data by rectangle have only been provided by Belgium (33% of total sole landings) and UK (16% of total sole landings). Unfortunately no rectangle information was available for France (51% of total sole landings).

The Belgian data originates only from beam trawls which accounts for more than 98% of the total Belgian landings. The time-series covers 1996 to 2007. The UK data are available by the following gear categories: beam trawl, gillnets, demersal otter trawl, dredges, pots and driftnets, which account respectively for 49%, 36%, 13%, 1%, 0,4% and 0,1 % of the UK sole landings. The time-series covers 1982 to 2007.

The Belgian spatial effort and landings patterns are very similar for all the years available. Efforts and landings have increased substantially since 2002, although the distribution has not changed remarkably over the years. Although the effort is distributed all over the whole area VIId, there is substantially more effort deployed along the UK coast, particularly in rectangle 30F0 and also in rectangle 29E9. The same pattern is also observed for the landings data (Figure 4.4.1 a–b).

For UK, only the gear categories with the most abundant sole landings are plotted sc. beam trawl (49%), gillnets (36%) and demersal otter trawls (13%).

Effort deployed by the UK beam trawl fleet has been spread over the whole area VIId for most of the time-series. The highest concentrations have been observed along the UK coast and in particularly in rectangle 30F0. UK landings by the beam trawl fleet have also been taken for most of the time-series from all over the area VIId. The highest uptake for 1984, the period 1991–1999 and 2006 was from rectangle 30F0. (Figure 4.4.2 a–b).

Effort deployment by UK gillnet fisheries over the whole time-series is concentrated over the UK coast. Since 2007, the effort in rectangles 30E8 and 30F0 was substantially higher than for the rest of the time-series. The landings are also taken from the rectangles along the UK coast where rectangle 30F0 has the highest abundances over the whole time-series. (Figure 4.4.3 a–b).

Effort by the UK otter trawl fleet has been deployed from 1982 to 1987 mostly along the UK coast, with the highest concentrations in rectangle 30F0. Since 1988, effort has also being deployed further south up to 50° N. For 1988 to 2005, no particularly high effort deployment was noticed in rectangle 30F0. However since 2006, again higher effort concentrations have been observed in this rectangle. The landings pattern of the UK demersal otter trawl fleet is very similar to the effort pattern apart that the landings form rectangle 30F0 is far dominant of the whole time-series compared with the other rectangles. (Figure 4.4.4 a–b).

4.5 Environmental drivers of stock dynamics

Vaz *et.al.*, 2007 concluded that four sub-communities in relation to depth, salinity, temperature, seabed, shear stress, sediment type and benthic community nature could be assumed. The community relationship with its environment was remarkably stable over the 17 years of observation (see stock annex for more details). No new information was available to the Benchmark Working Group.

4.6 Role of multispecies interactions

No evaluations of multispecies interactions have been carried out at the Benchmark Working Group.

4.7 Impacts on the ecosystems

The increasing concern about the ecosystem effects of fishing on the marine environment and particularly, the impact of trawling on benthic communities is reflected in numerous publications. The weight of this concern will very likely only increase in management decisions in the near future. Beam trawling has a negative reputation with regard to discarding and seabed impact and may be confronted with further constraints imposed by the fisheries management.

The fishing industry has, however, the opportunity to anticipate management decisions and to adopt improved fishing gears, i.e. with reduced discarding and reduced environmental impact. A proactive attitude and a voluntary uptake of improved gears allow the industry to shape the alterations to the specific conditions of the fishery and the fishing grounds.

For the chain matrix beam trawl, many studies have been carried out on a wide variety of technical alterations to the beam trawl to improve the length and species selectivity, to reduce ecosystem effects and to reduce fuel consumption. The ILVO-Fishery institute has carried out many of these experiments and has recently been testing and promoting a combination of successful alterations. The improved trawl has been called the "alternative beam trawl" and has already been commercially tested for two years on a beam trawler. It consists of a number of simple and cheap alterations to the beam trawl.

A compilation report was made by ILVO (Depestele *et al.*, 2008) of the most successful technical alterations for the beam trawl. The alternative beam trawl is not strictly defined and can consist of any combination of selective devices presented in this report or even new devices that prove to be successful. The basic idea is that each device that has undergone scientific scrutiny can be further developed by the industry in close cooperation with the fishery institute.

The table (Table 4.7.1) below gives an overview of the devices tested with a sketchy indication of their effects.

Table 4.7.1: overview of the devices tested with a sketchy indication of their effects.

	Roller gear	Cut-away top panel	Square mesh top panel	Benthos release panel	T-90 codend	Square mesh codend
Commercial flatfish catch	o	o	-	-	+	+
Commercial roundfish catch	o	---	---	o	-	-
Discards comm. fish <MLS	o	--	--	o	---	---
Discards non-comm. catch	o	o	o	---	---	---
Fuel consumption	-	-	-	o	o	o

+ = increase, - = decrease, 0 = no change.

Other devices like a narrow codend, a tunnel in square meshes, selective electric stimulation in the trawl, etc. are being tested by ILVO-Fishery. At present, though, sufficient effective selective devices are available to construct an alternative beam trawl with a significantly reduced environmental impact.

4.8 Stock assessment methods

4.8.1 Models

The assessment model used for sole in Division VIId (Eastern Channel) is XSA. No new models have been investigated during this Benchmark Working Group.

4.9 Stock assessment

Apart from investigations on disaggregated tuning indices (UK and French YFS indices-see Section 4.2.3.) no new data inputs were introduced in the stock assessment during this Benchmark Working Group.

4.10 Recruitment estimation

No new information was available.

4.11 Short term and medium term forecast

If the estimates of the two surveys (UK-BTS and French YFS) diverts substantially in estimating the year class strength, it may be considered to replace the final estimates by GM.

4.12 Biological reference points

The biological reference points for sole in division VIId are:

Bpa	Fpa	Flim
8000 t	0.4	0.55

The rationale behind these reference points is described in the Stock Annex. No alternative values were proposed by this Benchmark Working Group.

4.13 Recommended modifications to the stock annex

Influence of missing UK Young Fish Survey indices

In the absence of any update of the UK component of the YFS index the available time-series of the UK component should still be used in the assessment. Next to this series, the French component of the YFS index should also be used.

Horsepower correction for commercial tuning series

The horsepower correction for the commercial Belgian beam trawl fleet should still be applied as documented in the Stock Annex. However, if a new corrected effort series is available (see Section 4.2.4.1) it should be used under condition that they are reviewed and approved by ICES.

4.14 Recommendations on the procedure for assessment updates

Availability of French tuning series

There is no tuning information available from the French commercial fleets, accounting for about 50% of the sole landings in Area VIId.

The Working Group highly recommends that effort should be conducted to make data available for stock assessors to construct tuning series for these fisheries. Attempts have been made during this Benchmark Working Group to calculate an effort series for the French gillnet fishery which is responsible for about 25% of the sole landings in Area VIId (see Section 4.2.4.1 b).

Influence of missing UK Young Fish Survey indices

The UK component of the YFS index is not available for 2007 and 2008, resulting in the unavailability of the combined YFS-index. This combined index has been estimating the incoming year-class strength very consistently, hereby providing reliable estimates to the forecasts. Although results of using the YFS indices separately (YFS-France for 1987-present and YFS-UK for 1987–2006) did not display apparent changes in retrospective patterns for fishing mortality and SSB, recruitment estimates in recent years are highly variable impairing the short-term forecast.

The Working Group therefore recommends (1) that the UK survey should continue and (2) that the French YFS continues to be included in the assessment.

Horsepower correction for commercial tuning series

Investigations of a possible horse power correction for the Belgian beam trawl fleet indicate that a more realistic approach could be implemented.

The Working Group therefore recommends that the effort series for the Belgian beam trawl fleet should be recalculated and the XSA-diagnostics evaluated (see Section 4.2.4.1 a) before the next update assessment.

Spatial distribution of effort and landings

Information on spatial distribution of effort and landings was only available from the Belgian and the UK fleets. This only comprises around 50% of the total sole landings in Area VIId.

The Working Group recommends that, where possible, spatial distribution of effort and landings from the major fleets should be provided, and notes that this information could be incorporated into future tuning series.

Discards

The Working Group recognizes that the discards are not a substantial part of the catch for this highly valued species (around 5% by weight and around 10% by numbers). However there is still a need for age aggregated discard information for possible use in the assessment.

The Working Group therefore recommends that this information should be provided to the WGNSSK as soon as possible for the major fleets involved in the sole fisheries in Area VIId.

4.15 Industry supplied data

No data were provided by the industry on sole in Division VIId to the Benchmark Working Group.

4.16 References

Depestele, J., Polet, H., Van Craeynest, K. and Vandendriessche, S., 2008. A compilation of length and species selectivity improving alterations to beam trawls. Project report. Project no. VIS/07/B/04/DIV. Study carried out with the Financial support of the Flemish Community, the European Commission (FIOV) and Stichting Duurzame Visserijontwikkeling vzw. Promotor: Stichting Duurzame Visserijontwikkeling vzw. 56p.

Vaz *et al.*, 2007, Modelling Fish Habitat Suitability in the Eastern English Channel. Application to community habitat level. ICES CM 2004/ P:26.

Table 4.2.1. Sole in VIId. Fit model 1 results for standardization of log-transformed lpue of sole for the Belgium Beam trawl dataseries.

Effect	Year	Month	VessK	Estimate	StdErr
Intercept				-7.92141	3.213055
Year	1996			-0.7816	0.058183
Year	1997			-0.73195	0.050753
Year	1998			-1.03521	0.061101
Year	1999			-0.90257	0.058831
Year	2000			-0.70132	0.054266
Year	2001			-0.61682	0.050044
Year	2002			-0.56574	0.046801
Year	2003			-0.0949	0.043024
Year	2004			0.149689	0.042921
Year	2005			-0.05885	0.044485
Year	2006			-0.00068	0.043323
Year	2007			0	
Month		1		0.026013	0.034375
Month		2		0.071439	0.036496
Month		3		0.183559	0.036241
Month		4		0.218803	0.040038
Month		5		0.103676	0.050144
Month		6		-0.04503	0.053856
Month		7		-0.03488	0.053832
Month		8		-0.08827	0.051444
Month		9		-0.05114	0.048769
Month		10		0.066964	0.046492
Month		11		0.088353	0.039382
Month		12		0	
VessK			0	10.3228	3.213207
VessK			1	0	
HP				0.049091	0.014572
HP*VessK			0	-0.0477	0.014572
HP*VessK			1	0	

Table 4.2.2. Sole in VIId. Comparison of AIC criteria for the models of catch rates as function of year, month, HP and vessel class. Model 1 includes only fix factors assuming independence of observations. Model 2 assumes Vessel as unit subject (A repetitive measurements model) with an autoregressive (1) variance covariance matrix, that assumes a higher correlation between consecutive observations for a given vessel ID unit.

	Model 1	Vess ID AR(1)
-2 Res Log Likelihood	23015.5	22379.8
AIC (smaller is better)	23017.5	22383.8
AICC (smaller is better)	23017.5	22383.8
BIC (smaller is better)	23024.7	22390.0

Table 4.2.3. Sole in VIId. HP factor predictions.

Effect	VessK	Est	Std Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
VessK	0	2.657	0.033	157	80.933	0.0001	0.05	2.592	2.722
VessK	1	14.794	3.649	157	4.05418	0.0001	0.05	7.586	22.002

Table 4.2.4. Sole in VIId. Estimates of LSMeans for the fixed factors year, month, and vessel class.

Effect	Year	Month	VessK	Est	Std Error	DF	t Value	Pr > |t|	Alpha	Lower	Upper
Year	1996			8.389	1.8255	769	4.596	0.0001	0.05	4.805	11.972
Year	1997			8.438	1.8252	769	4.623	0.0001	0.05	4.855	12.021
Year	1998			8.135	1.8254	769	4.457	0.0001	0.05	4.552	11.719
Year	1999			8.268	1.8262	769	4.527	0.0001	0.05	4.683	11.853
Year	2000			8.469	1.8246	769	4.642	0.0001	0.05	4.887	12.051
Year	2001			8.553	1.8245	769	4.688	0.0001	0.05	4.972	12.135
Year	2002			8.605	1.8245	769	4.716	0.0001	0.05	5.023	12.186
Year	2003			9.075	1.8247	769	4.974	0.0001	0.05	5.493	12.658
Year	2004			9.320	1.8242	769	5.109	0.0001	0.05	5.739	12.901
Year	2005			9.111	1.8252	769	4.992	0.0001	0.05	5.529	12.694
Year	2006			9.170	1.8253	769	5.024	0.0001	0.05	5.586	12.753
Year	2007			9.170	1.8250	769	5.025	0.0001	0.05	5.588	12.753
Month		1		8.706	1.8245	1007	4.772	0.0001	0.05	5.126	12.287
Month		2		8.752	1.8248	1007	4.796	0.0001	0.05	5.171	12.333
Month		3		8.864	1.8247	1007	4.858	0.0001	0.05	5.283	12.445
Month		4		8.899	1.8251	1007	4.876	0.0001	0.05	5.318	12.481
Month		5		8.784	1.8252	1007	4.813	0.0001	0.05	5.202	12.366
Month		6		8.635	1.8243	1007	4.734	0.0001	0.05	5.055	12.215
Month		7		8.645	1.8261	1007	4.735	0.0001	0.05	5.062	12.229
Month		8		8.592	1.8265	1007	4.704	0.0001	0.05	5.008	12.176
Month		9		8.629	1.8254	1007	4.727	0.0001	0.05	5.047	12.211
Month		10		8.747	1.8240	1007	4.796	0.0001	0.05	5.168	12.327
Month		11		8.769	1.8245	1007	4.806	0.0001	0.05	5.188	12.349
Month		12		8.680	1.8243	1007	4.758	0.0001	0.05	5.100	12.260
VessK			0	2.657	0.0328	157	80.933	0.0001	0.05	2.592	2.722
VessK			1	14.794	3.6491	157	4.054	0.0001	0.05	7.586	22.002

Table 4.2.5. Sole in VIId. Estimates of fixed effects final model standardization cpue rates as function of HP and other variables. Model include vessel ID as subject and AR(1) variance-covariance matrix structure.

Effect	Year	Month	VessK	Est	Std Err	DF	tValue	Probt	Alpha	Lower	Upper
Intercept				-7.921	3.213	157	-2.47	0.015	0.05	-14.3	-1.6
Year	1996			-0.781	0.058	769	-13.43	0.001	0.05	-0.9	-0.7
Year	1997			-0.731	0.050	769	-14.42	0.001	0.05	-0.8	-0.6
Year	1998			-1.035	0.061	769	-16.94	0.001	0.05	-1.2	-0.9
Year	1999			-0.902	0.058	769	-15.34	0.001	0.05	-1.0	-0.8
Year	2000			-0.701	0.054	769	-12.92	0.001	0.05	-0.8	-0.6
Year	2001			-0.616	0.050	769	-12.33	0.001	0.05	-0.7	-0.5
Year	2002			-0.565	0.046	769	-12.09	0.001	0.05	-0.7	-0.5
Year	2003			-0.094	0.043	769	-2.21	0.028	0.05	-0.2	0.0
Year	2004			0.149	0.042	769	3.49	0.001	0.05	0.1	0.2
Year	2005			-0.055	0.044	769	-1.32	0.186	0.05	-0.1	0.0
Year	2006			-0.0007	0.043	769	-0.02	0.988	0.05	-0.1	0.1
Year	2007			0							
Month		1		0.026	0.034	1007	0.76	0.449	0.05	0.0	0.1
Month		2		0.071	0.036	1007	1.96	0.051	0.05	0.0	0.1
Month		3		0.184	0.036	1007	5.06	0.001	0.05	0.1	0.3
Month		4		0.219	0.040	1007	5.46	0.001	0.05	0.1	0.3
Month		5		0.104	0.050	1007	2.07	0.039	0.05	0.0	0.2
Month		6		-0.045	0.053	1007	-0.84	0.403	0.05	-0.2	0.1
Month		7		-0.035	0.053	1007	-0.65	0.517	0.05	-0.1	0.1
Month		8		-0.088	0.051	1007	-1.72	0.087	0.05	-0.2	0.0
Month		9		-0.051	0.048	1007	-1.05	0.295	0.05	-0.1	0.0
Month		10		0.067	0.046	1007	1.44	0.150	0.05	0.0	0.2
Month		11		0.088	0.039	1007	2.24	0.025	0.05	0.0	0.2
Month		12		0							
VessK			0	10.323	3.213	157	3.21	0.002	0.05	4.0	16.7
VessK			1	0							
HP				0.049	0.014	157	3.37	0.001	0.05	0.0	0.1
HP*VessK			0	-0.048	0.014	157	-3.27	0.001	0.05	-0.1	0.0
HP*VessK			1	0							

Table 4.2.6. Sole in VIId. Number of trips using trammelnets.

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1329	2292	8328	14 026	14 936	15 020	16 448	15 804	15 834	4383

Table 4.2.7. Sole in VIId. Number of trips with dimensions of the gear available.

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
861	1606	5792	10 235	11 479	11 979	13 306	14 566	15 181	3876

Table 4.2.8. Sole in VIId. Percentage of trips with dimensions of the gear available.

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
64,8%	70,1%	69,5%	73,0%	76,9%	79,8%	80,9%	92,2%	95,9%	88,4%

Table 4.2.9. Sole in VIId. Lpue (kilos per km*day) for the French trammelnet fishery in VIId.

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
16.65	19.44	18.54	20.84	21.86	18.51	18.09	19.40	20.57	

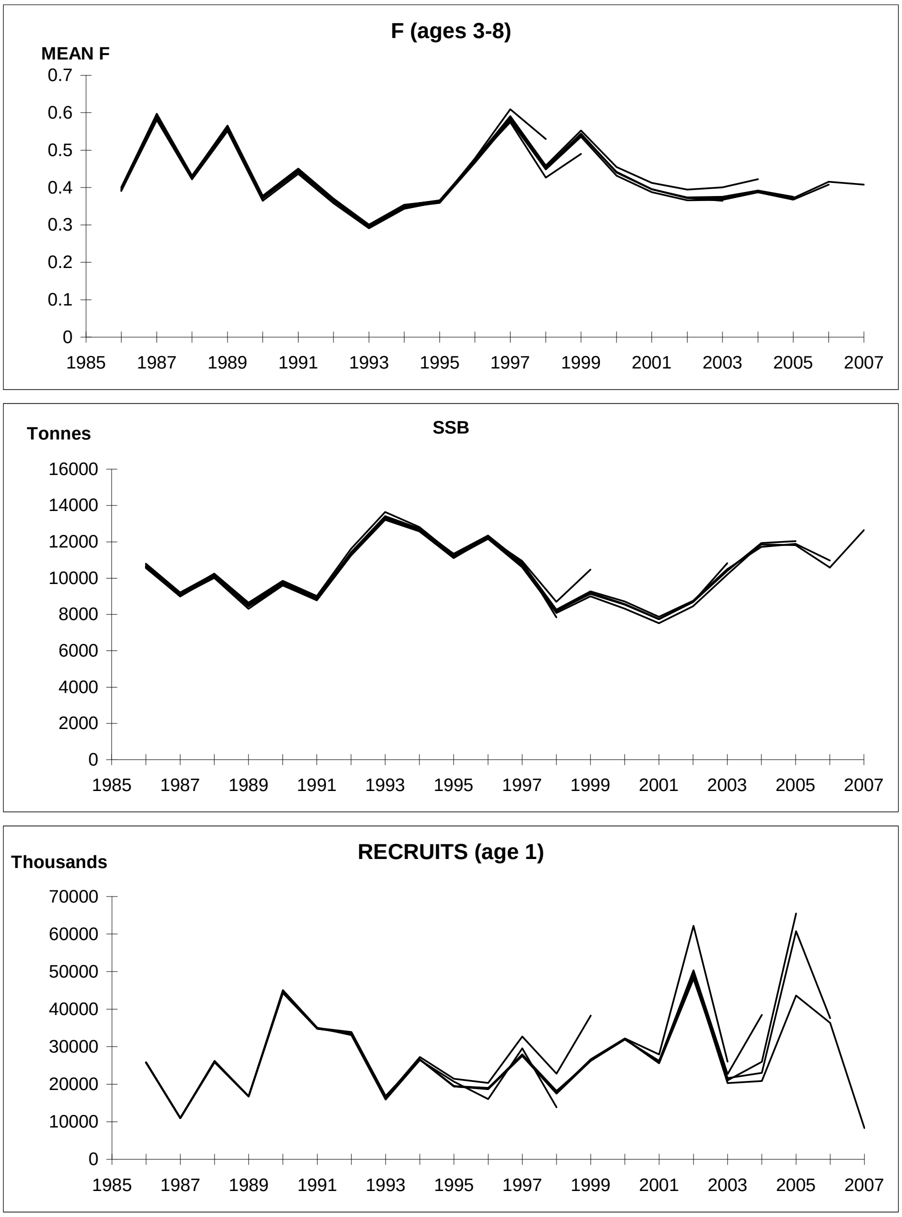


Figure 4.2.1. Sole in VIId. retrospective XSA analysis (shrinkage SE=2.0). Two Commercial fleets + UK-BTS survey + Combined YFS.

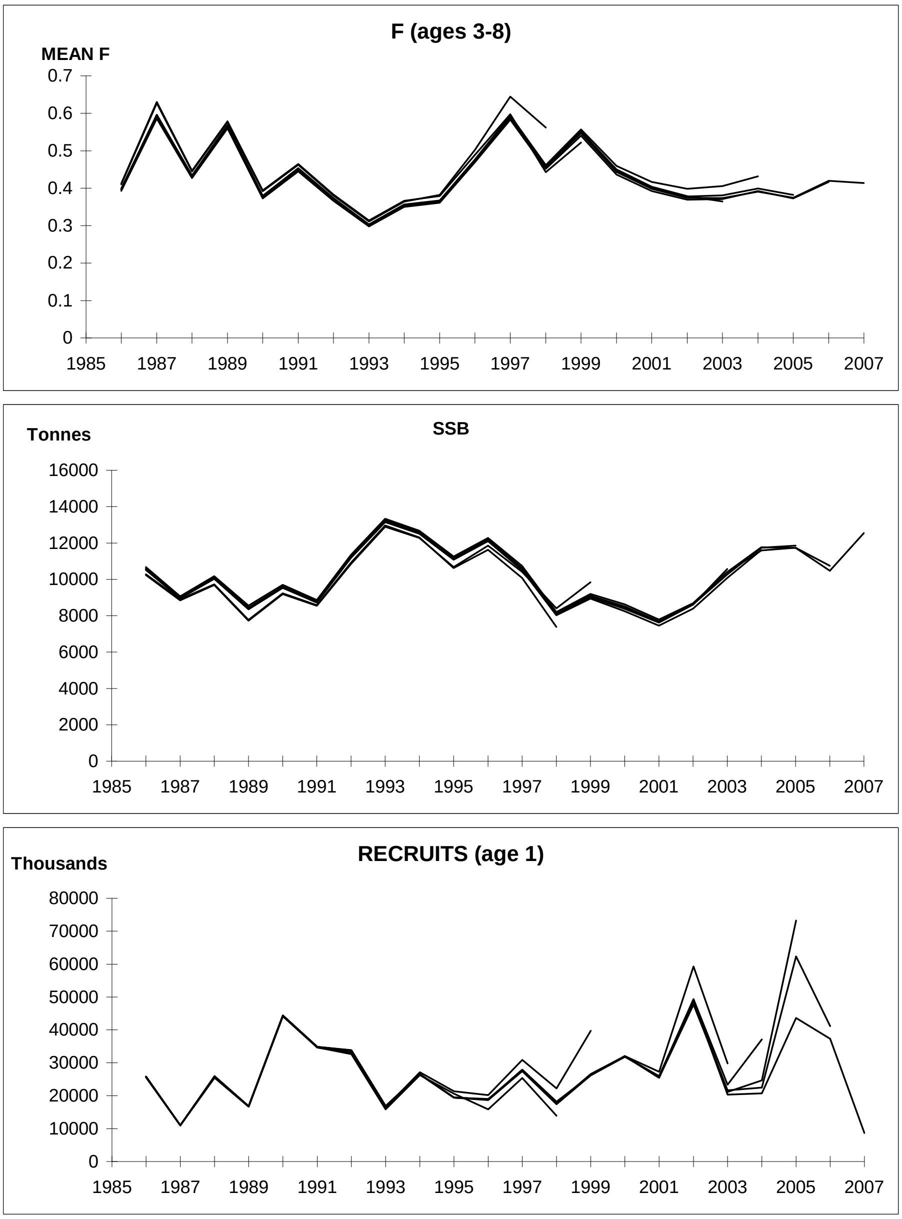


Figure 4.2.2. Sole in VIId. Retrospective XSA analysis (shrinkage SE=2.0). Two Commercial fleets + UK-BTS survey + FR-YFS + UK-YFS.

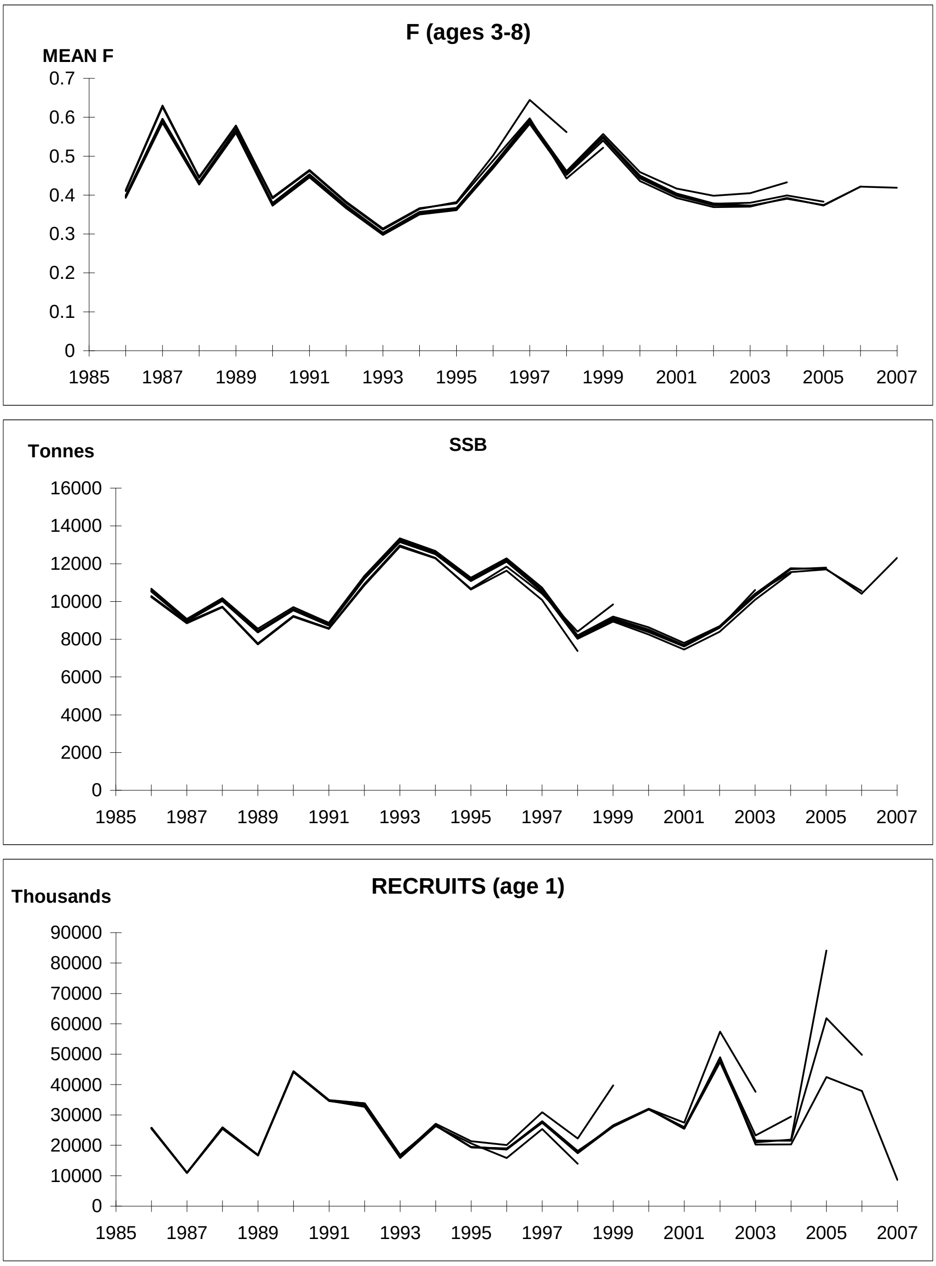


Figure 4.2.3. Sole in VIId. Retrospective XSA analysis (shrinkage SE=2.0) - All - min 5Y 2 Commercial fleets + UK-BTS survey + FR-YFS + UK-YFS (minimum 5 years).

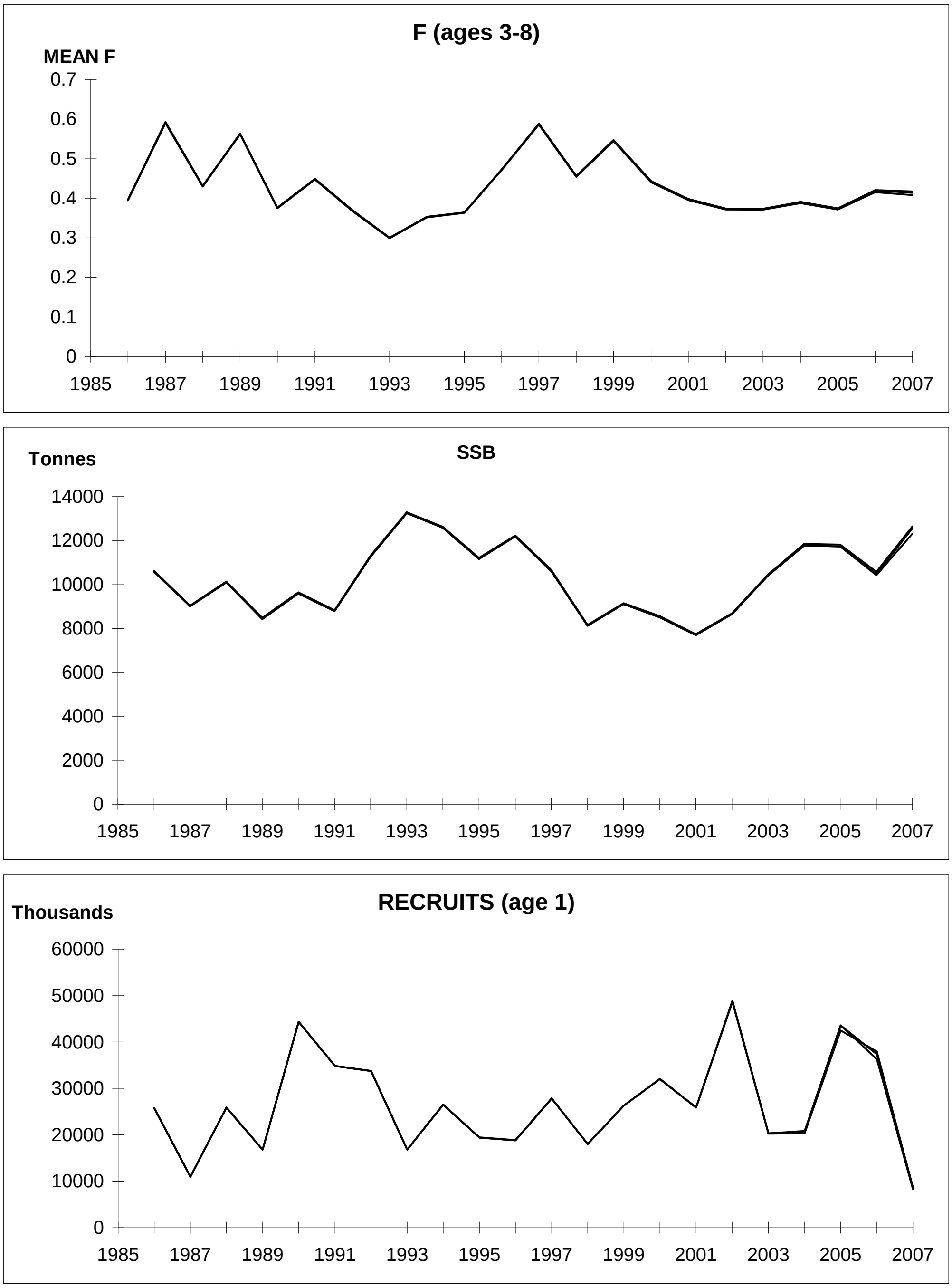


Figure 4.2.4. Sole in VIId. Retrospective XSA analysis (shrinkage SE=2.0).

Series a) 2 Commercial fleets + UK-BTS survey + YFS combined

Series b) 2 Commercial fleets + UK-BTS survey + FR-YFS + UK-YFS

Series c) 2 Commercial fleets + UK-BTS survey + FR-YFS

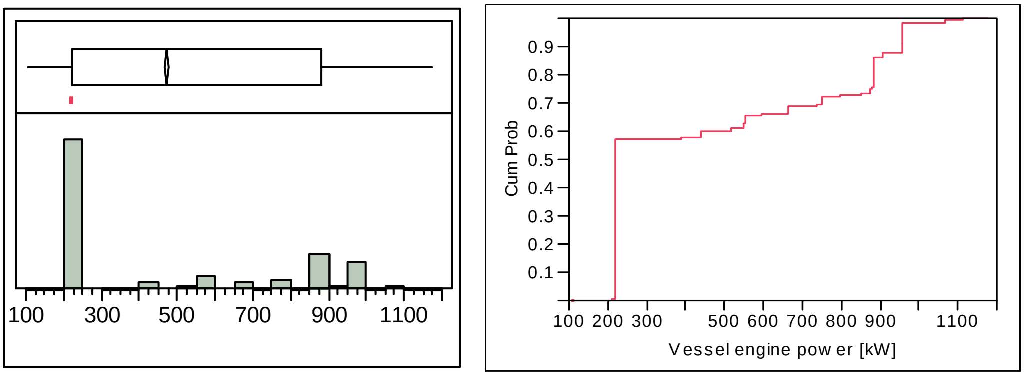
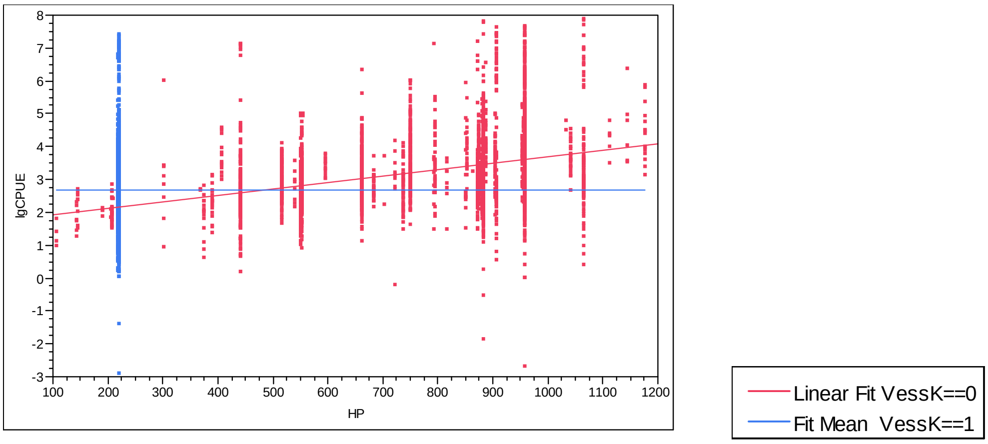


Figure 4.2.5. Sole in VIId. Distribution and cumulative density plot of HP for the Belgium beam trawl vessels lpue of sole from 1996 to 2007.



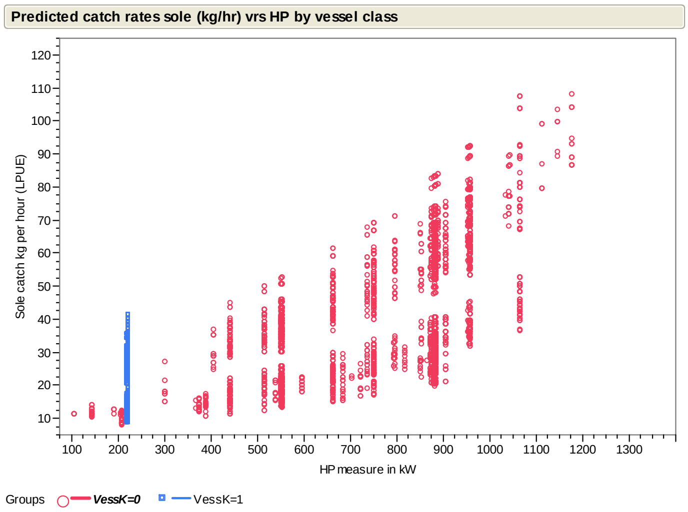


Figure 4.2.6. Sole in VIId Top panel: Nominal sole catch rate (Kg/h) against HP by vessels grouped into class 1 [216–224 HP] (blue) and class 0 all other vessels (red). Linear fit for lgcpue vr HP class 0 vessels, and mean lgcpue vessels class 1. Bottom panel: Nominal sole catch rate (Kg/h) against HP by vessels grouped into class 1 [216–224 HP] (blue) and class 0 all other vessels (red). Linear fit for lgcpue vr HP class 0 vessels, and mean lgcpue vessels class 1.

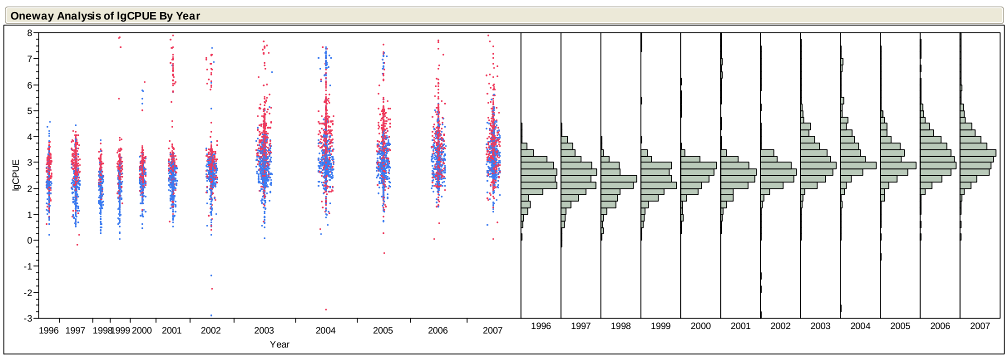


Figure 4.2.7. Sole in VIId. Nominal sole lpue (Kg/h) by year and vessel class. Blue dots represent class 1 vessels and red dots class 0 vessels.

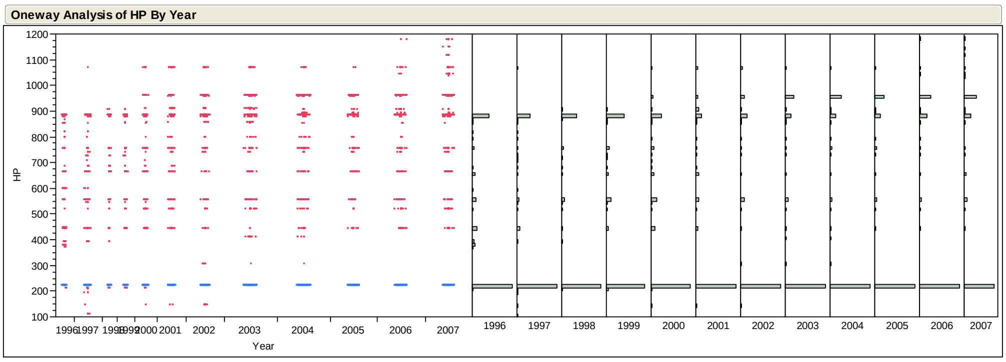


Figure 4.2.8. Sole in VIId. Distribution of HP by year and vessel class, blue dots represent class 1, red dots class 0.

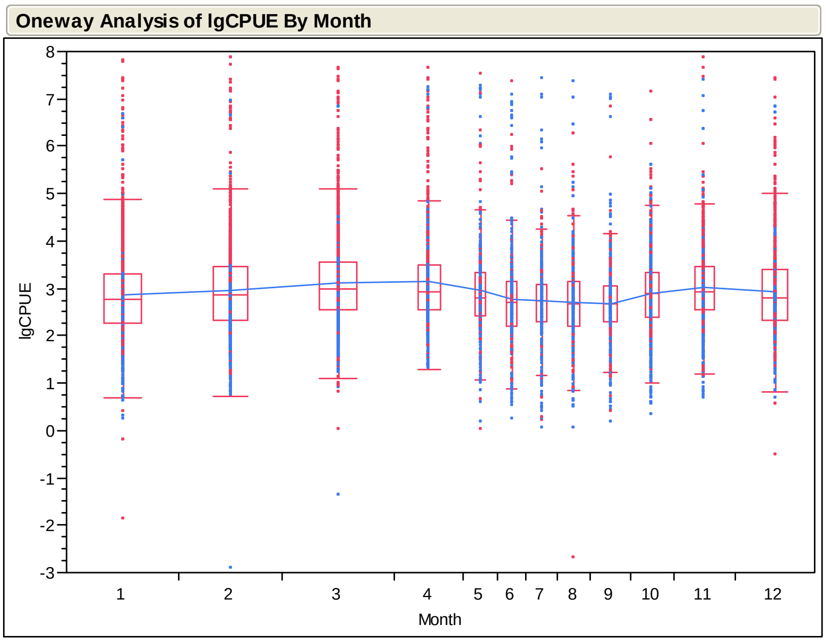


Figure 4.2.9. Sole in VIId. Nominal log transform catch rates of sole by month and vessel class.

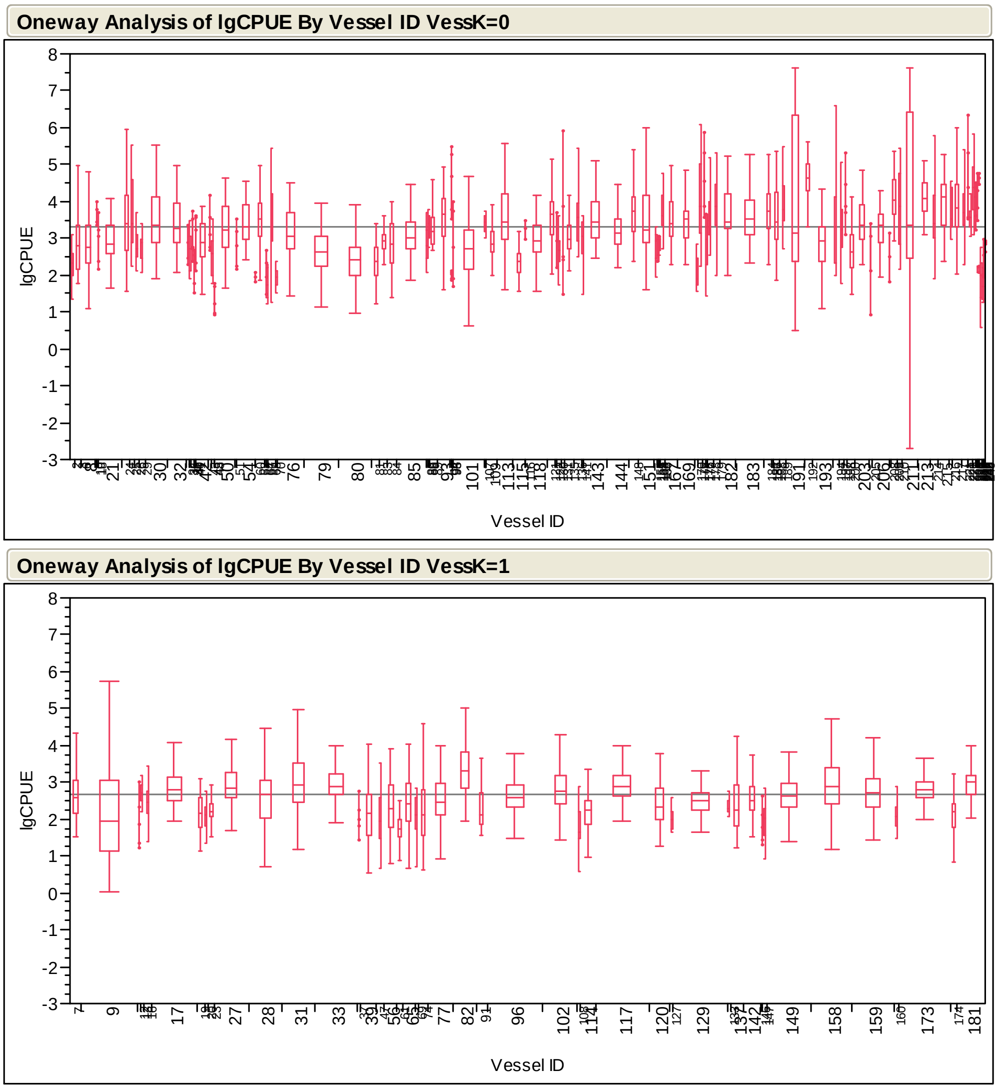


Figure 4.2.10. Sole in VIId. Nominal lpue rates per vessel by vessel class (1) [215–226 HP], and class 0 all others.

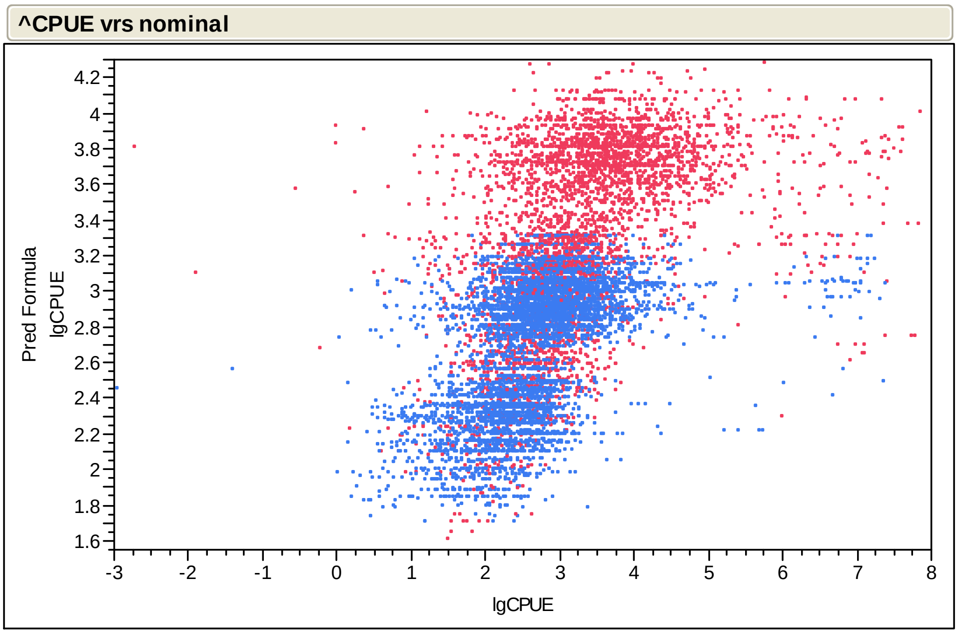


Figure 4.2.11. Sole in VIId. Plot of the predicted sole log transform lpue vs. the nominal rates by vessel class. Blue dots represent vessels class 1, red dots vessels class 0.

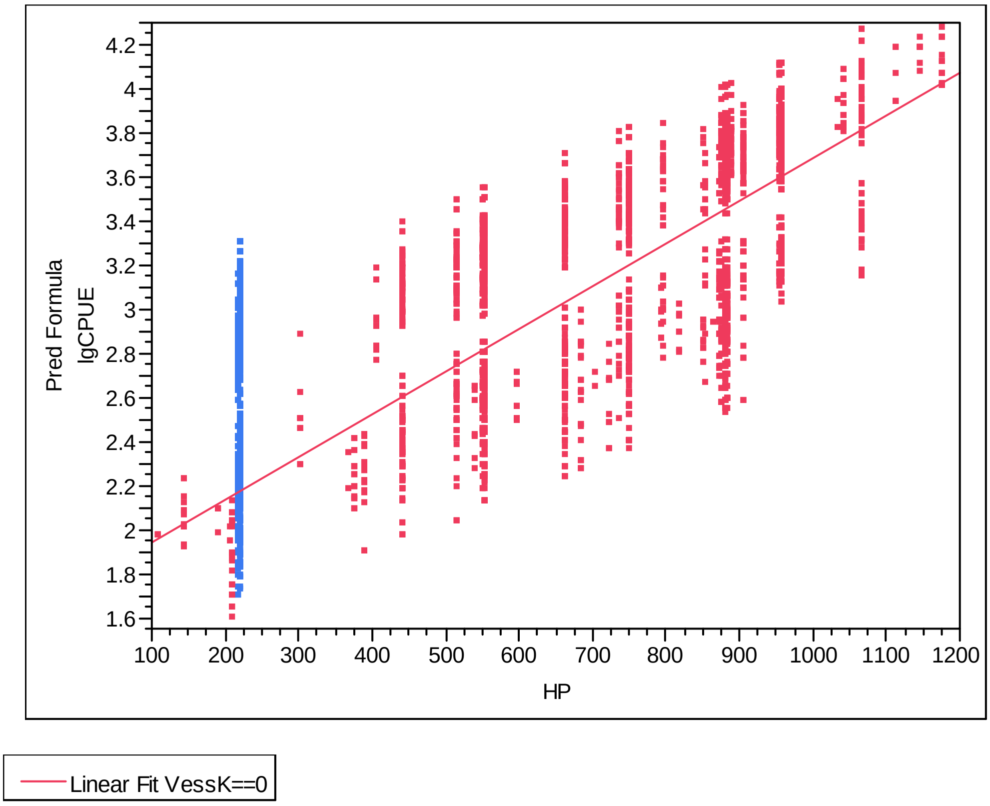


Figure 4.2.12. Sole in VIId. Standardized log-lpue rates for sole from the Belgium beam trawl fishery vs. the HP of the vessel by vessel class.

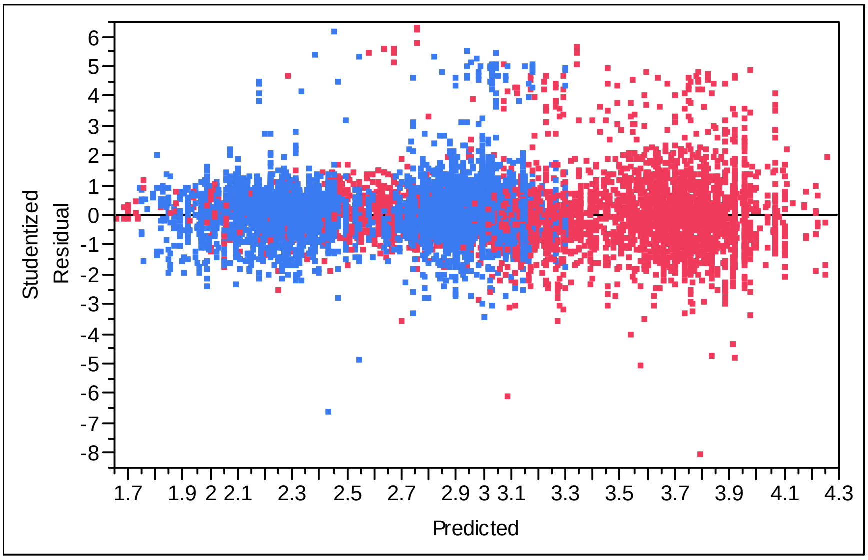


Figure 4.2.13. Sole in VIId. Diagnostic plot, studentized residuals by predicted and vessel class.

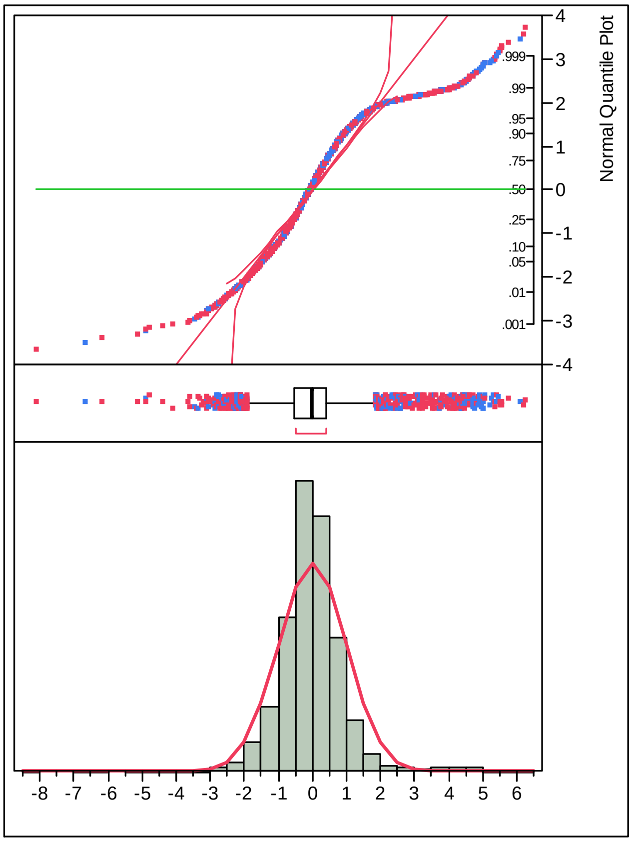


Figure 4.2.14. Sole in VIId. Distribution of studentized residuals.

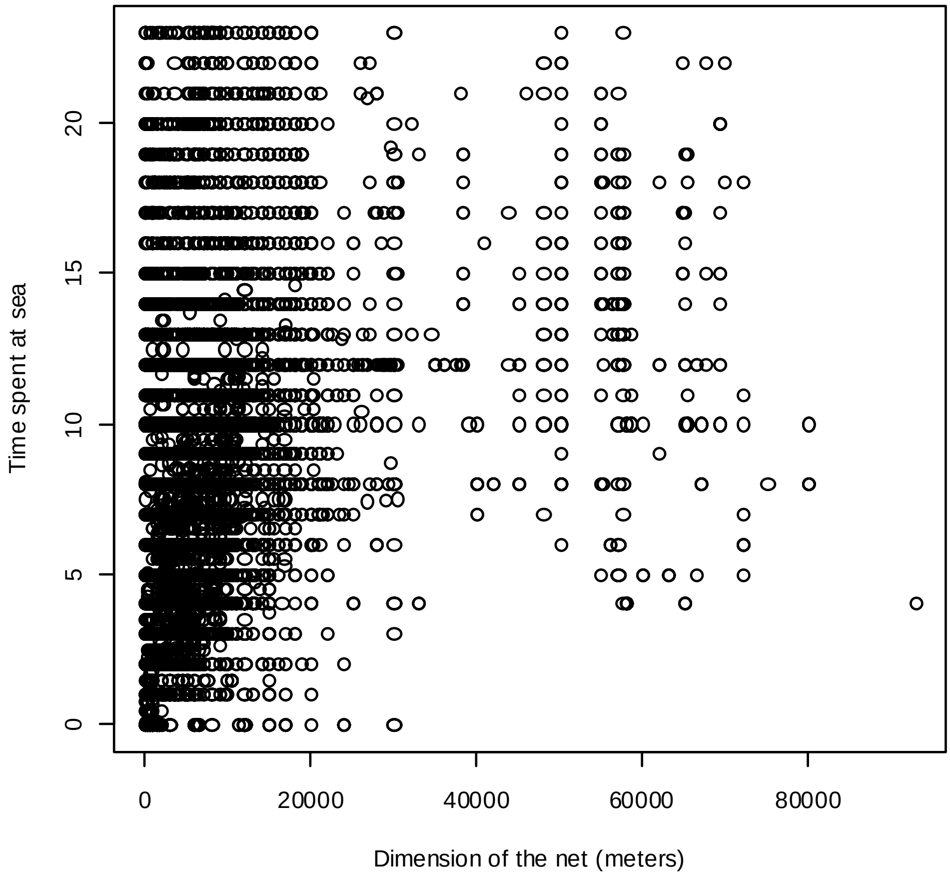


Figure 4.2.15. Sole inVIId. Scatterplot of time spent at sea vs. length of the nets for the French trammelnet fishery in VIId.

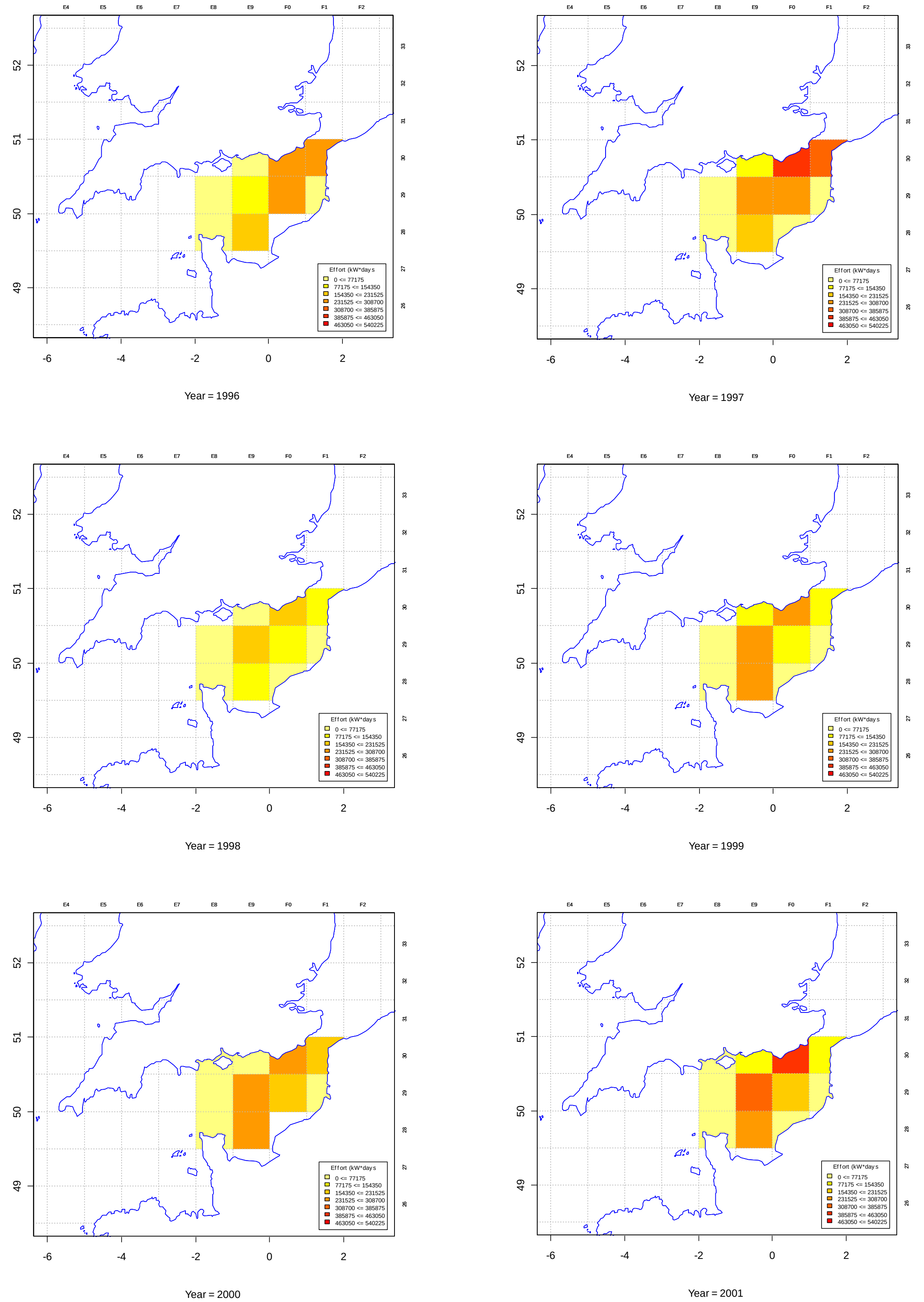


Figure 4.4.1 a) Spatial distribution of Belgian beam trawl effort.

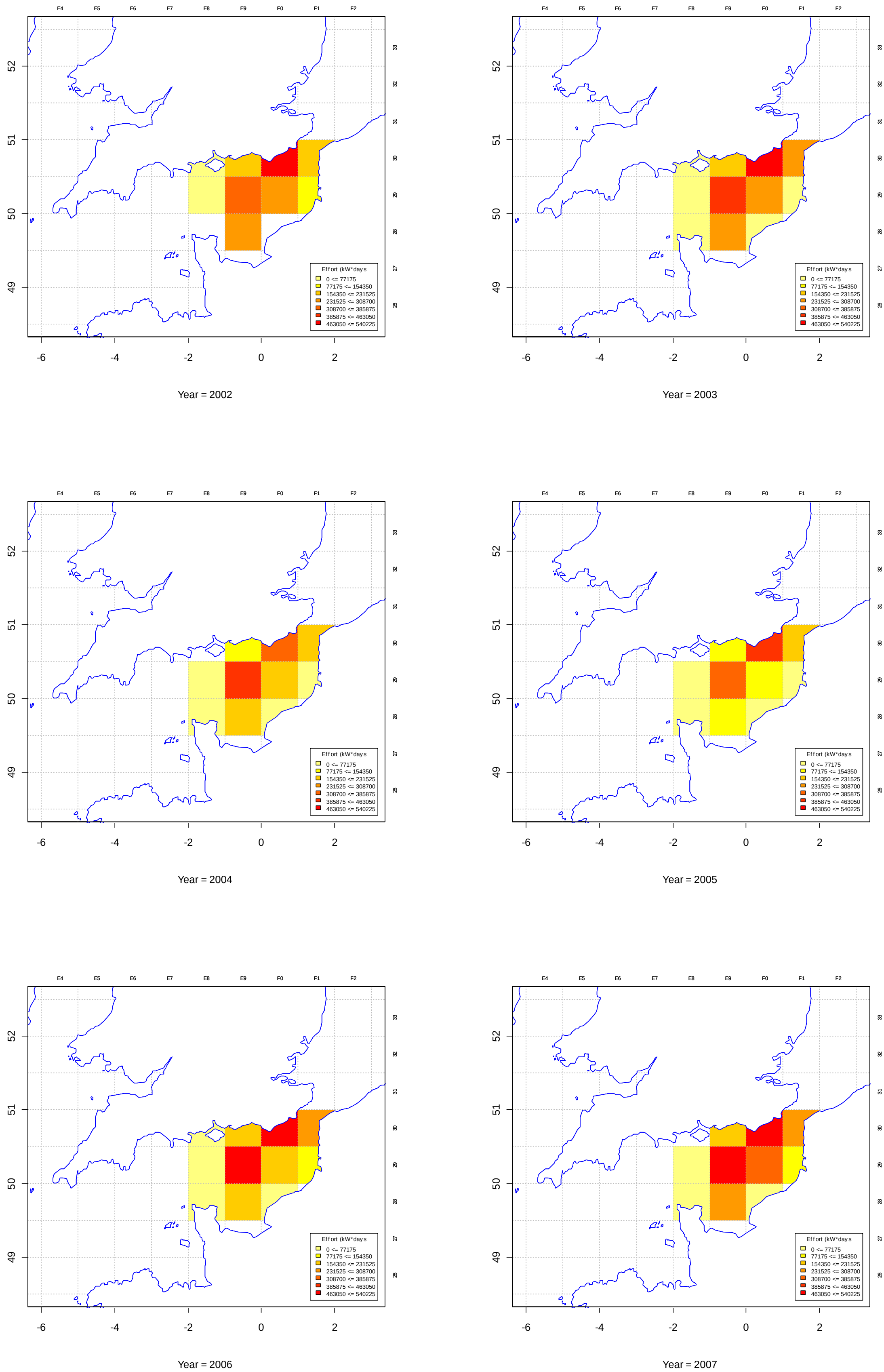


Figure 4.4.1 a) Spatial distribution of Belgian beam trawl effort, continued.

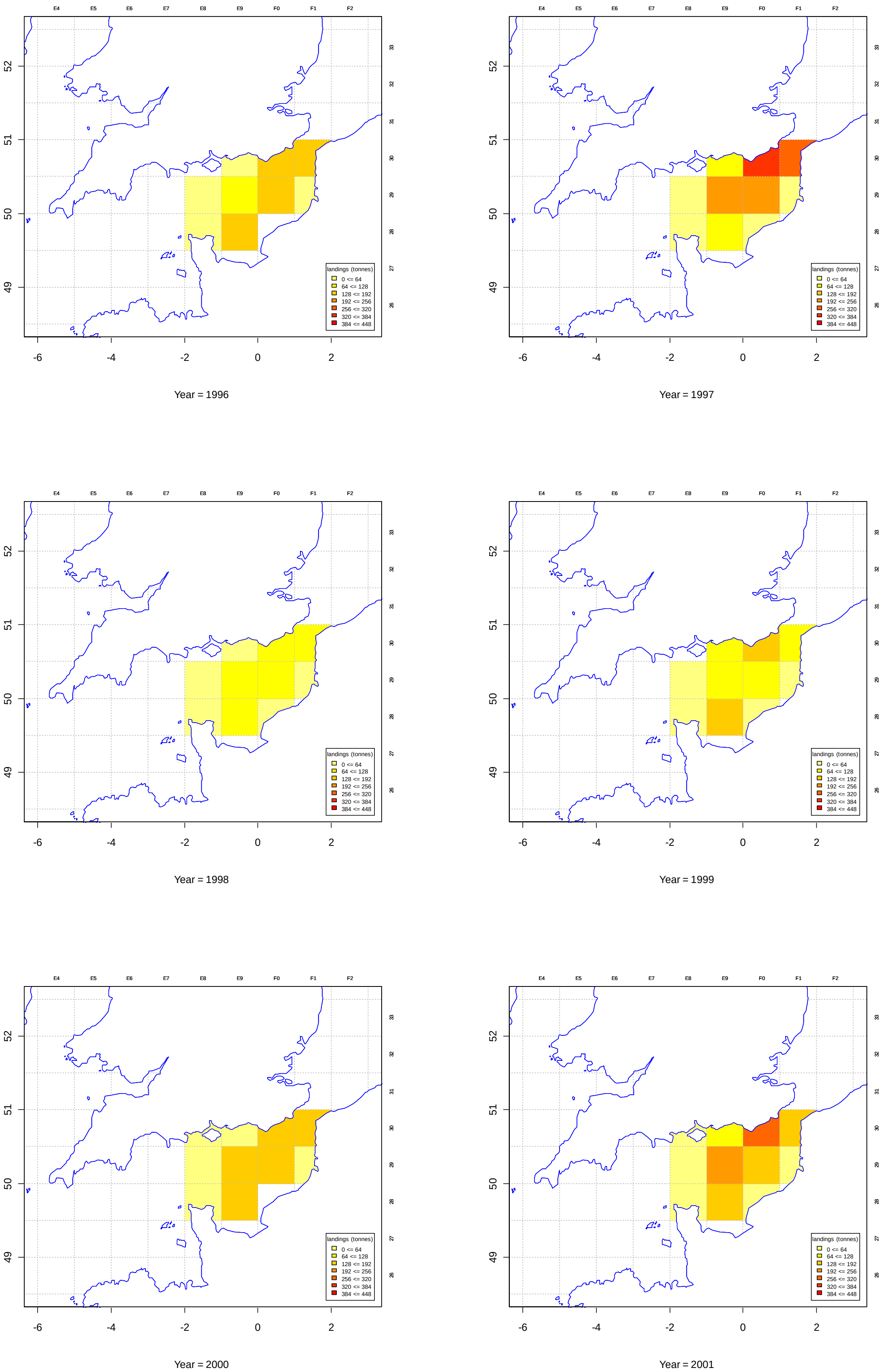


Figure 4.4.1 b) Spatial distribution of Belgian beam trawl landings.

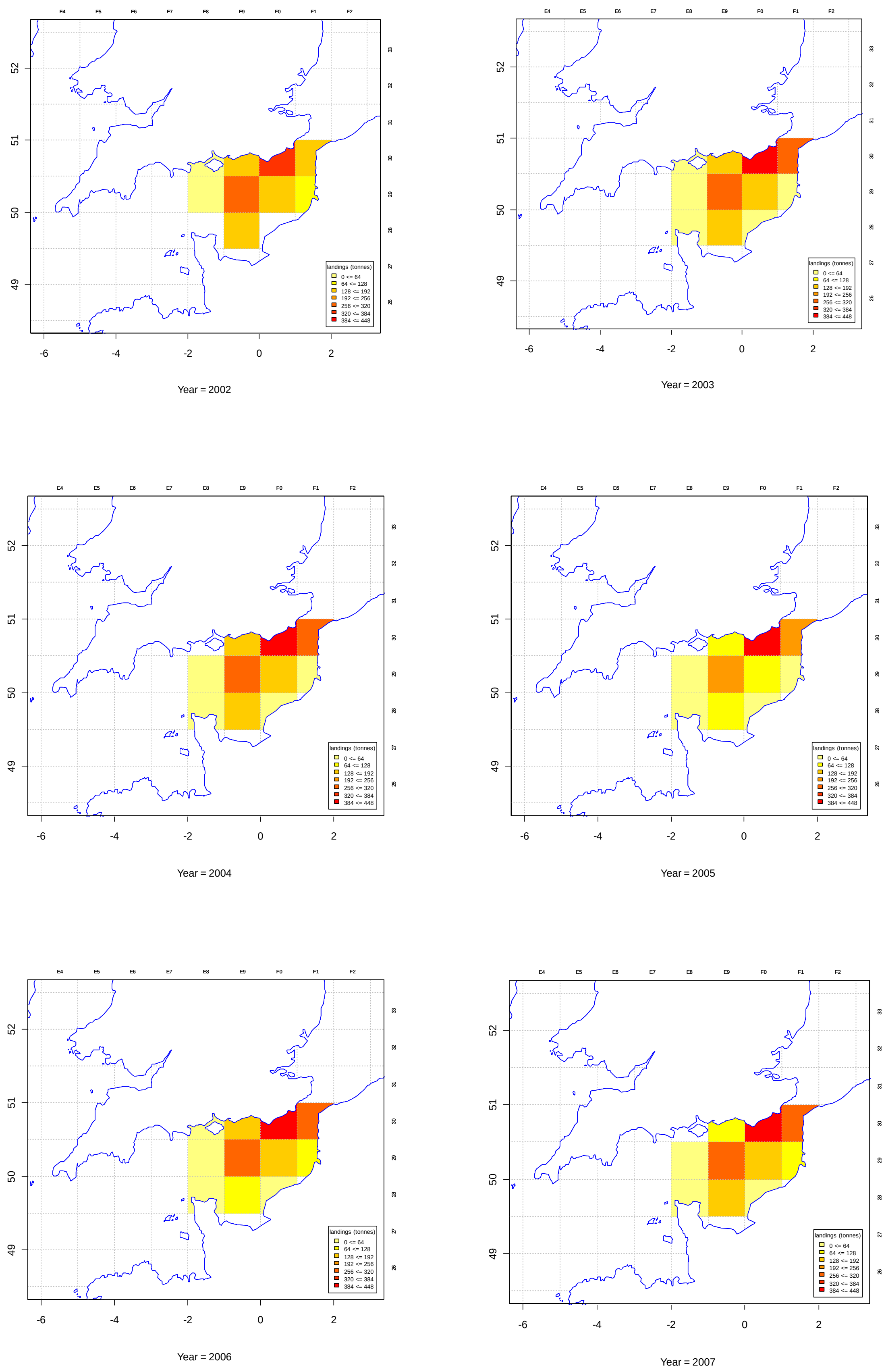


Figure 4.4.1 b) Spatial distribution of Belgian beam trawl landings, continued.

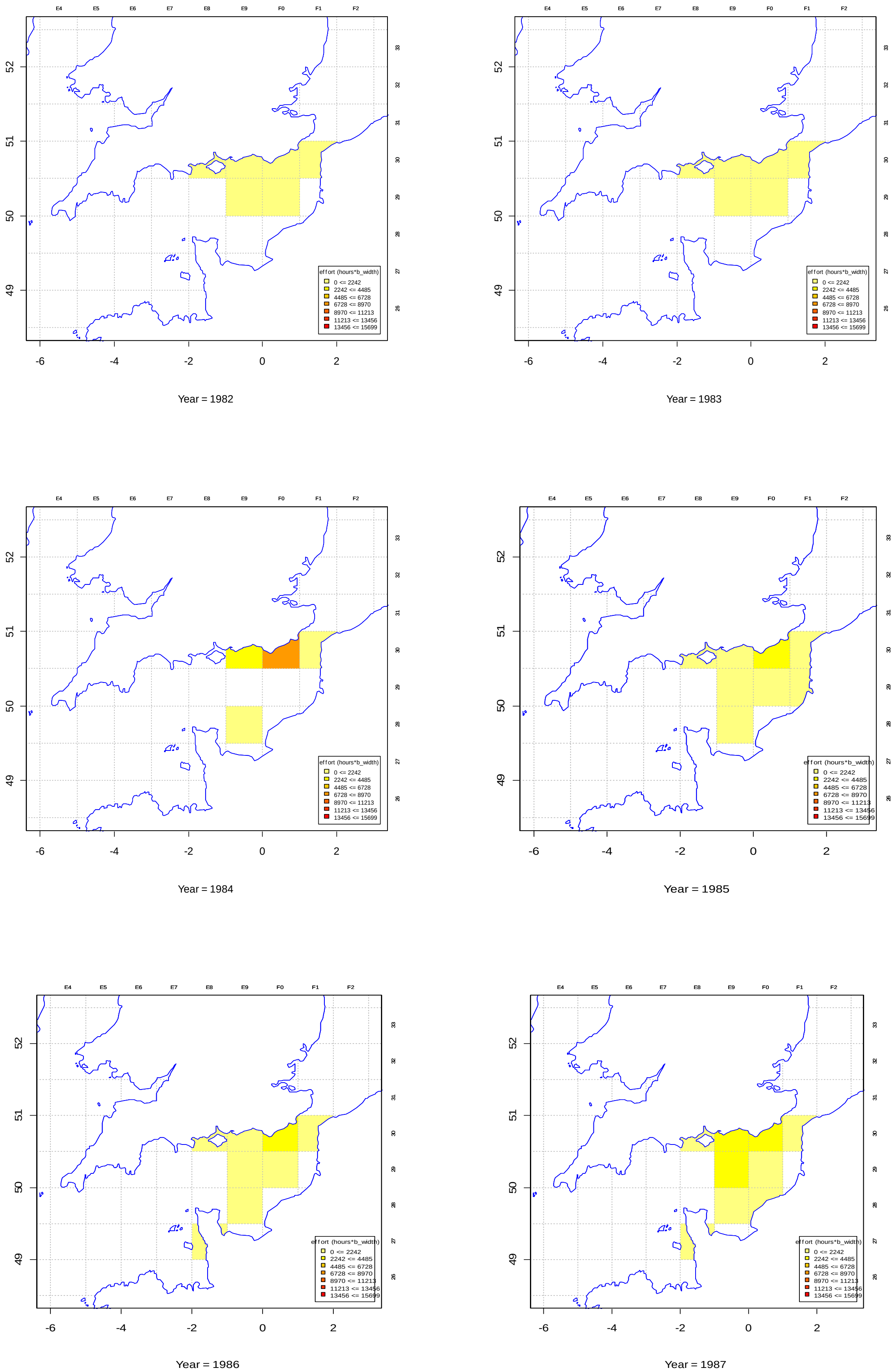


Figure 4.4.2 a) Spatial distribution of UK beam trawl effort.

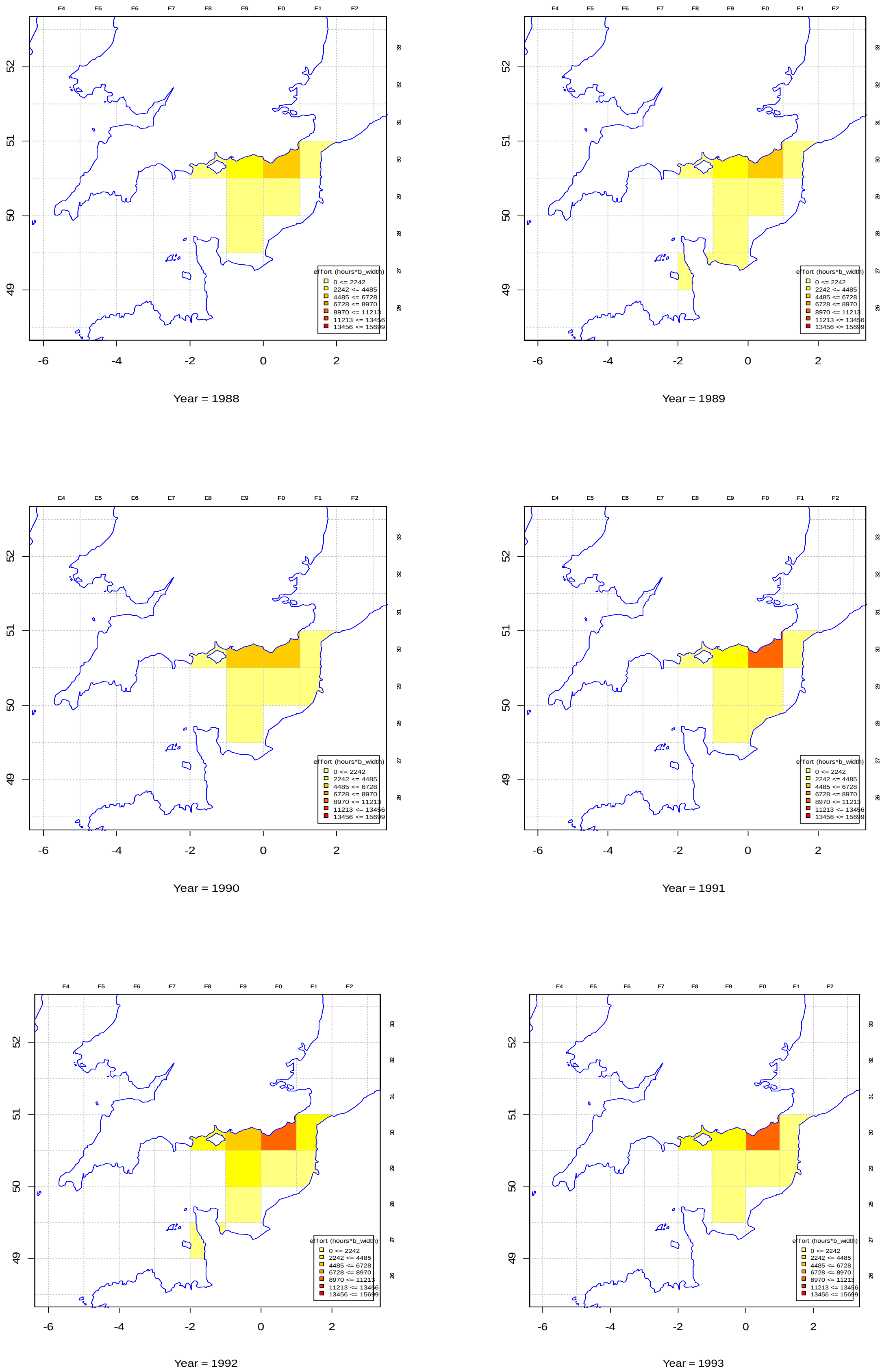


Figure 4.4.2 a) Spatial distribution of UK beam trawl effort, continued.

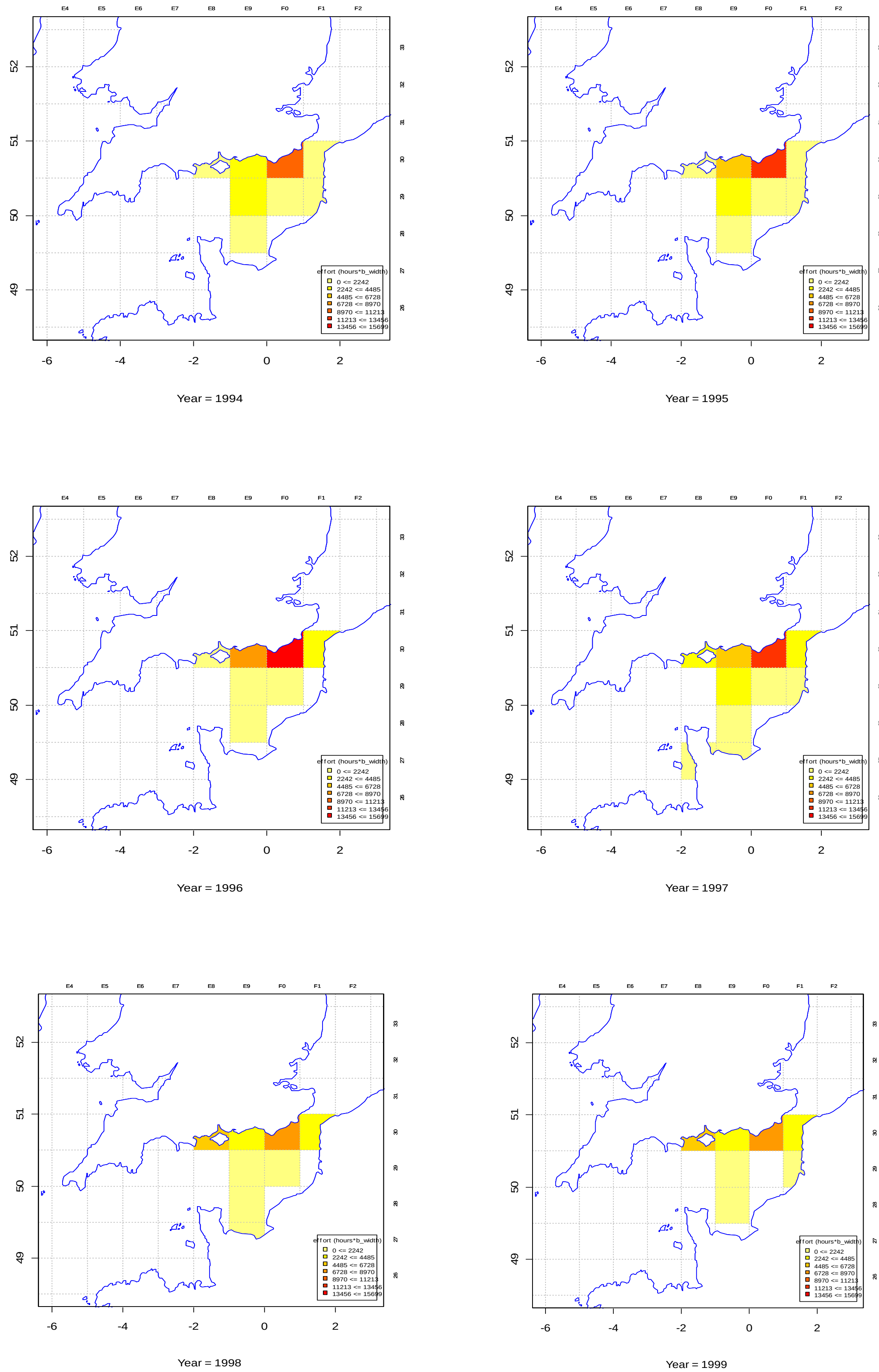


Figure 4.4.2 a) Spatial distribution of UK beam trawl effort, continued.

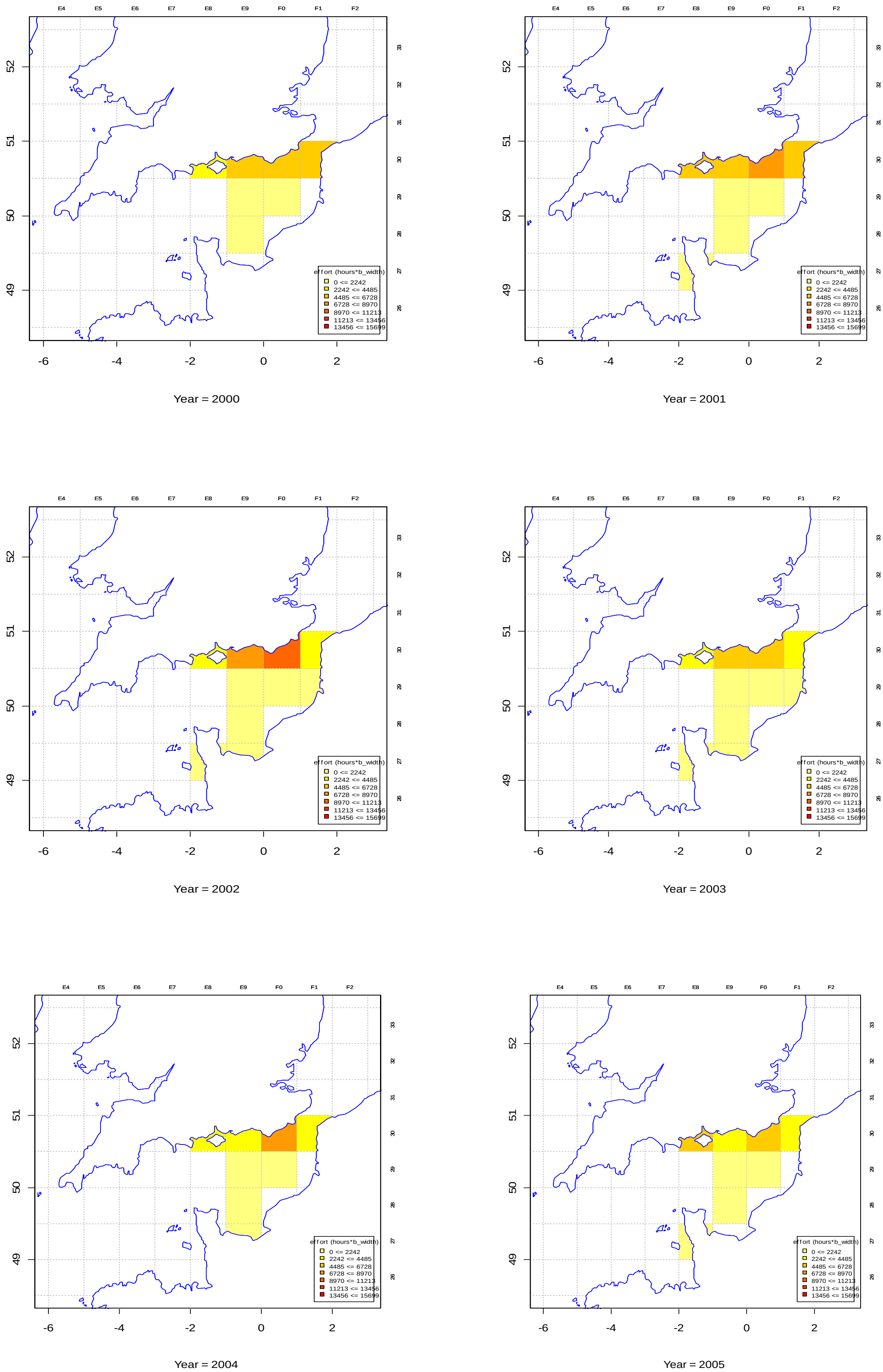
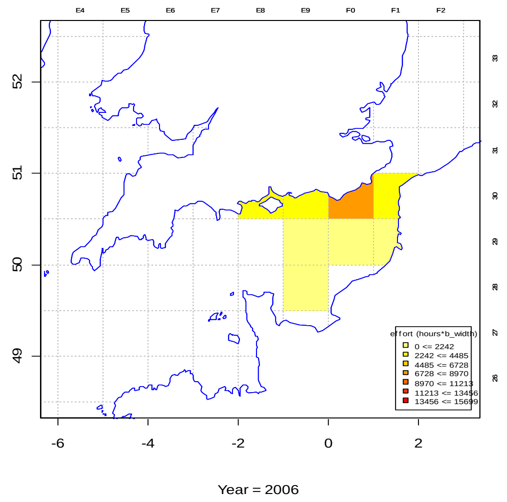
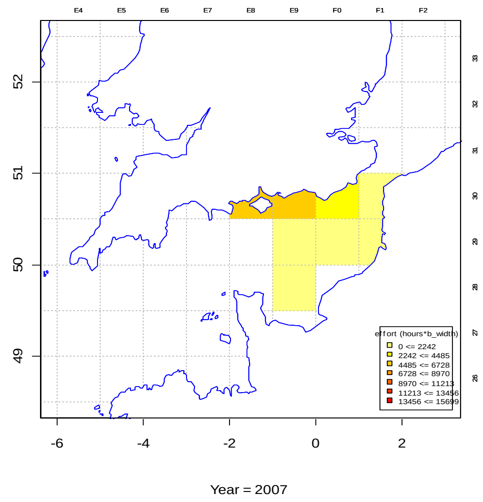


Figure 4.4.2 a) Spatial distribution of UK beam trawl effort, continued.





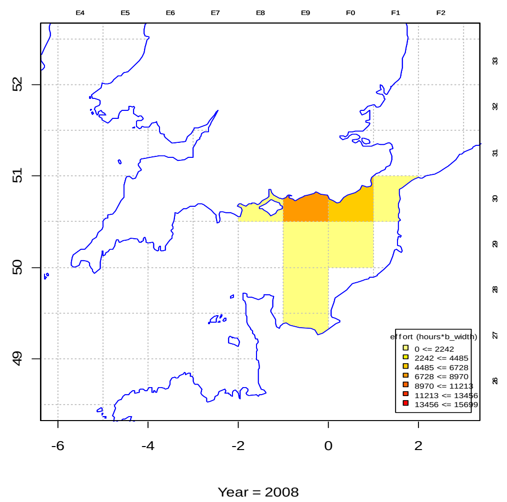


Figure 4.4.2 a) Spatial distribution of UK beam trawl effort, continued.

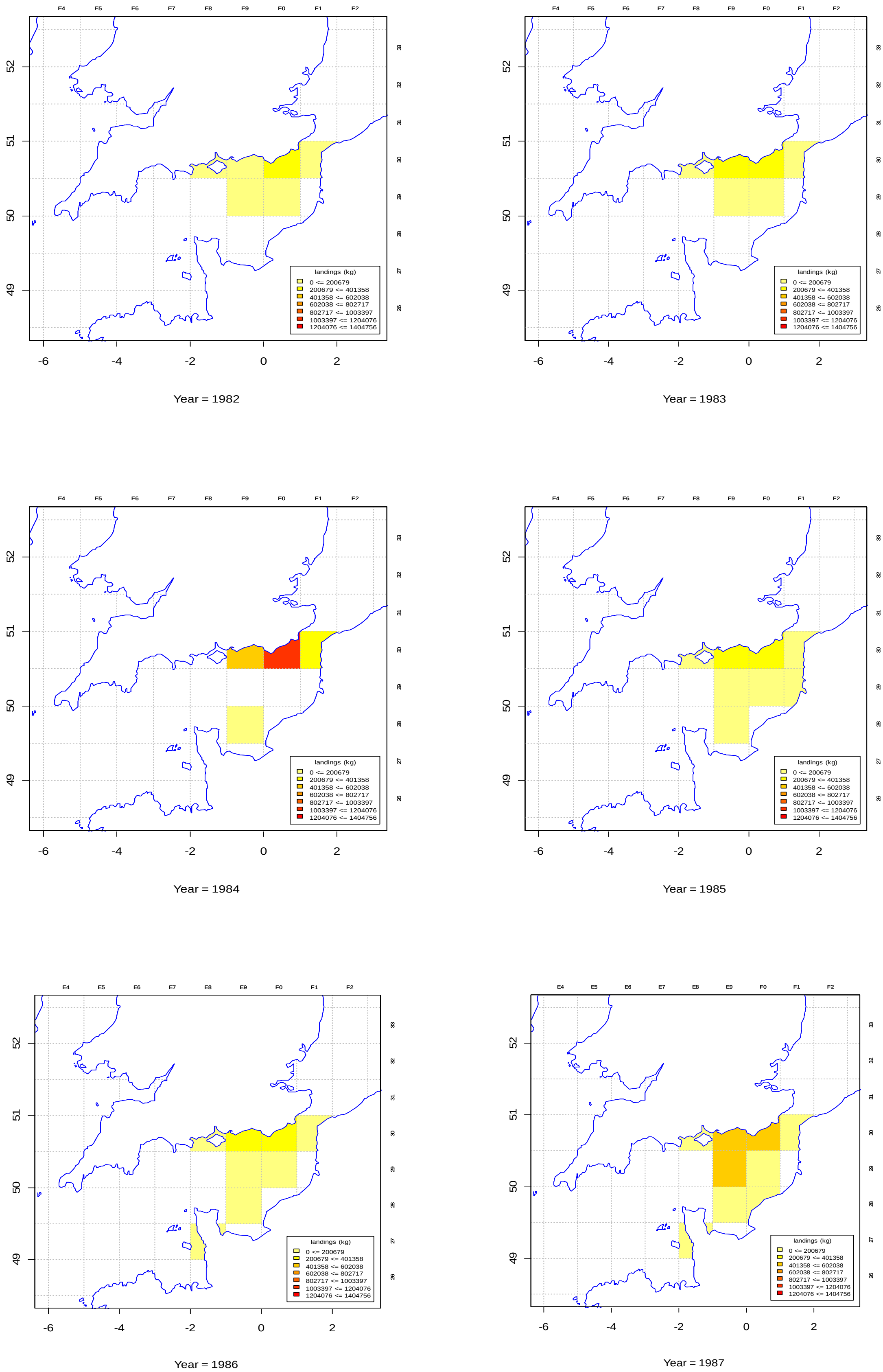


Figure 4.4.2 b) Spatial distribution of UK beam trawl landings.

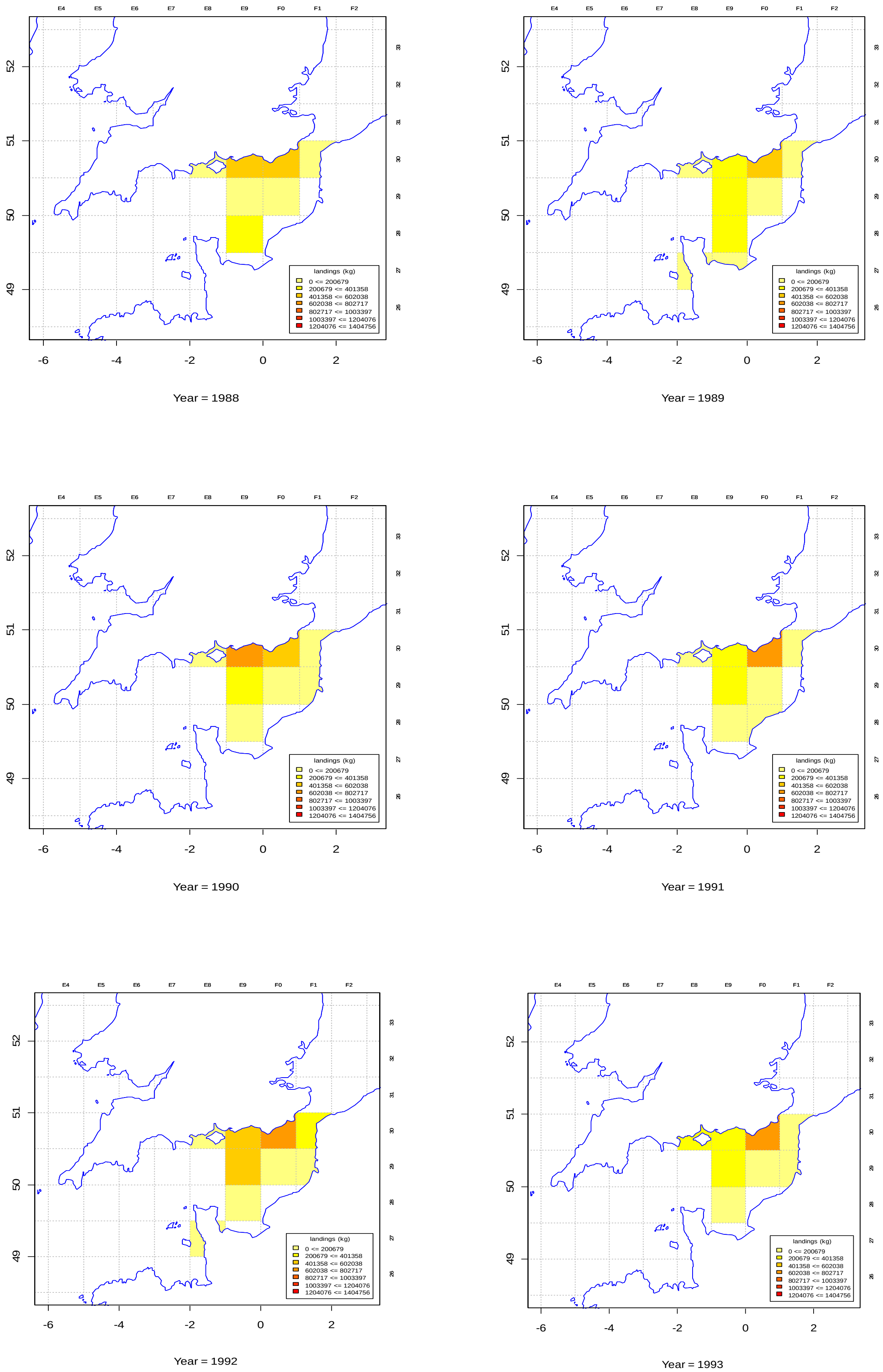


Figure 4.4.2 b) Spatial distribution of UK beam trawl landings, continued.

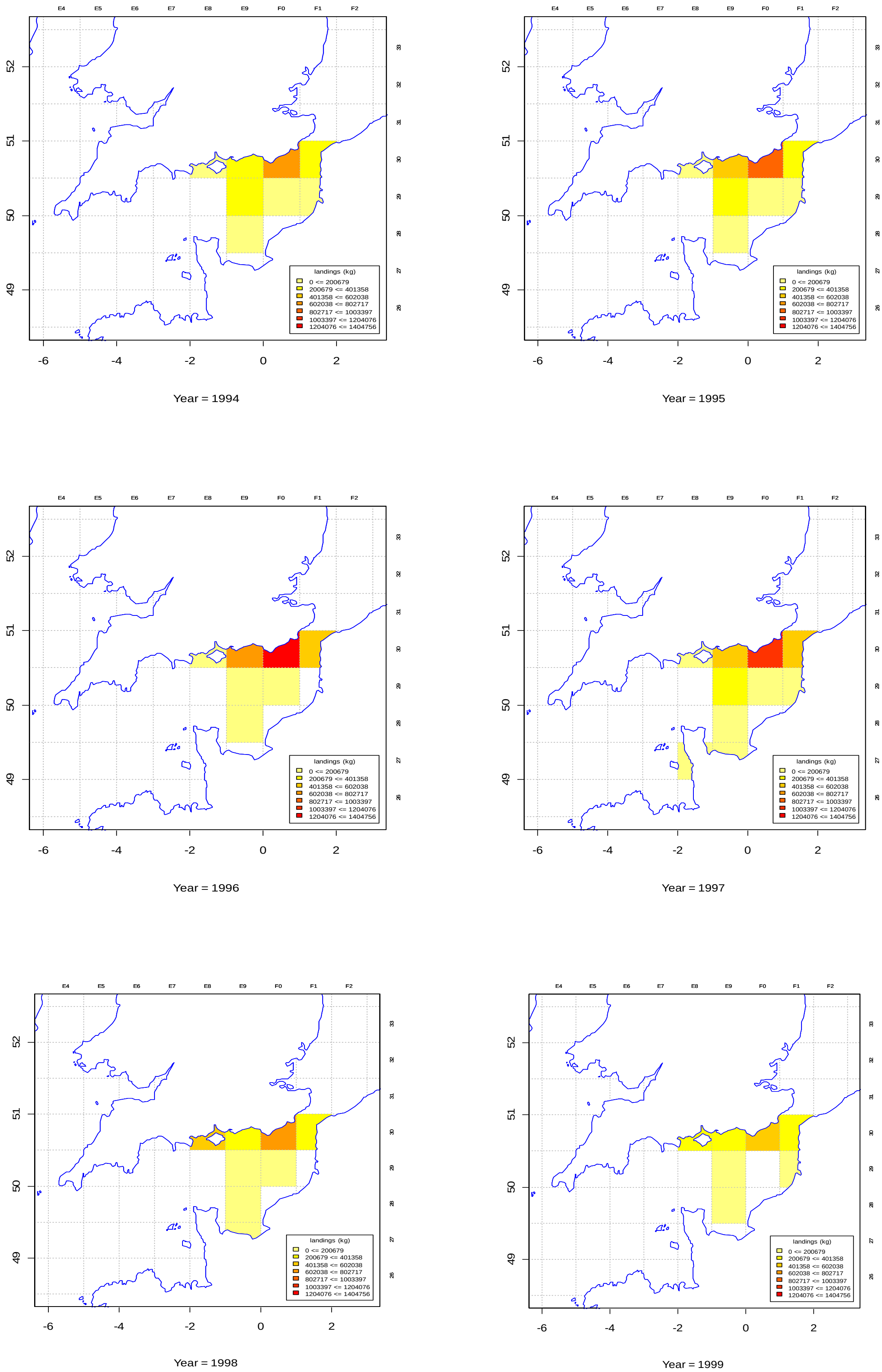
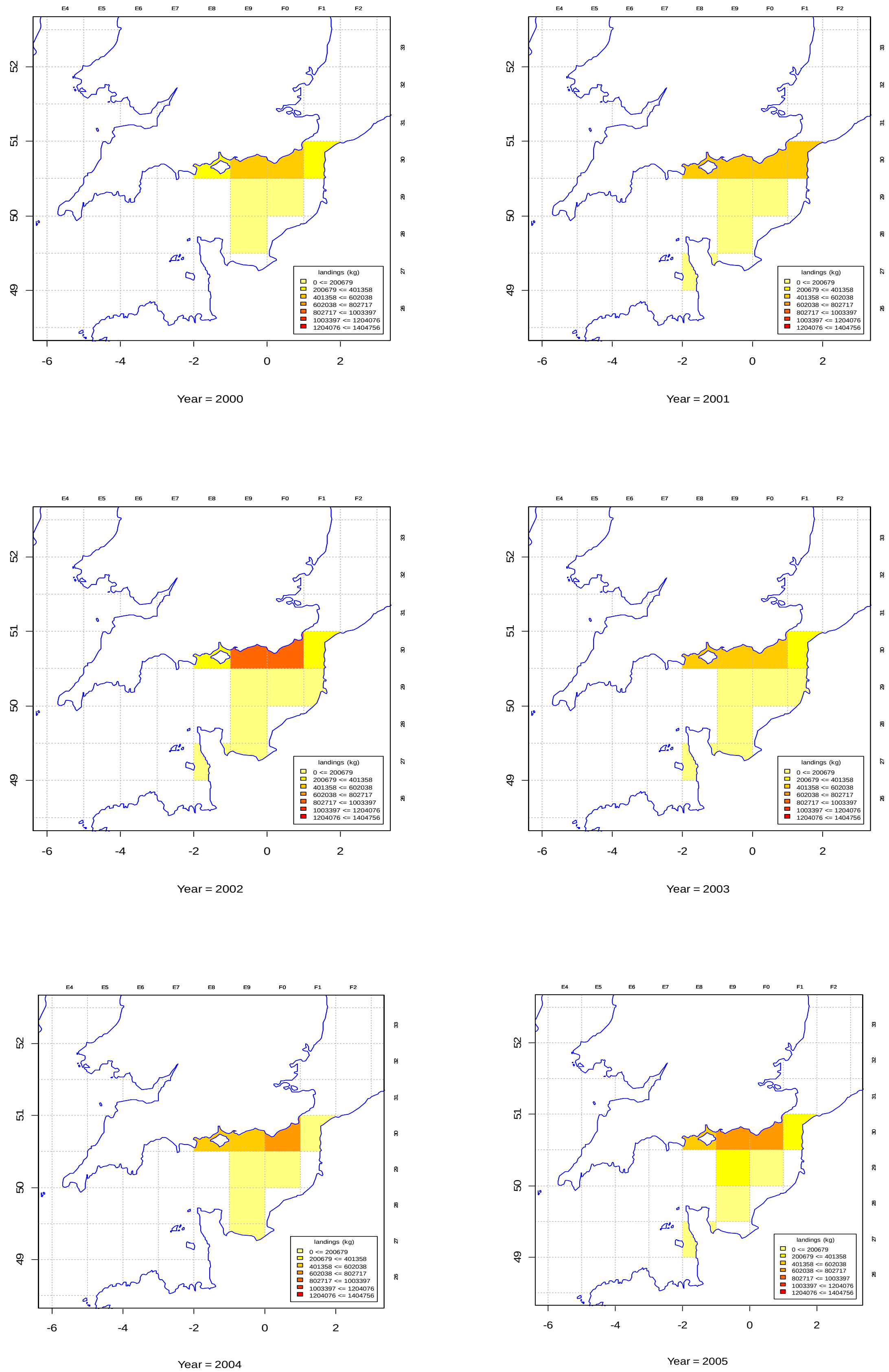


Figure 4.4.2 b) Spatial distribution of UK beam trawl landings, continued.



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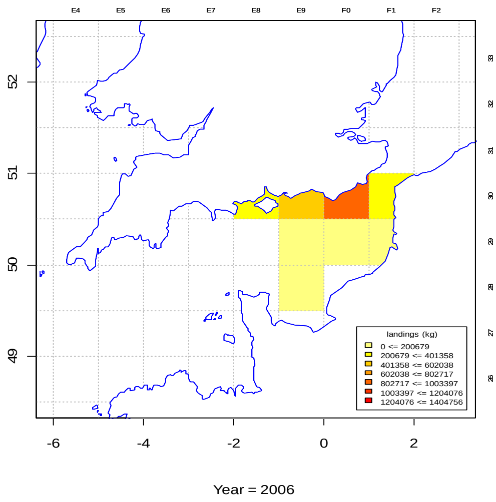

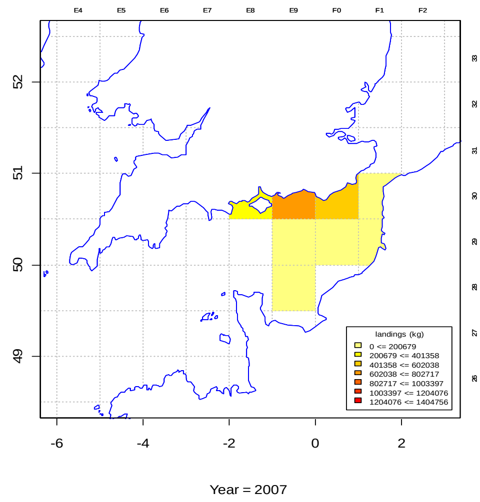

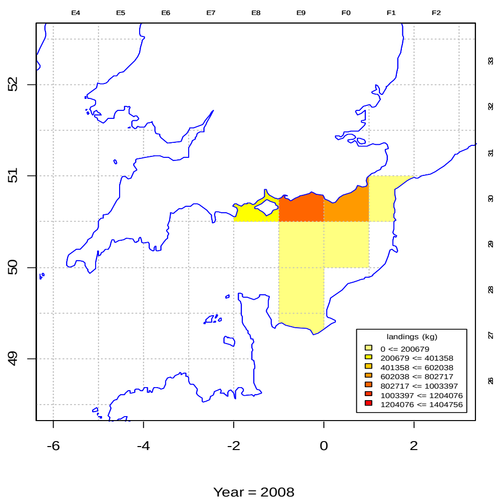

Figure 4.4.2 b) Spatial distribution of UK beam trawl landings, continued.

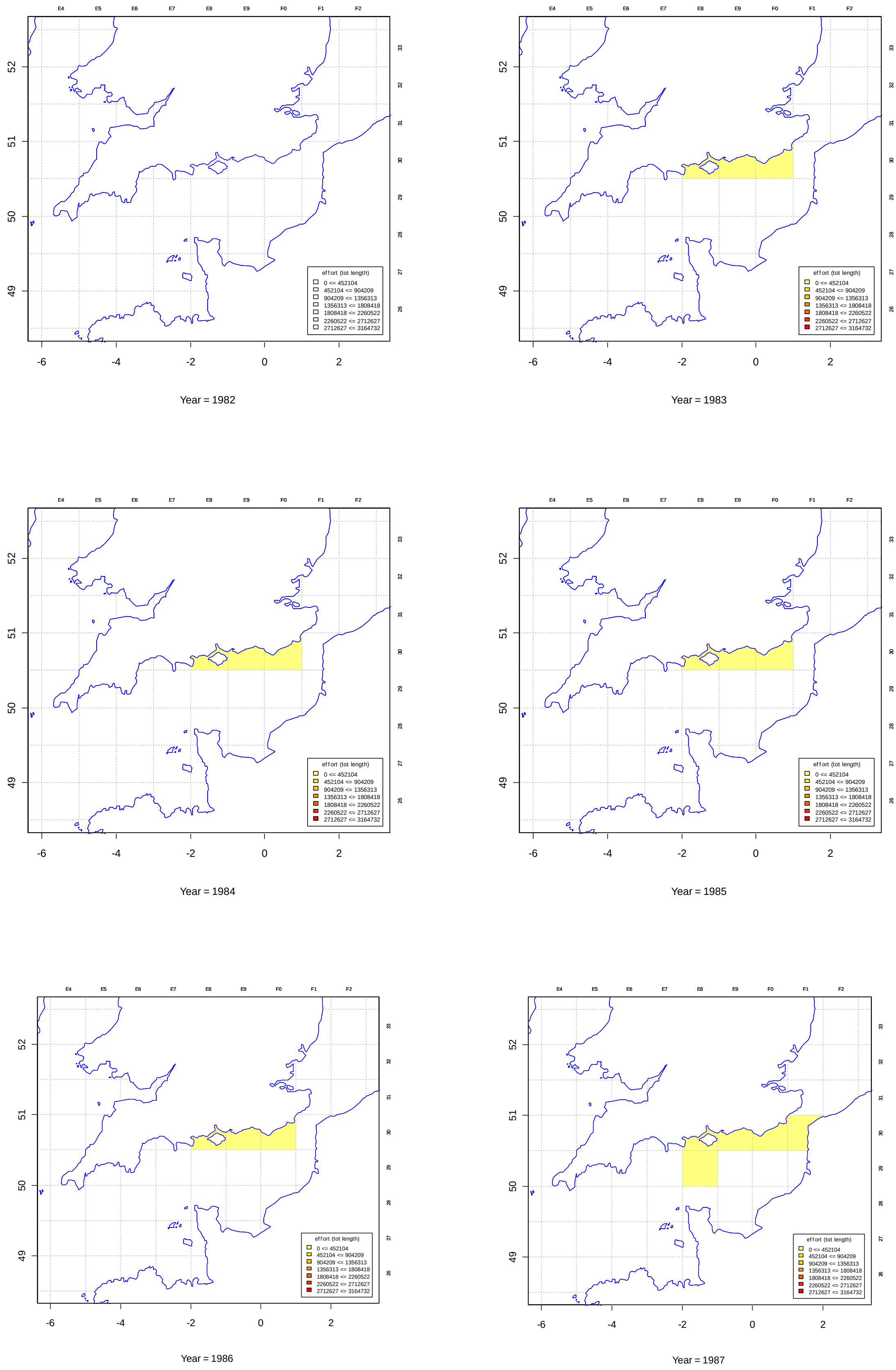

Figure 4.4.3 a) Spatial distribution of UK gillnets effort.

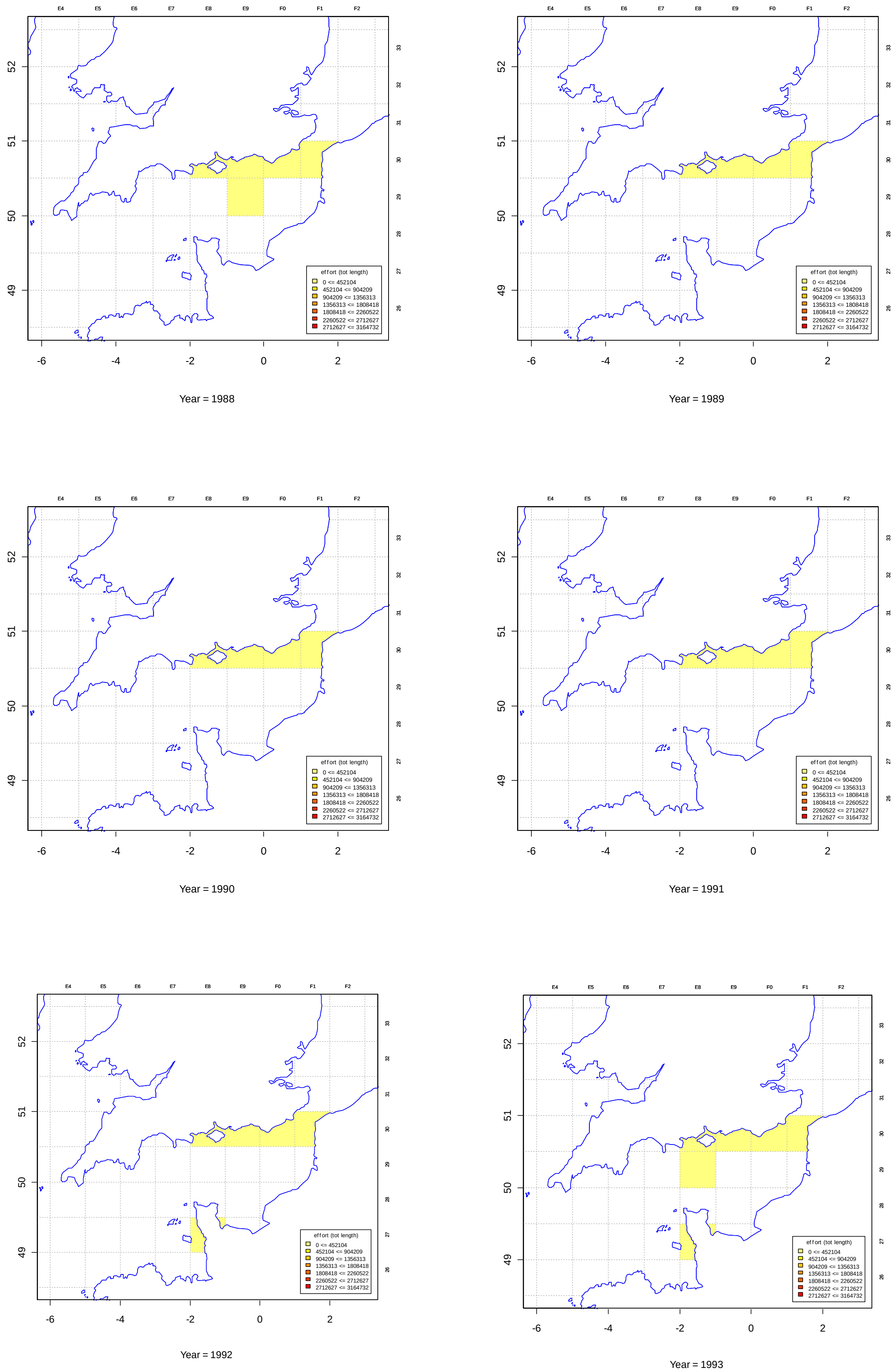

Figure 4.4.3 a) Spatial distribution of UK gillnets effort, continued.

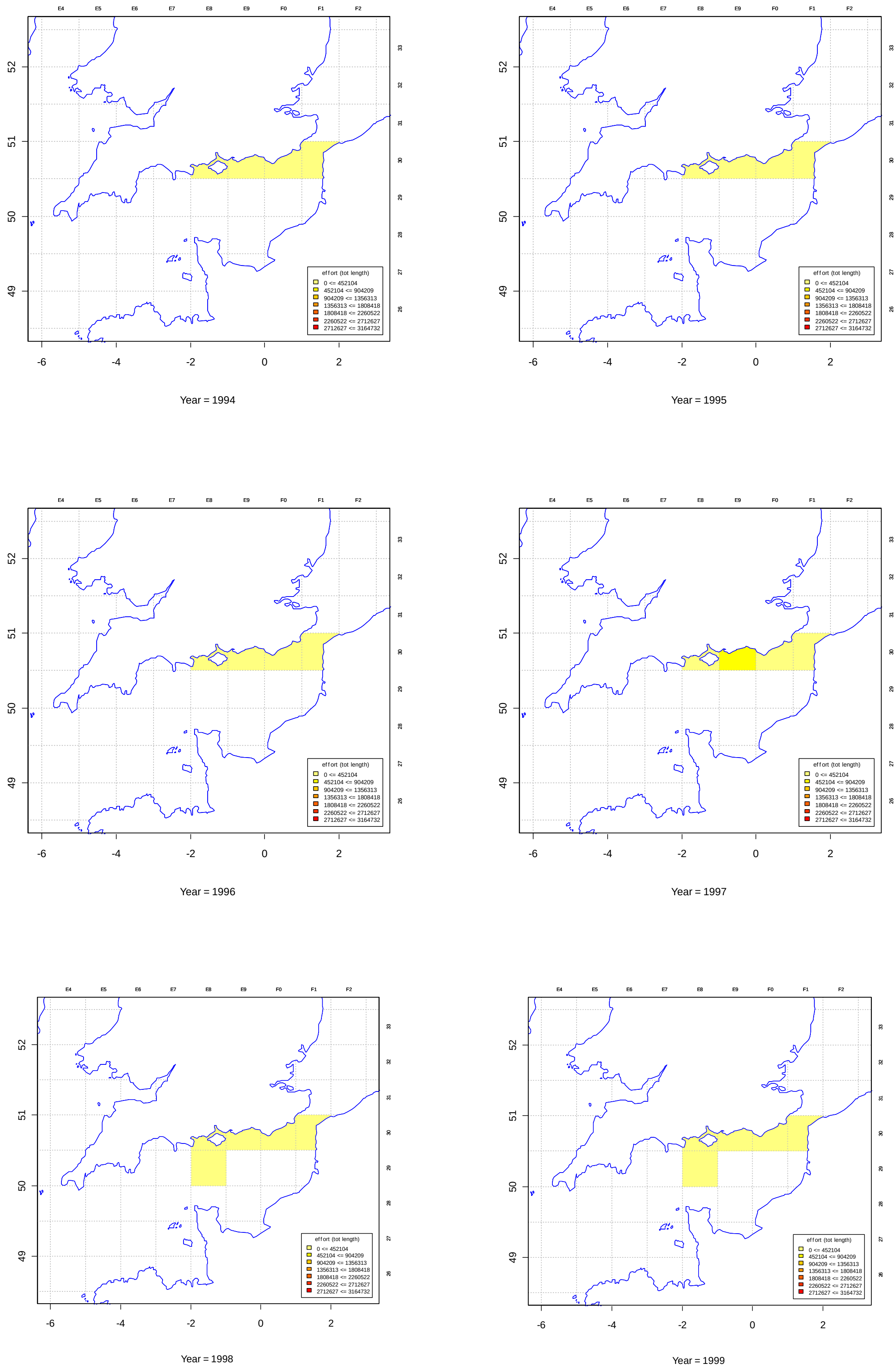

Figure 4.4.3 a) Spatial distribution of UK gillnets effort, continued.

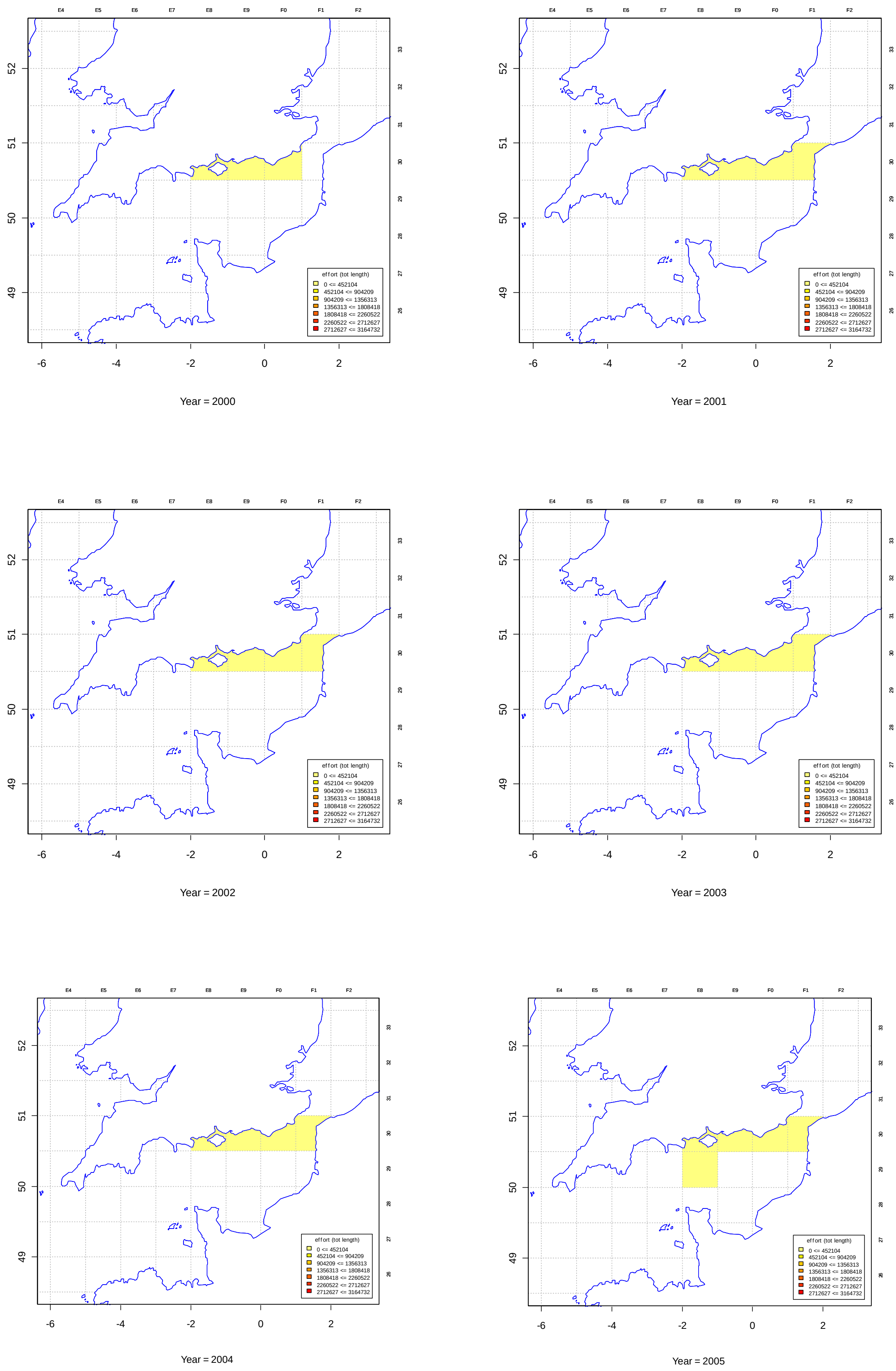

Figure 4.4.3 a) Spatial distribution of UK gillnets effort, continued.

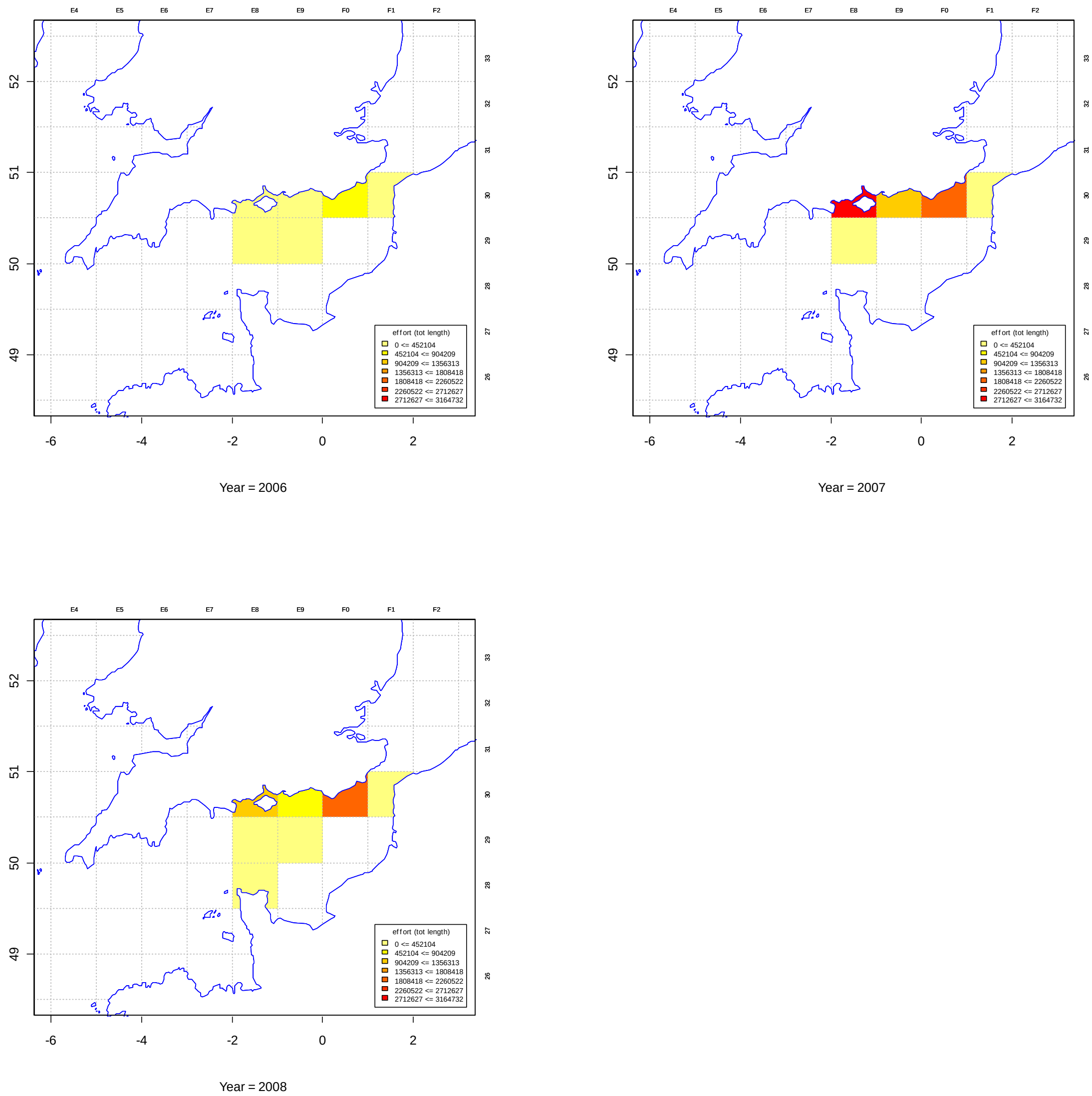

Figure 4.4.3 a) Spatial distribution of UK gillnets effort, continued.

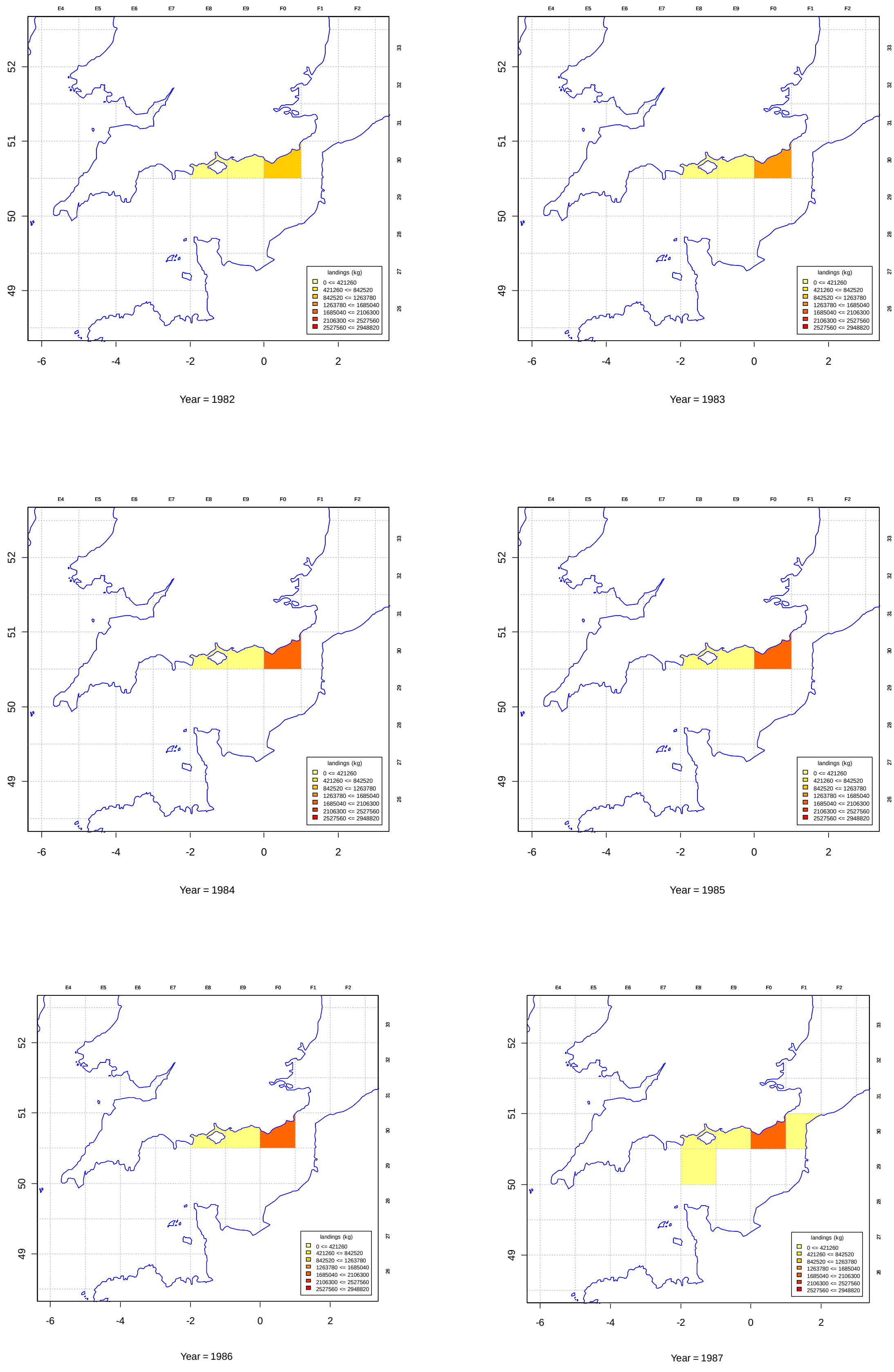

Figure 4.4.3 b) Spatial distribution of UK gillnets landings.

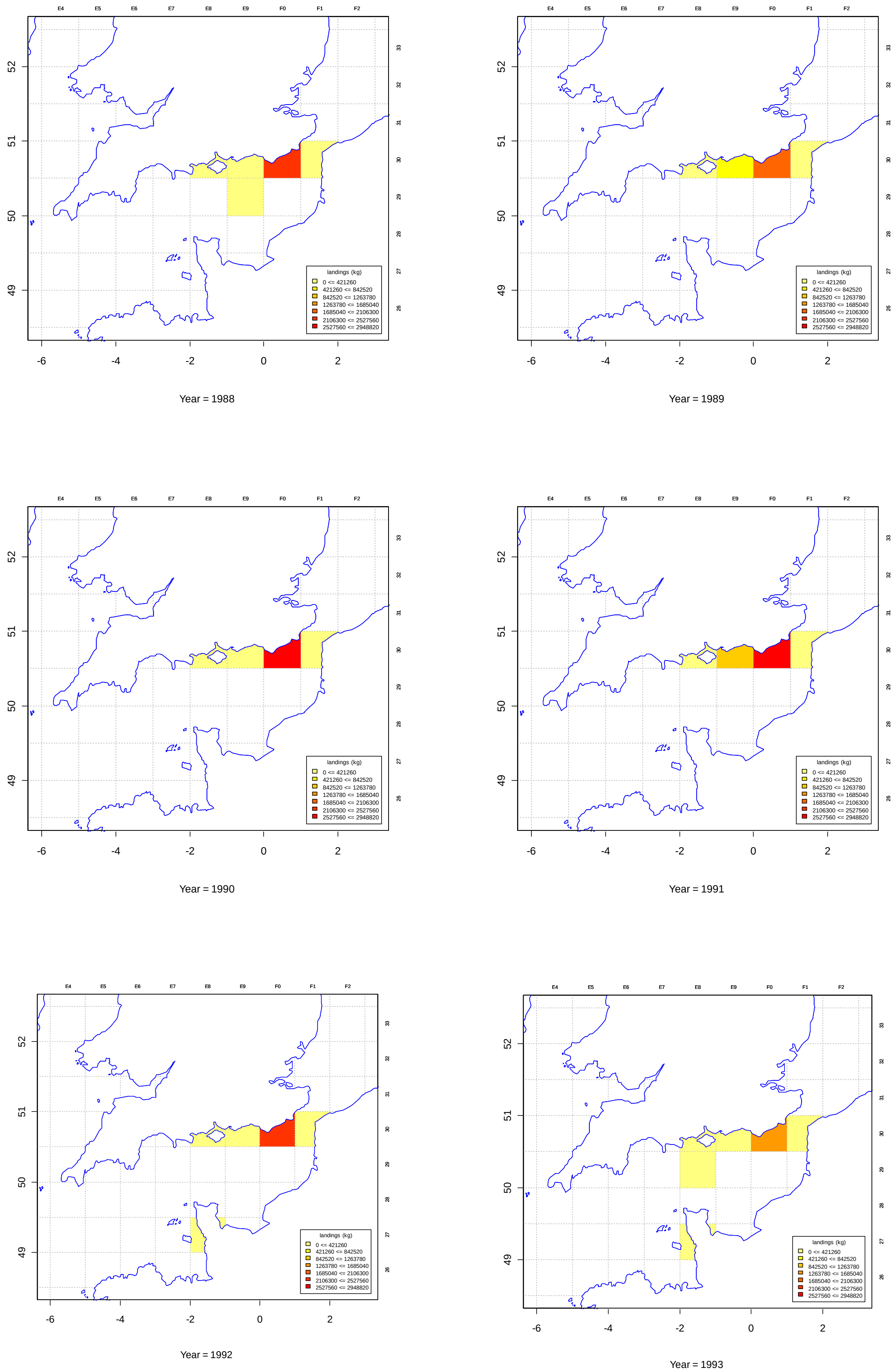

Figure 4.4.3 b) Spatial distribution of UK gillnets landings, continued.

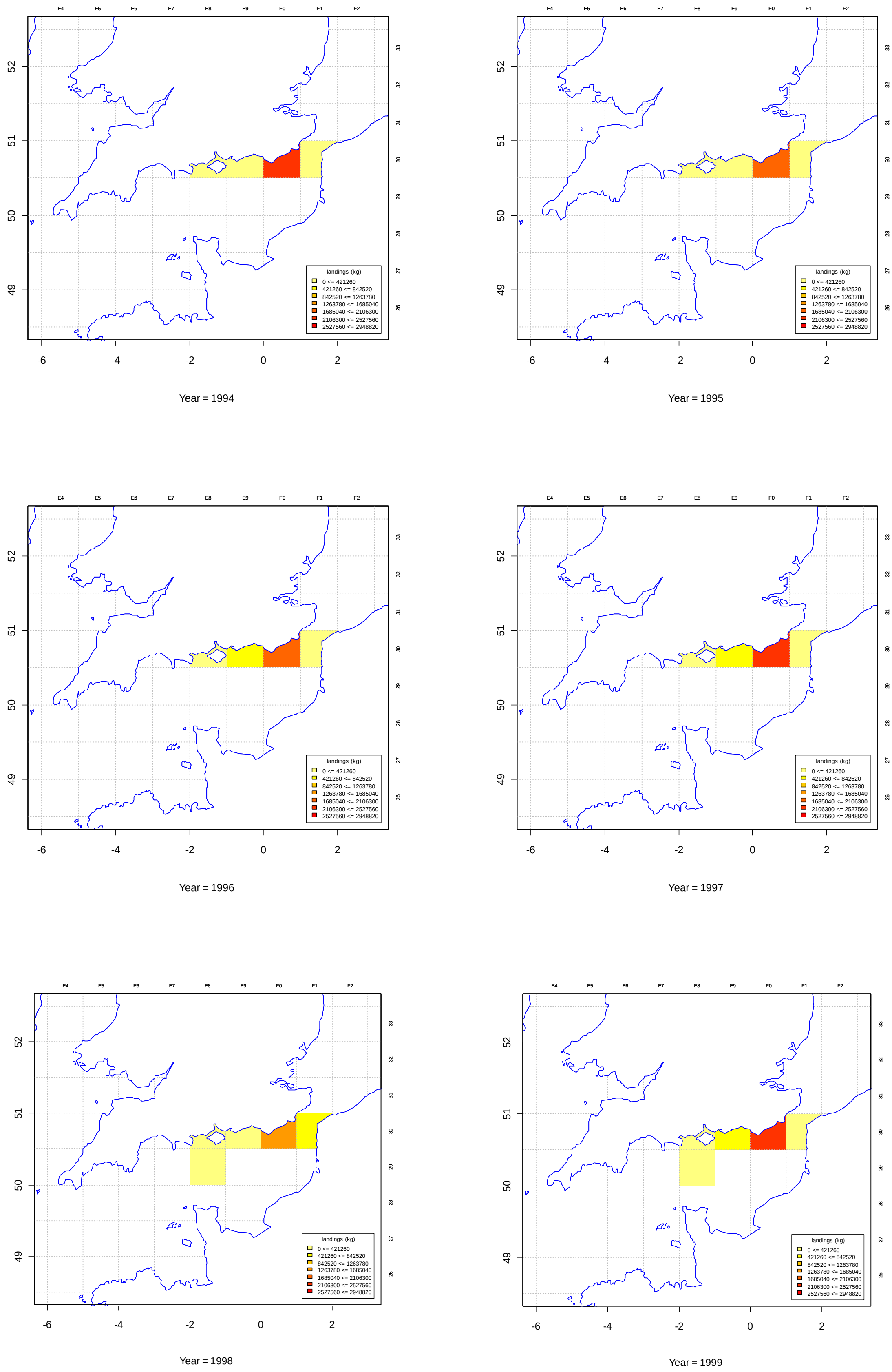

Figure 4.4.3 b) Spatial distribution of UK gillnets landings, continued.

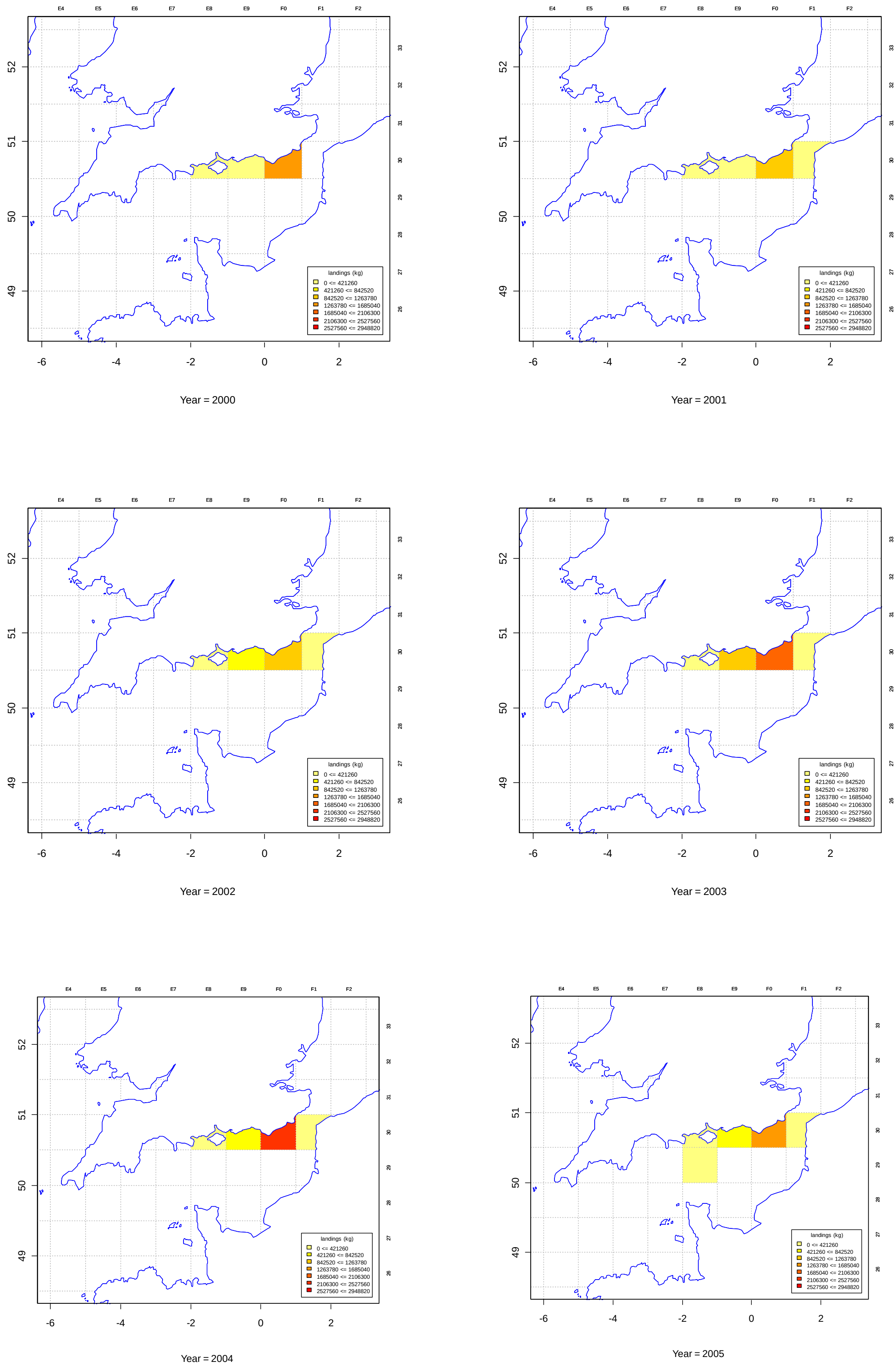

Figure 4.4.3 b) Spatial distribution of UK gillnets landings, continued.

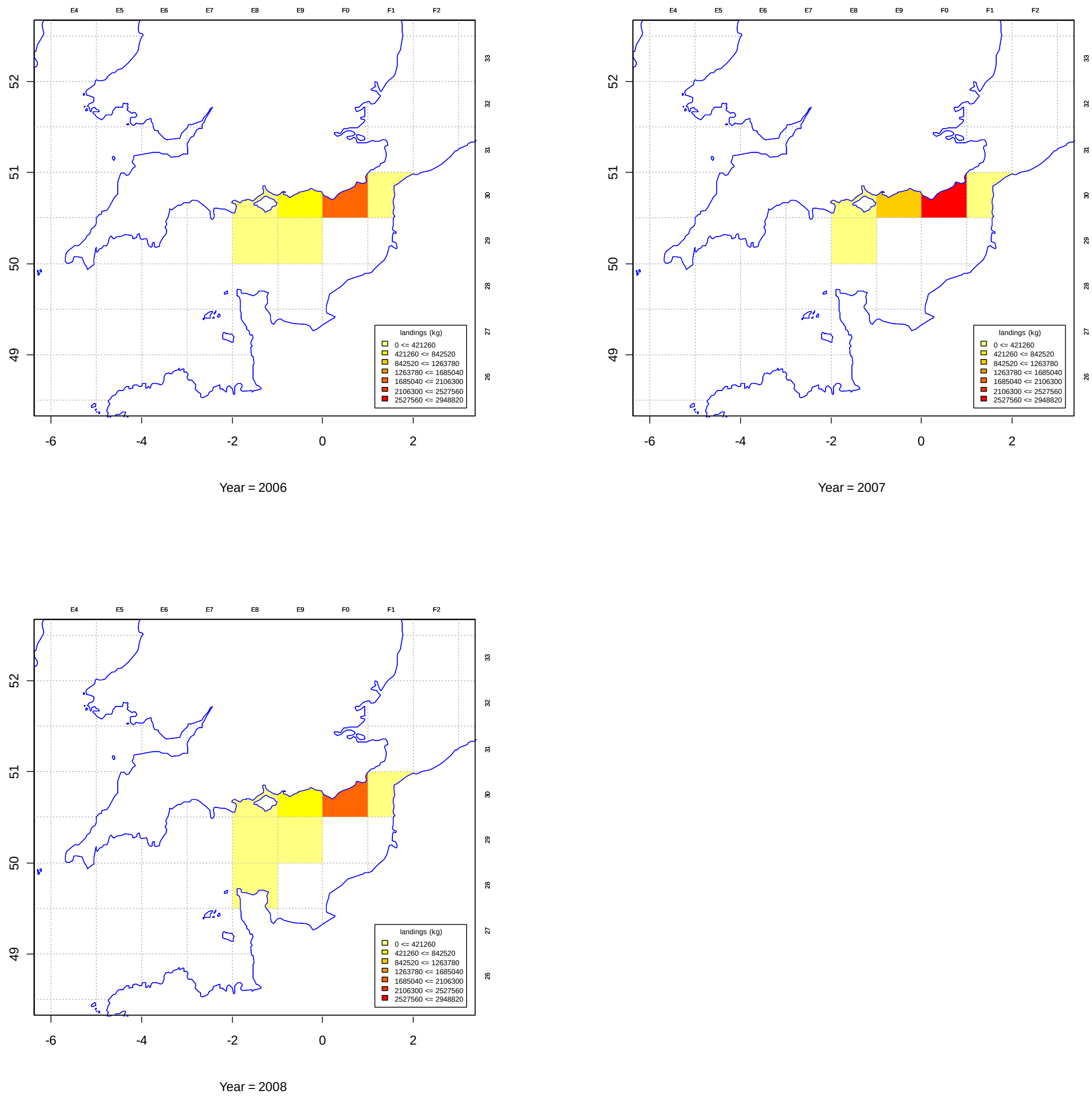

Figure 4.4.3 b) Spatial distribution of UK gillnets landings, continued.

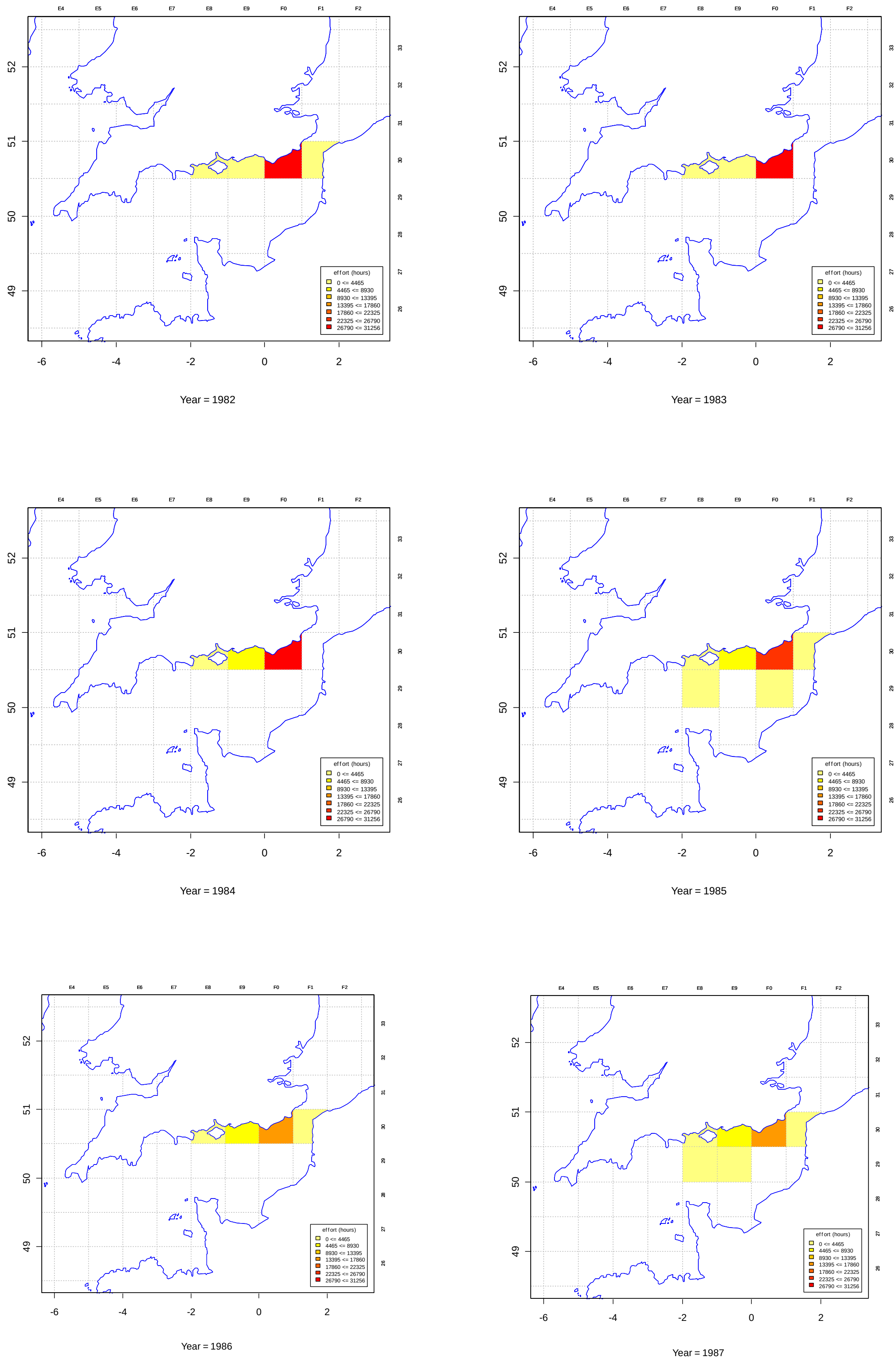

Figure 4.4.4 a) Spatial distribution of UK otter trawl effort.

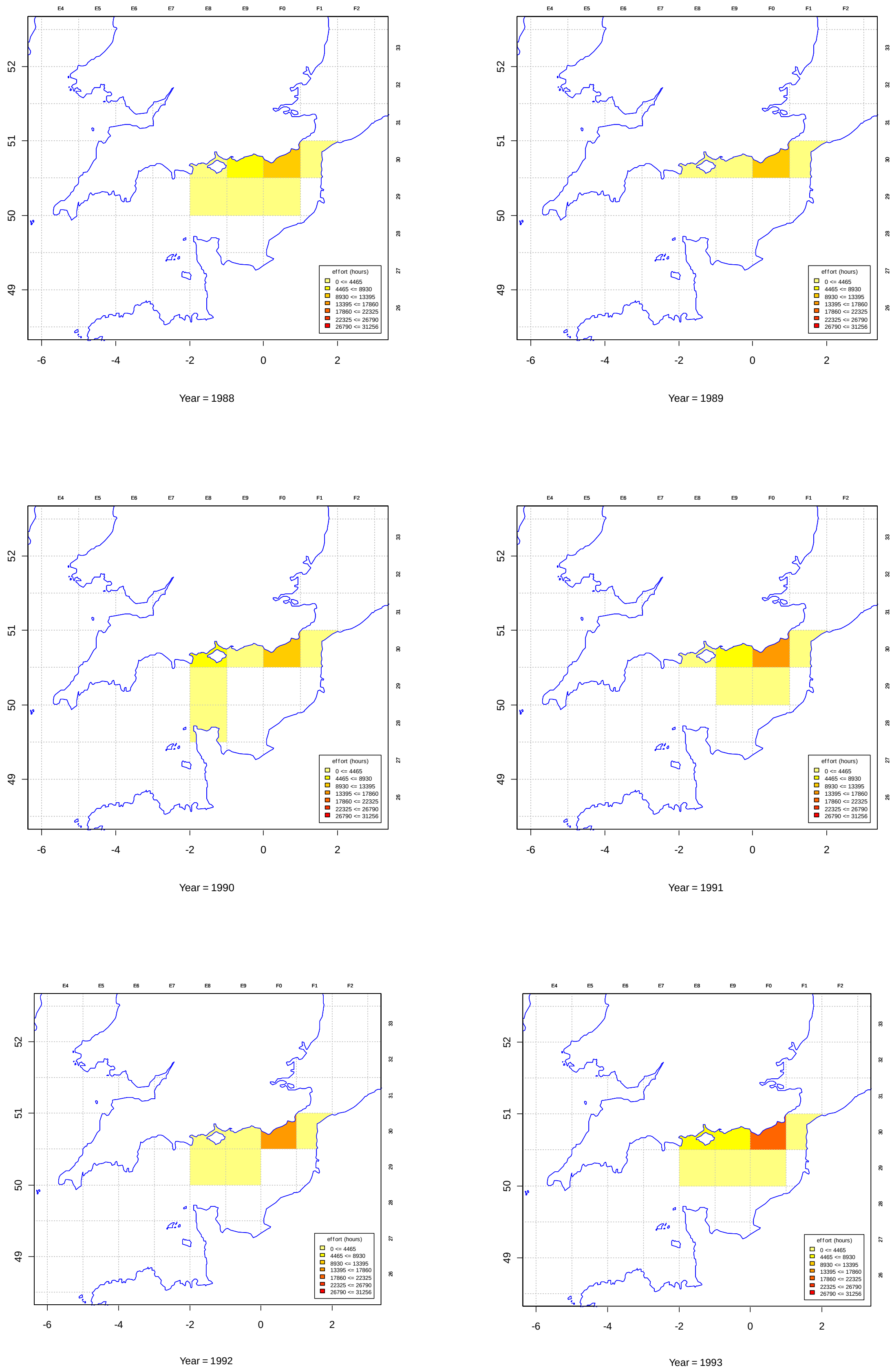

Figure 4.4.4 a) Spatial distribution of UK otter trawl effort, continued.

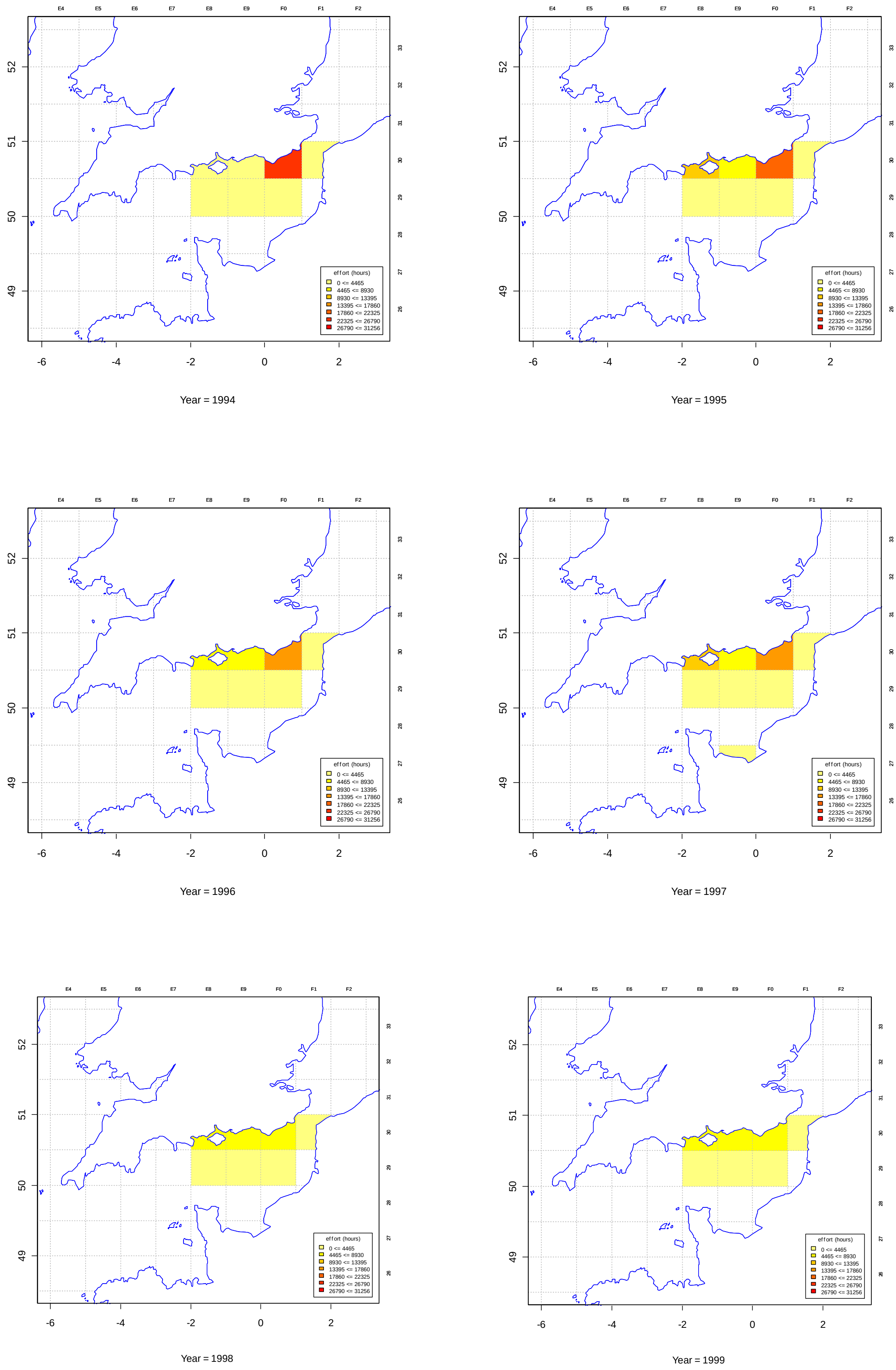

Figure 4.4.4 a) Spatial distribution of UK otter trawl effort, continued.

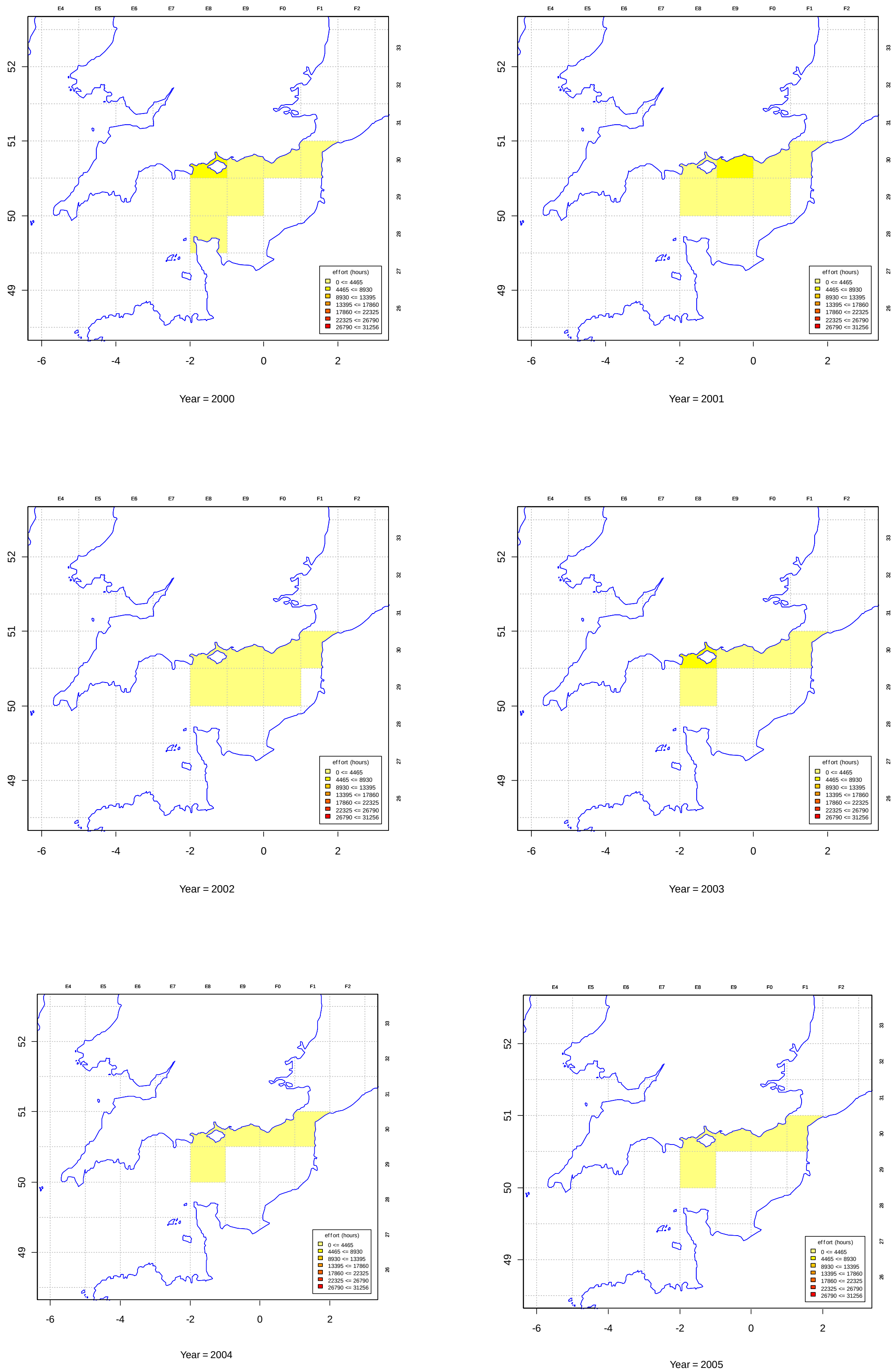

Figure 4.4.4 a) Spatial distribution of UK otter trawl effort, continued.

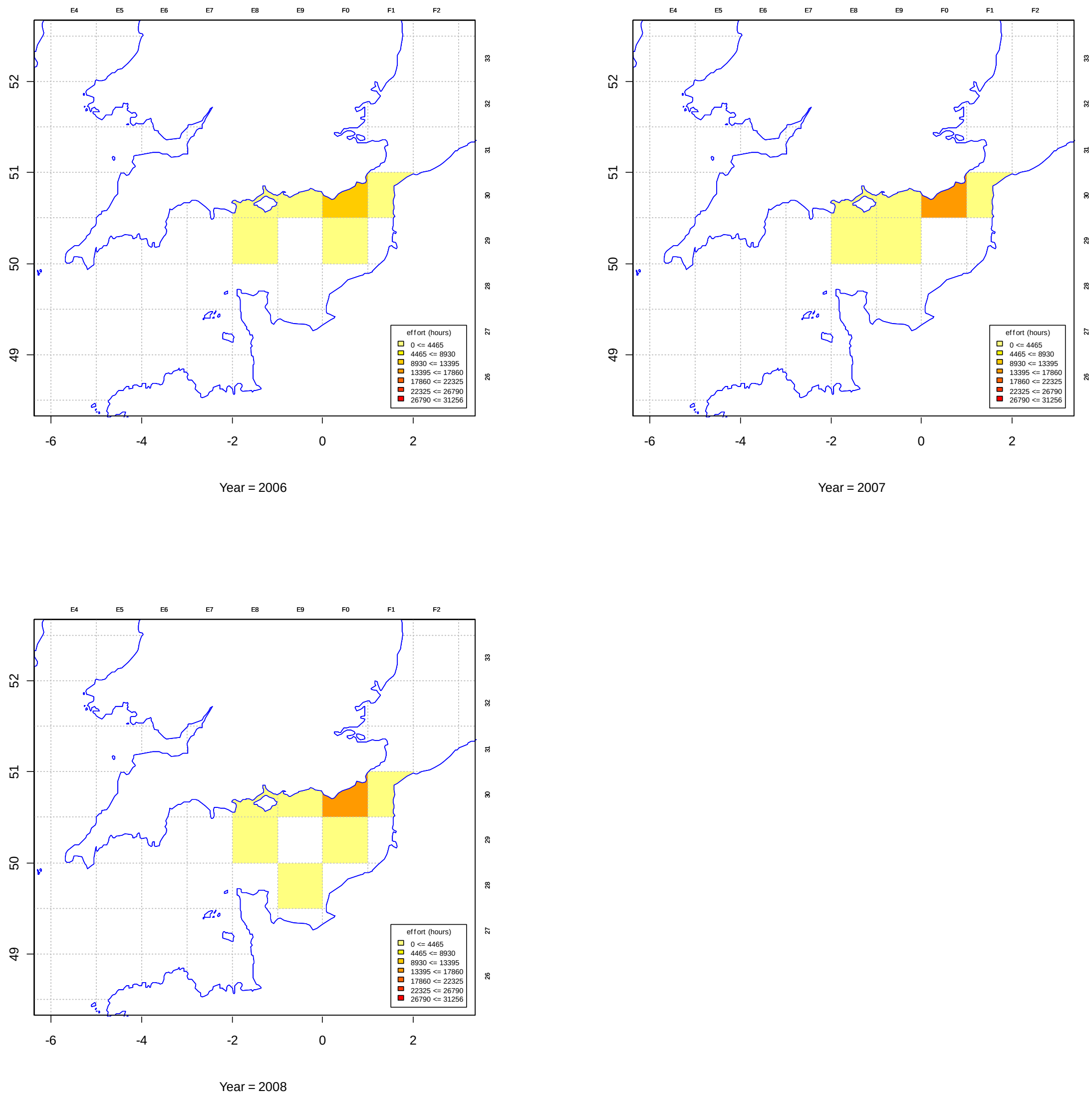

Figure 4.4.4 a) Spatial distribution of UK otter trawl effort, continued.

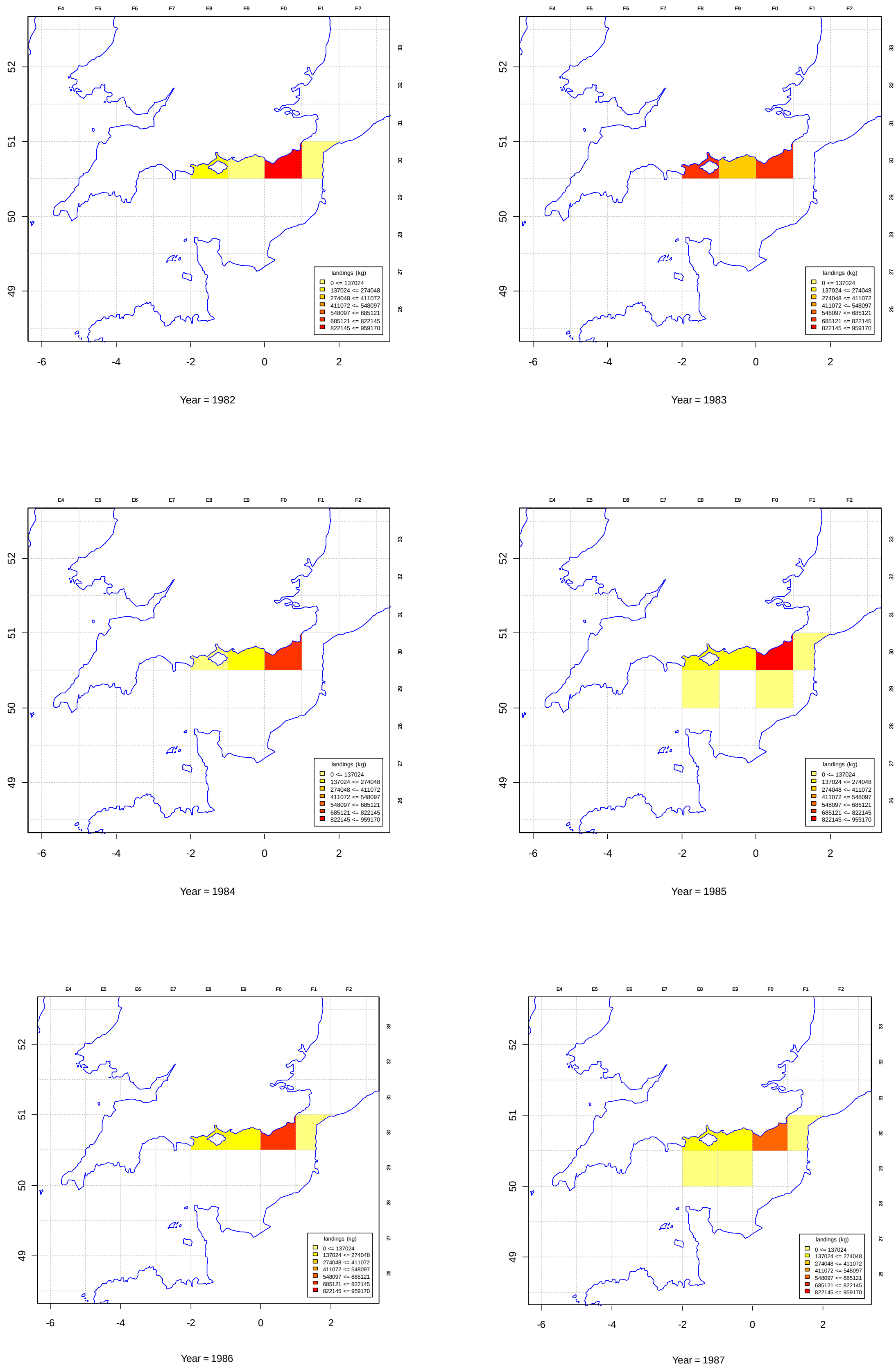

Figure 4.4.4 b) Spatial distribution of UK otter trawl landings.

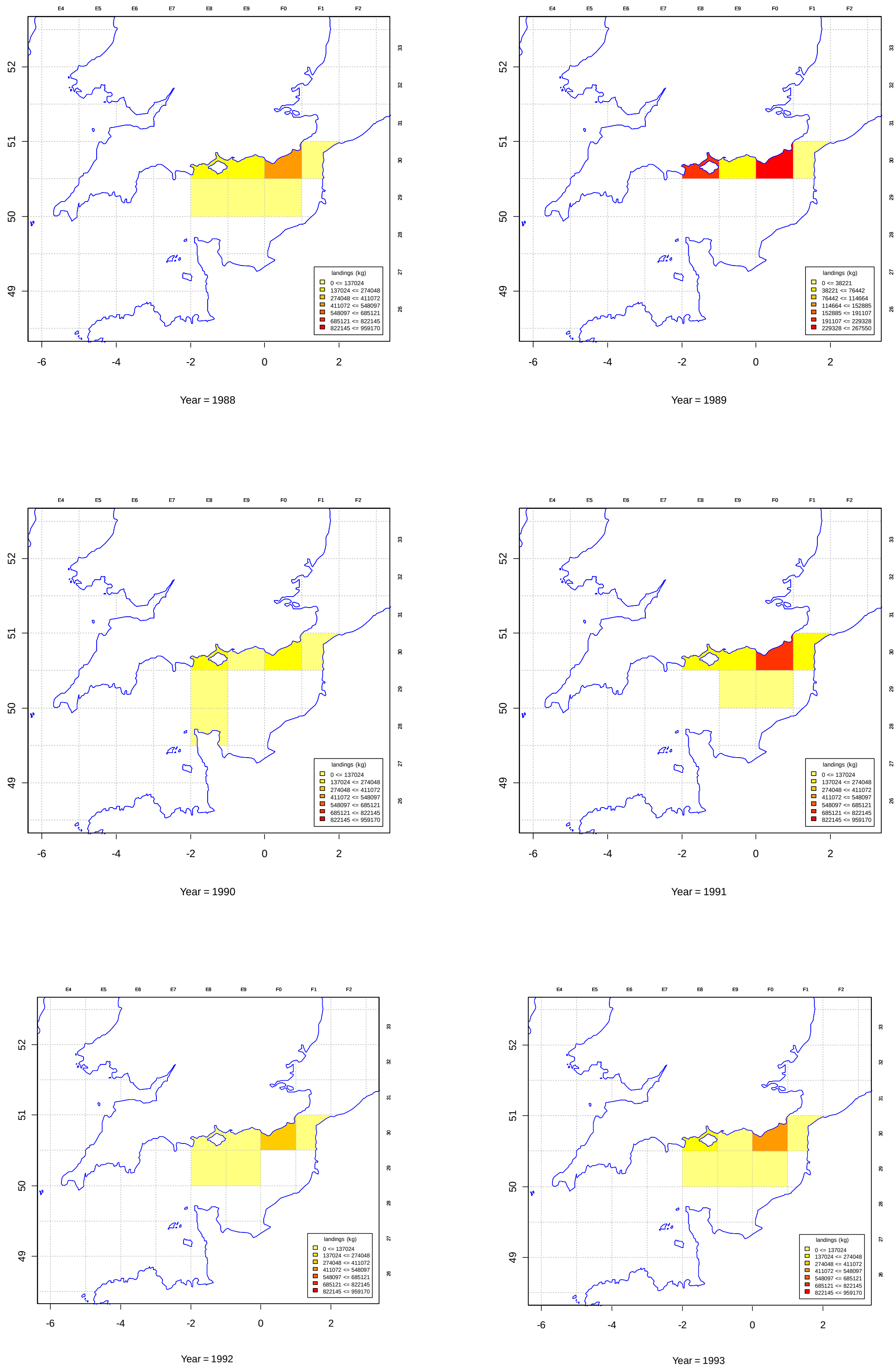

Figure 4.4.4 b) Spatial distribution of UK otter trawl landings, continued.

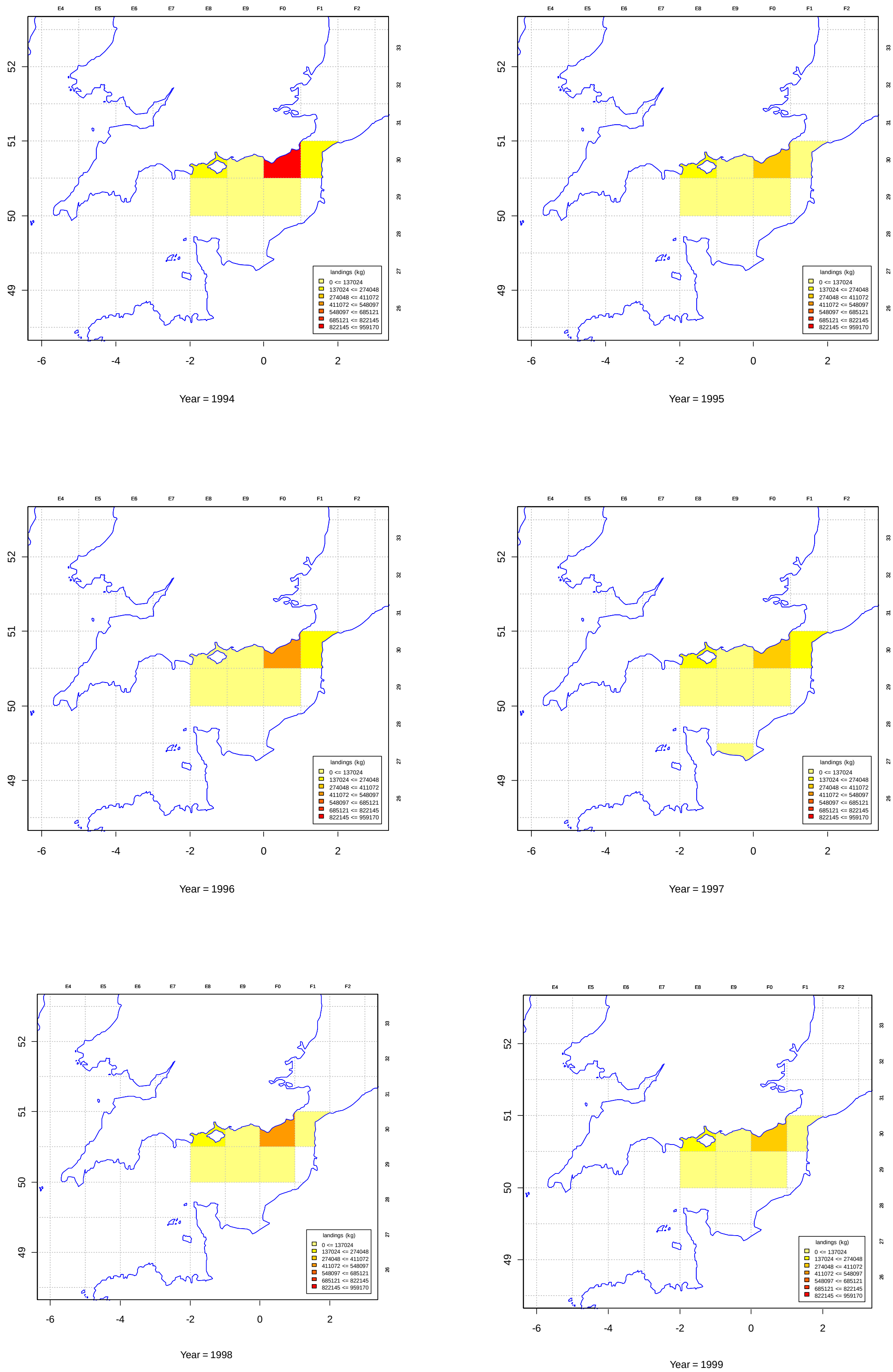

Figure 4.4.4 b) Spatial distribution of UK otter trawl landings, continued.

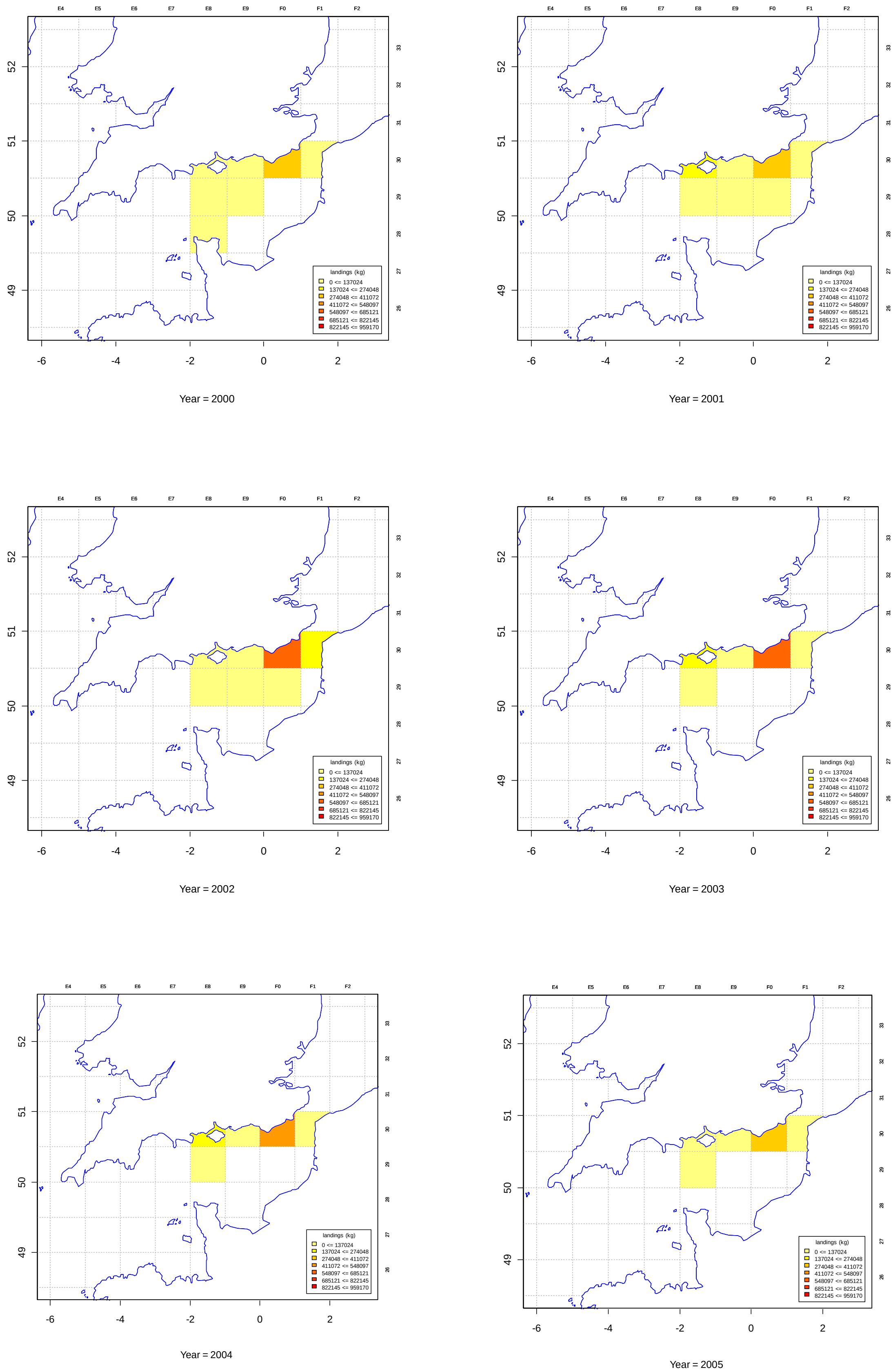

Figure 4.4.4 b) Spatial distribution of UK otter trawl landings, continued.

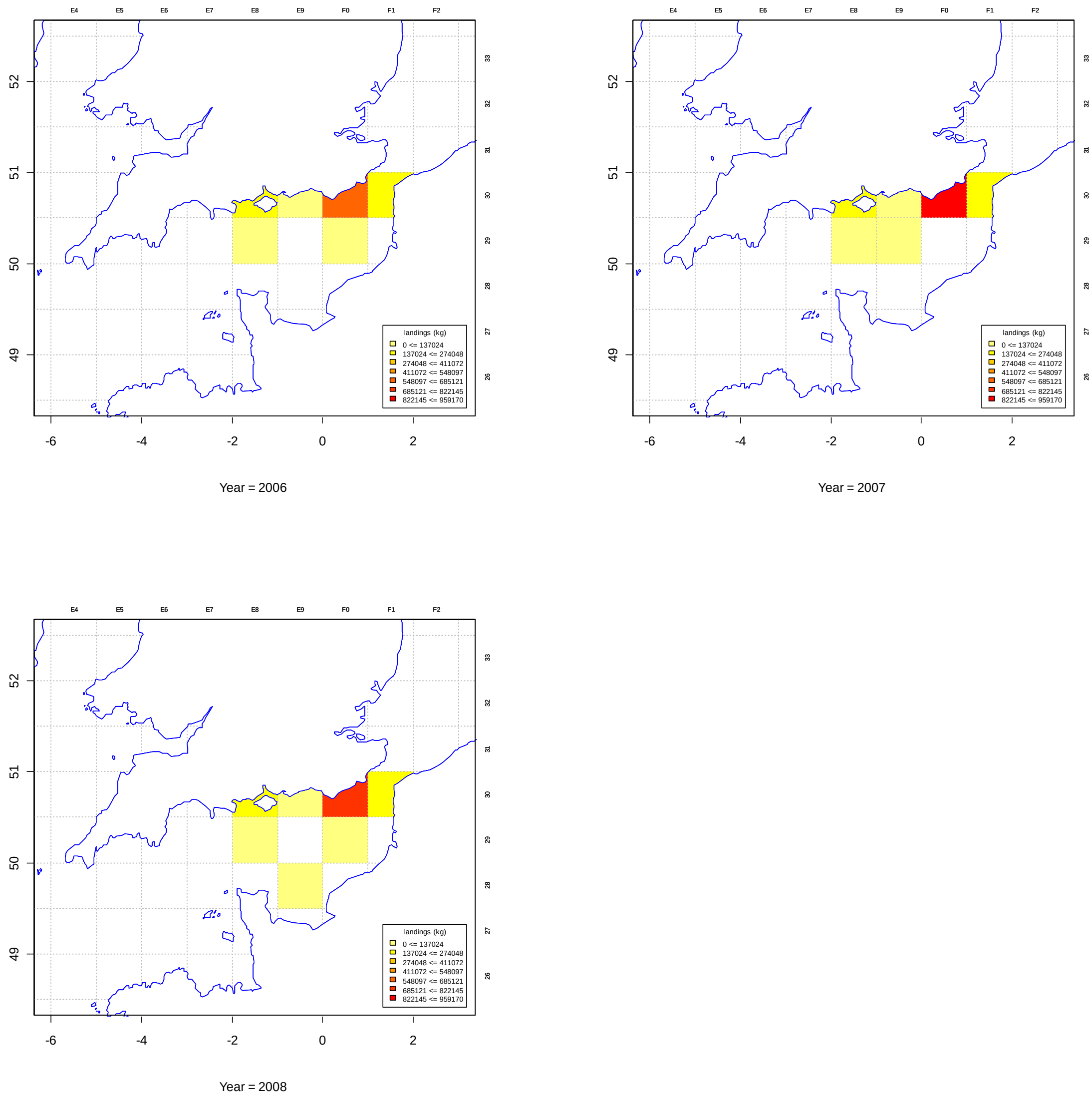

Figure 4.4.4 b) Spatial distribution of UK otter trawl landings, continued.

5 Plaice (*Pleuronectes platessa*) in the North Sea (Subarea IV)

5.1 Current stock status and assessment issues

The objective of this benchmark assessment is to improve the current assessment. First a review of the most recent literature has been made, most of which will be incorporated into the stock annex and different sections of this report.

In the WGNSSK assessment in 2008 two major assessment issues have been put forwards 1) the quality of the discard data from the UK fishery and >100mm Dutch fishery, and 2) the different signals in the three scientific tuning indices; the SNS, BTS-Isis and BTS-Tridens. Both aspects will be studied in more detail and suggestions for improvements will be made.

In the 2008 WGNSSK plaice IV assessment, it was also suggested that incorporating the commercial lpue series may improve the quality of the assessment. The effect of incorporating the commercial lpue series into the assessment will be investigated and a final advice on inclusion will be made.

Currently the assessment itself makes use of Extended Survival Analysis (XSA). Statistical catch-at-age models have been used frequently in different stocks, in particular in pelagic stocks and by the non-European fishery science community. This benchmark assessment will look at the pros and cons of the statistical catch-at-age models and in particular to the Statistical Catch-at-Age presented by Aarts and Poos, 2009.

This year the benchmark assessment will be carried out in close collaboration with stake-holders. The Dutch Fish Product board (PVis), present at the meeting, have extended on the results of their self-sampling discard programme. They also presented a plan to start their own industrial survey and have requested the WKFLAT to provide feedback.

5.2 Compilation of available data

5.2.1 Catch and landings data

Discards

Discard sampling programmes started in the late 1990s to obtain discard estimates from several fleets fishing for flatfish. These sampling programmes give information on discard rates from 1999 but not for the historical time-series. Observations indicate that the proportions of plaice catches discarded at present are high (80% in numbers and 50% in weight: (van Keeken *et al.*, 2004b)) and have increased since the 1970s (51% in numbers and 27% in weight: (van Beek, 1998)). The discards time-series are derived from Dutch, Danish, German and UK discards observations for 2000–2007.

For the period prior to 2000, a reconstructed discard time-series for 1957–1999 exists, based on a reconstructed population and selection and distribution ogives (ICES CM 2005/ACFM:07 Section 9.2.3). Aarts and Poos, 2009 present a Statistical Catch-at-Age model which incorporate flexible fishing and discard selectivity functions that can change over time. This method not only accounts for unaccounted mortality, e.g. as a result of historical discarding, it will also explicitly deal with uncertainty in the current discard data. Section 5.7.1 describes the methodology in more detail.

Currently, the total discard numbers-at-age are based on individual length measurements of the discard fraction of the catch which are transformed into age-structured discards using age–length keys. However, two key parameters in stock assessment methods, fishing selectivity and retention, are essentially length-based selection processes. The stock assessment methodology could be improved by including length measurements directly into the assessment. In particular, the number of parameters could be reduced, and a clearer and more direct link with the processes leading to fishing selectivity and retention would be obtained. For a discussion on alternative stock assessment models which use such length-based processes, see Section 5.7.1 of this report.

The quality of the estimation of total discards numbers-at-age depends on the quality of the available discards data, which are derived from low sampling level discards observations within the four countries that have provided discard estimates. A self sampling programme for discards was started by the Dutch beam trawl fishery in 2004, and is still running. This sampling programme has a large number of samples, taken on board by the fishers, estimating the percentage of discards by volume. The programme indicates a strong spatial pattern in the discarding of the fleet. The percentage discards estimated in the self sampling programme is significantly lower than that in the Dutch sampling programme in the same years, Aarts and van Helmond, 2007. Currently, an evaluation is being undertaken to analyse the causes of the difference.

Most discarding consists of individuals below MLS, but there are indications that some discarding of marketable plaice (highgrading) occurs, in particular in the first quarter of the year (see also Section 5.1.4). This is the consequence of high catchability of plaice in the southern and central North Sea as a consequence of aggregations of spawning plaice in these regions. For the estimation of stock size, the accurate estimation of discards at age is essential. However, the localized nature and short time span at which highgrading takes place makes accurate estimation difficult. In the near-future, effort should be made to estimate the size of this Section of the discards, by starting a more detailed sampling programme in collaboration with the industry.

Landings

Not further assessed during this benchmark.

5.2.1.1 Evaluation of the quality of the UK discards data

A considerable proportion of the total landings of Plaice in Subarea IV is attributed to the UK. For example, in 2007 24% of the total landings were made by UK vessels (Table 5.2.1). The plaice landings are made by Otter trawl and 80 mm and >100 mm beam trawl vessels. Considerable discarding will most likely coincide with such large landings and having accurate estimates for both landings and discards is essential to the assessment of the stock. However, the UK beam trawl and Dutch >100 mm fishery is very poorly sampled. For example in 2005 and 2007 no UK beam trawl vessels were surveyed, and the discard estimates are only based on the Otter trawl fishery.

Table 5.2.2 indeed shows considerable variability between years. For example in 2006, the estimated discards were 48 times higher as in 2005. In 2002 the number of discards-per-tonne was even higher than the Dutch fleet, while in that year almost all fishing took place in the more northern regions of the North Sea. The spatial analysis of the data from the Product board discard self sampling programme demonstrates that in the more northern regions the discards are much lower compared with the more coastal regions (Figure 5.2.1). From 2002 onwards the observed UK discard estimates declines considerably, although the amount of fishing in the more southern regions (characterized by high discards) increases considerable (Figure 5.2.2). This increase is a consequence of the fact that the UK-flagged vessels are bought by Dutch companies.

This discrepancy between the data on UK discards and the existing knowledge of the spatial and temporal patterns in fishing effort and discards, strongly suggest that the current estimates are incorrect.

During this WKFLAT meeting attempts are made to improve the UK discard estimates by incorporating discard data from the Dutch fleet. This could be done by modelling the age specific UK discard levels in the data as a function of the age and year specific discard estimates from the Dutch fleet, and to use this model to generate an age and year specific model estimate for the UK fleet.

Several models have been tested, relating the logarithm of the UK discard numbers-at-age to the logarithm of the Dutch discard numbers-at-age, using linear regression. This revealed no significant relationships between UK and Dutch discard data, most likely as a consequence of limited information in the UK discard data, the existence of outliers in the UK discard data, and the limited number of data points. In the absence of additional information, we therefore assume a constant ratio between the UK and Dutch discard numbers-at-age:

$$\hat{D}_{a,y}^{UK} = \frac{\sum_{y=2002}^{2007} D_{a,y}^{UK}}{\sum_{y=2002}^{2007} D_{a,y}^{NL}} \times D_{a,y}^{NL}$$

where $D_{a,y}^{UK}$, $\hat{D}_{a,y}^{UK}$, and $D_{a,y}^{NL}$ are the observed and estimated UK, and observed Dutch discard numbers of year *y* and age *a*, respectively.

Table 5.2.2 shows the new discard numbers-at-age for the UK fleet. Figure 5.2.3 shows the effect of including the effect of including the estimated discard numbers on Fbar and SSB, as estimated using XSA. While these estimates will be used in the XSA final assessment runs, we also evaluated the sensitivity to inaccurate discard estimates, by assuming zero UK discard from 2002–2007 and assuming that UK discard numbers are equal to the average of the Dutch, Danish and German 80 mm fleets.

Currently the difference between SSB and Fbar under the different assumptions is relatively small, but its effect may be more prominent in future population projections when the discarded ages enter the adult population.

5.2.2 Biological data

5.2.2.1 Weights-at-age

The stock weights of age groups 1–4 are calculated using modelled mean lengths from survey and back-calculation data (see ICES CM 2005/ACFM:07 Appendix 1) and converted to mean weight using a fixed length-weight relationship. Stock weights of the older ages are based on the market samples in the first quarter. Stock weight-at-age has varied considerably over time, especially for the older ages. Discard weights-at-age are calculated the same way as the stock weights of age groups 1–4, after which gear selection and discarding ogives are applied. Landing weights-at-age are derived from market sampling programmes. Catch weights-at-age are calculated as the weighted average of the discard and landing weights-at-age.

There appear to be cohort effects on landings weight-at-age, which are also reflected in the stock weights-at-age. In addition to the cohort effects, there is a long-term decline in weight-at-age for the older ages. In 2007, stock weight estimates for several of the older ages are below the weights of the same cohort in the previous year. This may be an extension of the long-term decline in stock weight-at-age. However it may also be as a consequence of non-representative sampling of the different sexes in the population, mainly in the Dutch sampling programme. The stock weights of the older ages are based on the market samples in the first quarter. In these market samples, the sex ratio for the older ages is skewed towards the lighter males. The WKFLAT suggests a close inspection of future weights-at-age observations during the upcoming WGNSSK assessments and a more in depth study into the causes and consequences of the perceived decreases in stock weights for the next benchmark assessment. One solution may be to assess the status of the stocks for the two sexes separately (see Section 5.1.2.5). No changes have been made in the current WKFLAT benchmark assessment.

5.2.2.2 Maturity-at-age

A fixed maturity ogive is used for the estimation of SSB in North Sea plaice, assuming maturity-at-age 1 is 0, maturity-at-age 1 and 2 is 0.5, and older ages are fully mature. However maturity-at-age is not likely to be constant over time (Grift *et al*., 2003, Grift *et al.*, 2007). The effects of assuming a constant maturity-at-age on the management advice was discussed in a study by Kell and Bromley, 2004. However, a study of the effect of the fluctuations of natural mortality on the SSB by the WG in 2004 demonstrated that incorporating the historical fluctuations had little effect on SSB estimates in the period 1999–2003.

5.2.2.3 Natural mortality-at-age

Natural mortality is assumed to be 0.1 for all age groups and constant over time. These estimates are probably derived from war-time estimates by Beverton and Holt, 1957. Using tagging studies Metcalfe, 1997, it may be possible to provide a rough estimate of mortality for the older ages, but only if considerable proportion of the tagged fish are recovered.

Also, some recently developed statistical catch-at-age can incorporate and estimate changes in unexplained mortality, by modelling 'natural mortality' as a random walk process. They idea is that natural mortality in year *t* is equal to the mortality in the previous year *t-1* plus a small value drawn from normal distribution with mean zero and prespecified standard deviation. The implicit assumption is that mortality can only change gradually over time. Although it may not be possible to estimate natural mortality separately, the method will allow for the estimation of unexplained mortality, and therefore improve the estimation of the stock size (pers. comm. Jim Ianelli).

5.2.2.4 Discard mortality-at-age

Industry questions the assumption that all discarded plaice do not survive. The most extensive study on plaice survival is done by van Beek, 1990. The mean discard mortality of plaice (18–27cm) was estimated at approximately 90% after 84 hours. Careful handling of discarded plaice can increase the survival, but this was only observed when the haul duration was relative short (60 minutes). Many additional factors influence the survival such as depth, water temperature and gear type, but those effects where relatively small compared with the effect of haul duration. Based on the study by van Beek, 1990 there are no indications that under the current fishing practices the survival is much higher. Currently, no changes have been made in the WKFLAT benchmark assessment. In future benchmark it may be worthwhile to investigate the effect on the stock size when reducing the discards mortality (assumed to by 100%) by 10%.

5.2.2.5 Sex ratios and sexual dimorphism in growth

There is a considerable difference in weight-at-age between the different sexes. Also fishing mortality, natural mortality, and the spatial and temporal distribution between the sexes may differ. No changes have been made in the current benchmark assessment, but we recommend that information on sex ratios is evaluated during the assessment process and that the assessment may improve, when sexes are modelled as separate components of the stock.

5.2.3 Survey tuning data

5.2.3.1 Evaluation of the quality of the survey data

Three different survey indices can be used as tuning fleets (Table 5.2.3 and Figure 5.2.4):

- Beam Trawl Survey RV Isis (BTS-Isis)
- Beam Trawl Survey RV Tridens (BTS-Tridens)
- Sole Net Survey in September-October (SNS)

The Beam Trawl Survey RV Isis (BTS-Isis) was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the southeastern part of the North Sea (RV Isis). The spatial sampling distribution of these surveys is depicted in Figure 5.2.5. Since 1996 the BTS-Tridens covers the central part of the North Sea, extending the survey area of the surveys. Both vessels use an 8-m beam trawl with 40 mm stretched mesh codend, but the Tridens beam trawl is rigged with a modified net. Currently, age groups 1 to 9 are used for tuning the North Sea plaice assessment.

The Sole Net Survey (SNS) was carried out with RV Tridens until 1995 then continued with the RV Isis. Until 1990 this survey was carried out in both spring and autumn, but after that only in autumn, except in 2003 when surveying took place in spring only. The gear used is a 6 m beam trawl with 40 mm stretched mesh codends. The stations fished are on transects along or perpendicular to the coast. This survey is directed to juvenile plaice and sole. Ages 1 to 3 are used for tuning the North Sea plaice assessment; the 0-group index is used in the RCT3.

Traditionally, the BTS-Isis and SNS surveys captured trends in the numbers of plaice of younger ages best, because their spatial sampling effort overlapped most with the distribution of fish of these ages. Conversely, the BTS-Tridens survey was believed to capture trends in numbers of fish of older ages best. However, in recent years, there has been a marked change in the spatial distribution of plaice of younger ages, which has resulted in a gradual increase in numbers of younger plaice being caught further offshore by BTS-Tridens (Kraak *et al.*, 2008). Because of this change in the spatial distribution of the younger ages relative to the areas covered by each of the surveys, it can no longer be assumed that the trends in the indices of these surveys independently reflect the trend in abundances of age classes in the whole of the north sea. However, tuning indices can only be included in stock assessments under the assumption of constant catchability (over years). This crucial assumption will be violated in case of a change in the spatial distribution of age classes as described above.

The relatively more positive trend in the BTS-Tridens survey for the younger ages is also reflected in the SSB and Fbar estimates obtained from XSA, particularly in the most recent years. Using the BTS-Tridens survey data only in the assessment results in an SSB estimate which is approximately 50% higher compared with the SSB estimate obtained by using the indices from the BTS-ISIS and SNS surveys only (Figure 5.2.7). The residuals obtained by regressing the SNS and BTS-ISIS survey indices on the XSA population estimates are positive before and negative after, the year 2000. In contrast, there is an opposite pattern in the residuals from the BTS-Tridens index (Figure 5.2.6).

5.2.3.2 Splitting tuning indices to achieve constant catchability

With the current settings in XSA, each tuning index receives an age-specific weighting based on how well it relates to the historical population estimates (inverse variance weighting). Historically, this may have been a good weighting scheme, but given the changes described above, the weightings may be inappropriate for the most recent years. As a solution, it would be possible to give more weight to more recent years (using e.g. the tapered weighting function available in XSA), or to include more recent years only. However, given that potential changes in catchability have taken place recently, bias could be introduced if weights are based partly upon historic parts of the time-series where the relationship between index and stock estimates was different. The tuning series could be split into parts, before and after the change had taken place. The WKFLAT therefore recommends splitting the SNS survey into two indices; before and after 2000.

5.2.3.3 Combining the survey indices

The rationale behind combining the indices from BTS-Tridens and BTS-Isis is that any changes in the population distribution in recent years would be entirely contained within the area covered by both surveys combined. Combining the indices is possible because BTS-Tridens and BTS-Isis fish with similar gear and their surveys overlap partly in time and space. Also, both surveys take place in the same period of each year. Therefore, differences in efficiency can be expected to arise exclusively from differences in gear used.

We have obtained gear selectivity ratios from the report of the 2005 Beam Trawl Working Group (WGBEAM05). In the WGBEAM project, pairs of hauls of BTS-Isis and BTS-Tridens within 10 miles of each other were compared in terms of differences in numbers of fish smaller than, or larger than, 15 centimetres. The following relationship was estimated for the relationship in catch efficiency between BTS-Isis and BTS-Tridens:

$$y = e^{A} x^{B} \,,$$

where y is the number of fish of a particular size class (≤ 15 or > 15 centimetres) caught by BTS-Isis, x the number of fish caught by BTS-Tridens, and *A* and *B* are parameters.

The following parameters estimates were obtained (WGBEAM05; Table 4.2.1):

	≤ 15 CENTIMETRES	> 15 CENTIMETRES
A	-0.42	-0.55
B	0.79	1.03
Mean catch efficiency ratio	0.34	0.66

The 'mean catch efficiency ratios quoted in the table above are the ratios of the catch of each gear-type and the catch of the standard BTS. The ratio is determined for the mean catch of each specific species/size group in the standard gear (WGBEAM05).

We used the mean catch efficiency ratios for the two size classes to create a new combined index by multiplying the numbers of fish caught by BTS-Tridens with (1/0.34)=2.941176 (fish <=15 cm) and (1/0.66) = 1.515152 (fish >15 cm). The numbers of fish caught by BTS-Tridens and BTS-Isis were then added together, and an age-specific index per year was obtained by applying the available spatio-temporal time-series of age–length keys (Table 5.2.2). It was found that relative catch efficiencies varied considerably with distance from the coast (WGBEAM05, Figure 4.2.3). BTS-Tridens (standard BTS with flip-up rope) demonstrates a different pattern where relative catch efficiency of small plaice initially increases up to 20 (plaice) or 25 (sole) miles after which it decreases).

We emphasize that the procedure that we have used here to compute the combined index needs to be checked by the WGBEAM team. Not all details involved in the estimation of the gear efficiency ratios are evident from the WGBEAM report. Furthermore, the impact of potential spatial patterns in gear efficiency ratios on the procedure for combining the indices that we have presented here needs to be further evaluated.

5.2.3.4 Description of the characteristics of the combined index in relation to the BTS-Tridens and BTS-Isis indices

The combined index was compared with the separate indices (Figure 5.2.8). For ages 1–3, the (standardized) combined index closely tracks the Isis index, but is higher in most recent years. This is in correspondence with our knowledge of the spatio-temporal changes in the distribution of younger plaice, which have moved partly out of the area surveyed by BTS-Isis, and into the area surveyed by BTS-Tridens. For the ages groups of 4 years and older, the combined index closely tracks the index of BTS-Tridens.

5.2.3.5 Assessment trials using the combining survey indices

Stock assessment trials were performed with different combinations of tuning indices. The following assessments were run:

1) With the current settings (BTS-Tridens, BTS-Isis and SNS included for all available years as tuning indices).
2) With the combined index and the SNS from 1982–2007.
3) With the combined index and the SNS from 1982–1999 and 2000–2007 separately.
4) With the BTS-Tridens from 1996–1999 and from 2000–2007, BTS-Isis from 1985–1999 and from 2000–2007, and the SNS from 1982–1999 and from 2000–2007.

No pattern was evident in the residuals of the combined index when it is used in XSA (Figure 5.2.9). Instead, a very strong residual pattern is still present in the index of the SNS (Figure 5.2.9). This residual pattern is much reduced when the SNS index is split into an index before and after 2000 (Figure 5.2.10). Identical results were obtained in XSA when the SNS tuning series before 2000 was included or left out of the analysis.

The SSB estimates of the four assessment trials are shown in Figure 5.2.11.

Also, the importance of the cut-off point for the SNS tuning series is investigated by varying this from 1998 to 2002 (Figure 5.2.12). While a pattern is apparent with increasing SSB estimates the more recent the cut-off point is chosen, the absolute differences in SSB estimates are small.

5.2.3.6 Conclusion

We propose that combining the tuning series from BTS-Tridens and BTS-Isis into a single tuning index, at least from 2000 onwards is something that needs to be considered, given the changes in the spatial distribution of fish of younger ages, the strong patterns in the residuals of the survey indices in XSA, and the relatively large influence on the estimates of F and SSB in the final year on the inclusion/exclusion of either of these tuning indices (Kraak *et al.*, 2008). For the same reasons, we propose that the SNS tuning series is used only from the year 2000 onwards

Here, we have presented a procedure for combining the tuning indices using gear selectivity ratios at mean catch as published in WGBEAM05. The combined index follows the trends of BTS-Isis for younger ages. However, in the most recent years, the combined index starts to deviate from that of the BTS-Isis, and now appears to lie between the indices of BTS-Tridens and BTS-Isis. This is in accordance with the information and knowledge of the changes in the distribution of fish of ages 2 and 3. For the older ages, the combined index follows the index of BTS-Tridens closely throughout the time-series. The combined index does not have a strong residual pattern when included in XSA.

Using the SNS tuning series from 2000 onwards greatly reduces the residual pattern, and increases the weight that this survey has in the estimates of the survivors in the final year for ages 1–3. However, residual patterns remain, with more negative residuals in the final years. This is reflected by the fact that the results from XSA indicate that the more recent the start of the SNS tuning series, the higher the estimates of SSB in the final year.

We emphasize that the procedure that we have used here to compute the combined index needs to be checked by the WGBEAM team, because this is their area of expertise. One assumption in our method is that the estimated gear efficiency ratios in the overlapping region are representative for the entire North Sea. However, as a consequence of the bottom structure in some areas of the North Sea (e.g. the coastal areas of the UK), gear efficiencies may be different from the overlapping region. This complexity has been mentioned in WGBEAM05, but no detailed quantitative information has been presented on this matter.

A second assumption is that the gear efficiency ratio within each length class (<= 15 cm or >15 cm), are constant. However, this assumption may be incorrect.

The processes described above will have an influence on the range of ages for which the indices should be combined. We suggest that WGBEAM further investigate these issues.

5.2.4 Commercial tuning data

5.2.4.1 Evaluation of the quality of the commercial tuning data

In stock assessment of commercial fish stocks, the terminal fishing mortality rates are generally estimated by tuning the estimated stock numbers to independent estimates of the stock, using research vessel survey data and Landings per unit of effort (lpue) series of commercial fleets. Commercial lpue series generally reveal a better performance for the older age groups, while the research vessel survey data demonstrate a better performance for the younger age groups. However, the potential for bias in commercial lpue series has raised substantial concern (Gulland, 1964; Harley *et al.*, 2001).

The ICES Assessment Working Group on Demersal Stocks in the North Sea and Skagerrak used both survey data and commercial lpue data until the mid nineties. At that time, however, it was realized that commercial plaice lpue data of the Dutch beam trawl-fleet, which dominated the fishery, were likely to be biased as a consequence of quota restrictions (Pastoors *et al.*, 1997). These issues were mainly relevant to plaice, so it was decided not to include commercial plaice lpue data in stock assessment. Lpue for sole has never been removed from the assessments, because of the scarcity of fishery-independent data for this stock.

Initially, one major objection for including the lpue data were that separation of age classes was impossible. In 2008 however, a series of landings per age class became available. In addition, data from the Danish fleet are included, because this fleet has an important role in plaice fishing. The second major objection was that the observed changes in the lpue could have been driven by changes in the distribution of effort, e.g. changes caused by increases in the fuel prices or quota restrictions. The current lpue has been standardized to accommodate such distributional changes in effort (sections of text taken from Quirijns and Poos WD WGNSSK 2008).

5.2.4.2 Analysis

The objective of this study is to explore the relationship between the lpue index and other tuning indices, to quantify its effect on stock size, and to create a table of advantages and disadvantages for including is as a tuning series. This information will be used to decide whether or not to include the lpue in the assessment.

Figure 5.2.13 shows high internal consistency, especially for the older ages. There is also a large agreement with other tuning indices (Figure 5.2.14). A regression analysis of lpue as a function of numbers-at-age as estimated through XSA using all data sources, but excluding lpue as a tuning index (Figure 5.2.15), also shows a strong correlation for ages 4 and older. However, there are also some differences. The standardized lpue index is lower in most recent years relative to the fishery-independent tuning indices. This leads to slightly lower SSB (and correspondingly higher Fbar) estimates when the lpue is included in XSA (Figure 5.2.16).

5.2.4.3 Pros and cons of using the standardized lpue

Possible advantages of using the lpue series

- The commercial fleet has the largest spatio-temporal coverage of the North Sea. This is an important potential advantage, especially given the problems with the separate fishery-independent tuning indices described above.
- The commercial fleet has information available on plaice of older ages; these are not caught in large numbers by the surveys.

Possible disadvantages: potential changes in efficiency

- Changes in fuel prices can be expected to have led to changes in fishing speeds and locations. While the changes in fishing locations are corrected for by the spatial weighting of the index, changes in fishing speed would lead to biased estimates of effort. Reductions of approximately10–20% in fishing speed in order to maximize fuel-efficiency have probably happened (Ben Daalder, pers. comm.).

- In the spawning period at the beginning of the year, the Dutch plaice fishers agree to reduce their landings. The agreement for 2009 is that producers' organizations will not land more than 30% of their quota from the 1st of January until the 28th of March (pers. comm. PVis). Each producer's organization is responsible of achieving this maximum of 30% and it usually results in individual fishers not landing more than 30% of their individual quota. 2009 will be the fourth year in which such a measure has been adopted. The first quarter of each year is characterized by a high catchability of plaice in the southern and central parts of the North Sea because of the aggregation of spawning plaice in these parts. Fisheries targeted on sole also take place in these regions, leading to considerable coincidental catches of plaice. This may result in exceeding the 30% of the contingent before the end of the first quarter. Therefore, marketable plaice may be discarded (highgrading). Those catches are not included in the landings and therefore the lpue series. Because the abundance of plaice has increased relative to the abundance of sole, and the price of sole has increased relative to that of plaice in recent years, this form of discarding may have increased. Such changes in discarding behaviour would lead to bias in the lpue series.

5.2.4.4 Conclusion and recommendation

We have documented potential advantages and disadvantages. Extensive attempts have been made to standardize the lpue index to account for spatial and temporal changes in the fishery. Nevertheless, concerns remain about potential unaccounted changes in the efficiency of the fishery (decrease in fishing speed in order to maximize fuel economy), and unregistered discards of marketable plaice.

To improve the lpue series, the WKFLAT advices to get discard estimates of marketable plaice. As a consequence of the local nature of this highgrading and the potentially small time-window during which this takes place, it may be difficult to quantify the extent of this form of highgrading in the current discard sampling programme. One solution may be to cut-off the period in question. A better, but more long-term solution would be to obtain accurate estimates by working in close collaboration with the industry, and adopt targeted discards sampling.

Using the lpue index in the stock assessments will provide better insights into biological and fishery related processes. However, as a consequence of the potential biases described above, we do not recommend the use of the lpue series in the final assessment run upon which the advice is based.

5.2.5 Industry/stakeholder data inputs

In close collaboration with IMARES, the Dutch Product board have introduced the lpue series of the Dutch beam trawl fleet, corrected for the spatial effort allocation.

5.3 Stock identity and migration issues

Many tagging studies exist on the migration patterns of mostly adult female plaice. The general pattern of plaice migration has been established from trawl surveys (Wimpenny, 1953) and mark-recapture experiments in the Southern Bight of the North Sea and the English Channel (see review by Harden Jones, 1968; de Veen, 1978; Rijnsdorp and Pastoors, 1995; Bolle *et al*., 2005). Houghton and Harding, 1976 demonstrated that 20–30% of the plaice catch from the eastern Channel in winter contained migratory North Sea fish that entered the Channel in autumn and left rapidly after spawning. Plaice tagged in the Channel during summer were not recaptured outside the Channel, but appeared to be members of two groups that returned to specific (east or west Channel) spawning areas each winter. An analysis combining estimates of spawning-stock biomass with fishing intensity at the recapture sites suggested that, of the plaice spawning in the Channel during January and February, 20% spent summer in the western Channel (VIIe), 24% in the eastern Channel (VIId), and approximately 56% migrated to the North Sea (IVb,c). Few plaice tagged in the southern North Sea during January and February were recaptured in the Channel (de Clerk, 1977).

Since the late 1960s, electronic tags that transmit acoustic signals have been used to track the movements of individual free-ranging fish for limited periods (Arnold and Dewar, 2001). Such work has demonstrated how, in the Southern Bight of the North Sea, plaice use selective tidal stream transport during their pre- and post-spawning migration (Greer Walker *et al*., 1978, Metcalfe *et al*., 1992). Fish exhibiting this behaviour leave the seabed and move into midwater at about the time of slack water and swim down tide for the major part of the ensuing north-going or south-going tide. As the tide turns again, the fish return to the seabed where they remain for the duration of the opposing tide. This behaviour allows fish to move rapidly (25 km per day is not exceptional) between feeding and spawning grounds while considerably reducing the cost of migration compared with swimming continuously over the same distance (Metcalfe *et al*., 1990). This understanding of plaice biology has allowed the development of computer simulation models that predict rates and scales of geographical movement by combining patterns of behaviour (vertical movements) with local hydrography (tidal stream vectors, Arnold and Holford, 1995). However, acoustically tagged fish can only be tracked for a few days and early versions of such models (Arnold and Cook, 1984) were based on relatively small amounts of behavioural data. Consequently, only simple assumptions could be made about how behaviour might change in time and space.

Advances in microelectronic technology have led to the development of electronic "data storage" or "archival" tags that are small enough to be carried by fish and record and store environmental data such as pressure (to give depth) and temperature. These data can then be used to derive detailed information about fish behaviour and movements at much finer temporal and spatial scales than is possible with mark-recapture experiments. Pressure measurements can be used to geolocate fish whenever they remain stationary on the seabed for a full tidal cycle (Metcalfe and Arnold, 1997; Hunter *et al*., 2003). Further, depth information can be used to derive information about fish behaviour such as vertical movements and patterns of activity. This new technology allows information to be gathered from many fish simultaneously, and over entire annual cycles of feeding, migration and spawning (Metcalfe and Arnold, 1997).

Since 1993, almost 1000 plaice equipped with electronic data storage tags (DST) have been released into the North Sea. Several hundred tags have now been returned through the commercial fishery, yielding several tens of thousands of days of data for geolocation (from tidal data, above), behaviour and environmental temperature that have changed the understanding of the structure of the plaice population in the North Sea. While the concept of plaice subpopulations in the North Sea is not new (de Veen, 1978; Cushing, 1990) previous mark-recapture data (de Veen, 1978) had suggested there were isolated plaice subpopulations that aggregated during winter spawning then dispersed during summer over distinct but overlapping feeding grounds. In contrast, detailed analysis of the data from these DSTs has revealed that the adult plaice population in the central and southern North Sea forms three geographically discrete feeding aggregations during summer, that disperse over the southern North Sea and eastern English Channel to spawn in winter (Hunter *et al.*, 2004).

No obvious single physical factor stands out that can explain the divergent feeding aggregations. For example, they cannot be explained solely by temperature because similar temperatures are found in areas where the fish occur at much lower densities. There are also no obvious physical features of these three areas that make them stand out from other parts of the central and northern North Sea. For example, the depths and bottom substrata are not unique to these areas (British Geological Survey, 1991). The level of dispersion observed during spawning does not appear to be ascribable to differential timing of individual fish migrations, but as a consequence of the widespread geographical area that the plaice visited to spawn, irrespective of summer location. The use of southerly spawning grounds may be for several reasons. First, there may be a need for warmer water during maturation of gonads and early development of larvae (Lam, 1983). Second, the tidal currents in the south will bring the larvae towards shallow coastal nursery areas (Harden Jones, 1968; Cushing, 1990).

The system of tidal streams that some North Sea plaice appear to exploit during their seasonal spawning migrations is relatively well defined, and several authors have suggested that plaice stocks are contained within the tidal streams (Harden Jones, 1968; Arnold and Cook, 1984; Cushing, 1990). Results from DST experiments indicate that two of the three feeding aggregations were indeed located at the branch terminals of the tidal streams, but the third (northern) lies outside the influence of the transport system. Northern fish often travelled in excess of 250 km to spawn, without the benefit of tidal transport. It should be noted that because we did not tag fish off the northeast coast of England during the spawning season, our results may mask the existence of a fourth subpopulation off the Scottish coast, where plaice are also known to occur (de Veen, 1978; Lockwood and Lucassen, 1984).

The majority of the northern plaice did not move south of the 0.3 ms^{-1} average tidal current velocity contour (Hunter *et al.*, 2004). Their migration occurred along an approximate north-south axis, at right angles to the primary axis of tidal flow (Harden Jones *et al.*, 1979). The observation that a few plaice from each of the aggregations were capable of entering, leaving, and sometimes crossing the tidal stream paths (Hunter *et al.*, 2004) suggests that although tidal streams may provide directional clues (Harden Jones, 1984; Gibson, 1997), a significant navigational component involving external cues may also be involved (Metcalfe *et al.*, 1993), and that the containment of tidally transporting fish is not absolute.

During summer period, the northern feeding aggregation remain separate from the eastern and western aggregations by the North Sea thermal front (Hunter *et al.*, 2004), the southern boundary of the area of seasonal thermal stratification (Pingree and Griffiths, 1978). The location of the front itself is determined by the strength of the tidal stream currents because the stronger currents in the southern North Sea prevent the establishment of a stratified surface layer of warm water.

The eastern and western feeding aggregations remain in warm, thermally mixed water south of the front, whereas the northern subunit are located in deeper, cold, thermally stratified water. The thermal front appears to represent a distributional limit for each of the aggregations, and may represent a physical barrier to the northward movement of warm-adapted plaice. Plaice from the western and eastern feeding aggregations rarely occur in water deeper than 40 m (Hunter *et al.*, 2004), the approximate depth of the thermally stratified layer (Pingree and Griffiths, 1978; Brown *et al*., 1999). In contrast, the plaice from the northern feeding aggregation migrate through the thermal front before the winter breakdown of stratification, at the onset of the prespawning migration (Hunter *et al*., 2003b).

The association of fish with the areas bordering thermally stratified areas may also have foraging implications, given that temporally these are relatively stable features (Pingree and Griffiths, 1978; Brown *et al*., 1999). There is a significant relationship between increased levels of primary productivity along thermal fronts (Pingree *et al*., 1978; Riegman *et al*., 1990; Heilmann *et al*., 1994), and increased productivity at higher levels in the food chain (Lindley and Williams, 1994; Josefson and Conley, 1997; Skov and Durinck, 1998). Although corroborative data are not available, it seems reasonable to assume that increased primary productivity in the water column would result in seasonally predictable increased food resources on the seabed (Barry and Dayton, 1991).

5.4 Spatial changes in the fishery and stock distribution

Changes in the fishery

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 of 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 catch-rates 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 cpue 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 cpue index for stock biomass in future. Collection of more comprehensive data on the catch-rate by individual tows in conjunction with the obligatory recording of fishing locations using VMS, is important to assess the quality of the cpue time-series on stock biomass, and may provide data to correct cpue time-series for variations in micro-scale targeting. Other factors that may cause bias in cpue: increasing efficiency of the fleet, vessel interactions and highgrading need to be estimated separately. The increase in efficiency can be readily estimated from the time-series of catch and effort data (Marchal *et al.*, 2002) and was estimated to be 2.8% and 1.6% per year in the period 1990–2004 for sole and plaice, respectively (Rijnsdorp *et al.*, 2006). Vessel interactions that reduce the catch-rate with increasing density of fishing vessels may be more difficult to analyse (Gillis, 2003), although (Poos and Rijnsdorp, 2007a, b) provided evidence of interference competition in the Dutch beam trawl fleet and estimated that a doubling of the vessel density within an ICES rectangle would reduce the catch-rate by approximately 10%. Discarding or nonreporting of a part of the catch of marketable fish will bias cpue and may have a similar effect as the redirecting of fishing effort to a fishing ground with a lower catch-rate. Hence, the targeting index developed may partly reflect variations in highgrading, or misreporting of catches. In the Dutch beam trawl fleet misreporting is considered to be negligible, but highgrading may occur under certain circumstances.

5.5 Environmental drivers of stock dynamics

Not further assessed during this benchmark.

5.6 Role of multispecies interactions

5.6.1 Trophic interactions

Not further assessed during this benchmark.

5.6.2 Fishery interactions

Not further assessed during this benchmark.

5.7 Impacts on the ecosystem

Not further assessed during this benchmark.

5.8 Stock assessment methods

5.8.1 Models

eXtended Survivors Analysis (XSA)

Currently the stock assessment of plaice in IV is done using XSA. XSA is a VPA type analysis, but also allows for the inclusion of different tuning indices (Shepherd, 1999). XSA is not a full statistical model and therefore lacks some of the advantages described below.

Statistical Catch-at-Age model (SCA) with time-varying fishing and discarding selectivity functions (Aarts and Poos, 2009)

The conceptual complexity of the current reconstruction of the historical (<2000) discards ((ICES 2005); (van Keeken *et al.*, 2004a)), has lead to 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 estimate 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 statistical catch-at-age model is that it allows for the inclusion of additional biological processes, use objective criteria (i.e. likelihood-based information criteria) to select the best model and explicitly estimate uncertainty in both the input data and the uncertainty in the stock summaries, such as SSB and fishing mortality F.

Length-based statistical assessment methods and other extensions to SCA

Both existing and new information on biological processes and changes thereof such as changes in maturation, growth and mortality are difficult to include in the current XSA. In contrast, SCA are more flexible. In Annex 8 a more detailed illustration is made on how such processes can be included into the stock assessment.

One of those extensions is the inclusion of length-based retention functions. The selectivity processes of the fishery and scientific surveys are length-based. Also the retention (and discarding) is a length-based process. For most stocks, including plaice, there is limited data available on historical discards. However, there is considerable historical data available on the numbers at length and age–length-key tables. Using this length-based information and incorporating it into the assessment may greatly improve our understanding of the fishery processes and the quality of the assessment. The flexibility of SCA to include different data sources and model components into the likelihood functions makes incorporation of such length-based processing relatively straight forward. The WKFLAT therefore recommends that future benchmark assessments should look into the inclusion of the length-based selectivity patterns.

5.8.2 Sensitivity analysis

Not further assessed during this benchmark.

5.8.3 Retrospective patterns

Not further assessed during this benchmark.

5.8.4 Evaluation of the models

Not further assessed during this benchmark.

5.9 Stock assessment

The stock assessment for North Sea plaice will continue to be the XSA, as it is described in last years' WGNSSK report, and the stock annex that is appended to this WKFLAT report. However, the UK discards input data are to be used as described in Section 5.2.1.1, where a constant ratio between the UK and Dutch discard numbers-at-age is assumed from 2000–2007. This change does not substantially alter the perception of the stock. Changes in this perception are only found in the most recent 10 years of the assessment (Figure 5.2.3).

In Section 5.14, we recommend to run an alternative stock assessment method for North Sea plaice in parallel with the current XSA in the update assessments, in order to test the robustness of this method. Also, we propose to further study the survey and commercial tuning indices.

5.10 Recruitment estimation

Not further assessed during this benchmark.

5.11 Short term and medium term forecasts

Not further assessed during this benchmark.

5.12 Biological reference points

Not further assessed during this benchmark.

5.13 Recommended modifications to the stock annex

A new stock annex has been constructed for North Sea plaice in IV.

5.14 Recommendations on the procedure for assessment updates

The following recommendations are being made by WKFLAT:

1) WKFLAT recommends assuming a constant ratio between the UK and Dutch discard numbers-at-age (Section 5.2.1.1) from 2000–2007, in order to estimate the UK discard numbers.
2) WKFLAT recommends revising the fishery-independent tuning indices in the light of the evidence of the spatio-temporal changes in the abundance of young plaice in the North Sea, because this would violate the assumption of constant catchability which cannot be relaxed in XSA. WKFLAT recommends that the tuning indices from BTS-Tridens and BTS-Isis are combined, and that the tuning series of the SNS is split into two series: one containing all the years up to (an including) 1999, and the other series from 2000 onwards However, until the WGBEAM group has agreed upon which gear efficiency ratios are to be used (and whether these need to vary between regions and/or ages (Section 5.2.3)), the separate indices are to be used for the final assessment runs upon which management advice is based.
3) WKFLAT recommends including the lpue index in to the assessment process. However, the lpue series is to be excluded in the final assessment run upon which management advice is based (Section 5.2.4). The reason for this is that there is concern that changes in the catchability have taken place, which have not been properly accounted for as yet.
4) WKFLAT recommends running the Statistical Catch-at-Age model (SCA model) in parallel with XSA, and evaluate the stock summaries. Once the Statistical Catch-at-Age model has been tested for a number of years, it should be adopted as the assessment method on which the management advice is based. The reason for his is that this methodology provides some major additional advantages such as its ability to incorporate biological processes, use model selection tools, and to quantify uncertainty in the assessment. Furthermore, in the SCA model, the assumption of constant catchability could be relaxed. Thus, changes in the catchability of the surveys owing to spatio-temporal changes in the abundance of young plaice in the North Sea could be estimated by the model. The intention is to improve the SCA model by including length-based processes explicitly in the model.
5) The spatio-temporal changes in the abundance of young plaice are likely to have changed the catchability of the age-1 and age-2 groups of the RCT3 survey, which is an important source of information used in the forecasting. WKFLAT therefore recommends that the SNS index is revised in the light of this evidence.

5.15 Industry supplied data

5.15.1 Self sampling-discards 2004–2008 (presented by Paula den Hartog, Dutch Fisheries Organisation)

In the Netherlands, discards in the Dutch beam trawl fishery (80 mm mesh size) are monitored following the European Commission Data Collection Regulations (DCR) 1543/2000 and 1639/2001 by IMARES since 2000.

In response to concerns about quality issues of these discard data, the Dutch beam trawl industry started, in close cooperation with the Dutch Fish Product Board (PVis), its own plaice (*Pleuronectes platessa*) discards programme in 2004. Since then, this self-sampling programme recorded discard data of about 20 Dutch commercial trawlers in the North Sea.

PVis requested Wageningen IMARES to analyse the data of the self-sampling programme for the period 2004–2007 (Aarts and van Helmond, 2007). The latest report, including the data collected in 2008, will soon be available and can be requested from PVis. PVis also requested IMARES to include their data in the North Sea plaice stock assessment. To this end the data were presented by the Dutch Fisheries Organisation at this ICES Benchmark Flatfish Workshop.

Results demonstrate a significant difference between the estimated plaice discards observed in the self-sampling programme and in the IMARES DCR programme, but this difference has decreased over the years. The discards are currently 50% and 59% respectively (Figure 5.15.1). The observed discard fractions from the self-sampling programme reveal clear spatial (Figure 5.2.1) and temporal trends (Figure 5.15.2). In the northern North Sea in the province of Zeeland in winter lower discards were observed. The variables latitude, longitude, date and the number of tickler chains from the rope head or a chain mat explain 55% of the observed variability in the data. Spatial position of the fishing vessel, explained most of the observed variability (44%). No significant difference was found between the discard estimates when both methods were directly compared for the same haul, concluding that the difference could not be explained by a difference in methodology, but it may be explained by the difference in implementation. The IMARES DCR programme takes samples from different sections of the discards, while the self sampling programme takes one sample from the catch, often only from the first section. This difference in sampling could have led to different discard estimates.

Conclusion

The major advantages of the self-sampling programme are that it samples a large number of trips from a large number of vessels which allows the quantification of detailed discard patterns in space and time. Few, if none, discards sampling programmes have such a large number of data points and such an extensive spatial and temporal coverage. This self-sampling programme had also led to a critical review of the current DCR discard sampling programme.

Recommendations

As it stands, the discards self-sampling data cannot be incorporated into the stock assessments because

1. it does not seem to represent an unbiased sample of the catch;
2. it cannot be used to directly estimate age composition of discards (see details in Aarts and van Helmond).

Work is in progress to quantify the spatial and temporal distribution of discard numbers-at-age using the discard data collected under the DCR programme. These models should be able to include the observations from the self-sampling programme and therefore improve the quality of the estimated patterns.

5.15.2 Dutch industrial survey (presented by Paula den Hartog, Dutch Fisheries Organisation)

The Dutch flatfish fishing industry will carry out an industry survey in close cooperation with IMARES. This is a request to the WKFLAT to consider the relevance of this industry survey for stock assessment of North Sea plaice. Based on this working plan it might be possible to assess the feasibility of using the results in future stock assessments or in discussions on fisheries management.

Objectives

1. A correction factor for the catch composition in the Beam Trawl Survey (BTS).

   The main objective of the survey is to compare catch compositions between the research vessel(s) during the BTS. All species and length classes will be considered in this comparison of catch compositions, but the main focus will be on commercial species. The comparison will result in a correction factor for a selection of species (and size class).

2. Time series of an industry survey index for commercial species.

   The second objective is to develop a time-series of an industry survey index, derived from annual monitoring. Preferably this index will be used as a tuning series in the stock assessments.

Methodology

Every year, during the BTS, a commercial vessel will fish close to the Dutch research vessel Tridens (and maybe also Isis). IMARES staff will be on board the commercial vessels to process the catch in the exact same way as is done on board the research vessel. The BTS lasts for 4–5 weeks. It is not yet clear if there will be funding to organize an industry survey for this entire period of time. It might be necessary to reduce the length of the industry survey to 1 or 2 weeks.

Recommendations

Carefully evaluate the objectives of the programme, because objective 1 and 2 may disagree with each other. Estimating a correction factor for the catch composition in the Beam Trawl Survey (objective 1) requires fishing side by side while setting up a time-series (objective 2) would benefit most from coverage of different regions and times of the year. When estimating differences in catchability, gear efficiency of the commercial vessels could be a representation of the current state-of-the-art fishing gear. However, when creating a tuning index, gear efficiency should be constant, or at least accurately estimated in an experimental setting. Irrespective of the objectives this survey should provide new insights and improve the communication between fishers and fishery scientists.

References

Aarts, G., and A. T. M. van Helmond. 2007. Discard sampling of Plaice (*Pleuronectes platessa*) and Cod (*Gadus morhua*) in the North Sea by the Dutch demersal fleet from 2004 to 2006. IMARES, IJmuiden.

Aarts, G., and J. J. Poos. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES Journal of Marine Science 66.

Arnold, G. P. and Cook P.H. 1984. Fish migration by selective tidal stream transport: first results with a computer simulation model for the European continental shelf. In: Mechanisms of migration in fishes. (J.D. McCleave, G.P. Arnold, J.J. Dodson, and W.H. Neill, eds) p. 227–261. Plenum Press, New York, London.

Arnold, G. P. and Holford, B. H. 1995. A computer simulation model for predicting rates and scales of movement of demersal fish on the European continental shelf. ICES Journal of Marine Science 52, 981–990.

Arnold, G.P. and Dewar, H. 2001. Electronic tags in marine fisheries research: a 30 year perspective. In: Electronic Tagging and Tracking In Marine Fisheries (J.R. Sibert and J.L. Nielsen eds), pp. 7–64, Kluwer Academic Press, Dordrecht, The Netherlands.

Barry, J.P. and Dayton, P.K. 1991. Physical heterogeneity and the organization of marine communities. Ecological heterogeneity (J. Kolasa and S.T.A. Pickett, eds), pp. 270–320. Ecological studies Vol. 86., Springer verlag, New York.

Beverton, R. J. H., and S. J. Holt. 1957. On the dynamics of exploited fish populations. Her Majesty's Stationery Office, London (UK).

Bolle, L.J., Hunter, E., Rijnsdorp, A.D, Pastoors, M.A., Metcalfe, J.D., Reynolds, J.D. 2005. Do tagging experiments tell the truth? Using electronic tags to evaluate conventional tagging data. ICES Journal of Marine Science, 62:236–246.

British Geological Survey 1991. Geology of the United Kingdom, Ireland and the Adjacent Continental Shelf. 1:1 000 000 Scale. British Geological Survey, Key-worth.

Brown, J., Hill, A.E., Fernand, L. and Horsburgh, K.J. 1999. Observations of a seasonal jet-like circulation at the central North Sea cold pool margin. Estuarine, Coastal and Shelf Science 48, 343–355.

Cushing, D.H. 1990. Hydrographic containment of a spawning group of plaice in the Southern Bight of the North Sea. Marine Ecology Progress Series 58, 287–297.

de Clerk, R. 1977. The migration of plaice on the spawning grounds. Noord-Hinder. Int. Coun. Explor. Sea CM1977/F:40, 9 pp. (mimeo).

de Veen, J.F. 1978. On selective tidal transport in the migration of North Sea plaice (*Pleuronectes platessa*) and other flatfish species. Netherlands Journal of Sea Research 12, 115–147.

Dunn, M.R. and Pawson, M.G. 2002. The stock structure and migrations of plaice populations on the west coast of England and Wales. Journal of Fish Biology. 61, 360–393.

Gibson, R.N. 1997. Behaviour and distribution of flatfishes. Journal of Sea Research 37, 241–256.

Gillanders, B.M. 2002. Connectivity between juvenile and adult fish populations: do adults remain near their recruitment estuaries? Marine Ecology Progress Series. 240: 215–223.

Gillis, D. M. 2003. Ideal free distributions in fleet dynamics: a behavioral perspective on vessel movement in fisheries analysis. Canadian Journal of Zoology 81:177–187.

Greer Walker, M., Harden Jones, F.R. and Arnold, G.P. 1978. The movements of plaice (*Pleuronectes platessa L.*) tracked in the open sea. Journal du Conseil International pour l'Exploration de la Mer 38, 58–86.

Grift, R. E., A. D. Rijnsdorp, S. Barot, M. Heino, and U. Dieckmann. 2003. Fisheries-induced trends in reaction norms for maturation in North Sea plaice. Marine Ecology Progress Series 257:247–257.

Grift, R. E., M. Heino, A. D. Rijnsdorp, S. Kraak, B. M., and U. Dieckmann. 2007. Three-dimensional maturation reaction norms for North Sea plaice. Marine Ecology Progress Series 334:213–224.

Gulland, J. A. 1964. The reliability of the catch per unit effort as a measure of abundance in North Sea trawl fisheries. Rapp.Cons.Explor.Mer 155:99–102.

Harden Jones, F.R. 1968. Fish migration. Edward Arnold (Publishers) Ltd., London.

Harden Jones, F.R. 1984. Could fish use inertial cues when on migration? Mechanisms of migration in fishes (eds J.D. McCleave, G.P. Arnold, J.J. Dodson and W.H. Neill), pp 67–78. Plenum Press, New York.

Harden Jones, F.R., Arnold, G.P., Greer Walker, M. and Scholes, P. 1979. Selective tidal stream transport and the migration of plaice (*Pleuronectes platessa L.*) in the southern North Sea. Journal du Conseil International pour l'Exploration de la Mer 38, 331–337.

Harley, S. J., R. A. Myers, and A. Dunn. 2001 Is catch-per-unit-effort proportional to abundance? Canadian Journal of Fisheries and Aquatic Sciences 58:1760–1772.

Hunter, E., Aldridge, J. N., Metcalfe, J. D. and Arnold, G. P. 2003. Geolocation of free-ranging fish on the European continental shelf as determined from environmental variables I. Tidal location method. Marine Biology, 142: 601–609.

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

ICES. 2005. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems.

Kell, L. T., and P. J. Bromley. 2004. Implications for current management advice for North Sea plaice (*Pleuronectes platessa L.*): Part II. Increased biological realism in recruitment, growth, density-dependent sexual maturation and the impact of sexual dimorphism and fishery discards. Journal of Sea Research 51:301–312.

Metcalfe, J. D., Arnold, G.P. 1997. Tracking fish with electronic tags. Nature 387:665–666.

Pastoors, M. A., W. Dol, and A. D. Rijnsdorp. 1997. Individual quota and the catch composition of Dutch beam trawl vessels.

Poos, J. J., and A. D. Rijnsdorp. 2007a. The dynamics of small-scale patchiness of plaice and sole as reflected in the catch rates of the Dutch beam trawl fleet and its implications for the fleet dynamics. Journal of Sea Research.

Poos, J. J., and A. D. Rijnsdorp. 2007b. An "experiment" on effort allocation of fishing vessels: the role of interference competition and area specialization. Canadian Journal of Fisheries and Aquatic Sciences 64:304–313.

Quirijns, F. J., J. J. Poos, and A. D. Rijnsdorp. 2008. Standardizing commercial CPUE data in monitoring stock dynamics: Accounting for targeting behaviour in mixed fisheries. Fisheries Research 89:1–8.

Rijnsdorp, A. D., N. Daan, and W. Dekker. 2006. Partial fishing mortality per fishing trip: a useful indicator of effective fishing effort in mixed demersal fisheries. ICES Journal of Marine Science 63:556–566.

Rijnsdorp, A.D. and Pastoors, M.A. 1995. Modelling the spatila dynamics of fisheries of North Sea plaice (*Pleuronectes platessa L.*) based on tagging data. ICES Journal of Marine Science 52, 963–980.

Shepherd, J. G. 1999. Extended survivor analysis: An improved method for the analysis of catch-at-age data and abundance indices. ICES Journal of Marine Science 56:584–591.

Skov, H. and Durinck, J. 1998. Constancy of frontal aggregations of seabirds at the shelf break in the Skagerrack. Journal of Sea Research 39, 305–311.

van Beek, F. A. 1990. Discard sampling programme for the North Sea Dutch participation.

van Beek, F. A. 1998. Discarding in the Dutch beam trawl fishery. ICES CM 1998/ BB:5:1–15.

van Keeken, O. A., F. J. Quirijns, and M. A. Pastoors. 2004b. Analysis of discarding in the Dutch beam trawl fleet. RIVO report C034/04, IJmuiden.

van Keeken, O. A., J. J. Poos, and M. A. Pastoors. 2004a. Discard sampling of the Dutch beam trawl fleet in 2002, CVO report 04.010. CVO, IJmuiden, The Netherlands.

Wimpenny, R.S. 1953. The Plaice.

Table 5.2.1 North Sea Plaice. Nominal landings.

YEAR	BELGIUM	DENMARK	FRANCE	GERMANY	NETHER-LANDS	NORWAY	SWEDEN	UK	OTHERS	TOTAL	UN-ALLOCATED	WG ESTIMATE	TAC
1980	7005	27 057	711	4319	39 782	15	7	23 032		101 928	38 023	139 951	
1981	6346	22 026	586	3449	40 049	18	3	21 519		93 996	45 701	139 697	105 000
1982	6755	24 532	1046	3626	41 208	17	6	20 740		97 930	56 616	154 546	140 000
1983	9716	18 749	1185	2397	51 328	15	22	17 400		100 812	43 218	144 030	164 000
1984	11 393	22 154	604	2485	61 478	16	13	16 853		114 996	41 153	156 149	182 000
1985	9965	28 236	1010	2197	90 950	23	18	15 912		148 311	11 527	159 838	200 000
1986	7232	26 332	751	1809	74 447	21	16	17 294		127 902	37 445	165 347	180 000
1987	8554	21 597	1580	1794	76 612	12	7	20 638		130 794	22 876	153 670	150 000
1988	11 527	20 259	1773	2566	77 724	21	2	24 497	43	138 412	16 063	154 475	175 000
1989	10 939	23 481	2037	5341	84 173	321	12	26 104		152 408	17 410	169 818	185 000
1990	13 940	26 474	1339	8747	78 204	1756	169	25 632		156 261	-21	156 240	180 000
1991	14 328	24 356	508	7926	67 945	560	103	27 839		143 565	4438	148 003	175 000
1992	12 006	20 891	537	6818	51 064	836	53	31 277		123 482	1708	125 190	175 000
1993	10 814	16 452	603	6895	48 552	827	7	31 128		115 278	1835	117 113	175 000
1994	7951	17 056	407	5697	50 289	524	6	27 749		109 679	713	110 392	165 000
1995	7093	13 358	442	6329	44 263	527	3	24 395		96 410	1946	98 356	115 000
1996	5765	11 776	379	4780	35 419	917	5	20 992		80 033	1640	81 673	81 000
1997	5223	13 940	254	4159	34 143	1620	10	22 134		81 483	1565	83 048	91 000
1998	5592	10 087	489	2773	30 541	965	2	19 915	1	70 365	1169	71 534	87 000
1999	6160	13 468	624	3144	37 513	643	4	17 061		78 617	2045	80 662	102 000
2000	7260	13 408	547	4310	35 030	883	3	20 710		82 151	-1001	81 150	97 000
2001	6369	13 797	429	4739	33 290	1926	3	19 147		79 700	2147	81 847	78 000
2002	4859	12 552	548	3927	29 081	1996	2	16 740		69 705	512	70 217	77 000
2003	4570	13 742	343	3800	27 353	1967	2	13 892		65 669	820	66 489	73 250
2004	4314	12 123	231*	3649	23 662	1744	1	15 284		61 008	428	61 436	61 000
2005	3396	11 385	112	3379	22 271	1660	0	12 705		54 908	792	55 700	59 000
2006	3487	11 907	132	3599	22 764	1614	0	12 429		55 933	2010	57 943	57 441
2007	3866	8128	144	2643	21 465	1224	4	11 557		49 031	713	49 744	50 261
2008													49 000

Table 5.2.2 North Sea plaice. UK Discard estimates used in WGNSSK (top) and new discards estimates produced in the benchmark assessment (bottom).

Fleet 2: UK (E&W sampling)			Number at age *1000						
age	1999	2000	2001	2002	2003	2004	2005	2006	2007
1		3178	409	70942	8124	1742	83	5001	8294
2		13323	2302	35630	56018	1648	208	6445	7103
3		7796	1792	19047	11739	1789	49	5356	3277
4		3598	922	5346	9642	388	65	1581	3062
5		253	571	1744	2813	202	6	1589	678
6		26	61	780	1270	87	18	396	1018
7		30	22	208	1422	14	2	521	317
8		0	18	156	66	39	1	102	390
9		0	46	26	201	13	3	72	123
10		0	0	111	353	3	1	23	297

Fleet 2: UK (E&W sampling)			Number at age *1000						
age	1999	2000	2001	2002	2003	2004	2005	2006	2007
1		10873	2858	26530	4479	16086	8084	19885	6690
2		12252	21992	10180	24727	9057	16780	12747	12003
3		4484	15588	5362	2749	6870	2523	8471	5297
4		8181	9665	1074	2403	282	2270	846	1021
5		18	6791	115	348	182	466	239	61
6		32	4	127	48	27	1531	32	1896
7		78	0	22	1726	0	69	234	58
8		68	0	0	0	0	0	68	662
9		0	0	0	0	0	30	0	462
10		0	0	0	0	0	0	388	437

Table 5.2.3. North Sea plaice. Survey tuning indices.

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BTS-Isis (Ages 1-8 used in the assessment)

		age								
year	effort	1	2	3	4	5	6	7	8	9
1985	1	116	179.9	38.81	11.84	1.371	1.048	0.362	0.167	0.098
1986	1	667	131.8	51.00	8.89	3.285	0.428	0.338	0.129	0.038
1987	1	226	764.3	33.06	4.77	2.039	1.017	0.352	0.087	0.072
1988	1	680	147.0	182.31	9.99	2.810	0.814	0.458	0.036	0.112
1989	1	468	319.3	38.66	47.30	5.850	0.833	0.311	0.661	0.132
1990	1	115	102.6	55.67	22.78	5.572	0.801	0.205	0.374	0.259
1991	1	185	122.1	28.55	11.86	4.264	5.710	0.257	0.219	0.099
1992	1	177	125.9	27.31	5.62	3.184	2.662	1.136	0.259	0.053
1993	1	125	179.1	38.40	6.12	0.931	0.812	0.629	0.465	0.167
1994	1	145	64.2	35.24	10.88	2.857	0.638	0.861	0.957	0.401
1995	1	252	43.5	14.22	8.11	1.195	0.868	0.356	1.131	0.218
1996	1	218	212.3	23.02	4.83	3.404	0.917	0.047	0.173	0.131
1997	1	NA	NA	19.91	2.79	0.219	0.390	0.171	0.121	0.000
1998	1	343	431.9	47.40	8.91	1.440	0.755	0.145	0.078	0.105
1999	1	306	130.0	182.52	3.65	2.107	0.137	0.140	0.029	0.032
2000	1	278	74.4	31.38	24.00	0.613	0.175	0.540	0.029	0.013
2001	1	223	78.4	19.39	9.97	9.474	0.294	0.143	0.041	0.043
2002	1	541	47.7	16.05	5.38	2.734	1.422	0.091	0.138	0.000
2003	1	126	170.1	10.78	5.94	1.525	1.214	0.684	0.112	0.104
2004	1	226	41.8	66.60	6.62	2.650	1.603	1.021	3.054	0.000
2005	1	158	69.6	7.23	13.74	1.167	1.254	0.313	0.164	0.530
2006	1	135	39.0	19.50	3.21	6.343	0.934	0.815	0.043	0.289
2007	1	329	72.3	21.22	15.53	3.168	6.553	0.737	0.895	0.168

BTS-Tridens

		Age								
Year	effort	1	2	3	4	5	6	7	8	9
1996	1	1.593	5.59	4.40	3.31	2.37	1.84	0.830	0.529	0.177
1997	1	NA	NA	10.41	3.95	2.84	1.93	0.471	1.102	0.424
1998	1	0.557	30.14	9.93	5.57	2.67	1.35	0.911	0.789	0.308
1999	1	2.387	8.29	36.93	6.47	2.65	2.13	0.600	0.771	0.326
2000	1	4.639	9.45	12.74	17.23	2.94	1.89	1.076	0.954	0.247
2001	1	0.672	6.93	.05	7.23	7.67	1.21	0.691	0.480	0.603

Table 5.2.3. North Sea plaice. Survey tuning indices. Continued.

2002	1	18.480	13.54	11.27	6.87	4.23	4.43	0.741	0.723	0.340
2003	1	4.108	34.84	11.91	8.57	4.75	2.72	3.973	0.699	0.703
2004	1	5.689	10.63	29.05	7.92	4.19	2.23	1.131	2.460	0.396
2005	1	7.340	23.70	11.30	16.20	2.57	5.42	1.552	0.536	3.335
2006	1	7.024	17.45	25.06	9.91	11.39	1.93	3.874	0.835	0.716
2007	1	29.707	21.89	17.26	20.79	4.55	9.70	1.829	3.545	0.314

SNS

		Age		
Year	effort	1	2	3
1970	1	9311	9732	3273
1971	1	13538	28164	1415
1972	1	13207	10785	4472
1973	1	65639	5046	1578
1974	1	15366	16509	1129
1975	1	11628	8168	9556
1976	1	8537	2403	868
1977	1	18537	3424	1737
1978	1	14012	12678	345
1979	1	21495	9829	1575
1980	1	59174	12882	491
1981	1	24756	18785	834
1982	1	69993	8642	1261
1983	1	33974	13909	249
1984	1	44965	10413	2467
1985	1	28101	13848	1598
1986	1	93552	7580	1152
1987	1	33402	32991	1227
1988	1	36609	14421	13153
1989	1	34276	17810	4373
1990	1	25037	7496	3160
1991	1	57221	11247	1518
1992	1	46798	13842	2268
1993	1	22098	9686	1006
1994	1	19188	4977	856
1995	1	24767	2796	381
1996	1	23015	10268	1185
1997	1	NA	NA	1391
1998	1	33666	30242	5014
1999	1	32951	10272	13783
2000	1	22855	2493	891
2001	1	11511	2898	370
2002	1	30813	1103	265
2003	1	NA	NA	NA
2004	1	18202	1350	1081
2005	1	10118	1819	142
2006	1	12164	1571	384
2007	1	14175	2134	140

Table 5.2.4. North Sea plaice. Combined tuning index.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	7.81	84.56	72.39	64.78	165.29	86.32	62.09	49.42	78.84	72.60	66.43
1	154.25	119.82	113.10	104.94	58.15	215.57	49.73	93.49	69.42	59.50	156.16
2	262.67	180.03	54.97	36.06	26.82	30.66	95.14	26.06	49.18	31.33	48.37
3	17.05	26.44	101.97	23.66	13.67	16.63	15.42	52.78	13.22	30.80	24.26
4	4.83	8.44	7.34	25.34	9.58	8.60	10.44	9.95	20.29	10.43	25.30
5	2.84	3.12	3.27	3.06	9.85	5.13	5.15	4.91	2.82	13.02	5.45
6	2.01	1.57	2.10	1.90	1.27	4.81	3.07	2.69	5.47	2.15	11.54
7	0.51	0.95	0.63	1.24	0.72	0.75	4.09	1.45	1.55	3.91	1.98
8	1.12	0.85	0.75	0.93	0.49	0.74	0.72	3.47	0.56	0.79	3.63
9	0.42	0.34	0.33	0.24	0.60	0.32	0.72	0.37	3.27	0.78	0.36
10	0.60	0.46	0.18	0.62	0.65	0.97	1.59	1.28	2.21	3.27	5.20

Table 5.2.5. North Sea plaice. Combined tuning index.

	AGE		
	1	2	3
Tridens	0.066	0.214	0.568
Isis	0.448	0.554	0.326
SNS	0.458	0.188	0.076
Fshk	0.028	0.043	0.03
	age		
	1	2	3
Tridens	0.042	0.136	0.567
Isis	0.267	0.279	0.265
SNS (2000+)	0.675	0.564	0.146
Fshk	0.017	0.02	0.023
	age		
	1	2	3
Combined	0.697	0.527	0.832
SNS	0.286	0.377	0.119
Fshk	0.017	0.096	0.048
	age		
	1	2	3
Combined	0.494	0.216	0.748
SNS (2000+)	0.494	0.756	0.218
Fshk	0.012	0.028	0.034

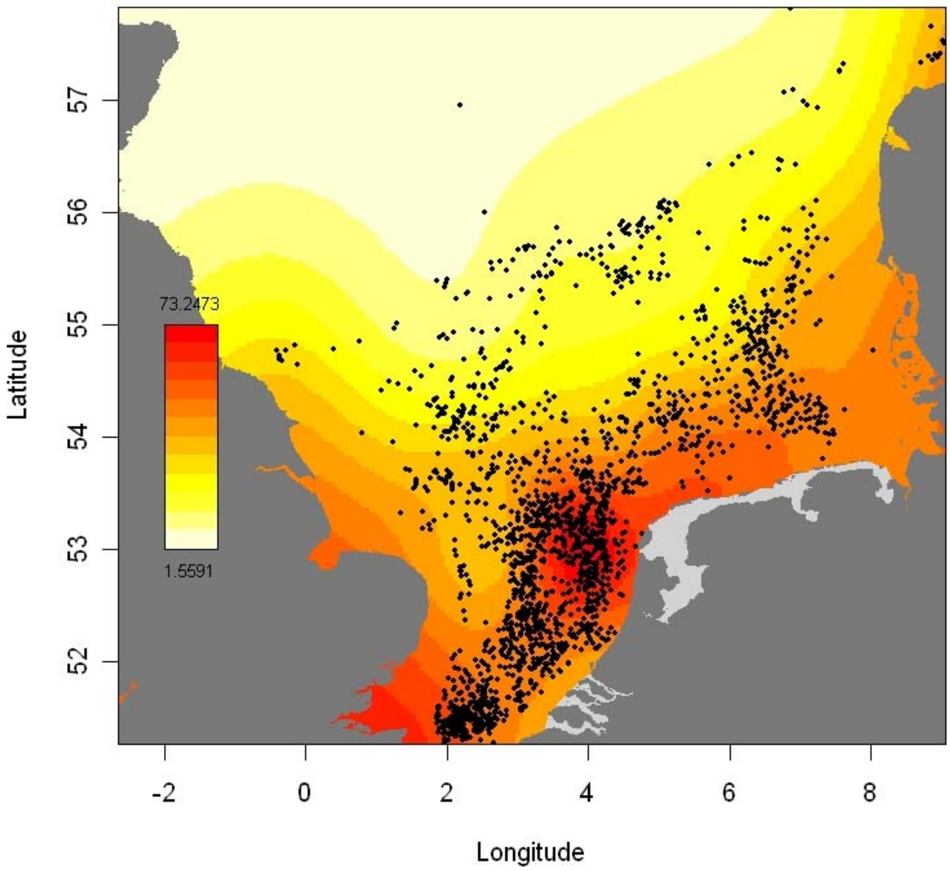

Figure 5.2.1. North Sea plaice. Model predictions of plaice discard percentages and distribution of the PVis data plotted on top. Predictions are made for the beginning of June 2008 (one month before the most recent data point) for a vessel with nine tickler chains from the groundrope (and no chain mat) and the absolute discard levels only apply to those conditions.

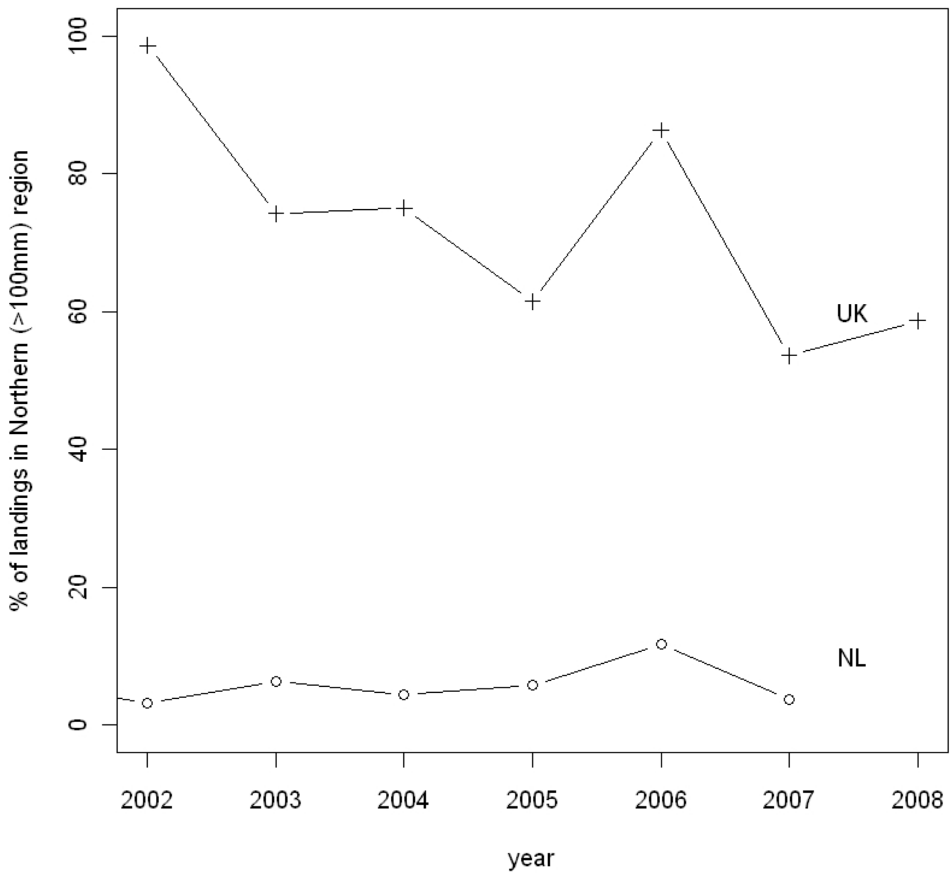

Figure 5.2.2. North Sea plaice. Percentage of UK and Dutch landings in the area where minimum mesh size is 100 mm, north of 55 degrees N.

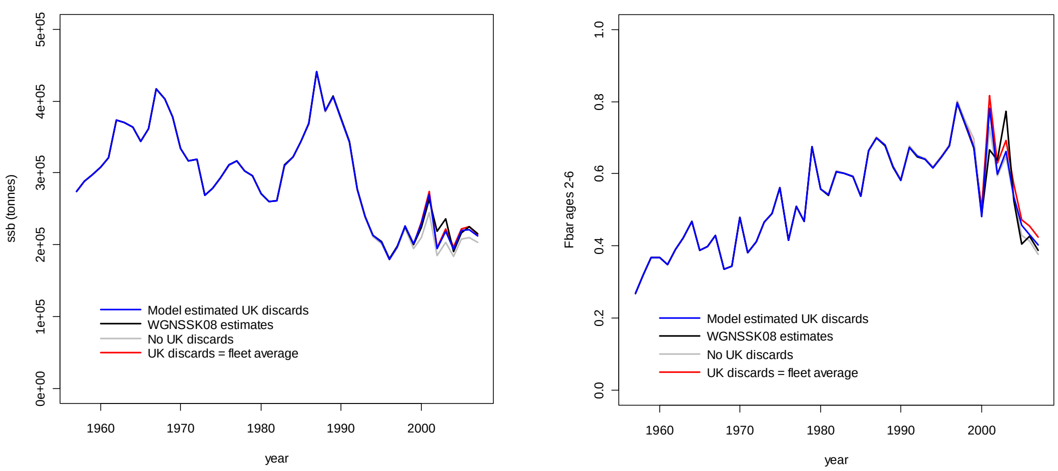

Figure 5.2.3. North Sea plaice. SSB estimate (left panel), and Fbar estimate (right panel) for different methods for UK discards estimation (see legend).

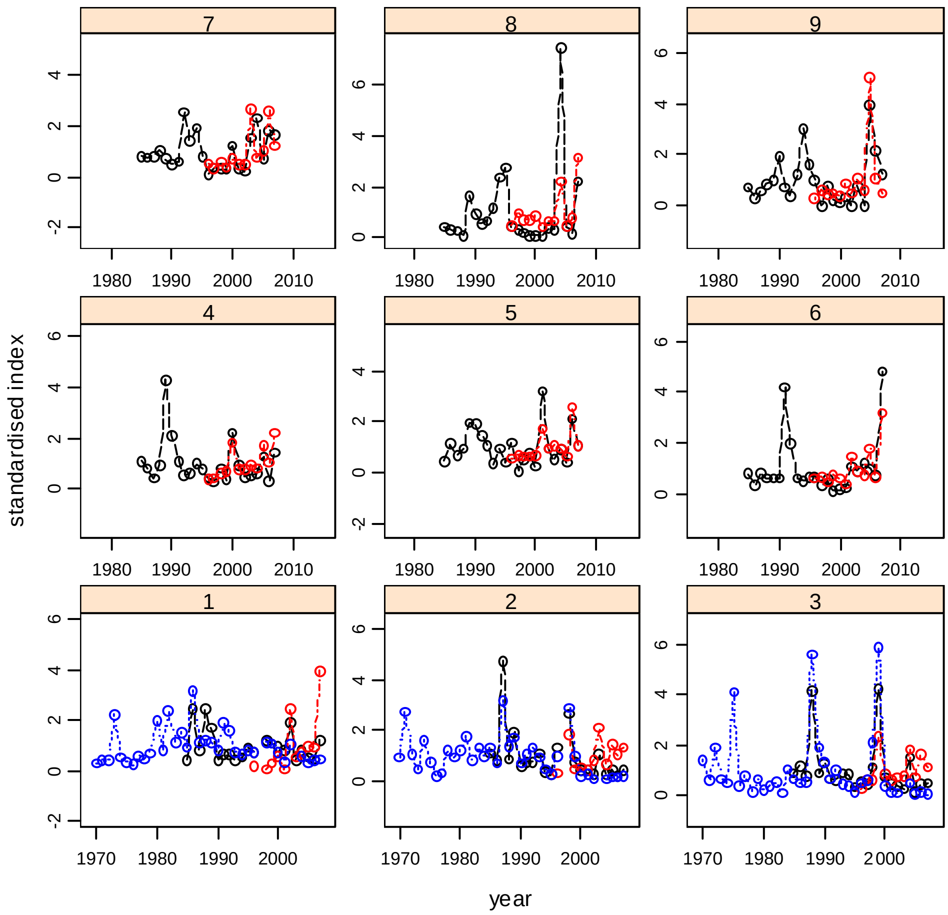

Figure 5.2.4 North Sea plaice. Standardized survey tuning indices used for tuning XSA: BTS-Isis (black), BTS-Tridens (red) and SNS (blue).

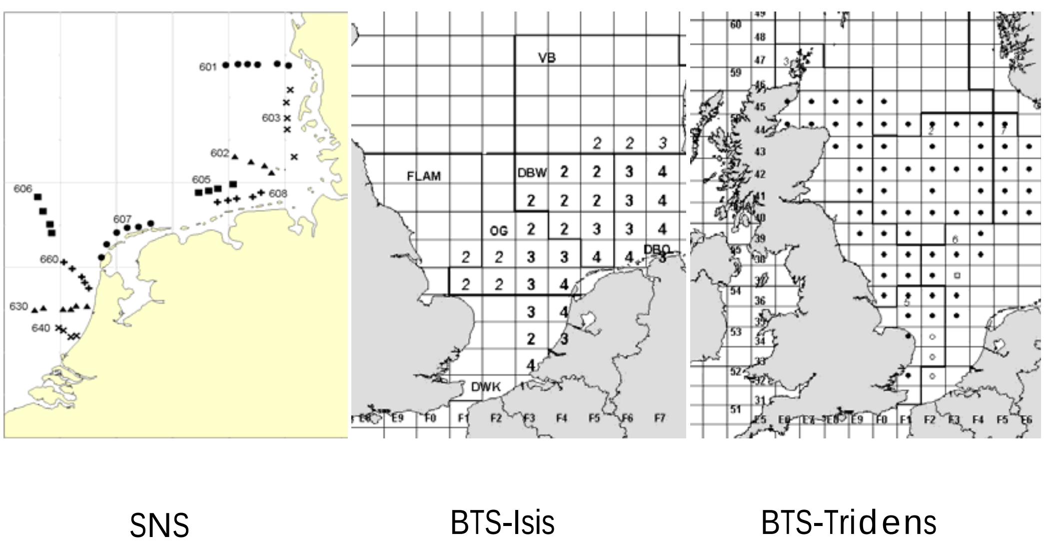

Figure 5.2.5. North Sea plaice, spatial distribution of sampling effort in the three survey series used for tuning the current stock assessment.

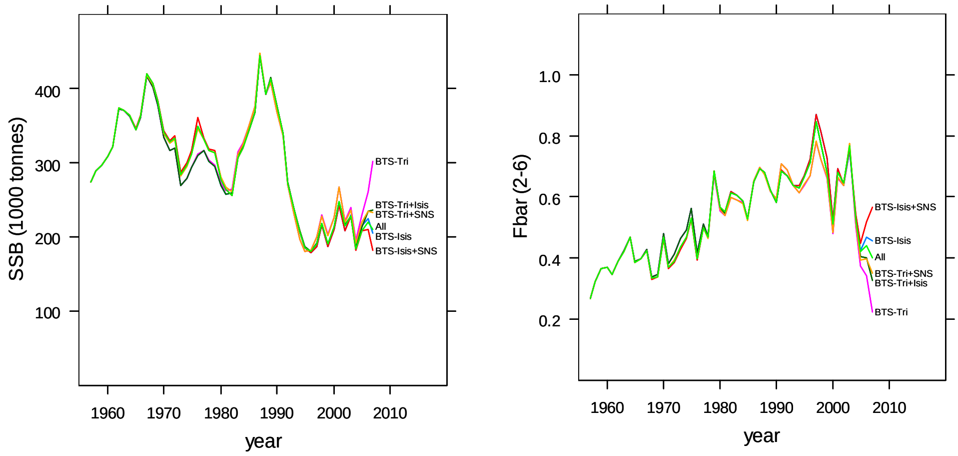

Figure 5.2.6. North Sea plaice. XSA results with respect to SSB (left) and F (right) estimates for different permutations of the available survey tuning indices. XSA run with only SNS survey tuning index is omitted because no reliable SSB or F estimates are available owing to the limited age range (only ages 1–3). Labels indicate used tuning indices (Figure 8.3.3 in WGNSSK 2008).

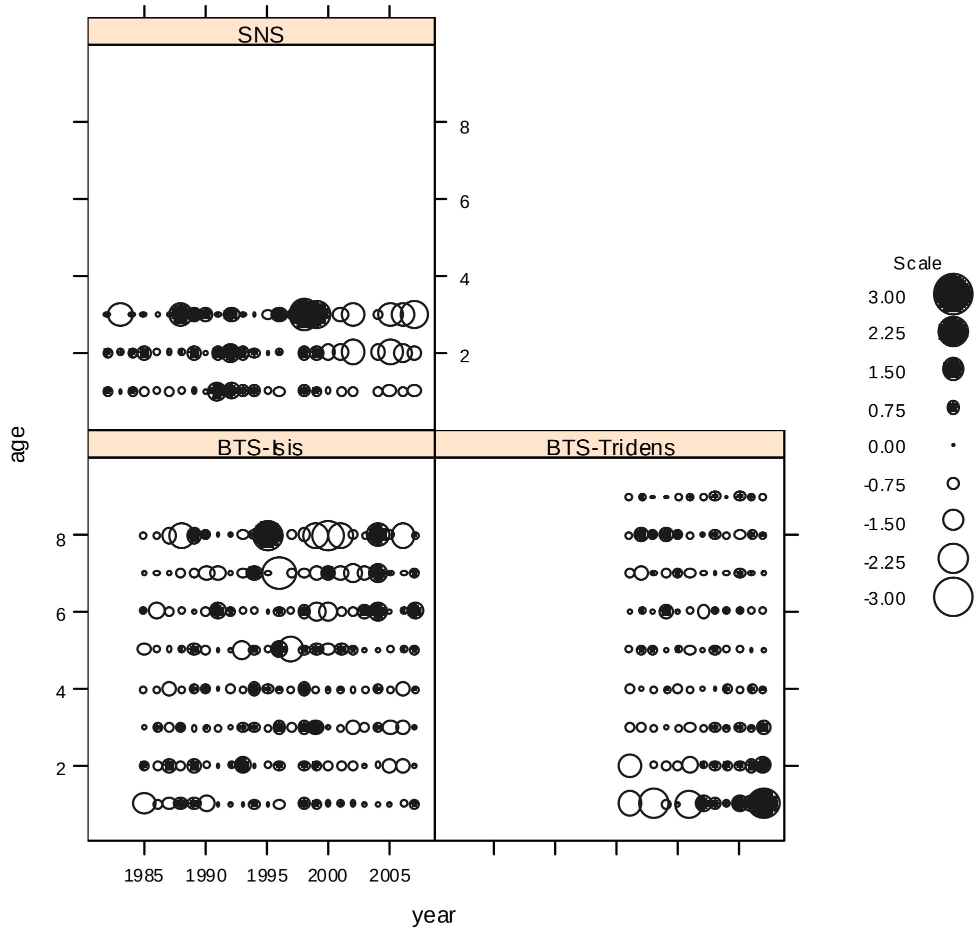

Figure 5.2.7 North Sea plaice. Log catchability residuals for the final XSA run from the three tuning series (Figure 8.3.4 in WGNSSK 2008).

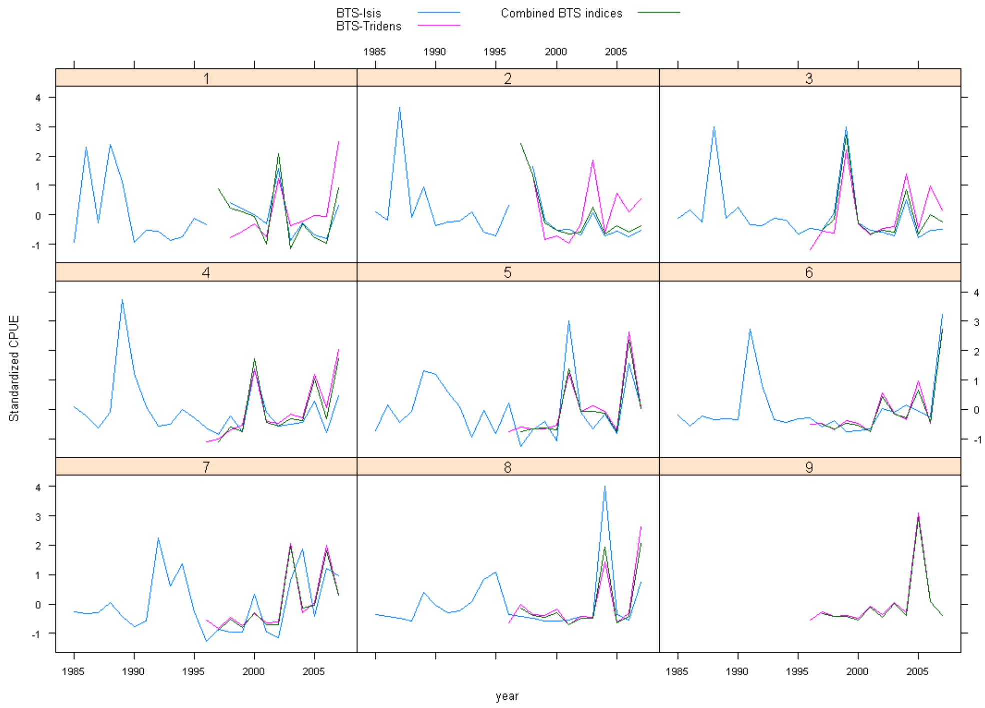

Figure 5.2.8. North Sea plaice. A comparison of the combined tuning index with the separate BTS-Tridens and BTS-Isis indices.

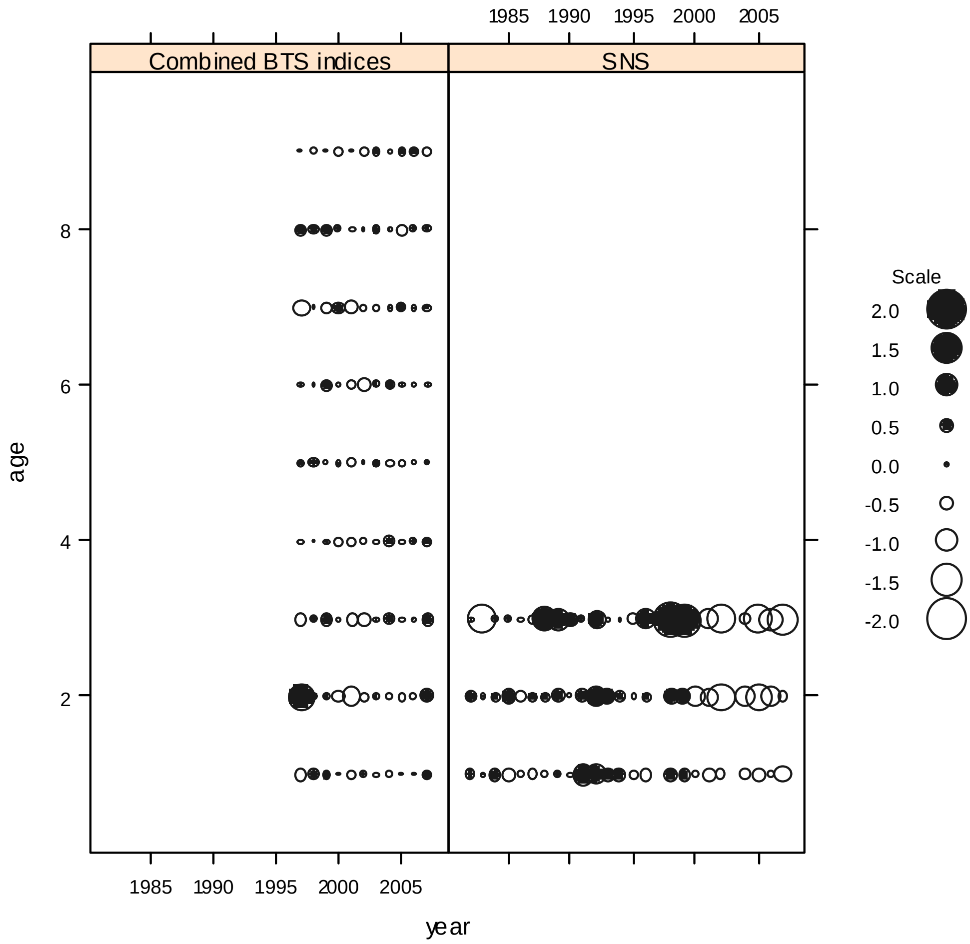

Figure 5.2.9. North Sea plaice. Tuning series residuals for combined BTS index and SNS from 1982 onwards

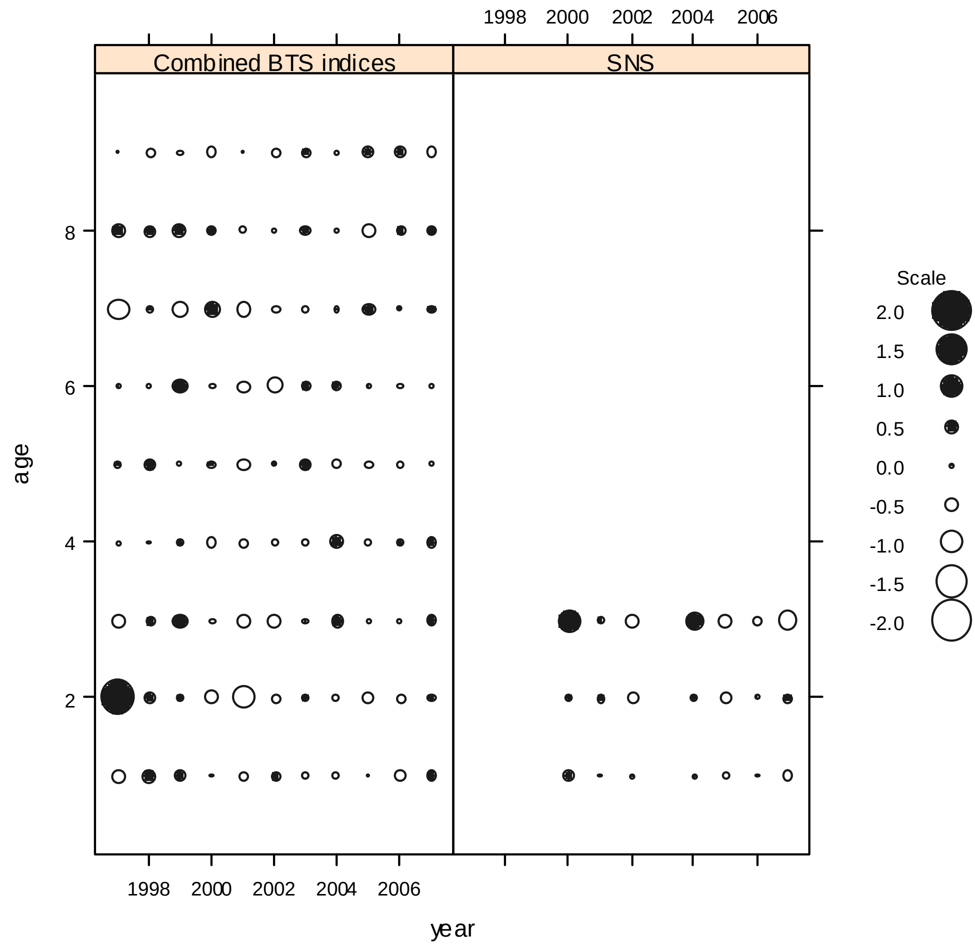

Figure 5.2.10. North Sea plaice. Tuning series residuals for combined BTS index and SNS from 1982 onwards

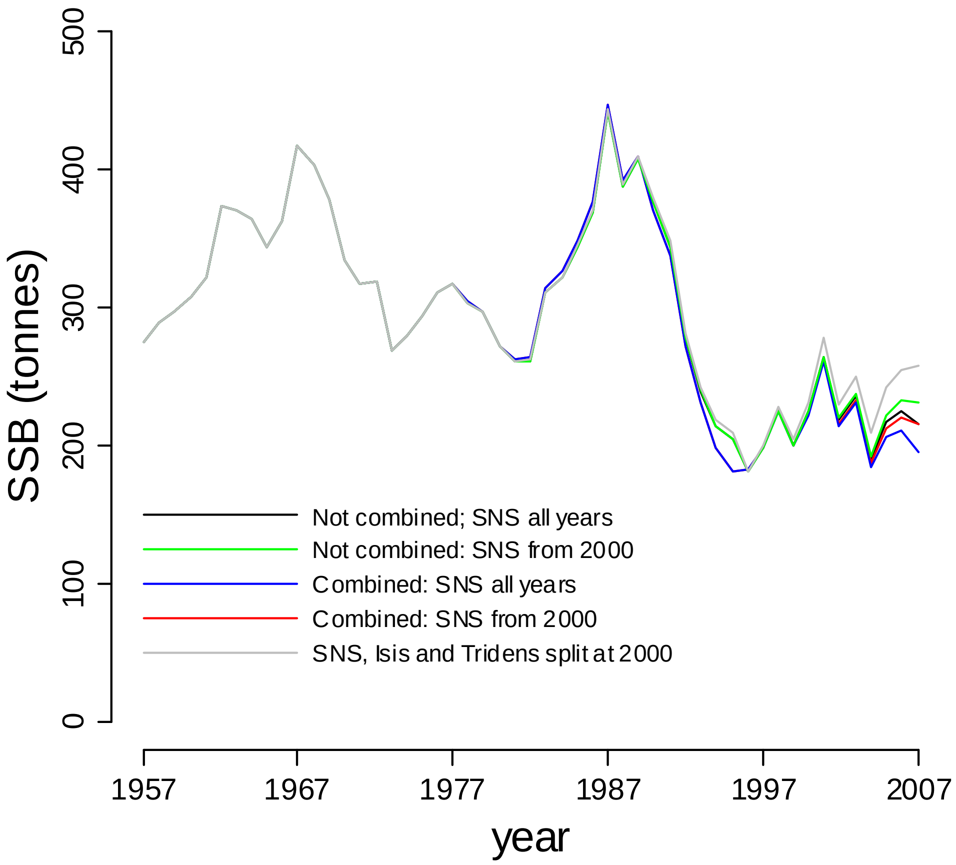

Figure 5.2.11. North Sea plaice. Estimates of SSB from XSA obtained by running XSA with different combinations of tuning indices. The following combinations were used: With the current settings (BTS-Tridens, BTS-Isis and SNS included for all available years as tuning indices: black line). With the combined index and the SNS from 1982–2007 (blue line). With the combined index and the SNS from 1982–1999 and 2000–2007 separately (red line). With the BTS-Tridens from 1996–1999 and from 2000–2007, BTS-Isis from 1985–1999 and from 2000–2007, and the SNS from 1982–1999 and from 2000–2007 (grey line).

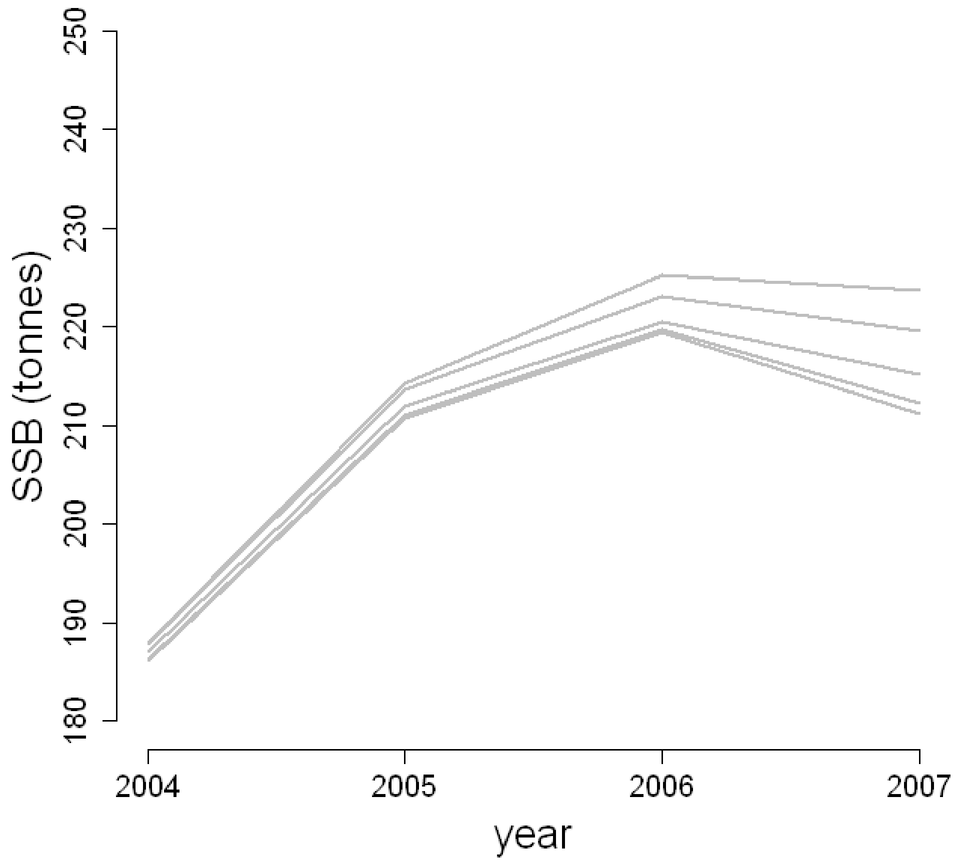

Figure 5.2.12 Evaluation of the importance of the choice of cut-off point for the SNS. Cut-off points were chosen from 1998–2002. The bottom line (lowest SSB) results from the 1998 cut-off point, the second line from the bottom is the result from the 1999 cut-off point, etcetera until the top line (highest SSB estimates) which resulted from the 2002 cut-off point.

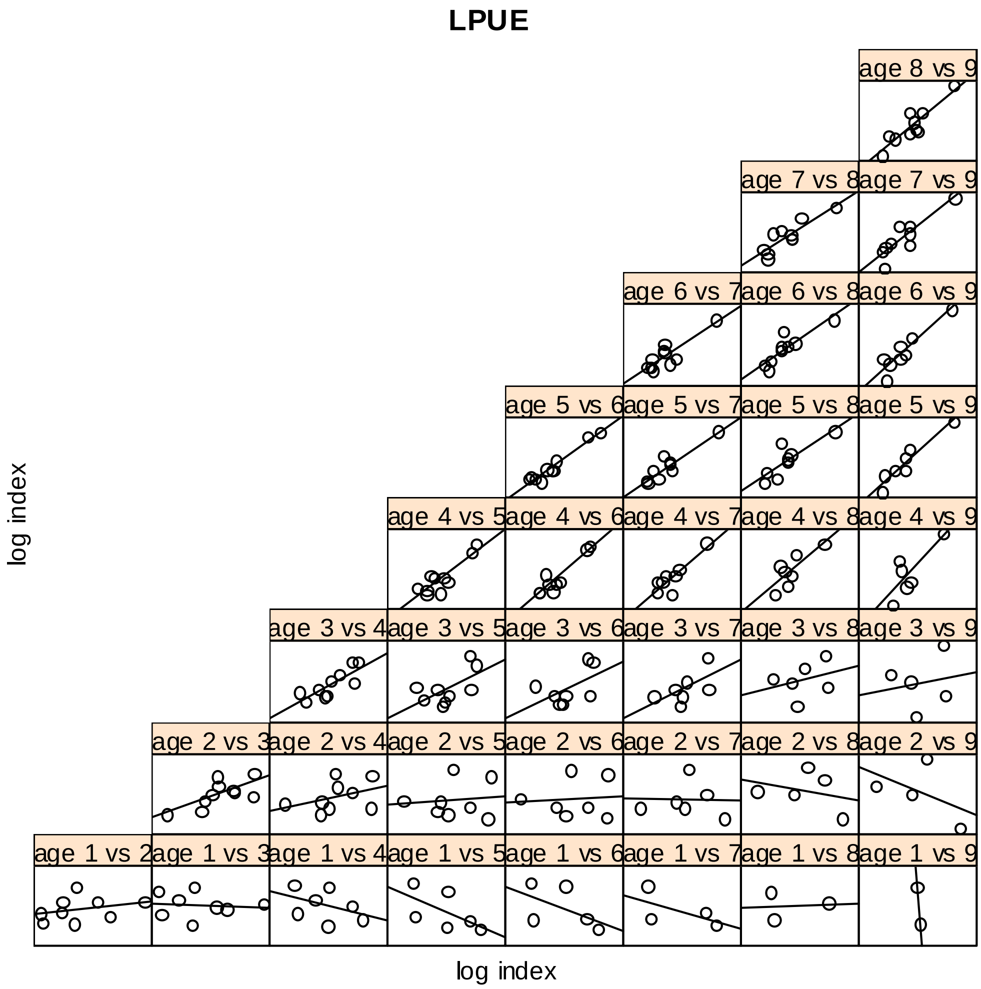

Figure 5.2.13. North Sea plaice. Internal consistency plot for the corrected age structured lpue (Figure 8.3.5. in WGNSSK 2008).

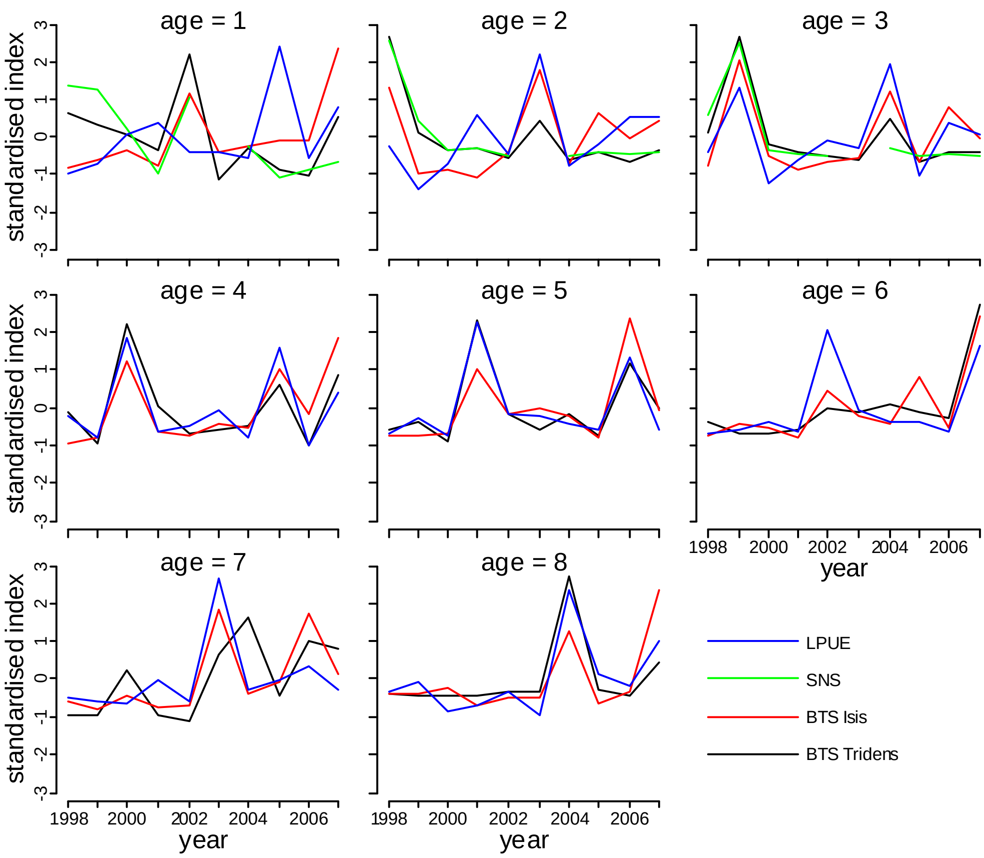

Figure 5.2.14. North Sea plaice. Comparison of the lpue indices with the BTS and SNS indices. Shown are standardized indices per age group from 1998–2007.

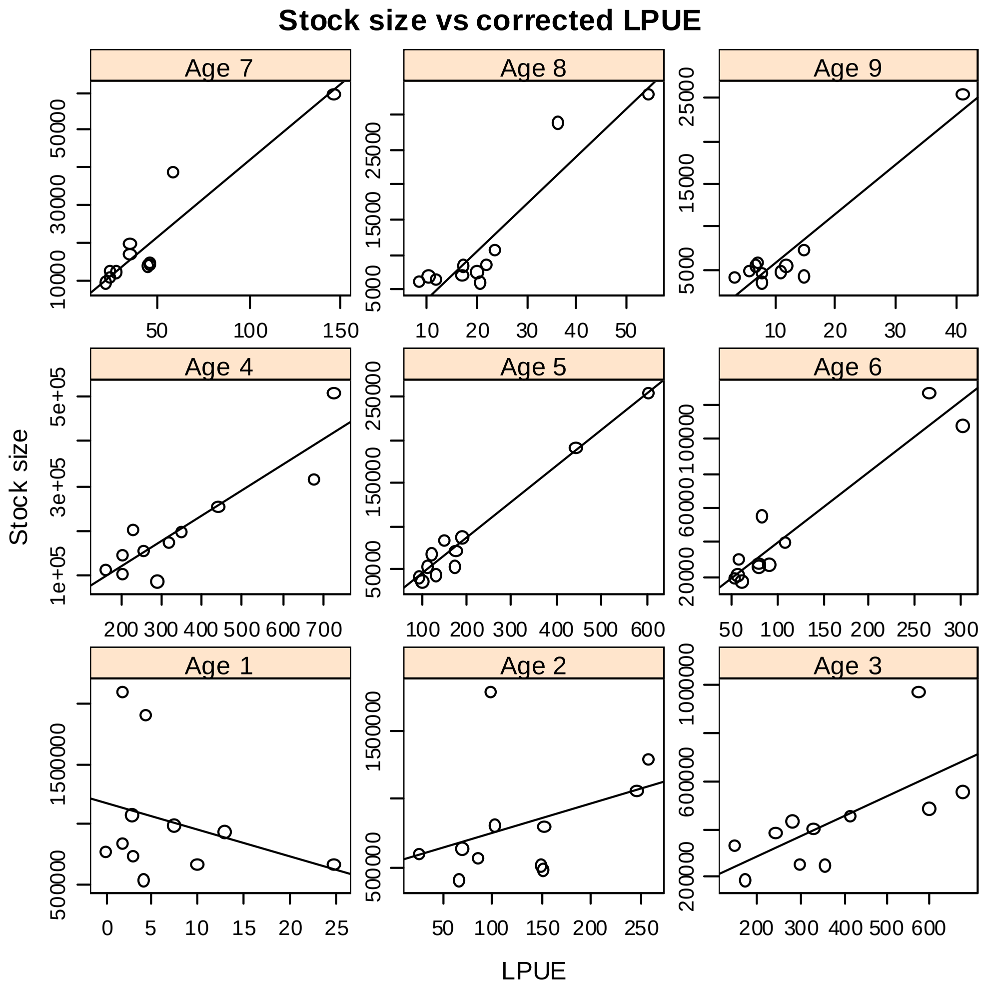

Figure 5.2.15. North Sea plaice. Stock size as a function of the corrected lpue for ages 1–9 (Figure 8.3.6. in WGNSSK2008).

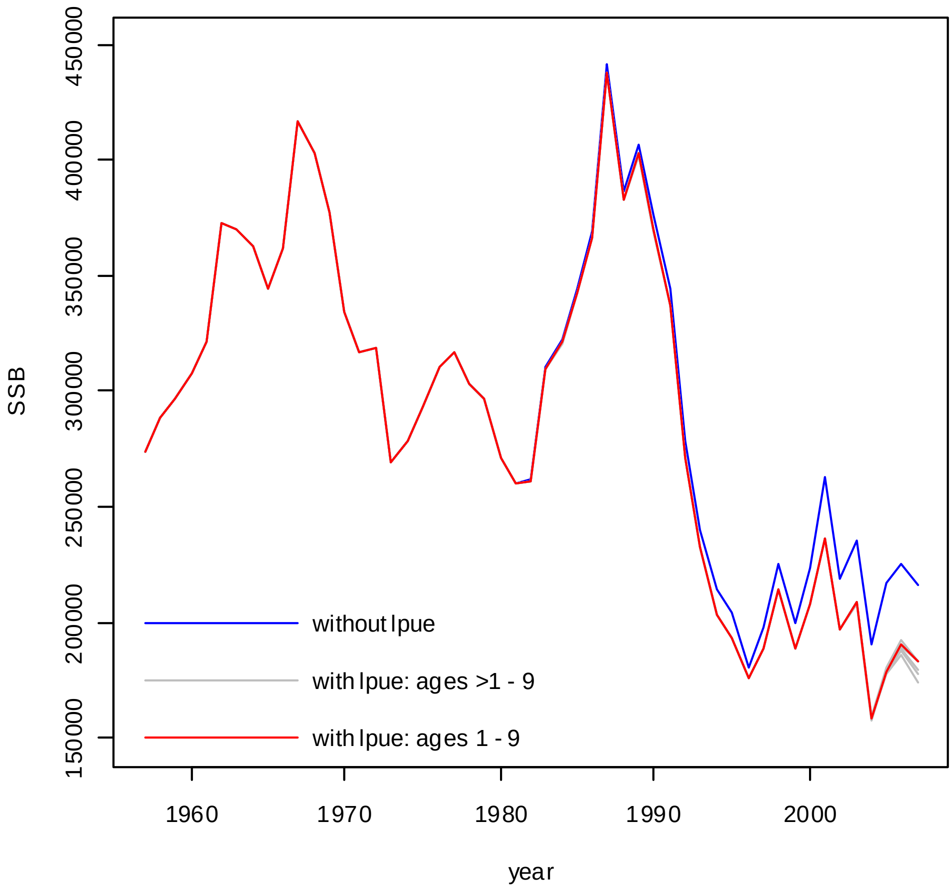

Figure 5.2.16. North Sea plaice. XSA output. A comparison of SSB estimates obtained by running XSA with the BTS and SNS survey tuning indices only (blue line: without lpue) and with the lpue in addition to the BTS and SNS tuning indices (grey and red lines: with lpue). The lpue was used as a tuning index for ages 1–9 inclusive (red line: ages 1–9), and for ages 2–9, 3–9, etc. (grey lines: with lpue: ages >1–9).

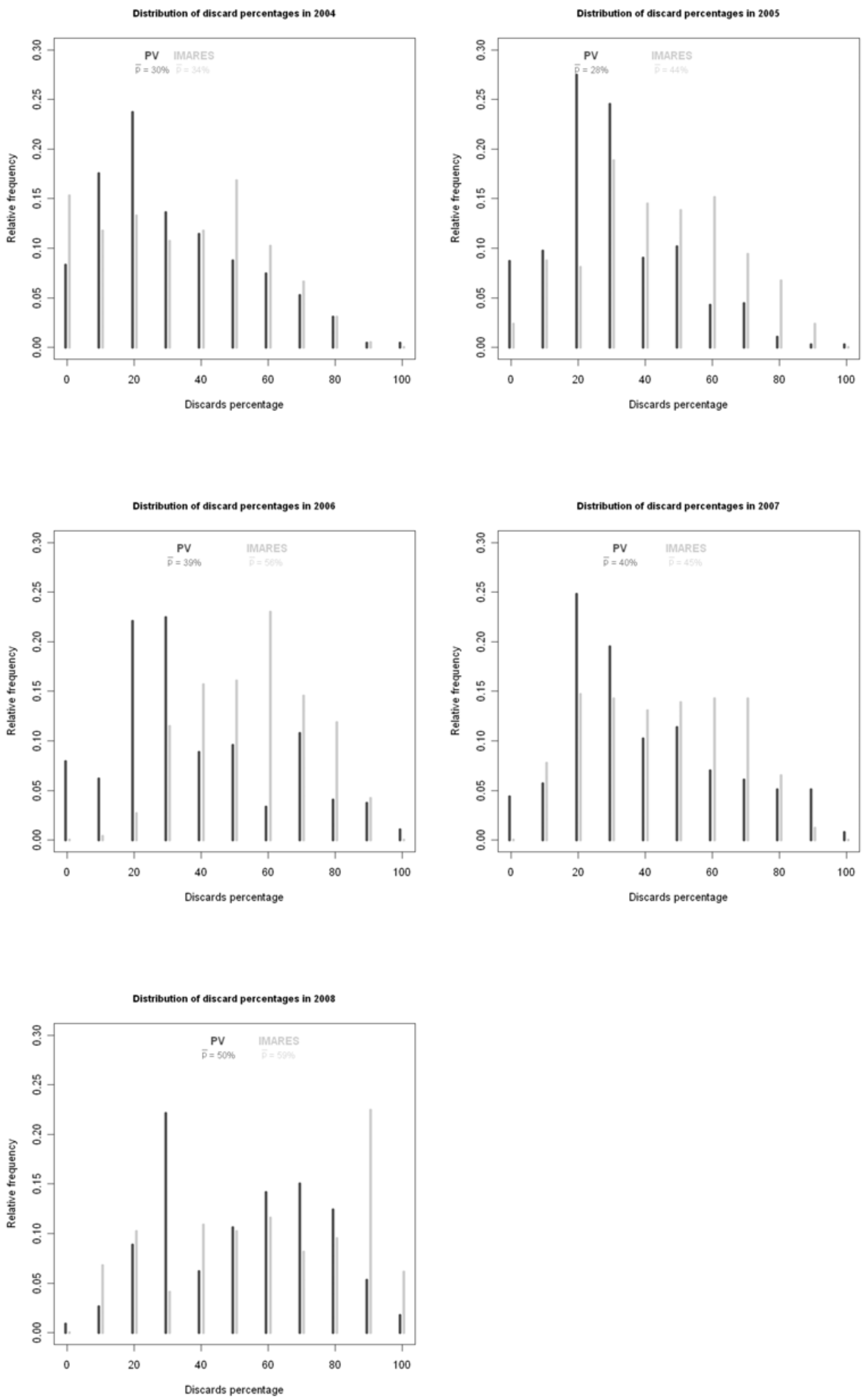

Figure 5.15.1. North Sea plaice. Year by year comparison between discard percentage of plaice observed by the Product Board and IMARES.

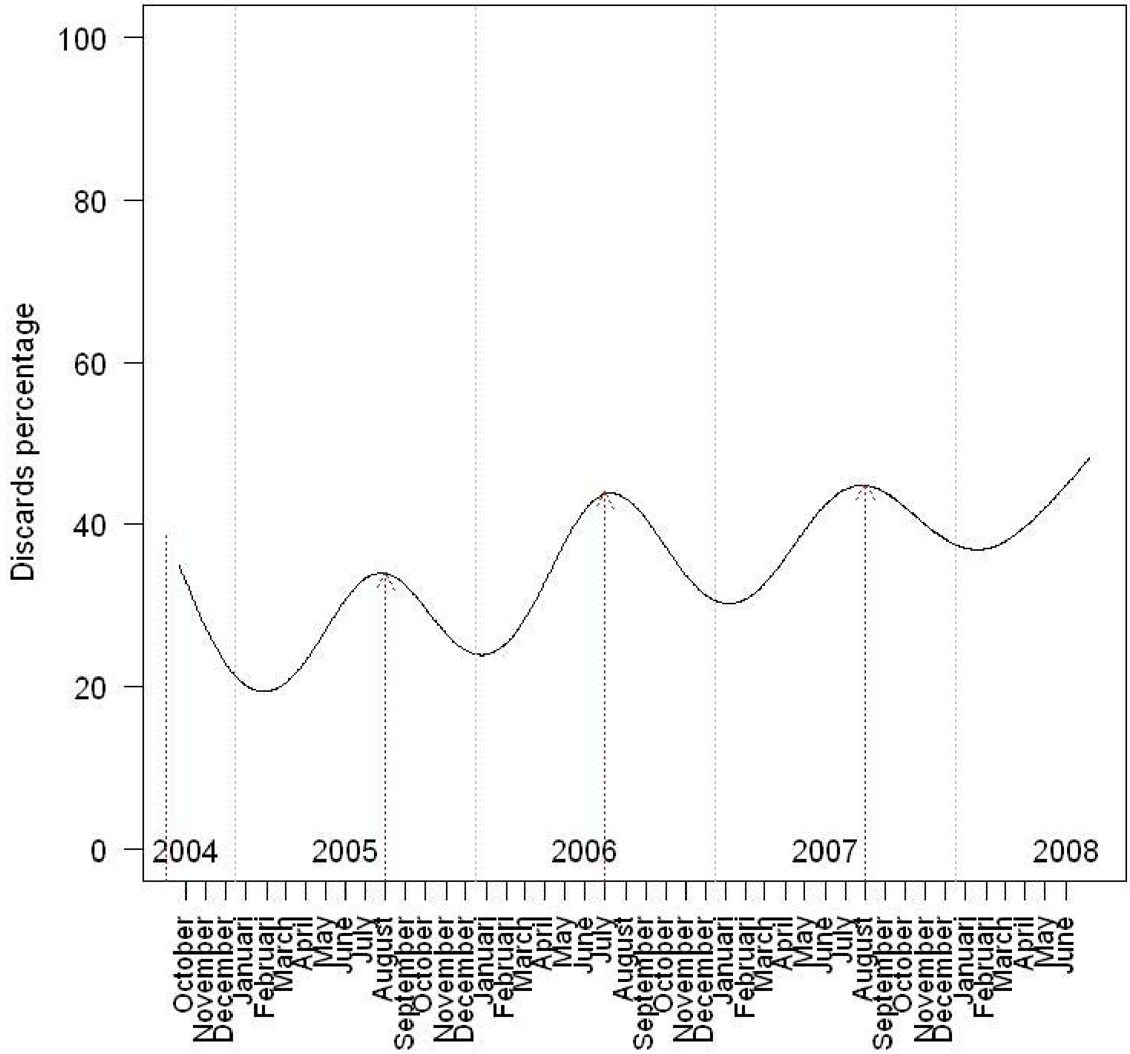

Figure 5.15.2. North Sea plaice. Model (see Table 4) predictions of plaice discard percentage for a point in space (54°latitude, 4°longitude) and a vessel with nine tickler chains.

6 Eastern Channel plaice

The assessment for this stock has been rejected by ACOM since 2005. VIId plaice was originally identified for review in the Workshop, but could not be evaluated because of lack of availability of experts for the main part of the meeting. Key issues for the assessment, identified during the data workshop, included very limited discard data and uncertainty about stock structure. The meeting was told that much more intensive monitoring of discards for the French fleet will commence in 2009.

7 Recommendations from the Workshop

Recommendations from the Plenary

GENERAL RECOMMENDATIONS	TO WHOM
Improving the process for benchmark assessments WKFLAT encountered a number of difficulties in addressing its terms of reference. These stemmed in the main from lack of prior preparation or additional work to address the terms of reference prior to the meeting. Several members of the working group observed that the notice given of the meeting was quite short, and that there was an issue of time and resources in preparing data and additional analyses. The consequence however was that nearly all the review of data and testing of new methods derived from work conducted in the meeting rather than prior to it, leaving little time for proper review. Another problem arose from the low level of attendance, resulting in two stocks being dropped entirely from the work programme and one stock being represented by only one scientist. WKFLAT recommends that much longer notice to prospective participants is required to make benchmark reviews effective, and that dedicated resources need to be allocated to ensure that analyses addressing key issues and the terms of reference are available prior to the actual meeting. ACOM should draw lessons about the process from the first two benchmark workshops and take active steps to correct current deficiencies.	ACOM?
Data access and availability Access to and availability of data were a problem for the WK. This was no doubt partly attributable to the issues described above, but also seems related to a more fundamental problem that the primary observational data are not easily accessible, or in some instances (for older data) perhaps not accessible at all. The group frequently had to rely for provision of primary data on short notice requests to individuals in national laboratories, some of which could not be complied with for practical reasons. WKFLAT recommends that ICES databases should include all data needed to allow assessments to be carried out without relying on data requests to national laboratories. This should include at a minimum landings, discards and effort by fleet and flag at a suitable spatial and temporal resolution (at least by statistical square and month), length and age data for retained and discarded catch and for surveys, and all survey indices used for tuning.	ACOM ICES Data Centre
Data quality issues Several issues affecting current and future data quality were highlighted during the workshop. For example, current data collection on discards appears to be inadequate (an important issue for plaice), and at least one key survey (the UK Young Fish Survey in the Channel) has apparently been terminated. It was not possible to review properly other sampling strategies such as the national collection of landings data and the associated size and age sampling, nor were details of survey design and execution examined. WKFLAT recommends that sampling protocols and programmes be evaluated against the quality criteria outlined in the PGCCDBS 2008 report. Data used for assessments should be reviewed against these criteria and agreed by working groups (and periodically by benchmark groups) prior to incorporation into ICES databases (see also previous recommendation).	Working groups and future benchmarks

GENERAL RECOMMENDATIONS	TO WHOM
Data analysis The workshop identified lpue analysis and standardization as an area for improvement in pre-model data analysis. For some stocks, lpue is calculated simply as annual catch over annual effort (by fleet). While additional factors are taken into account in some lpue analyses (e.g. corrections for horsepower in Belgian VIId sole lpue), a more systematic and statistical approach to deriving lpue (such as use of GLM and related models) would likely improve such model inputs as indices of abundance. The methods by which data are aggregated up to international catch-at-age and other key model inputs also bear closer scrutiny. In particular, an improved statistical basis for error propagation should be adopted. WKFLAT recommends that statistical methods such as use of general linear models and related methods be used to standardize lpue time-series used in assessments. (For a general overview of such methods, see special issue of Fisheries Research 2004 Volume 70).	ACOM PGCCDBS Methods WG? Future benchmarks
Assessment methods The workshop discussed a range of issues around analytical assessment methods (see Annex 3 for a more detailed discussion). Key issues included: 1) the relative advantages and disadvantages of "XSA" type methods vs. "statistical catch-at-age" methods; 2) estimating and accounting for discards; 3) including sex and length in flatfish assessments; 4) robustness of assessment methods to poor or missing data; and 5) the need to evaluate uncertainty in model results (e.g. using classical variance estimates, non-parametric bootstrap, or MCMC protocols). To the extent that time and resources permitted, the implications of some of these issues for specific assessments were investigated in the workshop but much more work needs to be done. WKFLAT notes and applauds moves to develop and apply new assessment methods to some flatfish stocks (such as North sea plaice), particularly methods that deal better with discards, length, sex, and missing data, and that can provide explicit estimates of uncertainty in assessments and model-based projections. WKFLAT recommends continued application of such alternative models as parallel assessments (for the moment). In time, and following proper review, such methods are likely to be adopted as benchmark assessments for some stocks and be incorporated into the Stock Annexes.	Methods Working Group Assessment WGs
Biological reference points Even relatively modest changes to assessment methods, or simply incorporation of new data into existing benchmark assessments, can have implications for the calculation of biological reference points. The workshop was concerned that for some assessments there is a mismatch between current assessments and biological reference points. WKFLAT notes and supports the recommendations of WKROUND on biological reference point and further recommends that the implications of significant changes to assessments for biological reference points be assessed and reported in addition to existing advice from WGs. Ideally, calculation of reference points and current status relative to them will be incorporated directly in the assessment methods.	ACOM?

GENERAL RECOMMENDATIONS	TO WHOM
Communicating uncertainty in advice While sensitivity analyses are often included in detailed WG reports, the way in which uncertainties in assessments are summarized and included in advice appears to be highly variable. WKFLAT recommends that, particularly where there is substantial uncertainty in assessments, advice should include ranges as well as median or best estimates of key management quantities. Ranges might be derived from statistical uncertainty related to benchmark model outputs, as well as from alternative plausible model runs and even from alternative models.	ACOM?
Detail in Stock Annexes The workshop noted that some of the details of assessment methods, particularly regarding data preparation and raising, are not well described in Stock Annexes. WKFLAT recommends that more detail on data analysis and preparation be included in Stock Annexes, including documentation of data collection protocols and problems, and how data are aggregated from primary sampling up to whole of fishery data used in assessments. As a first step, Stock Annexes should reference documents that describe such methods, and should describe where primary data and the software used to analyse them, can be obtained.	ICES Secretariat Future benchmarks
Involvement of Industry members in assessments The workshop appreciated the attendance and contributions by stakeholders from the Dutch, English and Belgian fisheries, and noted the increasing use of science-industry partnerships and the willingness of industry to collect information in a cost-effective way. WKFLAT endorses the recommendation of WKROUND to consider setting aside a day prior to key assessment meetings for industry and assessment scientists to discuss developments in fisheries and interpretations of data. This would include the impacts of changes in fleets, gear, effort distribution and management arrangements on landings, discards, effort and size distribution of the catch.	ICES Secretariat PGCCDBS
Archiving of Working Documents WKFLAT endorses the WKROUND recommendation that working documents presented at WG or WK meetings should be numbered and archived by ICES in a database that is accessible to present or future WG or WK members. Numbered documents can be referenced in the text of WG or WK reports when the information in the WG or WK reports is not available in published form.	ICES Secretariat

GENERAL RECOMMENDATIONS	TO WHOM
Discard mortality WKFLAT recommends that the mortality resulting from discarding is studied in more detail. Currently, all stock assessments incorporating discards assume none of the discarded fish survive. This is assumption is generally based on studies done in the 80s. Since then, much of the fishing operation has changed in many fisheries. The effects of these changes is unknown. Therefore WKFLAT recommends studying the fate of discards, in order to improve the stock assessment estimates of mortality and biomass.	Working groups and future benchmarks
STOCK SPECIFIC RECOMMENDATIONS	
VIIe sole (Western Channel)	
Use of current models to provide management advice Both the current assessment model (XSA) and a statistical catch-at-age model trialled in the workshop (AM) demonstrated consistent retrospective bias patters, overestimating F and underestimating SSB in recent years. Despite a fairly intensive investigation during the workshop, neither the exact source of this problem nor its solution could be identified. WKFLAT recommends that the current assessment model not be used for stock projections or to provide management advice until these problems have been resolved.	WGCSE
Further development of the "AM" model While not developed specifically for sole, the AM statistical catch-at-age model proved useful for a rapid evaluation of the stock and in many ways allowed a more straightforward analysis of sensitivities to data. WKFLAT recommends that further investigation of statistical catch-at-age models be undertaken for this stock.	WGCSE, next benchmark
Biological reference points The current biological reference points in the stock annex were developed using a no longer current assessment model for the stock. WKFLAT 2009 recommends that the current reference points be reviewed once a new analytical assessment has been accepted. Until such time, these reference points should not be used in management.	next benchmark

GENERAL RECOMMENDATIONS	TO WHOM
Use of industry survey data A survey of western Channel sole and plaice has been carried out each autumn since 2003 as part of the UK Fisheries Science Partnership (www.cefas.co.uk/fsp). Although the time-series is only six years long, the survey indices contain information on trends in abundance and appear suitable for evaluation within a catch-at-age assessment framework. WKFLAT 2009 recommends that the western Channel sole and plaice autumn survey be investigated further with a view to its incorporation in future assessments.	WGCSE, next benchmark
VIId sole (Eastern Channel)	
Availability of French tuning series There is no tuning information available from the French commercial fleets, accounting for about 50% of the sole landings in area VIId. Attempts were made during this benchmark working group to calculate an effort series for the French gillnet fishery which is responsible for about 25% of the sole landings in area VIId (see Section 4.2.4.1. b). WKFLAT recommends that effort should be conducted to make French commercial fleet data available for stock assessors to construct tuning series for these fisheries.	WGNSSK, IFREMER, next benchmark
Influence of missing UK Young Fish Survey indices The UK component of the YFS index is not available for 2007 and 2008, 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. Although results of using the YFS indices separately (YFS-France for 1987–present and YFS-UK for 1987–2006) did not demonstrate apparent changes in retrospective patterns for fishing mortality and SSB, recruitment estimates in recent years are highly variable impairing the short-term forecast. WKFLAT recommends (1) that the UK survey should continue and (2) that the French YFS continues to be included in the assessment.	WGNSSK, CEFAS, IFREMER
Horsepower correction for commercial tuning series Investigations of a possible horse power correction for the Belgian beam trawl fleet indicate that a more realistic approach can be implemented. WKFLAT recommends that the effort series for the Belgian beam trawl fleet should be recalculated and the XSA-diagnostics evaluated (see Section 4.2.4.1. a) before the next update assessment.	WGNSSK, ILVO in cooperation with ICES secretariat

GENERAL RECOMMENDATIONS	TO WHOM
Spatial distribution of effort and landings Information on spatial distribution of effort and landings was only available from the Belgian and the UK fleets. This only comprises around 50% of the total sole landings in area VIId. WKFLAT recommends that, where possible, spatial distribution of effort and landings from the major fleets should be provided, and notes that this information could be incorporated into future tuning series.	WGNSSK, CEFAS, IFREMER, ILVO
Discards WKFLAT recognizes that the discards are not a substantial part of the catch for this highly valued species (around 5% by weight and around 10% by numbers). However there is still a need for age aggregated discard information for possible use in the assessment. WKFLAT recommends that discard data should be provided to the WGNSSK as soon as possible for the major fleets involved in the sole fisheries in area VIId.	WGNSSK, data coordinators
IV plaice (North Sea)	
Combined BTS-Isis and Tridens tuning indices During the benchmark workshop for flatfish, the North Sea plaice tuning was reviewed. WKFLAT concluded that combining the tuning series from BTS-Tridens and BTS-Isis into a single tuning index, at least from 2000 onwards should be considered. WGBEAM is asked to provide a procedure for a combined index calculation for the 2010 WGNSSK meeting, based on the procedure as proposed in the WKFLAT report. A more detailed request will be send to the WGBEAM representatives.	WGBEAM
Data on the level of discards of marketable plaice As a result of fishery management regulations, quota restrictions and the high catchability of plaice in the first quarter of the year, considerable discarding of marketable plaice (mostly spawning or spent females) may take place. The current DCR discard sampling programme may not (accurately) estimate this section of the discards. This may lead to both underestimates of the lpue and total discards. WKFLAT recommends that in close collaboration with PVis attempts will be made to improve those estimates.	IMARES, PVis
Extending the Statistical Catch-at-Age models WKFLAT recommends that a SCAA will be run in parallel with the current XSA and that in the next benchmark assessment the extensions described in annex 8 will be explored in more detail	WGNSSK, Next benchmark

GENERAL RECOMMENDATIONS	TO WHOM
Plaice in VIId (Eastern Channel)	
Discards time-series are missing France, UK and Belgium have begun sampling otter trawlers, gillnetters and beam trawlers targeting demersal fish for discards since 2002, but with a very low sampling rate. In the DCR, more sampling should be allocated to the three métiers cited above in ICES division VIId, and should cover the 4 quarters. There is scope for sharing the discards samples collected so far and raise by métier at the scale of the division VIId. There is also scope for searching a way/proxy to reconstruct a discards time-series back in time. Belgium and UK need to send all discards samples in VIId to the stock coordinator (J. Vigneau) before April, together with raising figures by quarter and métier. Sampling intensities from 2009 onwards to be discussed in RCM NS and EA.	WGNSSK, ILVO, CEFAS, RCM NS&EA

Annex 1. Terms of Reference

2008/2/ACOM31 A Benchmark Workshop on Flatfish [WKFLAT] (Chair: Tony Smith (Australia), ICES coordinator: Jan Jaap Poos (Netherlands) and two invited external experts) will be established and will meet in ICES HQ, Copenhagen, Denmark, 6–13 February 2009 to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term outlook taking agreed or proposed management plans into account for the stocks listed in the Text Table below. The evaluation shall include consideration of fishery-dependent, fishery-independent, and life-history data currently being collected for use in the current assessment work and the proposed assessment;

b) Agree and document preferred method for evaluating stock status and (where applicable) short-term outlook and update the assessment handbooks as appropriate;

c) Develop recommendations for future improving assessment methodology and data collection;

d) As part of the evaluation:

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

   ii) consider the possible inclusion of environmental drivers for stock dynamics in the assessments and outlook;

   iii) evaluate the role of stock identity and migration;

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

The Benchmark Working Group will report for the attention of ACOM by 6 March 2009.

Annex 2. List of participants

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Annex 3. A brief comment by the invited experts on assessment methods

The invited experts at the meeting (Ortiz, Ianelli, Smith) noted that the assessment method of choice for flatfish assessments within ICES is XSA, although useful progress has been made recently in the North Sea plaice assessment in developing a statistical catch-at-age model (SCA). They observed that SCA methods are now used routinely in assessments in many parts of the world, and noted the following potential benefits of these methods over the current implementation of XSA:

1. Ability to incorporate more biological realism and more of the data that have been collected (sex, length, movement, etc);
2. Improved and more consistent treatment of uncertainty (observation and process error);
3. Ability to provide estimates of these uncertainties in status and stock projections;
4. Ability to fit directly to observed data rather than having to create data;
5. Ability to provide better diagnostics of model fit to data;
6. Much better ability to deal with missing data in time-series;
7. Ability to directly assess status relative to biological reference points, where the latter are updated at each assessment consistent with changes in the data and model assumptions.

Annex 4. Cpue report card

DESCRIPTION OF THE DATA SOURCE

1. Fishery Independent Indices

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the survey design (e.g. fixed sampling sites, random stratified sampling), location, seasons/months and years of sampling.					
B. Describe sampling methodology (e.g. gear, vessel, soak time, etc.)					
C. Describe any changes in sampling methodology (e.g. gear, vessel, sample design, etc.)					
D. Describe the variables reported in the dataset (e.g. location, time, temperature, catch, effort, etc.).					
E. What species or species assemblages are targeted by this survey (e.g. red snapper, reef fish, pelagic)?					
F. Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.					

2. Fishery Dependent Indices

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Describe the data source and type of fishery (e.g. commercial handline, commercial longline, recreational hook and line, etc.).					
B. Describe any changes to reporting requirements, variables reported, etc.					
C. Describe the variables reported in the dataset (e.g. location, time, temperature, catch, effort, etc.).					
D Describe the size/age range that the index applies to. Include supporting figures (e.g. size comp) if available.					

METHODS

1. Data Reduction and Exclusions

	Not Applicable	Absent	Incomplete	Complete
A. Describe any data exclusions (e.g. gears, fishing modes, sampling areas, etc.). Report the number of records removed and justify removal.				
B. Describe data reduction techniques (if any) used to address targeting (e.g. Stephens and MacCall, 2004; gear configuration, species assemblage, etc).				
C. Discuss procedures used to identify outliers. How many were identified? Were they excluded?				

2. Management Regulations (for FD Indices)

	Not Applica-ble	Absent	Incomplete	Complete
A. Provide (or cite) history of management regulations (e.g. bag limits, size limits, trip limits, closures, etc.).				
B. Describe the effects (if any) of management regulations on cpue				
C. Discuss methods used (if any) to minimize the effects of management measures on the cpue series.				

Working Group Comments:

3. Describe Analysis Dataset (after exclusions and other treatments)

	Not Applicable	Absent	Incomplete	Complete
A. Provide tables and/or figures of number of observations by factors (including year, area, etc.) and interaction terms.				
B. Include tables and/or figures of number of positive observations by factors and interaction terms.				
C. Include tables and/or figures of the proportion positive observations by factors and interaction terms.				
D. Include tables and/or figures of average (unstandardized) cpue by factors and interaction terms.				

E. Include annual maps of locations of survey sites (or fishing trips) and associated catch rates ***OR*** supply the raw data needed to construct these maps (Observation, Year, Latitude, Longitude (or statistical grid, area), Catch, Effort).				
F. Describe the effort variable and the units. If more than one effort variable is present in the dataset, justify selection.				
G. What are the units of catch (e.g. numbers or biomass, whole weight, gutted weight, kilograms, pounds)?				

4. Model Standardization

A. Describe model structure (e.g. delta-lognormal).				
B. Describe construction of GLM components (e.g. forward selection from null, etc.)				
C. Describe inclusion criteria for factors and interactions terms.				
D. Were YEAR*FACTOR interactions included in the model? If so, how (e.g. fixed effect, random effect)? Were random effects tested for significance using a likelihood ratio test?				
E. Provide a table summarizing the construction of the GLM components.				
F. Summarize model statistics of the mixed model formulation(s) (e.g. log likelihood, AIC, BIC, etc.)				
G. Report convergence statistics.				

MODEL DIAGNOSTICS

Comment: Other model structures are possible and acceptable. Please provide appropriate diagnostics to the cpue indices working group.

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
1. Binomial Component					
A. Include plots of the Chi-squared residuals by factor.					
B. Include plots of predicted and observed proportion of positive trips by year and factor (e.g. year*area)					
C. Report overdispersion parameter and other fit statistics (e.g. Chi-squared / degrees of freedom).					
2. Lognormal/Gamma Component					
A. Include histogram of log (cpue) or a histogram of the residuals of the model on cpue. Overlay the expected distribution.					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.					
C. Include QQ-plot (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					
F. Include plots of the residuals by factor.					
3. Poisson Component					
A. Report overdispersion parameter and other fit statistics (e.g. Chi-squared/degrees of freedom).					

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor.					
C. Include QQ-plot (e.g. Student deviance residuals vs. theoretical quantiles), Overlay expected distribution.					
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					***The feasibility of this diagnostic is still under review.***

4. Zero-inflated model

	Not Applicable	Absent	Incomplete	Complete	Working Group Comments:
A. Include ROC curve to quantify goodness-of-fit.					
B. Include plots describing error distribution (e.g. Studentized residuals vs. linear predictor).					
C. Include QQ-plot (e.g. Student dev. residuals vs. theoretical quantiles), Overlay expected distribution.					

MODEL DIAGNOSTIC (CONT.)

	Not Applica-ble	Absent	Incomplete	Complete	Working Group Comments:
D. Include diagnostic plot for variance function (e.g. square root of std residuals vs. fitted values). Overlay expected distribution.					
E. Include diagnostic plot for link function (e.g. linear response variable vs. linear predictor). Overlay expected distribution.					

IF MULTIPLE MODEL STRUCTURES WERE CONSIDERED:

(***Note: this is always recommended but required when model diagnostics are poor***.)

	Not Applica-ble	Absent	Incomplete	Complete	Working Group Comments:
1. Plot of resulting indices and estimates of variance					
2. Table of model statistics (e.g. AIC criteria)					

	Date Received	*Workshop Recommendation*	*Revision Deadline*	*Author and Rapporteur Signatures*
First Submission				
Revision				

Justification of Working Group Recommendation

Annex 5. Stock Annex sole in Division VIIe

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sole in Division VIIe (Western Channel)
Date	19 February 2009
Revised by	Sven Kupschus (WKFLAT)

A. General

A.1. Stock definition

The management area for this stock is strictly that for Area VIIe. Biologically speaking however the picture is much less clear. Sole in general are relatively sedentary once settled at which point the management unit becomes well defined. However, the sources of recruits are much more poorly defined, as are the nursery areas. There is good evidence to suggest that the stock is split into two biological stocks on either side of the Hurd Deep, with likely relatively little exchange between the two. The French industry almost exclusively exploits the southern area of the stock with the UK fishery operating mostly in the northern part of the stock distribution. Additionally, tagging information suggests that during years of strong sole recruitment in Areas VIIf and g some juveniles may migrate to VIIe. The stock boundary to VIId is also likely to be poorly defined as it represents no natural boundary to sole movement. During period of strong recruitment a substantial portion of the VIId recruits (up to 30%) may move into VIIe where their impact will be felt very strongly as a consequence of the much smaller stock size in the latter region. The assessment method used until 2008 does not deal with uncertainty about stock boundaries.

A.2. Fishery

The principal gears used for sole in the Western Channel are otter- and beam trawls, for the UK fleet and entangling nets and otter trawls for the French fleet. In recent years, UK vessels have accounted for around three quarters of the total international landings, with France taking approximately a quarter and Belgian vessels the remainder. UK landings were low and stable between 1950 and the mid-1970s, but increased rapidly after 1978 as a consequence of the replacement of otter trawlers by beam trawlers. Because the UK fleet is the major component of the international landings, they follow a similar trend. Sole is the target species of an offshore beam trawl fleet, which is concentrated off the south Devon and Cornish coasts, and also catches plaice and anglerfish. In recent years a winter fishery targeting cuttlefish has developed for the English beam trawl fleet in the Western Channel, lasting from November to the end of March. This has taken some of the reliance of the fleet away from sole, but sole still represents a substantial portion of the catch during this time so it is not clear to what degree the switch to cuttlefishing has reduced fishing mortality on sole.

Discarding of sole in this fishery is thought to be minor. Landings of sole reached a high level above 1400 t in the 1980s, boosted initially by high recruitment in the late 1970s, followed by an increase in exploitation. Landings declined between 1988 and 1991, following the recruitment of three below-average year classes (1986–1988); since 1991 they have fluctuated between 800 t and 1100 t. Substantial quantities of sole caught in VIIe have been reported to two rectangles in VIId in order to avoid quota restrictions. Corrections for this misreporting were first made during the 2002WG, but misreporting to other areas has been more difficult to identify. In addition, black landings are likely to have occurred to various degrees since quotas became restrictive in the late 1980s. No estimates of the scale of the problem exist so that this uncertainty has not been incorporated into the assessment process.

A.3. Ecosystem aspects

Little is known with regards of the effect of the environment on the stock dynamics of VIIe sole. Certainly the division is on the convergence between the Celtic Sea proper and the Channel/North Sea ecosystem. If predicted increases in temperature were to materialize changes to the stock dynamics of this and other species in the division would be expected. To date there is good evidence of a sizeable increase in the abundance of bass in the area, a species with a similar pan European distribution as sole. In addition there is some anecdotal evidence of changes in the range of some species such as langoustine, triggerfish, and black sea bream from warmer parts of the Atlantic. In the North Sea it has also been suggested that cold periods immediately prior to spawning have a tendency to increase year-class strength and there is some indication of this for this stock, but no statistical analysis has been carried out to date.

Beamtrawling is known to have a significant impact on the seabed. It is understood though that those areas impacted continue to be productive in terms of the target species. After the initial degradation of the habitat usually associated with the loss of sessile macro fauna, continued use of beam trawls seems to have few further impacts.

B. Data

B.1. Commercial catch

UK (>60%) and France (>30%) together provide almost all the catches for this stock. UK Landings data are based on EU logbook data for 7e catches. In 2002 the UK industry indicated that there had been substantial misreporting of landings to two rectangles in Area VIId. It was possible to identify the misreported landings spatially and by reported lpue. Having identified misreported landings, data were corrected back to 1985 by the 2002 WG. This method of correction is ongoing. French official landings statistics have been poor since 1997, but since 1997 landings data have been calculated much more accurately using buyer and sellers notes. France has provided corrected landings information to the Working Group since 2002.

Numbers-at-age prior to 1994 are calculated by raising the UK age composition to UK and Channel Island Catches, adding the French age composition data, and finally raising the resulting age composition to the total international landings. From 1995WG to 2005WG the International landings for the stock were based entirely on English quarterly sampling effort then raised to quarterly international landings. Since 2006WG French age data from 2003 onwards have been included.

Numbers-at-age 1 in the catch are low or zero in most years and most likely reflect variation in the sampling, rather than variation in the stock itself. Therefore, these were not considered to add useful information and are replaced by zeros.

Table A shows the history of the derivation of catch numbers-at-age.

B.2. Biological

Weights-at-age

Total international catch and stock weights-at-age for each year's catch data 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:

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

where catch weights-at-age are mid-year values, and stock weights-at-age are 1 January values. Following the estimation of the weights-at-age catch-numbers are adjusted to so that the sum of products of the weights and catches sum to the estimated Landings (SOP correction). Catch numbers-at-age 1 are replaced by zeros, but the catch weights-at-age 1 were retained because they are part of the smoothing procedure and do not affect the assessment. They are also essential if a medium-term forecast is performed.

A smoother is applied to sampled catch weights-at-age to adjust for variation in the weight-at-age that may result from low levels of sampling rather than differences in growth rate between cohorts. It also allows estimation of the stock weights-at-age by extrapolation of the curve rather than by using quarter 1 samples, which may be sparse. However this smoother is applied through the plus group and the age range in the plus group is such that this will tend to overestimate the weights at the younger ages. This needs to be corrected as soon as possible.

Natural mortality and maturity-at-age

Natural mortality is assumed constant over ages and years at 0.1. This is consistent with the natural mortality estimates used for sole by other ICES working groups (WGNSSK: IV, VIId, WGNSDS: VIIa, WGSSDS: VIIfg, VIIIa,b) and consistent with estimates of M reported in Horwood, 1993 for VIIfg sole as well as other stocks and papers cited therein.

Assessments prior to 1997 had use knife edge maturity-at-age 3. This was changed in 1997 to a maturity ogive from Area VIIf and g according to Pawson and Harley (WD presented to WGSSDS in 1997), which is applied in all years, 1969 to present, since the 1997 WG.

AGE	1	2	3	4	5	6,7, ...12+
Prop. Mature	0.00	0.14	0.45	0.88	0.98	1.00

Proportions of F and M before spawning are both set to zero to reflect the SSB calculation date of 1 January.

B.3. Surveys

Currently the only available survey for this stock is the Western Channel Beam trawl Survey conducted by the UK in late September, early October (UK-BTS). The survey covers a relatively small area of VIIe from Start Point through to the middle of Lyme Bay and out to the edges of the Hurd Deep covering the immediate area of fishing for the Brixham and Plymouth fleets. Sampling started originally in 1984 on the chartered commercial fishing vessel 'Bogey One', replaced in 1988 by the 'Carhelmar' and moved to the research vessel 'Corystes' in 2002 to 2004. Concerns were raised regarding differences in catchability between the Carhelmar and Corystes, and in 2003 the survey was carried out on both vessels. The results of the comparison convinced Cefas to return the survey to the long-serving Carhelmar and to replace the 2003 data with the data from the comparison trials in order to improve consistency. Consequently, the time-series has been largely recovered, with only 2002 and 2004 data coming from the RV Corystes.

The survey cpue demonstrates a decline from 1986 to 1995 in line with the commercial data, after which SSB seems to have largely stabilized at lower levels. The abundance indices at ages 1 and 2 demonstrate little overall trend, but ages 3 to 6 indicate a decline over the middle part of the series, despite intermittent peaks and troughs.

The 1989 year class is indicated to be strong at all ages and this year class can also be traced through the catch-at-age matrix. More recently the 1998 year class can be tracked reasonably consistently.

Appendix 1 provides a history of the survey and details the survey methodology and objectives.

B.4. Commercial cpue

In the early part of the 20th century the fishery for VIIe sole was largely prosecuted by otter trawlers and inshore netters. During the mid to late 1970s landings sharply increased with a considerable increase in nominal effort as the beam trawl fleet developed. Otter trawl effort declined with levels in 2002 being about half that of effort found in the late seventies. Beam trawl effort in terms of hours fished has continued to rise since 1988, but at a slower rate than previously as a consequence of licensing and quota restrictions, but boat size and power as well as beam sizes have also increased suggesting that the effective effort has continued to rise more sharply than suggested by the effort data alone.

Lpue has declined since the late eighties in both the otter and beam trawl fleets suggesting a marked decline in the SSB of this stock. Interestingly the catch-at-age information for these fleets does not suggest a marked decline in the age structure over this time suggesting the decline may be associated with environmental impacts rather than fishing, but given the uncertainty in current landings data it is difficult to distinguish between the potential causes of the discrepancy between the lpue and catch-at-age data. Little information is currently available regarding the development of the French fishery on this stock on the southern side of the Channel.

The UK beam trawl fleet in recent years has been landing large quantities of cuttlefish during winter. Investigations of the landings data indicated that misreporting was particularly high during the period of the cuttlefish fishery indicating that lpue was unlikely to be substantially lower than during the remainder of the year, justifying the inclusion of all trips in the lpue time-series. Similarly, there was no indication of differences in lpue for those trips split between divisions (misreporting to VIId) so that trips reporting to VIIe as well as those reporting to the two adjacent rectangles in VIId were included in the derivation of the tuning fleets.

UK beam trawl effort has climbed markedly since 1992. Otter trawl effort has stabilized following its decline during the 1980s and early 1990s.

For the purpose of the lpue tuning effort used in the assessment until 2008 a subset (vessels greater than 13.27 m) of the boats operating in VIIe is taken and their combined landings over the period are used to calculate lpue. The commensurate effort figure in kWh for their effort is used for each individual landing. The relationship between the kWh and the landings is then used to determine the relationship between lpue and power, and a correction made to effort values for changes in the fleet composition. The latter procedure is now very dated and should be look at with some urgency, as it may be contributing to the retrospective pattern.

For the calculation of lpue, landings misreported to VIId (see catch data section) are corrected in the same manner as the catch data. No corrections are made to the effort statistics, as the time spent in VIId for the purposes of misreporting has been negligible.

B.5. Other relevant data

None.

C. Historical stock development

WKFLAT 2009 concluded that at the present time it is not possible to perform a quantitative assessment on the stock that could be seen to be representative of recent trends in F and SSB. Therefore no assessment, short-term forecast or sensitivity analysis can be performed. Some suitable information is available from the survey (Appendix 1) that could be used for management until such time that a suitable assessment model can be developed.

Although this stock has been exploited historically for a long time at low levels, official landing statistics and catch-at-age data are available from 1969 onwards. At this time landings were 353 t mainly attributable to otter trawlers and netters. The development of a beam trawl fleet in UK waters lead to rapid increases in landings from the stock in the late 1970s which resulted in a commensurate decline in SSB after an initial increase in stock size to its maximum in 1980 as a consequence of particularly good recruitment in 1976. The decline as assessed by XSA occurred despite subsequent good recruitment in 1980, 1984, 1986 and 1990 leading to an apparently depressed recruitment period since 1991. It is unclear whether this reduction in recruitment is linked to the decline in SSB, environmental effects, or is an artefact of the misreporting of landings as a consequence of the TAC constraints introduced in 1987, and becoming restrictive in 1989.

Key uncertainties with regards to the data quality/assessment quality of this stock are the uncertainty regarding the degree of mixing between this and adjacent stock, particularly with regards to recruitments, the fact that the survey covers only a small portion of the stock the lack of a discernible stock recruit relationship which does not allow us to determine reference points with any certainty.

Table B shows the history of VIIe sole assessments and details the assessment model used (XSA) and the parameters and settings used in each year's assessment until 2008.

D. Short-term projection

In lieu of an assessment no short-term prediction is carried out.

E. Medium-term projections

Not applicable for the time being.

F. Long-term projections

Not applicable for the time being.

G. Biological reference points

Biological reference points in this stock were originally set in 1998 as described in the table below along with the reasoning and amended in 2001 to take account of a change to the assessment methodology.

	WG(1998)/ACFM(1998)	SINCE WG(2001)/ACFM (2001)
		Age range extended from 1–10+ to 1–12+
Flim	0.36 (Floss WG98)	0.28 (Floss WG01)
Fpa	0.26 (Flim*0.72)	0.20 (Flim*0.72)
Blim	1800 t (Bloss= B73 WG98)	2000 t (Bloss= B00 WG01)
Bpa	2500 t (Blim*1.4)	2800 t (Historical development)

The assessment methodology that formed the basis for these precautionary reference points is rejected by WKFLAT and these reference points are therefore no longer considered appropriate. The reference point table will therefore be updated as follows:

	Type	Value	Technical basis
Precautionary approach	Blim	Undefined	
	Bpa	Undefined	
	Flim	Undefined	
	Fpa	Undefined	
Targets	Fmgt	0.27	EC Multi-annual plan.

(unchanged since 2009)

Once a new assessment methodology has been accepted its implications on reference points will need to be evaluated.

H. Other issues

A management plan was agreed for VIIe sole in 2007:

Council Regulation (EC) No 509/2007 establishes a multi-annual plan for the sustainable exploitation of VIIe sole. Years 2007–2009 are deemed a recovery plan, with subsequent years being deemed management plan. For 2008 the TAC is required to be at a value whose application will result in a 20% reduction in F compared to Fbar (03–05). If this value exceeds a 15% change in TAC, a 15% change in TAC shall be implemented.

I. References

Horwood, J. 1993. The Bristol channel sole (*Solea solea* (L.)): a fisheries case study. Advances in marine biology 1993, vol. 29, pp. 215–367.

Pawson, M.G and Harley, B.F.M. 1997. (unpubl.: Cefas internal report).

WKFLAT 2009.

Table A. VIIe sole. Catch Derivation table for assessment years 1981–2007.

		Source			
Year of WG	Data	UK	France	Derivation of international landings	% sampled
1981	length composition	quarterly	quarterly	UK ALKs applied to French LDs	95
	ALK	quarterly	-	UK+France raised to total international	
	Age composition	quarterly	-		
1982		As for 1981	As for 1981	As for 1981	99
1983		As for 1981	As for 1981	As for 1981	92
1984		As for 1981	As for 1981	As for 1981	96
1985		As for 1981	As for 1981	As for 1981	96
1986		As for 1981	As for 1981	As for 1981	96
1987	length composition	quarterly	quarterly	UK+France raised to total international	95
	ALK	quarterly	quarterly		
	Age composition	quarterly	quarterly		
1988		As for 1987	As for 1987	As for 1987	96
1989		As for 1987	As for 1987	As for 1987	95
1990		As for 1987	As for 1987	As for 1987	94
1991		As for 1987	As for 1987	As for 1987	96
1992		As for 1987	As for 1987	As for 1987	97
1993		As for 1987	As for 1987	As for 1987	94
1994	length composition	quarterly	quarterly	UK ALKs applied to French LDs	92
	ALK	quarterly	-	UK+France raised to total international	
	Age composition	quarterly	-		
1995	length composition	quarterly	-	UK raised to total international	81
	ALK	quarterly	-		
	Age composition	quarterly	-		
1996		As for 1995	-	As for 1995	78

		Source			
Year of WG	Data	UK	France	Derivation of international landings	% sampled
1997		As for 1995	-	As for 1995	73
1998		As for 1995	-	As for 1995	64
1999		As for 1995	-	As for 1995	57
2000		As for 1995	-	As for 1995	56
2001		As for 1995	-	As for 1995	59
2002		As for 1995	-	As for 1995	60
2003	length composition	As for 1995	quarterly	UK and French raised to total international	~95%
	ALK	As for 1995	biannually		~95%
2004		As for 1995	As for 2003	As for 2003	~95%
2005		As for 1995	As for 2003	As for 2003	~95%
2006		As for 1995	As for 2003	As for 2003	~95%
2007		As for 1995	As for 2003	As for 2003	~95%
2008		As for 1995	As for 2003	As for 2003	~95%

Table B. History of VIIe sole assessments.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Assmnt Age Range	1-9+	1-9+	1-9+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-10+	1-12+	1-12+	1-12+	1-12+	1-12+	1-12+	1-12+	1-12+
Fbar Age Range	F(3-8)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)	F(3-7)
Assmnt Method	L.S.	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Tuning Fleets																		
UK Inshore beam Ages	1983-92 2-9	1973-92 2-9	1973-92 2-9	1973-93 2-9	1973-93 2-9	1986-95 2-9	1987-96 2-9	1983-97 2-9	1984-98 2-9	1986-99 2-9	1986-00 2-11			1973-87 2-11	1973-87 2-11	1973-87 2-11	1973-87 2-11	1973-87 2-11
UK Offshore beam Ages	1983-92 3-9	1973-92 3-9	1973-92 3-9	1973-93 3-9	1973-93 3-9	1986-95 3-9	1987-96 3-9	1983-97 3-9	1984-98 3-9	1986-99 3-9	1986-00 3-11			1973-87 3-11	1973-87 3-11	1973-87 3-11	1973-87 3-11	1973-87 3-11
UK < 24 m beamtr Ages												1989-01 2-11						
UK > 24 m beamtr Ages												1988-01 2-11						
UK combined beam Ages													1988-02 3-11	1988-03 3-11	1988-04 3-11	1988-05 3-11	1988-06 3-11	1988-07 3-11
UK otter trawl Ages												1988-01 3-11	1988-02 3-11	1988-03 3-11	1988-04 3-11	1988-05 3-11	1988-06 3-11	1988-07 3-11
UK BTS yrs Ages		1984-91 2-6	1984-92 2-6	1984-93 1-6	1984-94 1-6	1986-95 1-6	1987-96 1-6	1983-97 1-6	1984-98 1-6	1984-99 1-6	1984-00 1-6	1984-01 1-6	1988-02 1-6	1988-03 1-9	1988-04 1-9	1988-05 1-9	1984-06 1-9	1988-07 1-9

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Time taper		20yr tri	20yr tri	20yr tri	20yr tri	No	No	No	No	No	No	No	No	No	No	No	No	No
Power model ages		1	1-2	1-4	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	1-6	No	No	No	No
P shrinkage		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q plateau age		8	5	6	7	7	7	7	7	7	9	9	9	9	9	8	8	8
F shrinkage S.E		0.3	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
Num yrs		5	5	5	5	5	5	5	5	5	5	5	5	5	3	4	5	5
Num ages		5	3	5	3	3	3	3	3	3	5	5	5	5	5	5	5	5
Fleet S.E.		0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.5	0.5	0.5

Appendix 1. Beam trawl surveys of the western English Channel (ICES Division 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'.

As a consequence of 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)

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 present)

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)

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 present)

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'.

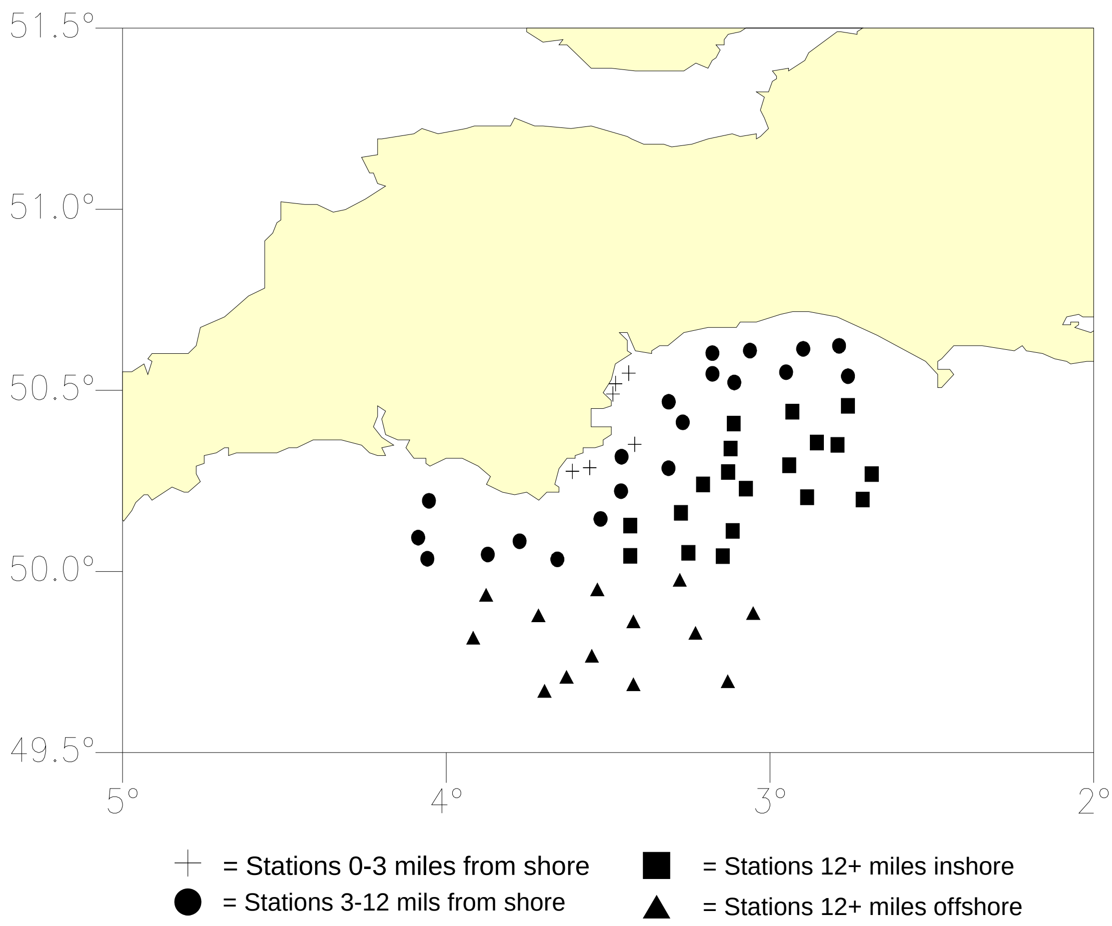
Between 1984 and 1990 a total survey age–length key was applied to the 'grid' length distribution, but from 1990 onwards stratum stratified age–length keys were used.

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

		ALK stratified by			LD stratified by			
Species	**Sector**	**Sector**	**Depth band**	**Sex**	**Sector**	**Depth band**	**Sex**	**Used in assessment?**
Plaice	VIIe	✓	✓	✓	✓	✓	✓	✓
Sole	VIIe	✓	✓	X	✓	✓	X	✓

5. Map of survey grid

Additional stations have been fished throughout the 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 * 6 m beam trawls
	-	1989–present , except 2002,2004 – 2 * 4 m beam trawls
		2002, 2004 – 1* 4 m beam trawl
Mean towing speed	-	4 knots over the ground
Tow duration	-	30 minutes
Vessel used	-	F.V. Bogey 1 1984–1988
	-	F.V. Carhelmar 1989–2001, 2003 and 2005–present
	-	R.V. Corystes 2002 and 2004

Annex 6. Stock Annex sole in Division VIId

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sole in Division VIId (Easter Channel)
Working Group:	ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)
Date:	February 2009
Revised by	Willy Vanhee (WKFLAT)

A. General

A.1 Stock definition

The sole in the eastern English Channel (VIId) are considered to be a separate stock from the larger North Sea stock to the east and the smaller geographically separate stock to the west in VIIe. There is some movement of juvenile sole from the North Sea into VIId (ICES CM 1989/G:21) and from VIId into the western Channel (VIIe) and into the North Sea. Adult sole appear to be largely isolated from other regions except during winter, when sole from the southern North Sea may enter the Channel temporarily (Pawson, 1995). The assessment does not take account of these stock movements.

A.2 Fishery

There is a directed fishery for sole by small inshore vessels using trammelnets and trawls, which fish mainly along the English and French coasts and possibly exploit different coastal populations. Sole represents the most important species for these vessels in terms of the annual value to the fishery. The fishery for sole by these boats occurs throughout the year with small peaks in landings in spring and autumn. There is also a directed fishery by English and Belgian beam trawlers who are able to direct effort to different ICES divisions. These vessels are able to fish for sole in winter before the fish move inshore and become accessible to the local fleets. In cold winters, sole are particularly vulnerable to the offshore beamers when they aggregate in localized areas of deeper water. Effort from the beam trawl fleet can change considerably depending on whether the fleet moves to other areas or directs effort at other species such as scallops and cuttlefish. In France, there are some few small beam trawlers operating inshore in a few local areas, and offshore trawlers fishing for mixed demersal species taking sole as a bycatch.

The minimum landing size for sole is 24 cm. Demersal gears permitted to catch sole are 80 mm for beam trawling and 90 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.

A.3 Ecosystem aspects

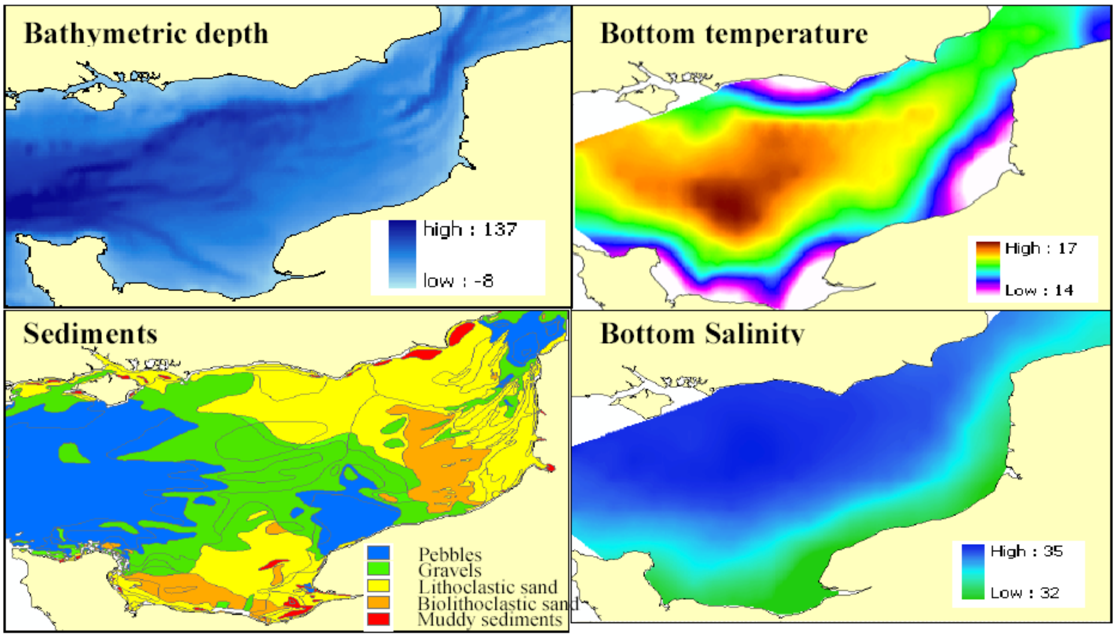


Figure 1. Eastern English Channel physical and hydrological features: Bathymetric depth and simplified sediment types representation. Survey bottom temperature and bottom salinity (averaged for 1997 to 2003) obtained by Kriging. (in Vaz *et al.*, 2004).

Biology: Adult sole feeds on worms, small molluscs and crustaceans. In the English Channel, reproduction occurs between February and April, mainly in the coastal areas of the Dover Strait and in large bays (Somme, Seine, Solent, Mont-Saint-Michel, Start and Lyme Bay). Pelagic eggs hatch after 5 to 11 days leading to larvae that are also pelagic and that will metamorphose into benthic fry after 1 or 2 weeks. Juveniles spend the first 2 or 3 years in coastal nurseries (bays and estuaries) where fast growth occurs (11 cm at 1 year old) before moving to deeper waters.

The spatial distribution of life stages of common sole demonstrates a particular pattern: larval distribution (on spawning grounds) and juvenile distribution (in nursery grounds) overlap. If larvae are found everywhere during spring, the potential habitat for stage 2 larvae is along the Flanders coast and near the Pays de Caux, to the central zone of the English Channel. Older larvae have a more coastal habitat preference, which can be explained by a retention phenomenon linked to estuaries.

Environment: A benthic species that lives on fine sand and muddy seabeds between 0 and 150 meters depth. It ranges from marine to brackish waters in temperatures between 8 and 24°C.

Geographical distribution: Eastern Atlantic, from southern Norway to Senegal, Mediterranean Sea including Sea of Marmara and Black Sea.

Vaz *et al.*, 2007 used 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. One Group (class 4 in Figure 2 below) 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.

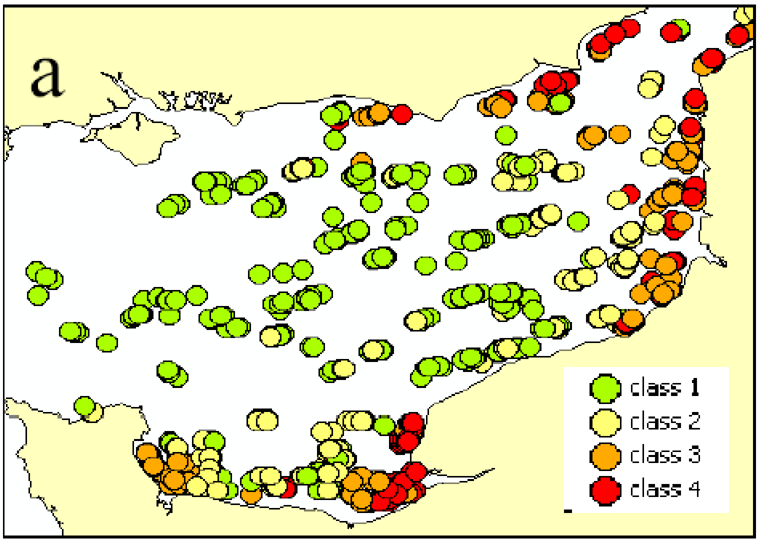


Figure 2. Spatial distribution of Fish Subcommunities in the Eastern Channel from 1988 to 2003. Observed assemblage type at each station, These illustrate the gradation from open sea community to coastal and estuarine communities (In Vaz *et al.*, 2004).

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.

B. Data

B.1 Commercial catch

The landings are taken by three countries: France (50%), Belgium (30%) and England (20%). Age sampling for the period before 1980 was poor, but between 1981 and 1984 quarterly samples were provided by both Belgium and England. Since 1985, quarterly catch and weight-at-age compositions were available from Belgium, France, and England.

An initiative for undertaking combined sampling of VIId sole between France, Belgium and the UK has been agreed from January 2008. The result was a framework for the collection of age data in relation to an international ALK. The division VIId has been stratified in three geographical areas and the data collected in line with them for 2008.

These data will be used to provide the assessment advice in 2009. A limited otolith exchange was arranged between the laboratories involved, specifically looking at VIId sole, in order to assess the likely quality of the ALK provided. The reason for restricting the exchange to those involved in the reading of VIId sole was so that any stock-specific issues could be addressed. The agreement achieved between institutes was 91% across all ages.

Belgium

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.

In 2003 a pilot study started on on-board sampling with respect to discarded and retained catch. Since 2004 it is part of the DCR.

France

French commercial landings in tonnes by quarter, area and gear are derived from logbooks for boats over 10m and from sales declaration forms for vessels under 10 m. These self declared productions are then linked to the auction sales in order to have a complete and precise trip description.

The collection of discard data has begun in 2003 within the EU Regulation 1639/2001. The first years of collection were incomplete in term of time and métier coverage. It is expected an increase of sampling effort from 2009 designed for the use of the information for assessment purpose, as required by ICES/ACOM.

The length measurements are done by market commercial categories and by quarter into the principal auctions of Grandcamp, Port-en-Bessin, Dieppe and Boulogne. Samplings from Grandcamp and Port-en-Bessin are used for raising catches from Cherbourg to Fecamp and samplings from Dieppe and Boulogne are used to raise the catches from Dieppe to Dunkerque.

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 close quarter.

Weight, sex and maturity-at-length and -at-age are obtained from the fish sampled for the age–length keys.

England

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 but it is known to be low. Discarding from vessels >10 m has been obtained since 2002 under the EU Data Collection Regulation and is also relatively low.

Length samples are combined and raised to monthly totals by port and gear group for each stock. 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 international level. Age structure from otolith samples are combined to the quarterly level, and generally include all ports, gears and months. For sole the sex ratio from the randomly collected otolith samples are used to split the unsexed length composition into sex-separate length compositions. The quarterly separate age–length-keys are used to transform quarterly length compositions by gear group to quarterly age compositions. At this stage the age compositions by gear group are combined to give total 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.

Weight-at-age is derived from the length samples using the length/weight relationship W=aL^b, where a and b are reference condition factors for the stock.

The text table below shows which countries supply which kind of data:

Kind of data supplied quarterly					
Country	Caton (catch-in-weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition-in-catch
Belgium	x	x	x		x
England	x	x	x		x
France	x	x	x		x

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 coordinator 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, either under w:\acfm\nsskwg\2002\data\sol_eche or w:\ifapdata\eximport\nsskwg\sol_eche.

B.2 Biological

Natural mortality

Natural mortality is assumed constant over ages and years at 0.1.

Maturity

The maturity ogive used is knife-edged with sole regarded as fully mature at age 3 and older as in the North Sea.

Weight-at-age

Prior to 2001 WG, stock weights were calculated from a smoothed curve of the catch weights interpolated to the 1st January. Since the 2002 WG, second quarter catch weights were used as stock weights in order to be consistent with North Sea sole.

Proportion mortality before spawning

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

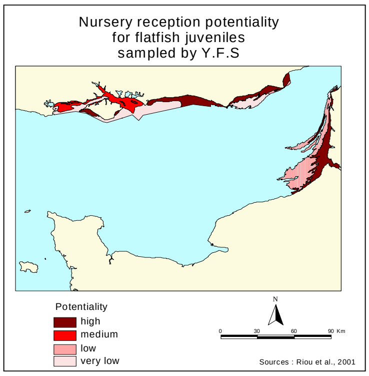
B.3 Surveys

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 are 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 full period back to 1981. 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. 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% (See table and figure below).

Nursery reception potential used for the combination of FR and UK YFS

Potentiality surface (Km²)	South England	Bay of Somme
High	756	575.1
Medium	484.7	0
Low	30.5	953.1
Very low	993.3	21.3
Total	2264.5	1549.5
Total (Low–Med–High)	1271.2	1528.2



However, the UK component of the YFS was last conducted in 2006. In the absence of any update of the UK component of the YFS index the available time-series of the UK component should still be used in the assessment next to the French component of the YFS index. The lack of information from the UK YFS may impede the recruitment estimates and therefore the forecast.

B.4 Commercial cpue

Three commercial fleets have been used in tuning. The Belgian beam trawl fleet (BEL BT), the UK Beam Trawl fleet (UK BT) and a French otter trawl fleet (FR OT). The two beam trawl fleets carry out fishing directed towards sole but can switch effort between ICES areas. The UK BT cpue data are derived from trips where landings of sole from VIId exceeded 10% of the total demersal catch-by-weight on a trip basis.

The effort of the Belgian beam trawl fleet is corrected for horse power, based on a study carried out by IMARES and CEFAS in the mid 1990s (no reference available). The study calculated an effort correction for HP applicable to sole and plaice effort in the beam trawls fisheries. The corresponding equations for sole is P=0.000204 BHP^1.23.

This horsepower correction for the commercial Belgian beam trawl fleet should still be applied. However, if a new corrected effort series is available (based on Section 4.2.4.1 in ICES 2009) it should be used under condition that this is reviewed and approved by ICES.

No French commercial tuning data are available for the otter trawl and fixed nets. A first attempt to create an effort series for the French trammelnets has been presented but is not deemed sufficient. If a new effort series is produced this too should be used under condition that they are reviewed and approved by ICES.

B.5 Other relevant data

None.

C. Historical stock development

Model used: XSA

Software used: IFAP/Lowestoft VPA suite

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 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 0.500

Since 2004-S.E. of the mean to which the estimate are shrunk = 2.000

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 1982–present year. However, there were no French age compositions before 1986 and large catchability residuals were observed in the commercial data before 1986. In the final analyses only data from 1986–present are used in tuning.

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1982–last data year	2–11+	Yes
Canum	Catch-at-age in numbers	1982–last data year	2–11+	Yes
Weca	Weight-at-age in the commercial catch	1982–last data year	2–11+	Yes
West	Weight-at-age of the spawning stock at spawning time.	19682–last data year	2–11+	Yes-assumed to be the same as weight-at-age in the Q2 catch
Mprop	Proportion of natural mortality before spawning	1982–last data year	2–11+	No-set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1982–last data year	2–11+	No-set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1982–last data year	2–11+	No-the same ogive for all years
Natmor	Natural mortality	1982–last data year	2–11+	No-set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Belgian commercial BT	1986–last data year	2–10
Tuning fleet 2	English commercial BT	1986–last data year	2–10
Tuning fleet 3	English BT survey	1988–last data year	1–6
Tuning fleet 4	UK YFS	1987–2006	1–1
Tuning fleet 5	French YFS	1987–last data year	1–1

D. Short-term projection

Model used: Age structured

Software used: MFDP

Initial stock size is taken from the XSA for age 3 and older and from RCT3 for age 2. The long-term geometric mean recruitment is used for age 1 in all projection years.

Since 2004 initial stock size for age 2 was taken from XSA.

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: Average weight over the last three years

Weight-at-age in the catch: Average weight over the three last years

Exploitation pattern: Average of the three last years, scaled to the level of Fbar (3-8) in the last year

Intermediate year assumptions: F status quo

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

Procedures used for splitting projected catches: Not relevant

E. Medium-term projections

Not performed for this stock.

In the past an age structured model was used (WGMTERMc software). Medium-term projections were carried out with settings as in short-term projection except for the weights in the catch and in the stock which are averaged over the last 10 years. Since 2005 medium-term projections have not been done for this stock.

F. Long-term projections, yield-per-recruit

Not performed for this stock.

In the past an age structured model was used (WGMTERMc software). Medium-term projections were carried out with settings as in short-term projection except for the weights in the catch and in the stock which are averaged over the last 10 years. Since 2005 medium-term projections have not been done for this stock.

G. Biological reference points

	Type	Value	Technical basis
Precautionary approach	Blim	Not defined	
	Bpa	8000 t	Lowest observed biomass at which there is no indication of impaired recruitment. Smoothed Bloss
	Flim	0.55	Floss, but poorly defined; analogy to North Sea and setting of 1.4 Fpa = 0.55. This is a fishing mortality at or above which the stock has displayed continued decline.
	Fpa	0.40	Between Fmed and 5th percentile of Floss; SSB>Bpa and probability (SSBmt<Bpa), 10%: 0.4.
Targets	Fy	Not defined	

(unchanged since 1998)

H. Other issues

None.

I. References

CEFAS 1999. PA software users guide. The Centre for Environment, Fisheries and Aquaculture Science, CEFAS, Lowestoft, United Kingdom, 22 April 1999.

Riou *et al*., 2001. Relative contributions of different sole and plaice nurseries to the adult population in the Eastern Channel: application of a combined method using generalized linear models and a geographic information system. Aquatic Living Resources. 14 (2001) 125–135.

Vas *et al*., 2007, Modelling Fish Habitat Suitability in the Eastern English Channel. Application to community habitat level. ICES CM 2004/ P:26

Annex 7. Stock Annex plaice in Area IV

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea plaice
Working Group	WGNSSK
Date	7 February 2009
By	Jan Jaap Poos

A. General

A.1 Stock definition

The North Sea plaice is defined to be a single-stock in ICES Area IV. However, data from data storage tag experiments reveal that about one third of plaice released in the Southern Bight of the North Sea visit the eastern English Channel in December and January. In contrast, analysis of the movements of mark-recapture experiments with plaice of a similar size and released at similar times indicates that only 13% of plaice released in the Southern Bight visit the eastern English Channel at this time (Hunter *et al*., 2004). This difference between DST and mark-recapture experiments is not observed in the central North Sea and German Bight, where the movements of plaice derived from the two approaches are relatively similar (Bolle *et al*., 2005). The differences may possibly be as a consequence of the fact that these fish migrate to their spawning grounds by selective tidal stream transport. Studies (Kell *et al*., 2004) have demonstrated that the migration between North Sea and the adjacent areas is more problematic for the smaller adjacent areas than it is for management in IV.

Genetic analysis of plaice population structure in northern Europe using microsatellites and mitochondrial DNA data (Hoarau *et al*., 2004) reveals relatively strong differentiation between "shelf" plaice and those from Iceland and Faroe, suggesting that deep water may serve as a barrier to movement between these populations. However, within the area of the European continental shelf, only weak differentiation could be detected between North Sea-Irish Sea and other areas (Norway, the Baltic and the Bay of Biscay, Hoarau *et al*., 2004). Although the spatial location of sampling within the North Sea was not sufficient to reveal any sub-structure. The lack of any genetic differentiation between Irish Sea and North Sea plaice populations (Hoarau *et al*., 2004) despite the evidence from mark-recapture studies that indicate extremely low transfer of individuals between these sea areas (0.36% over 17 years, calculated from (Dunn and Pawson, 2002)) demonstrates how differently genetic and tagging studies provide an understanding fish population structure. Nonetheless, it seems unlikely that Irish Sea and North Sea plaice are a single "stock", at least in a fisheries management sense.

A.2 Fishery

North Sea plaice is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea. Directed fisheries are also carried out with seines, gillnets, and twin trawls, and by beam trawlers in the central North Sea. As a consequence of the minimum mesh size enforced (80 mm in the mixed beam trawl fishery), large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea plaice have generally decreased in number of vessels in the last 10 years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions. For example, approximately 85% of plaice landings from the UK

(England and Scotland) is landed into the Netherlands by Dutch vessels fishing on the UK register. Vessels fishing under foreign registry are referred to as flag vessels. As described by the ICES WGNSSK in 2001(ICES CM 2002/ACFM:01) the fishing pattern of flag vessels can be very different from that of other fleet segments. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000HP (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). Also, the decrease in fleet size may partially have been compensated by slight increases in the technical efficiency of vessels. In the Dutch beam trawl fleet indications of an increase of technical efficiency of around 1.65% by year was found over the period 1990–2004 (Rijnsdorp *et al.*, 2006). Because the commercial tuning series are not currently used in the assessment, these estimates do not affect the current assessment.

The Dutch beam trawl fleet, one of the major operators in the mixed flatfish fishery in the North Sea, has seen a shift towards more inshore fishing grounds, changing the catchability of the fleet. This shift may be caused by a number of factors, such as the implementation of fishing effort restrictions, the increase in fuel prices and changes in the TAC for the target species (Quirijns, 2008). However, the contribution of each of these factors is yet unknown. Other factors affecting the catchability of the fleet include the changes in the fishing speed of the vessels, and discarding marketable fish in certain seasons and areas, as a result of the TAC management (Rijnsdorp, 1991).

Conservation schemes and technical conservation measures

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

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

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

The minimum landing size of North Sea plaice is 27 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 ex-empted from the regulation. An evaluation of the Plaice Box has indicated that: From trends observed it was inferred that the Plaice Box has likely had a positive effect on the recruitment of plaice but that its overall effect has decreased since it was established. There are two reasons to assume that the Plaice Box has a positive effect on the recruitment of Plaice: 1) at present, the Plaice Box still protects the majority of undersized plaice. Approximately 70% of the undersized plaice are found in the Plaice Box and Wadden Sea, and despite the changed distribution, densities of juvenile plaice inside the box are still higher than outside; 2) In the 80 mm fishery, discard percentages in the box are higher than outside. Because more than 90% of the plaice caught in the 80 mm fishery in the box are discarded, any reduction in this fishery would reduce discard mortality. There is, however, no proof of a direct relationship between total discard mortality and recruitment.

A.3 Ecosystem aspects

Adult North Sea plaice have an annual migration cycle between spawning and feeding grounds. The spawning grounds are located in the central and southern North Sea, overlapping with the distribution area of Sole. The feeding grounds are located more northerly than the sole distribution areas. Juvenile stages are concentrated in shallow inshore waters and move gradually off-shore as they become larger. The nursery areas on the eastern side of the North Sea contribute most of the total recruitment. Sub-populations have strong homing behaviour to specified spawning grounds and rather low mixing rate with other sub-populations during the feeding season (de Veen, 1978; Rijnsdorp and Pastoors, 1995). Genetically, North Sea and Irish Sea plaice are weakly distinguishable from Norway, Baltic and Bay of Biscay stocks using mitochondrial DNA (Hoarau *et al*., 2004).

Juvenile plaice were distributed more offshore in recent years. Surveys in the Wadden Sea have demonstrated that 1-group plaice is almost absent from the area where it was very abundant in earlier years (van Keeken *et al*., 2007). The Wadden Sea Quality Status Report 2004 (Vorberg *et al*., 2005) notes that increased temperature, lower levels of eutrophication, and de-cline in turbidity have been suggested as causal factors, but that no conclusive evidence is available; taking into account the temperature tolerance of the species there is ground for the hypothesis that a temperature rise contributes to the shift in distribution.

A shift in the age- and size-at-maturation of plaice has been observed (Grift *et al*., 2007, Grift *et al*., 2003): plaice become mature at younger ages and at smaller sizes in recent years than in the past. This shift is thought to be a genetic fisheries-induced change: Those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This results in a population that consists ever more of fish that are genetically programmed to mature early at small sizes. Reversal of such a genetic shift may be difficult. This shift in maturation also leads to mature fish being of a smaller size at age, because growth rate is reduced after maturation.

B. Data

B.1 Commercial catch

Discard sampling programmes started in the late 1990s to obtain discard estimates from several fleets fishing for flatfish. These sampling programmes give information on discard rates from 1999 but not for the historical time-series. Observations indicate that the proportions of plaice catches discarded are high (80% in numbers and 50% in weight: (van Keeken *et al*., 2004)) and have increased since the 1970s (51% in numbers and 27% in weight: (van Beek, 1998)). The discards time-series are derived from Dutch, Danish, German and UK discards observations for 2000–2007. For the period prior to that, a reconstructed discard time-series for 1957–1999 exists, based on a reconstructed population and selection and distribution ogives (ICES CM 2005/ACFM:07, Section 9.2.3).

The discard data from the sampling programmes in the individual countries are raised totals, based on samples from on-board observers. These observers generally take length structured samples that are converted into age structured data using age-length keys obtained from the discard samples, or research surveys.

The UK discards estimates have strong interannual variation, caused by the low sample sizes, and sampling different strata in the UK fleet. For example, the UK discard samples for 2007 were taken mainly from the UK *Nephrops* and otter trawl fishery. These fisheries represent only a small fraction of the total UK plaice landings, and raising the UK discards using only samples from this fleet would potentially lead to incorrect estimates. Because the UK landings represent 24% of the total nominal landings, obtaining accurate discard estimates is crucial. In order to gain better estimates of discards, the proportionality of the English discards to the Dutch discards is calculated in the observations since 2000. The UK estimates are recalculated assuming a constant ratio between the UK and Dutch discard numbers-at-age:

$$\hat{D}_{a,y}^{UK} = \frac{\sum_{y=2002}^{2007} D_{a,y}^{UK}}{\sum_{y=2002}^{2007} D_{a,y}^{NL}} \times D_{a,y}^{NL}$$

where $D_{a,y}^{UK}$, $\hat{D}_{a,y}^{UK}$, and $D_{a,y}^{NL}$ are the observed and estimated UK, and observed Dutch discard numbers of year y and age a, respectively.

After raising to the fleet total and estimation of discards-at-age using age length keys from the Dutch BTS surveys, discard observations-at-age are thus available from the Dutch, Danish, German and the UK discard sampling programmes. The quality of the estimation of total discards numbers-at-age depends on the quality of the available discards data, which are derived from low sampling level discards observations within the four countries that have provided discard estimates.

Discards-at-age were raised from the Dutch and UK sampling programmes by effort ratio (based on hp days at sea for the Dutch fleets, and on trips for the UK fleets). Discards-at-age from the Danish and German sampling programmes were raised by landings. Discards-at-age for the other fleets for which no estimates were available, were calculated as a weighted average of the Dutch, Danish, German and UK discards-at-age and raised to the proportion in landings (tonnes). This is the same method as used in the final assessment by WGNSSK 2005 (method B).

A self sampling programme for discards was started by the Dutch beam trawl fishery in 2004, and is still running. This sampling programme has a large number of samples, taken on board by the fishers, estimating the percentage of discards by volume. The programme indicates a strong spatial pattern in the discarding of the fleet. The percentage discards estimated in the self sampling programme is significantly lower than that in the Dutch sampling programme in the same years (Aarts and van Helmond, 2007).

To reconstruct the number of plaice discards-at-age before 2000 that are required for an XSA assessment, catch numbers-at-age are calculated from fishing mortality-at-age corrected for discard fractions, using a reconstructed population and selection and distribution ogives (ICES CM 2005/ACFM:07 Appendix 1). Alternatively, the discards previous to 2000 can be estimated using the statistical catch-at-age approach as described in (Aarts and Poos, 2009).

Landings

The landings by country are collected by different countries, segregated by sex for the Netherlands and Belgium (accounting for approximately 50 % of the landings). Age structure is available for the Netherlands, France, Germany, Denmark and Belgium (accounting for approximately 75% of the landings). The total age structured landings are estimated using a weighed procedure for the age structure by country, based on the proportionality of the weight of the total landings.

B.2 Biological

Weight-at-age

The stock weights of age groups 1-4 are calculated using modelled mean lengths from survey and back-calculation data (see ICES CM 2005/ACFM:07 Appendix 1) and converted to mean weight using a fixed length-weight relationship. Stock weights of the older ages are based on the market samples in the first quarter. Stock weight-at-age has varied considerably over time, especially for the older ages. Discard weights-at-age are calculated the same way as the stock weights of age groups 1–4, after which gear selection and discarding ogives are applied. Landing weights-at-age are derived from market sampling programmes. Catch weights-at-age are calculated as the weighted average of the discard and landing weights-at-age. There appear to be cohort effects on landings weight-at-age, which are also reflected in the stock weights-at-age. In addition to the cohort effects, there is a long-term decline in weight-at-age for the older ages. The stock weights of the older ages are based on the market samples in the first quarter. In these market samples, the sex ratio for the older ages may be skewed towards one of the sexes. The WG suggests a more in depth study into the causes and consequences of the perceived decreases in stock weights for the next benchmark assessment.

Natural mortality

Natural mortality is assumed to be 0.1 for all age groups and constant over time. These values are probably derived from war-time estimates (Beverton and Holt, 1957).

Maturity

A fixed maturity ogive is used for the estimation of SSB from the assessment in North Sea plaice, assuming maturity-at-age 1 is 0, maturity-at-age 1 and 2 is 0.5, and older ages are fully mature. However maturity-at-age is not likely to be constant over time (Grift *et al.*, 2003, Grift *et al.*, 2007) (Grift *et al.*, 2007, Grift *et al.*, 2003). The effects of assuming a constant maturity-at-age on the management advice was discussed in a study by (Kell and Bromley, 2004). However, a study of the effect of the fluctuations of natural mortality on the SSB by the WG in 2004 demonstrated that incorporating the historical fluctuations had little effect on SSB estimates in the period 1999–2003.

B.3 Surveys

Three different survey indices can been used as tuning fleets are:

- Beam Trawl Survey RV Isis (BTS-Isis);
- Beam Trawl Survey RV Tridens (BTS-Tridens);

- Sole Net Survey in September-October (SNS).

Additional Survey indices that can be used for recruitment estimates are (Table 8.2.12):

- Demersal Fish Survey (DFS).

The Beam Trawl Survey RV Isis (BTS-Isis) was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea (RV Isis). Since 1996 the BTS-Tridens covers the central part of the North Sea, extending the survey area of the surveys. Both vessels use an 8 m beam trawl with 40 mm stretched mesh codend, but the Tridens beam trawl is rigged with a modified net. Owing to the spatial distribution of both BTS surveys, consider-able numbers of older plaice and sole are caught. Previously age groups 1 to 4 were used for tuning the North Sea plaice assessment, but the age range has been extended to 1 to 9 in the revision done by ACFM in October 2001.

The Sole Net Survey (SNS and SNSQ2) was carried out with RV Tridens until 1995 then continued with the RV Isis. Until 1990 this survey was carried out in both spring and autumn, but after that only in autumn. The gear used is a 6 m beam trawl with 40 mm stretched mesh codends. The stations fished are on transects along or perpendicular to the coast. This survey is directed to juvenile plaice and sole. Ages 1 to 3 are used for tuning the North Sea plaice assessment; the 0-group index is used in the RCT3. In an attempt to solve the problem of not having the survey indices in time for the WG, the SNS was moved to spring in 2003. However, because of the gap in the spring series these data could not be used in the plaice assessment or in RCT3. In 2004, the SNS was moved back to autumn as before, based on the recommendation of the WGNSSK in 2004.

The 1997 survey results for the 1995 and 1996 year classes (at ages 1 and 2) in the BTS and SNS surveys cannot be used in the assessment, owing to age reading problems in that year. Also, the research vessel survey time-series have been revised in May 2006 by WGBEAM (ICES 2006), because of small corrections in databases and new solutions for missing lengths in the age-length-keys.

When WGBEAM will provide these combined series, those should be used instead in the assessment.

The Demersal Fish Survey (DFS) is the more coastal of the surveys, conducted by several countries. This survey is not used in the assessment, but rather used to estimate the recruitment of juvenile fish in the RCT3 analysis. The survey estimates abundances for North Sea plaice age 0 and age 1. However, the age 1 has not been used for recruitment estimation since a number of years, and the time-series for this age was stopped in 2005. The UK contribution to the DFS survey was revised in 2008, affecting the estimates between 2001 and 2006.

B.4 Commercial lpue

Commercial age structured lpue series (consisting of an effort series and landings-at-age series) that can be used as tuning fleets are:

- The Dutch beam trawl fleet (since 1989);
- The Dutch beam trawl fleet corrected for spatial effort allocation (since 1997);
- The UK beam trawl fleet excluding all flag vessels (between 1990 and 2002).

Effort has decreased in the Dutch beam trawl fleet since the early/mid 1990s. Up until 2002, the age-classes available in both the Dutch and the UK fleets generally demonstrate equal trends in lpue through time.

The WG used both survey data and commercial lpue data for tuning until the mid 1990s. The commercial lpue was calculated as the ratio of the annual landings over the total number of fishing days of the fleet. At that time, however, it was realized that the commercial lpue data of the Dutch beam trawl-fleet, which dominated the fishery, were likely to be biased as a consequence of quota restrictions. Vessels were reported to adjust their fishing patterns in accordance to the individual quota available for that year. Fishers reported to leave productive fishing grounds because they lacked the fishing rights and moved to areas with lower catch rates of the restricted species with a bycatch of non-quota, or less restricted species.

A method that corrects for the spatial effort allocation is to calculate lpues at a smaller spatial scale, e.g. ICES rectangles, then calculate the average of these ICES rectangle-specific lpues. Age-information is available at this spatial level since 1997, and lpue series could be used for tuning an age structured assessment method (alternatively, age-aggregated tuning series could be used in other analytical assessment methods than XSA). Only under the assumption that discarding is negligible for the older ages, the lpue represents cpue, and this time-series could be used to tune age structured assessment methods.

Also, age-aggregated lpue series, corrected for directed fishing under a TAC-constraint (see Quirijns and Poos, 2007), by area and fleet component, can be used as indication of stock development. Available are:

- The Dutch beam trawl fleet (only large cutters with engine powers above 221 kW);
- The UK beam trawl flag vessels landing in the Netherlands (only large cutters with engine powers above 221 kW);
- Several Danish fleets (trawl, gillnet and seines) mainly operating in the Northern area;
- Effort of the Dutch beam trawl fleet and of the English beam trawl vessels landing in the Netherlands, by area and fleet component.

B.5 Other relevant data

To be done.

C. Historical stock development

There are currently two methods that could be used to provide an assessment of North Sea plaice, being XSA, and a model developed by (Aarts and Poos, 2009). The XSA uses the reconstructed discard set described in the catch section. The Aarts and Poos methods estimate the discards from the mortality signals in the surveys, the landings-at-age and the discards-at-age in the most recent period. WKFLAT 2009 suggest to run both models concurrently, in order to estimate the stability of the Aarts and Poos method.

Model used as a basis for advice

The North Sea plaice 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) + (reconstructed) discards based on NL, DK + UK + GE fleets. Discards reconstruction between 1957–1999), observations since 2000
Tuning indices	BTS-Isis 1985-2007 1–8 BTS-Tridens 1996–2007 1–9 SNS 1982-2007 1–3
Plus group	10
First tuning year	1982
Time series weights	No taper
Catchability dependent on stock size for age <	1
Catchability independent of ages for ages >=	6
Survivor estimates shrunk towards the mean F	5 years/5 years
s.e. of the mean for shrinkage	2.0
Minimum standard error for population estimates	0.3
Prior weighting	Not applied

The Aarts and Poos model

SETTING/DATA	VALUES/SOURCE
Catch-at-age	Landings (since 1980, ages 1:9) + discards based on observations since 2000 NL, DK + UK + GE fleets (ages 1:8). No reconstruction
Tuning indices	BTS-Isis 1985–2007 1–8 BTS-Tridens 1996–2007 1–9 SNS 1980–2007 1–3
Plus group	No plus group
First tuning survey year	1980
Catchability independent of ages for ages >=	8 (for catches)
Minimum standard error for likelihood function	0.05
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 (1.4.3). Weight-at-age in the stock and weight-at-age in the catch are taken to be the average over the last 3 years. The exploitation pattern was taken to be the mean value of the last three years, scaled to F in 2007. The proportion of landings-at-age was taken to be the mean of the last three years; this proportion was used for the calculation of the discard and human consumption partial fishing mortality. Population numbers-at-ages 3 and older are XSA survivor estimates.

Numbers at age 2 are based on RCT3 estimates if the estimates from RCT3 demonstrate sufficient consistency.

Numbers-at-age 1 and recruitment of the incoming year-class are taken from the long-term geometric mean of age 1 assessment estimates, where the most recent 4 years are removed from the time-series. The management options are given for three different assumptions on the F values in the intermediate year;

A. F is assumed to be equal to the estimate for F in the final year of the assessment,

B. F is 0.9 times F in the final year of the assessment, and

C. F is set such that the landings in the intermediate year are equal to the TAC of that year.

E. Medium-term projections

Generally, no medium term projections are done for this stock.

F. Long-term projections

Generally, no medium term projections are done for this stock.

G. Biological reference points

The current reference points were established by the WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock/recruitment relationship for North Sea plaice did not display a clear breakpoint where recruitment is impaired at lower spawning stocks. Therefore, ICES considered that $\mathbf{B_{lim}}$ be set at 160 000 t and that $\mathbf{B_{pa}}$ then be set at 230 000 t using the default multiplier of 1.4. $\mathbf{F_{lim}}$ was set at $\mathbf{F_{loss}}$ (0.74). $\mathbf{F_{pa}}$ was proposed to be set at 0.6 which is the 5th 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 0.6 is consistent with an SSB of around 230 000 t. In 2008, a target F was added to the reference points, based on the F stated in the long-term management plan for plaice and sole. This target F is supposedly based on an estimates of F_{msy}.

	Type	Value	Technical basis
Precautionary approach	Blim	160 000 t	Bloss = 160 000 t, the lowest observed biomass in 1997 as assessed in 2004.
	Bpa	230 000 t	Approximately 1.4 Blim.
	Flim	0.74	Floss for ages 2–6.
	Fpa	0.60	5th percentile of Floss (0.6) and implies that Beq>Bpa1) and a 50% probability that SSBMT~Bpa.
Targets	Fmgt	0.3	EU management plan

(unchanged since 2004, target added in 2008)

The F_{msy}, F_{max} and $F_{0.1}$ should be estimated given the 10 most recent years of the stock assessment.

H. Other issues

None identified.

I. References

AARTS, G. and POOS, J. J. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES Journal of Marine Science, 66.

AARTS, G. and VAN HELMOND, A. T. M. 2007. Discard sampling of Plaice (*Pleuronectes platessa*) and Cod (*Gadus morhua*) in the North Sea by the Dutch demersal fleet from 2004 to 2006. ICES Document Report number C120/07. 42 pp.

BEVERTON, R. J. H. and HOLT, S. J. 1957. On the dynamics of exploited fish populations, Her Majesty's Stationery Office, London (UK).

BOLLE, L. J., HUNTER, E., RIJNSDORP, A. D., PASTOORS, M. A., METCALFE, J. D. and REYNOLDS, J. D. 2005. Do tagging experiments tell the truth? Using electronic tags to evaluate conventional tagging data. ICES Journal of Marine Science, 62: 236–246.

DE VEEN, J. F. 1978. On selective tidal transport in the migration of North Sea plaice (*Pleuronectes platessa* L.) and other flatfish species. Netherlands Journal of Sea Research, 12: 115–147.

DUNN, M. R. and PAWSON, M. G. 2002. The stock structure and migrations of plaice populations on the west coast of England and Wales. Journal of Fish Biology, 61: 360–393.

GRIFT, R. E., HEINO, M., RIJNSDORP, A. D., KRAAK, S., B. M. and DIECKMANN, U. 2007. Three-dimensional maturation reaction norms for North Sea plaice. Marine Ecology Progress Series, 334: 213–224.

GRIFT, R. E., RIJNSDORP, A. D., BAROT, S., HEINO, M. and DIECKMANN, U. 2003. Fisheries-induced trends in reaction norms for maturation in North Sea plaice. Marine Ecology Progress Series, 257: 247–257.

HOARAU, G., PIQUET, A. M.-T., VAN DER VEER, H. W., RIJNSDORP, A. D., STAM, W. T. and OLSEN, J. L. 2004. Population structure of plaice (*Pleuronectes platessa L.*) in northern Europe: a comparison of resolving power between microsatellites and mitochondrial DNA data. Journal of Sea Research, 51: 183–190.

KELL, L. T. and BROMLEY, P. J. 2004. Implications for current management advice for North Sea plaice (*Pleuronectes platessa* L.): Part II. Increased biological realism in recruitment, growth, density-dependent sexual maturation and the impact of sexual dimorphism and fishery discards. Journal of Sea Research, 51: 301–312.

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.

RIJNSDORP, A. D. 1991. Selection differentials of male and female North Sea plaice Pleuronectes platessa L. and changes in maturation and fecundity. *In* The exploitation of evolving populations. Ed. by R. LAW, T. K. A. STOKES and J. M. MCGLADE. Springer Verlag.

RIJNSDORP, A. D., DAAN, N. and DEKKER, W. 2006. Partial fishing mortality per fishing trip: a useful indicator of effective fishing effort in mixed demersal fisheries. ICES Journal of Marine Science, 63: 556–566.

RIJNSDORP, A. D. and PASTOORS, M. A. 1995. Modelling the spatial dynamics and fisheries of North Sea plaice (*Pleuronectes platessa* L.) based on tagging data. ICES Journal of Marine Science, 52: 963–980.

VAN BEEK, F. A. 1998. Discarding in the Dutch beam trawl fishery. ICES CM 1998/ BB:5: 1–15.

VAN KEEKEN, O. A., QUIRIJNS, F. J. and PASTOORS, M. A. 2004. Analysis of discarding in the Dutch beam trawl fleet. 96 p. pp.

VAN KEEKEN, O. A., VAN HOPPE, M., GRIFT, R. E. and RIJNSDORP, A. D. 2007. Changes in the spatial distribution of North Sea plaice (*Pleuronectes platessa*) and implications for fisheries management. Journal of Sea Research, 57: 187–197.

VORBERG, R., BOLLE, L. J., JAGER, Z. and NEUDECKER, T. 2005. Chapter 8.6 Fish. *In* Wadden Sea Quality Status Report 2004.

Annex 8. Extending the statistical catch-at-age model for plaice in Area IV

Background

The Terms of Reference state that the Workshop should "Agree and document preferred method for evaluating stock status and (where applicable) short-term outlook and update the assessment handbooks as appropriate and develop recommendations for future improving assessment methodology and data collection."

Based on presentations, the workshop considered the SCAA approach outlined in Aarts and Poos, 2009 as valuable, particularly because the framework provides an innovative way to deal with reconstructing discards. This method shares many features of statistical catch-age methods and allows for specifications of likelihoods and more formal evaluation of uncertainty.

It was recommended that the SCAA model be included as part of the assessment models, with further testing and run in parallel with the XSA to determine stock status. Another recommendation was to use SCAA models for evaluating changes in biological parameters for North Sea plaice stock. Scientific literature indicates that this stock demonstrates changes in maturity schedules and spawning towards younger age-classes, as well changes in mean size-at-age (Grift *et al*., 2007, Kell and Bromley, 2004). These changes in the population whether in response to environmental factors or fishing activity posses a question of what are the appropriate levels of the population that should be used as reference benchmarks (Kell *et al*., 2005).

Alternative evaluations

For North Sea place, a few different model configurations were developed. Initially, the time-series of estimated discard levels (totals by weight and by age) was treated as a separate fishery. Secondly, the catch-age estimates were combined to a single fishery. Finally, data from Rijnsdorp and Milner, 1996 were adapted and a model configuration that extended from 1892 to 2008 was analysed. Initial estimates indicated some poor residual patterns. To illustrate the model flexibility, an alternative natural mortality-at-age was used. In place of a constant value fixed and 0.1 over all ages, age 1 and age 15+ mortality was specified to be 0.2 with all ages in between fixed at 0.1. This was set to attempt to resolve issues about initial conditions. These can serve to enhance understanding on the levels of assessment uncertainty. Results are revealed for illustrative purposes only. Further details (code and model runs) can be made available on request to Jim.Ianelli@noaa.gov.

One of the differences from the XSA approach is that the catch-age data were assumed to be estimates of the actual catch. As such, they are tuned as proportions for ages 1–15 following a multinomial sampling process. The total landings were conditioned to be fit precisely although annually varying levels of uncertainty can be specified. The "effective sample size" for the fishery proportions-at-age was assumed to be 100 for each year (for fitting assuming a multinomial likelihood). The research survey indices were used as "bulk" values expressed as numbers of fish per unit area. The ages 1–15 were summed and fit as an index of population number and, as a separate likelihood component, age-composition data were fit assuming a multinomial process with an assumed sample size of 50 for each year. For computation of spawning biomass, females only are presented (assuming a 50:50 relationship) and a constant assumed weight-at-age was used (taken as the most recent 5-year mean from the "stock weights-at-age"). Some divergence from the XSA approach is expected because SSB is computed using annually varying mean weights-at-age). Note that for the fishery data, the mean weights-at-age are specified for each year as in the XSA runs.

Results from the statistical application indicate that recruitment variability was relatively high (Figure 1). Historically, the spawning biomass is highly uncertain and gives a significantly different pattern than that from the XSA (Figure 2). This could be as a consequence of the differences with not including the commercial lpue data. Residuals from the survey are shown in Figure 3.

Size-based discard process

A second line of investigation involved evaluating an approach that more closely follows the at-sea practice of discarding plaice (typically involving smaller sizes). A model with "plaice-like" characteristics was developed in a spreadsheet. This model allowed both simulations under different levels of recruitment variability and also explicitly accounted for a hypothetical size-retention process. The steps of the model can be thought of as follows:

1) Compute numbers-at-age in an initial year and in subsequent years gains from recruitment and losses from fishing and natural mortality are calculated (the recruitment levels can be arbitrarily specified; the default was lognormal with a specified value for variability;
2) Calculate the "true" fishery catch-at-age given a "true" selectivity-at-age function;
3) Convert the catch-at-age into length frequencies (e.g. Figure 4) using an age–length conversion matrix (Figure 5). Note that this assumes a constant growth (but annual and seasonal versions can be constructed as needed);
4) **Select fish** by size to keep and to discard. For example, imagine that nearly all fish less than 24 cm are discard prior to landing;
5) "Observe" the landed length frequencies;
6) Because true catch-at-age is known from step 2), use this and the age–length relationship to construct a full age–length key;
7) Apply the age–length key constructed in step 6) to the landed length frequencies and get landed age-compositions for each year;
8) Compute difference between landed catch-at-age in each year over the actual catch-at-age. Expressed as a proportion of all discards, this vector then represents the age-specific discard pattern for each year, which with modest recruitment variability can result in annually varying discards-at-age (Figure 6).

Note that the present model assumption is that the process of discarding plaice is based on a (mainly) constant age-specific discard rate. This illustrates how year-class variability alone (assuming constant growth) creates annually varying age-specific retention rates (which is currently assumed in the statistical age-structured model presented at the workshop; Aarts and Poos, 2009). It is unknown if the impact will be significant.

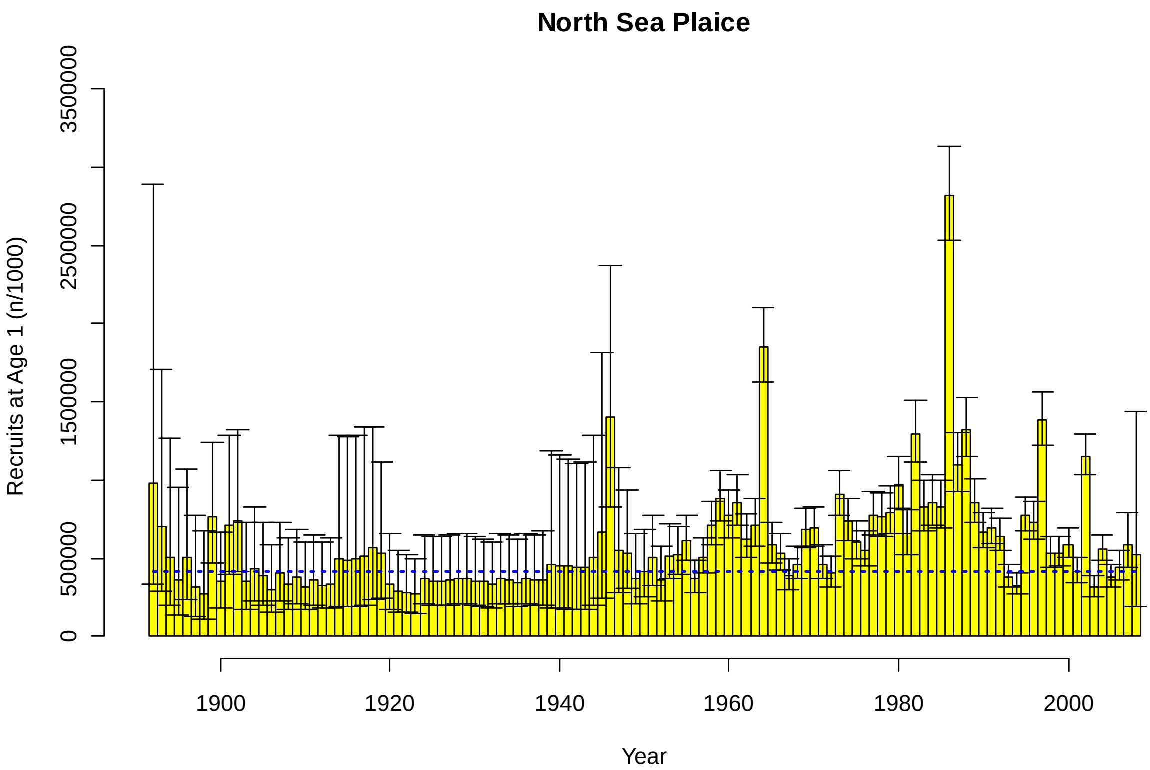
References

Engelhard, Georg H., Julian Martin, and Mike Armstrong. 2008. Programme 6: Western Channel sole and plaice. Fisheries Science Partnership 2008/09. Final Report. 43 pp.

Grift, R. E., M. Heino, A.D. Rijnsdorp, S.B.M. Kraak and U. Dieckmann. 2007. Three-dimensional maturation reaction norms for North Sea plaice. Mar. Eco. Prog. Ser. 334:213–224.

Kell L.T. and P.J. Bromley. 2004. Implications for current management advice for North Sea plaice (*Pleuronectes platessa L.*): Part II. Increased biological realism in recruitment, growth, density-dependent sexual maturation and the impact of sexual dimorphism and fishery discards. J. Sea Research. 51: 301–312.

Kell, L.T., M.A. Pastoors, R.D Scott, M.T. Smith, F.A. Van Beek, C.M. O'Brien, and G.M. Pilling. 2005. Evaluation of multiple management objectives for northeast Atlantic flatfish stocks: sustainability vs. stability of yield. ICES J. Mar. Sci. 62:1104–1117.



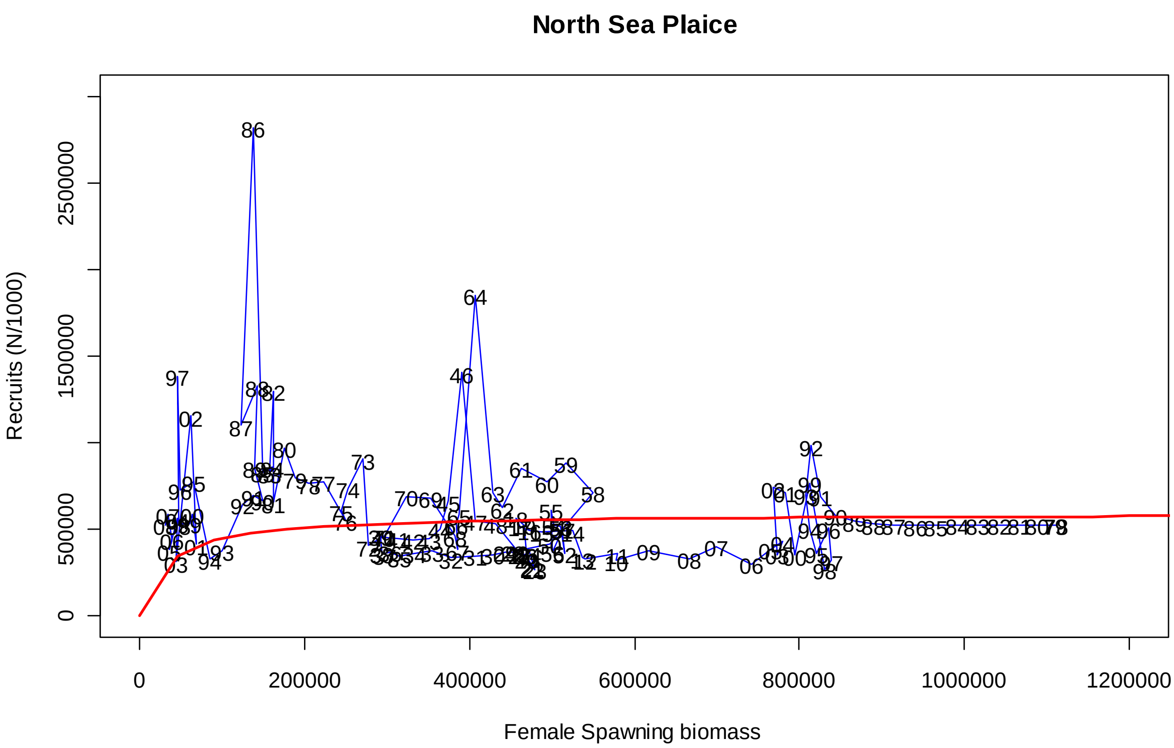


Figure 1. Recruitment estimates with ±2 standard deviations (top panel) and stock recruitment pattern (bottom panel) for North Sea Plaice, 1892–2008. Note that the age structured data commences in 1957.

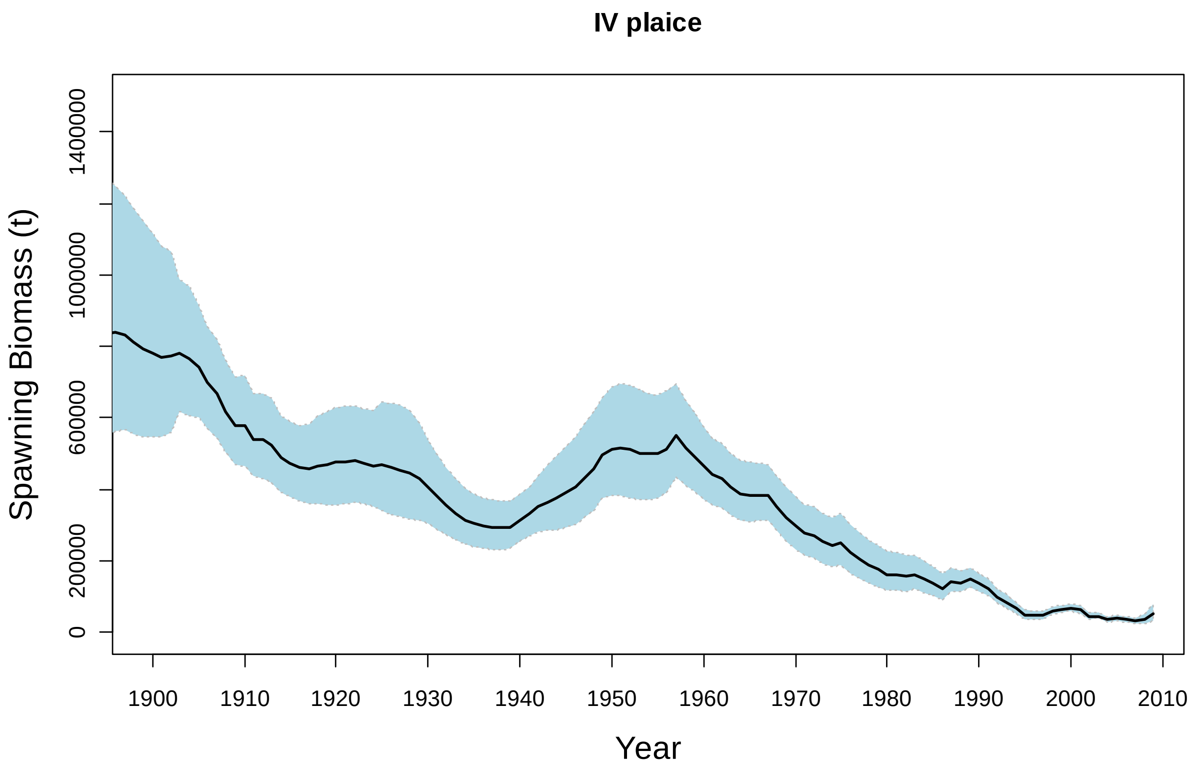


Figure 2. Female spawning biomass estimates relative to that of XSA. Shaded band represents approximate ±2 standard deviations confidence bands.

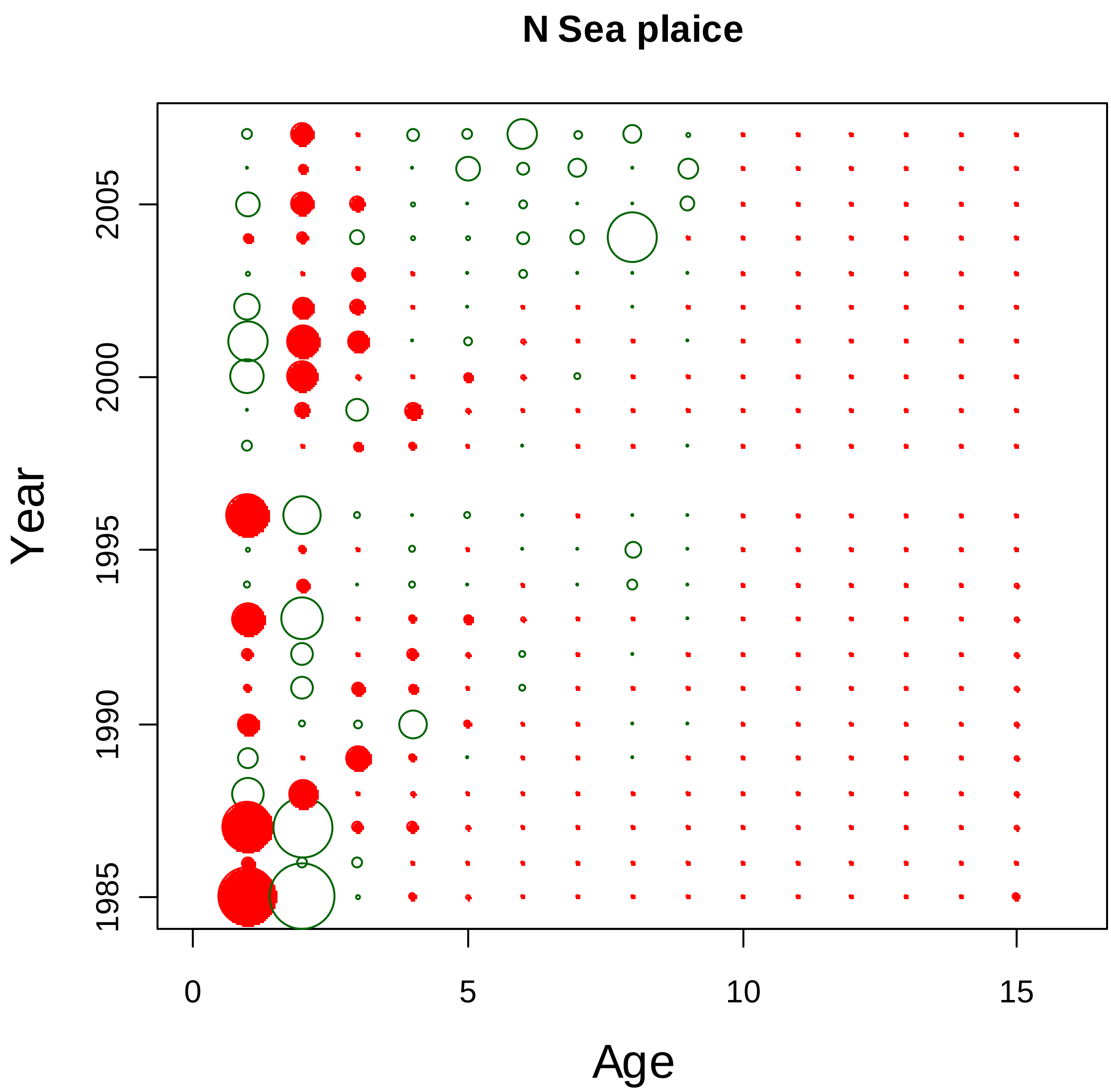


Figure 3. Pearson residuals for the IBTS survey for North Sea plaice. Negative residuals are shown as filled circles.

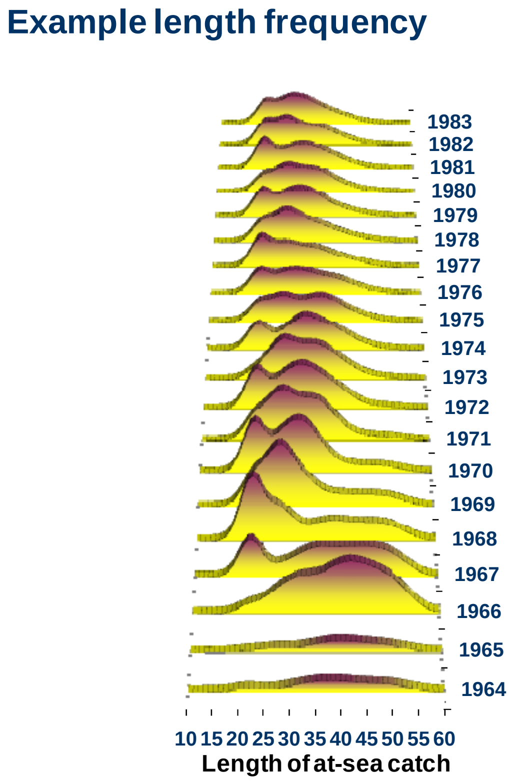


Figure 4. Length frequency distribution for a simulated stock where fishing mortality increases in the third year (from the bottom).

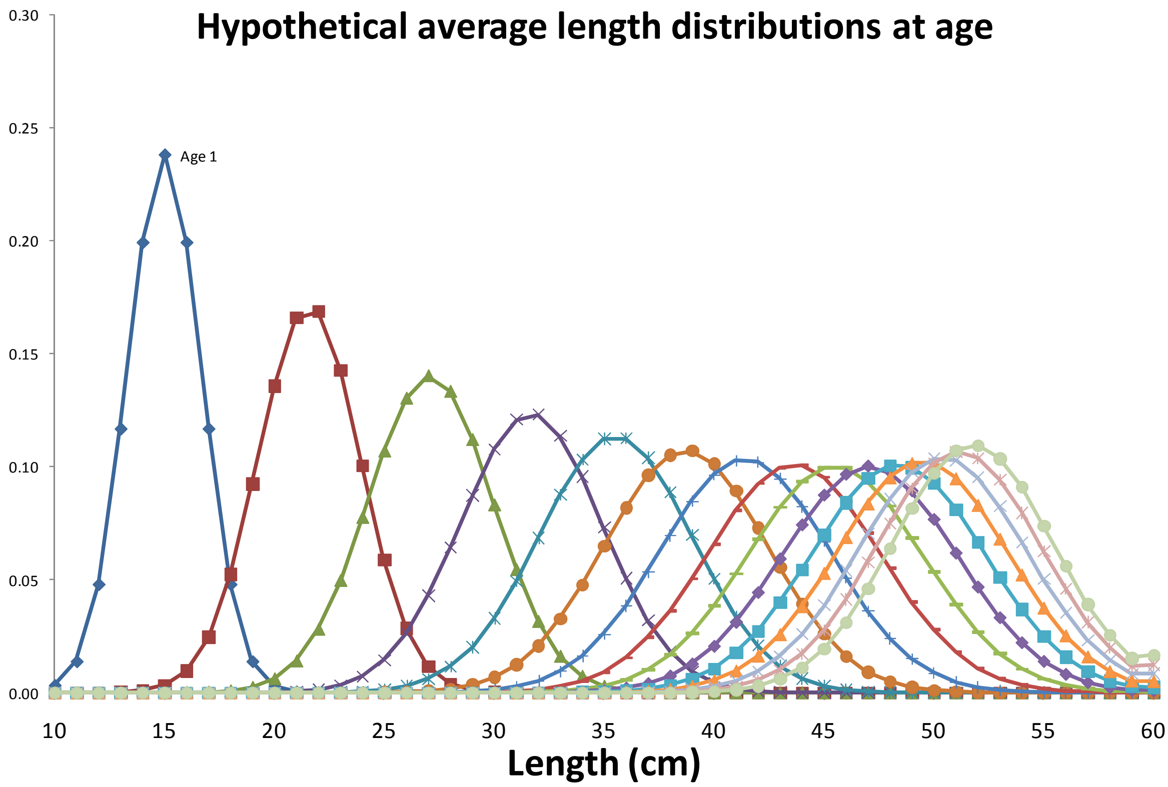
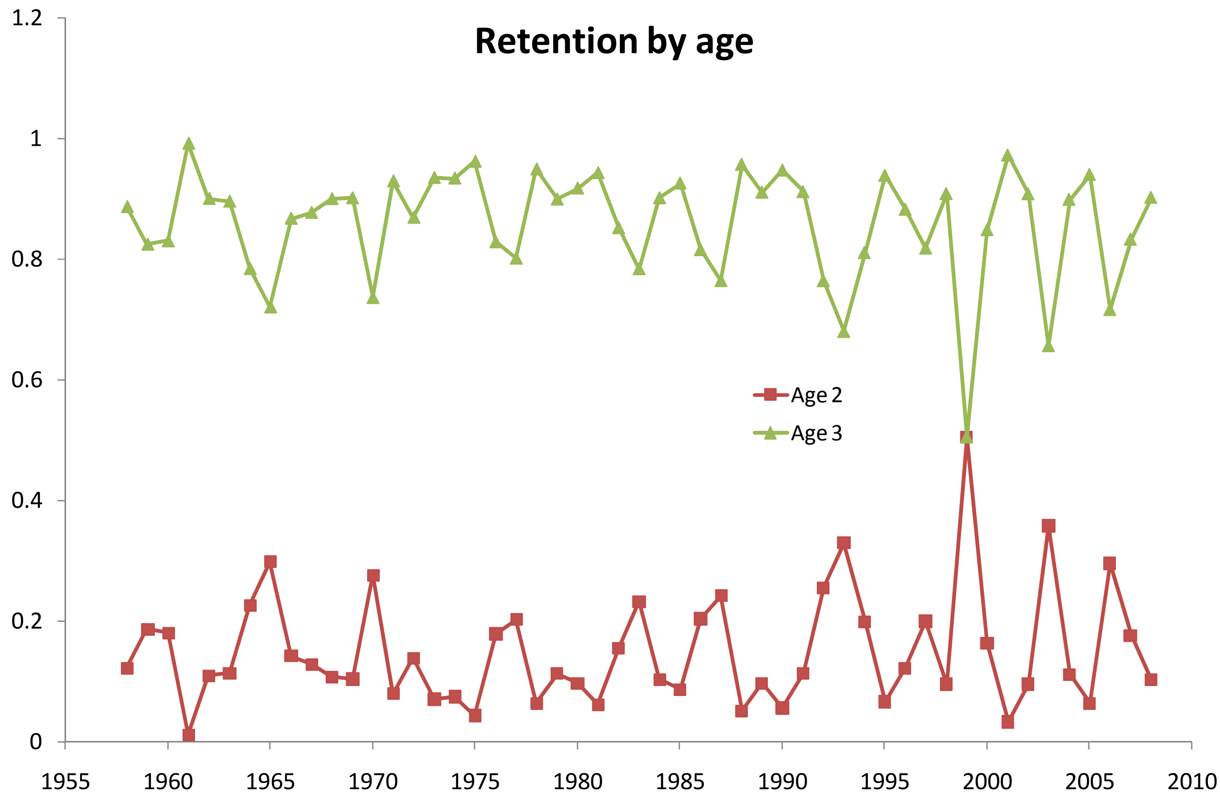


Figure 5. Invented length distributions-at-age used for the age–length conversion matrix (not to be confused with an age–length key, which converts lengths to ages. This relationship is used to convert ages to length frequencies).



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