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Report of the Benchmark Workshop on Celtic Sea stocks (WKCELT)

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1 Executive summary

WKCELT was set up to provide standards for assessing the stocks of Whiting in VIIe-k, Sole in VIIfg and Nephrops in Fishing Units 19 and 20-21.

For the whiting, was decided to redefine the stock unit to include the wider area VIIb–c and e–k, since this covers the distribution of whiting in the area as seen in commercial as well as the survey data. Furthermore, it coincides with the TAC management area, except for Division VIId, the advice for which is provided as part of the advice for the North Sea whiting.

Several major changes were made to the whiting assessment. Discard data were provided back to 2004 for France and 1995 for Ireland. Commercial data were updated to include discards back to 1999 by interpolation. The two IBTS Q4 bottom-trawl surveys EVHOE (France) and IGFS (Ireland) were merged to become one survey time-series. Moreover, the natural mortality was changed by applying the Lorenzen formula and it was decided to present Biomass as 2+ rather than SSB as measure of abundance. The inclusion of discard data reduced the time frame of the assessment to the years from 1999 onwards. An XSA assessment with these data performed well enough to be acceptable as a provisional assessment and basis for advice in the short term. Reference points were revised accordingly.

For the Sole XSA has been well established as assessment tool. However, a close scrutiny of data and diagnostics revealed problems that led the WKCELT to conclude that this assessment, despite some improvements, could only be regarded as provisional. It may be basis for advice in the short term but could not be recommended as a standard procedure for the future.

For both these stocks, it is strongly recommended to explore assessment methods that are less sensitive to noise in the data, for example state-space models. Preliminary runs made with SAM for the whiting were promising, but still not at the stage where it can be proposed for a routine assessment of that stock.

The Nephrops in FU 19 is currently assessed using UVTW surveys. The procedure was refined and is now formally approved for this stock by a benchmark process.

The Nephrops in FU20-21 is still to be handled as a data poor stock, but there is development towards an UWTV based advice. The WKCELT considered this to be a development in the right direction, but concluded that the UWTV approach for this stock was not yet sufficiently mature to be used as basis for advice.

2 Introduction

The WKCELT met at ICES HQ from 3 to 7 February 2014 to address the following terms of reference.

A **Benchmark Workshop on Celtic Sea stocks** (WKCELT), chaired by External Chair Dankert Skagen, Norway and ICES Chair Colm Lordan, Ireland, and attended by invited external expert Gary Melvin, Canada will be established and will meet at Galway, Ireland for a data compilation meeting 10–12 December 2013 and at ICES HQ for a 5 day Benchmark meeting 3–7 February 2014 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:
    i. Stock identity and migration issues;
    ii. Life history data;
    iii. Fishery-dependent and fishery-independent data;
    iv. Further inclusion of environmental drivers, multispecies information, and ecosystem impacts for stock dynamics in the assessments and outlook.
b) Agree and document the preferred method for evaluating stock status and (where applicable) short-term forecast and update the stock annex as appropriate. Knowledge of environmental drivers, including multispecies interactions, and ecosystem impacts should be integrated in the methodology If no analytical assessment method can be agreed, then an alternative method (the former method, or following the ICES data-limited stock approach) should be put forward;
c) Evaluate the possible implications for biological reference points, when new standard analyses methods are proposed. Propose new MSY reference points taking into account the WKFRAME results and the introduction to the ICES advice (section 1.2);
d) Develop recommendations for future improving of the assessment methodology and data collection;
e) Compile and review available fleet and fisheries data for fisheries in the Celtic Sea (VIIfg);
f) Produce a mixed fisheries annex for the Celtic Sea region (VIIfg);
g) As part of the evaluation:
    i. Conduct a 3 day data compilation workshop (DCWK). Stakeholders are 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. Following the DCWK, produce working documents to be reviewed during the Benchmark meeting at least 7 days prior to the meeting.

The Benchmark Workshop will report by 1 April 2014 for the attention of ACOM.

The Workshop was preceded by a Data Collection Workshop 10–12 December 2014.

There was a change of external experts after the ToR had been formulated. The external experts who attended the WKCELT were Gary Melvin (Canada) and Dankert Skagen (Norway).

WKCELT was set up to provide standards for assessing the stocks of Whiting in Divisions VIIe-k, Sole in Divisions VIIfg and Nephrops in Fishing Units 19 and 20–21. For the whiting, it was decided to consider the wider area VIIb–c and e–h, since this covers the distribution of whiting in the area, as also indicated by the survey data.

For the Sole there is a well-established procedure using XSA as assessment tool. However, a close scrutiny of data and diagnostics revealed problems, that led the WKCELT to conclude that this assessment could only be regarded as provisional that may be basis for advice in the short term but not recommended as a standard procedure for the future.

For the whiting, the advice has so far been based on an assessment with XSA which is regarded as problematic, and does not include discards. Discard data were now provided back to 2004 for France and 1995 for Ireland. Commercial data were updated to include discards back to 1999 for both countries by interpolation. The two IBTS Q4 bottom-trawl surveys EVHOE (France) and IGFS (Ireland) were merged to become one survey time-series. Moreover, the natural mortality was changed using the Lorenzen formula. It was also decided to present Biomass 2+ rather than SSB. Some age 1 fish is known to spawn, but it is not clear how stable the fraction mature is, or how fecund these fish are. Applying 2+ as a measure of abundance brings this stock in line with other whiting stocks, where a knife-edge maturity ogive is assumed. The two bottom-trawl surveys EVHOE and IRGFS VIIb–k were merged to become one survey time-series. This reduced the time frame of the assessment to the years 2003 onward. An XSA assessment with these data performed well enough to be acceptable as a provisional assessment.

For both these stocks, it is strongly recommended to explore assessment methods that are less sensitive to noise in the data, for example state—space models. Some work along that line was done for the whiting, but is still not at the stage where it can be proposed for a routine assessment of the whiting stock.

The Nephrops in FU 19 is currently assessed using UVTW surveys, the procedure is now formally approved by a benchmark process.

The Nephrops in FU20-21 is handled as a data poor stock, but there is a development towards an UWTV based advice. The WKCELT considered this to be a development in the right direction, but concluded that this approach was not yet sufficiently mature to be used as basis for advice.

The main outcome of the WKCELT is revised stock annexes for all the stocks. The present report describes changes made and justifications for the choices made in the stock annex. Section 7 has some comments from the external reviewers.

The ToR f (Mixed fisheries annex) could not be fully addressed due to the lack of expertise and data. Recent work in the field in the Celtic sea was presented and discussed.

The participants are listed in Annex1.

3 Celtic Sea sole (VIIfg)

3.1 ALK's by fishery

The assessment of sole in the Celtic Sea has been using separate ALK's by country to create the international age distribution for this stock. Belgium, UK (E and W) and Ireland providing these data, are responsible for about 75%, 15% and 5% of the total international landings respectively. WKCELT investigated the possible use of a combined ALK over all countries. Figures 3.1.1-3 show the landings distribution of sole by ICES rectangles for the major beam trawl fleets of Belgium, UK (E and W) and Ireland. It is apparent that these three fleets are operating in different parts of the Celtic Sea. The Belgian fleet is mainly fishing in the ICES rectangles of the Trevose box (30E4, 31E4 and 32E3). The UK (E and W) beam trawl fleet operates predominantly in the lower rectangle of the Trevose box (31E4) and below the Trevose box (29E4), and the Irish beam trawl fleet fishes South West of the Small's (outside the Trevose box) and in front of the Irish coast.

Exploratory data analysis (Hans Gerritsen, WD to WKCELT) on raw data from Belgium (2005-2012), UK (E and W) (2005-2012) and Ireland (2005-2012 length data; 2009-2012 age data) lead to the following conclusions:

- Belgium catches more small fish (25 cm) compared to UK (E and W) and Ireland (30 cm) (Figure 3.1.4).
- The proportions at age are similar between Belgium and UK (E and W). However in 2006 and 2007 the Belgian data consistently show higher length-at-age (Figure 3.1.5-6).
- The length-weight relationship is similar for the three countries. In 2005, the UK (E and W) data showed strange outliers and was therefore removed from the dataset. (Figure 3.1.7).
- The use of a combined ALK did not result in a better cohort tracking compared to the use of a country- specific ALK. (Figure 3.1.8).

WKCELT noted that a national raising procedure differs from a combined raising procedure as the first procedure is by quarter and or by port (UK) where in the second procedure all data are lumped together. In case of sole in the Celtic Sea this is very important as the Belgian landings in the first and second quarter dominate total landings (see section 3.4 on Trevose box evaluation). Also, UK (E and W) has more landings in February/March compared to the rest of the year. WKCELT noted that the sampling levels of the two major countries, Belgium and UK (E and W) are satisfactory with yearly about 1000 fish aged by each country.

WKCELT therefore concluded that the current raising procedure, using separate ALK by county should be maintained.

3.2 Revisions of Belgian catch data and cpue

The assessment of sole in the Celtic sea is currently tuned with 2 commercial fleets (Belgium and UK (E and W) beam trawl fleet) and one survey (UK (E and W) quarter 3). The UK (E and W) commercial (started in 1991) as well as the survey (started in 1988), provide information up to the present day. The Belgian tuning file was halted in 2003 when weird residuals occurred and further investigation at that time could not resolve the problems in the assessment. From 2003 onwards, only the UK (E and W) commercial beam trawl fleet, accounting for about 15% of total international landings, provides information on the older ages. WKCELT considered the possibility of reintroducing the Belgian commercial tuning file as it is responsible for about 75% of the international landings. Detailed data were available for the period 1997-2012.

WKCELT noted that in the period 2002-2004 a significant part of the total international landings used by ICES ended up in the “unallocated” category. Therefore investigations were done for possible misreporting. At first priority the analyses were performed on the Belgian data as Belgium is responsible for about 75% of the landings. It should be noted that discards for this stock are minimal (2-5% in weight) and LPUE could therefore be interpreted as plausible cpue values. cpue information on about 8500 trips in area VIIfg and neighbouring area VIIj-k were investigated over the period 1997-2012. Figure 3.2.1 shows box plots with the cpue values of the two areas, VIIfg and VIIj-k by year for the period 1997-2012. Figure 3.2.2 shows histograms of the frequency distribution of the cpue’s in both areas over the same period. A few outliers above 250 kg/hour for VIIfg and above 1400 kg/hour for VIIj-k were initially removed.

For both areas, VIIfg and VIIj-k, it is apparent that since 2002 cpue values above 40 kg/hour were registered. However for area VIIfg these comprise only for about 2-3% of the registrations. Figure 3.2.1 also shows that using a boxplot range of 1.5 times SE, a cpue of 40 kg/hour could be taken as the threshold for possible misreporting. Taken into account the area distribution and the biological characteristics of sole, a cpue frequency distribution as registered for area VIIj-k (Figure 3.2.2 right panel) seems rather unlikely. Moreover, investigations of Belgian observer trips (56 trips) over the period 2004-2012 show an average cpue of 17 kg/hour (SE=9) with a maximum value of 36 kg/hour. Only 4% of the 1241 hauls measured had cpue’s slightly above 40 kg/hour. Using the distribution of these observer trips on the available 8500 registered trips, gives an expectation of 1.7 trips out of 56 (3%) with a cpue of more than 40 kg/hour. WKCELT therefore concluded that all trips with a registered cpue above 40 kg/hour should be considered as misreporting. Taken into account the above criteria, Table 3.2.1 shows the amounts of sole misreported from VIIfg into VIIj-k. Effort misreporting was considered not to take place between the two areas and was therefore not revised (note also that the effort registered in VIIj-k is about 1% of the effort in VIIfg). The misreporting in 2003, 2004 and 2005 was estimated to be 149 tonnes, 143 tonnes and 71 tonnes respectively. They comprise of 23%, 21% and 12% of the total landings of sole registered in VIIfg. In the other years (before 2003 and after 2005) the estimated misreporting level never exceeded 5%. WKCELT decided to correct 2003-2005 for misreporting, implying that for these years the registered landing with cpue’s above 40 kg/hours should be added to the sole VIIfg landings.

Taken into account the corrections mentioned above for 2003-2005, a new Belgian tuning file was assembled for the period 1997-2012 (BE-CBT-2) with the same HP correction for the effort as the original Belgian tuning series (BE-CBT). The period of the original tuning series (BE-CBT) was shortened to 1971-1996, avoiding “double use” of data.

3.3 Revision of catch-at-age weights and stock weights

The total international catch weights at age are calculated as the weighted mean of the annual weight at age data supplied by Belgium, UK (E and W) and Ireland, which account for about 95% of the total international landings (weighted by landed numbers). Historically, these catch weights at age were smoothed using a quadratic fit where catch weights at age are mid-year values (age = 1.5, 2.5 etc.). Stock weights-at-age were the first quarter catch weights smoothed by fitting a quadratic fit. Catch weights at age and stock weights at age have been scaled to give a SOP of 100%.

WKCELT decided to deviate from this procedure by using the weighted mean of the annual weight at age without smoothing for the longest possible period prior to 2012. Original catch weights from all countries were available for the period 2008-2012 and were used in the assessment. The stock weights were obtained using the Rivard weight calculator (http://nft.nefsc.noaa.gov./) that conducts a cohort interpolation of the catch weights. WKCELT decided that this protocol should be maintained in future assessments. These revisions resulted in a SSB reduction over the period 2008-2012 of about 10-20% compared with the use of the smoothed estimates (Figure 3.3.1). The smoothed catch- and stock weights (WGCSE-2013) next to the proposed original catch weights and the Rivard calculated stock weights are shown in Figure 3.3.2. WKCELT noted the overall lower values in 2008, as there was an ascendancy of males in the sampled fish.

3.4 Evaluation of the Trevose box (ICES rectangles 30E4, 31E4 and 32E3) closure

Council Regulation (EC) No 27/2005, Annex III, part A 12 (b) prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 (named as “the Trevose box”) during January-March 2005 . This prohibition did not apply to Beam trawlers during March. From 2006 up to present day, the Trevose box was closed during February and March with derogations for vessels using pots, creels or nets with a mesh size less than 55 mm. The prohibition does not apply within 6 nautical miles from the baseline.

The evaluation of the Trevose box closure was based on Belgian data that accounts for about 75% of the total international landings. Furthermore, the Belgian fleet is predominantly active in the Trevose Box (Figure 3.1.1). Figure 3.4.1 shows the effort deployed in the first 4 months of 2012 for the “fishing activity” of the Belgian beam trawl fleet (speed between 1.5 and 7 knots), based on VMS data. Plots were also available for 2006-2011 showing similar patterns. Figure 3.4.2 shows the effort deployed of the same fleet and months accounting for “all speeds”, illustrating the activity of boats passing through the box on their way to the Irish Sea. For 2006-2011 similar patterns were observed. These figures show that there is little “fishing activity” in the Trevose box during the closure and that some boats are passing through the box on their way to the Irish Sea.

The trips (very few) with a registered cpue above 40 kg/hour were excluded as they were classified as misreporting (see section 3.2). As the current available information allocates landingsat the market date and not at the real capture date of the fish, trips marketing at the beginning of February (on February 1, 2, 3 and 4) were counted as “not fishing in the box” as they probably fished before the closure. Individual trips that reported fishing during the closure in the box, were cross checked with VMS data. These trips appeared to have no fishing activities in March and some in February. Average cpue was calculated for trips fishing in the box and outside the box, before (Avg-pre) and after (Avg-after) the introduction of the Trevose box closure (Figure 3.4.3). The cpue from the trips outside the box appear to be on the same level before and after the introduction of the closure. For trips within the box and after the introduction of the closure, cpue substantially increased in the month after the closure (April). This apparently results in a lower cpue from September onwards compared with the period before the introduction of the closure.

Figure 3.4.4 shows the average cumulative Belgian quota uptake (1997-2012) before and after the introduction of the Trevose box closure. The uptake by the trips catching sole, in the box (Avg-pre-IN) and outside the box (Avg-pre-OUT), before the introduction of the closure are illustrated on the left panel. The cumulative uptake of the same trips after the introduction of the closure are illustrated on the right panel. In all periods the quota uptake is predominantly obtained by the trips fishing in the Trevose box. Before the introduction of the closure, the uptake is more evenly spread over the year, whereas since the introduction of the closure, the quota uptake substantially increased in April. However as the Belgian fleet is subjected to a limited quota uptake by month, the overall uptake levels off at the end of the year. WKCELT also noted that the annual quota has not been exceeded since the introduction of the closure.

3.5 Revised XSA assessments

3.5.1 Input data

As mentioned in Section 3.2, the landings have been modified taking into account the misreporting in 2003-2005. The catch weights were constructed using original mean catch weights without the use of a quadratic smoother for the period 2008-2012 and the stock weight were derived by a cohort interpolation of the catch weights (section 3.3). The original Belgian commercial tuning file (BE-CBT) has been shortened to 1971-1996 and a new commercial Belgian tuning file has been added (BE-CBT-2) for the period 1997-2012, also taking into account the misreporting in 2003-2005. A calculation error in the catch numbers and weights at age for 2011 was discovered and corrected. The consistency plots between ages for the tuning fleets are presented in Figure 3.5.1.1. There exist other tuning data for this stock (e.g. UK otter trawl fleet), but these have not been included in the assessment as they were not considered to be representative for the sole catches in the Celtic Sea. The Irish Groundfish survey, held in the 4th quarter is available since 2003.The possible inclusion of the Irish Groundfish survey was examined at WKCELT, but not retained because the consistency between ages appears to be very poor (Figure 3.5.1.2).

Total international landings are presented in Table 3.5.1.1.

Catch numbers-at-age are given in Table 3.5.1.2, and weights-at-age in the catch and the stock are given in Tables 3.5.1.3–3.5.1.4.

The available tuning indices are presented in Table 3.5.1.5 (indices in bold are used in the assessment).

In 2007, 2008, 2009, 2010, 2011 and 2012, discarding of sole in the UK fleet was estimated at about 3%, 1%, 6%, 9%, 9% and 6% respectively. Discard rates of sole in the Belgian beam trawl fleet were available for 2004–2005 and 2008–2012 accounting for about 2%–5% of the total sole catches in weight. WKCELT decided that inclusion of discard estimates in the assessment is currently less important.

3.5.2 XSA results

The assessment of the Celtic sea sole has been performed with XSA for a number of years, and the results have been to some extent satisfactory. However, the fishing mortality estimate in 2012 was far higher than in 2011. Although some increase in the fishing mortality would be expected, a 70% increase from 2011 to 2012 did not seem realistic. A detailed inspection of the diagnostics also revealed a marked shift in the residuals from positive to negative around 2005, for the UK commercial cpue dataseries (Figure 3.5.2.1). This coincided with a strong reduction in effort, and raised the question whether the actual effort relative to the nominal effort might have increased. In contrast, the residuals of the other tuning series had a downwards trend over time, if any (Figure 3.5.2.2). Single fleet runs however revealed no trends or residual patterns for any fleet (Figure 3.5.2.3).

The obvious measure to take would be to split the UK commercial dataseries in 2005. Doing so, the assessment became very unstable and the fishing mortality in the last year increased even more drastically. Moreover, the F-estimate became entirely dependent on the choice of shrinkage, and a strong retrospective pattern appeared (Figure 3.5.2.4). So, this reasoning/option was not retained.

The strong increase in the estimate of F in the last year was traced back to two sources. First, the catches-at-age in the last few years for the weak year classes 2005 and 2006 were high compared to those for the years before (Table 3.5.1.2), which should be associated with an increased fishing mortality. Secondly, in the UK beam trawl survey, these year classes were almost absent in 2012 (Table 3.5.1.5). That would indicate that these year classes were almost depleted and led to estimates of a high fishing mortality combined with low survivors. Although this was not confirmed by the other tuning fleets, the effect on the F-estimates was considerable. A closer inspection of this survey tuning series indicated that above age 5-6, the index was very often 1 (with only one valid digit), and sometimes 0. Hence, at the higher ages, this survey would hardly be informative. Using the survey with 5 as the highest age led to an F estimate for 2012 that is still high compared to the years before, but within reason, since some increase in F would be expected according to the catch data. The retrospective pattern with this conditioning was considered acceptable (Figure 3.5.2.5).

The diagnostics of the final XSA are presented in Table 3.5.2.1 and Figure 3.5.2.6 (residuals). The fishing mortalities are given in Table 3.5.2.2 and the stock numbers in Table 3.5.2.3. A summary of the XSA results is given in Table 3.5.2.4 and trends in yield, fishing mortality, recruitment and spawning-stock biomass are shown in Figure 3.5.2.7 (compared with WGCSE-2013).

WKCELT noted that with the inclusion of the new commercial Belgian tuning series (1997-2012), the weighting of the final survival estimates are more equally spread over the two commercial series and the survey for the older ages with relative similar estimates by the commercial tuning files (Figure 3.5.2.8). The survey provides the only estimate for the incoming recruiting age 1 and may result in an overestimation when big year classes come through (Figure 3.5.2.5). WKCELT therefore decided that for prediction, the estimates of the incoming "big year classes" at age 2 should be reduced by 23% (calculated as the average reduction from the first year estimate to the converged estimate – 4 years later).

The standard procedure for setting the fishing mortality in the forecast is to take the mean over the last three years, not rescaled. However, if a trend occurs in fishing mortality (3 consecutive higher or lower estimates), the Working Group may use a scaled F to the last year. Nevertheless, WKCELT decided as an interim solution to change the standard procedure for setting the fishing mortality. In case the estimate of fishing mortality is considered to be uncertain such as in 2012, the fishing mortality should not be rescaled to the last year, but taken as the mean of the last three years. The long-term geometric mean (starting year up to assessment year minus 3) should be assumed for age 1 in the forecast and weights at age in the catch and in the stock should be the averaged values over the last three years.

WKCELT investigated if there was a need to change the plus group, the catchability independent of stock size, the Q plateau and/or the reference points.

As the cumulative numbers of fish using age 10 as a plus group comprise between 95% and 98% of the total numbers, WKCELT decided that there was no need to change the plus group (currently set at age 10).

It also seemed appropriate to keep the catchability independent of stock size for all ages and the catchability independent of age for ages ≥7. There was no need to change the Fbar (4-8) as it comprises about 85% of the fish and the use of an Fbar (3-7) had a negligible change in retrospective pattern.

The use of a shrinkage SE=1.5 gives a weighting of less than 2% for all ages and was therefore still considered to be the appropriate setting, as well as the use of 5 years and 5 oldest ages. The minimum standard error for population estimates derived from each fleet was also kept at the default value of 0.3.

3.6 Reference points

By using the original catch weights and the derived stock weights for 2008-2012 instead of the smoothed catch- and stock weights, the TSB and SSB dropped with about 10-20% for the period 2008-2012 (Figure 3.3.1). However, WKCELT decided that there was no need to revise the current reference points.

3.7 Conclusions

The WKCELT concluded that this assessment would be acceptable as a provisional assessment. However, because of the conflicting signals in the data, in particular the strange pattern of residuals in the UK commercial fleet and the sensitivity to leaving out tuning series despite their moderate quality, the WKCELT could not recommend this as a permanent procedure for the coming years.

The way forward should be along two lines:

1. Improvement of the tuning information, in particular the surveys, which may need starting a new survey series with a new design.

2. Establishing assessment methods that are less sensitive to noise in the data. The most promising would be the state-space kind of approach, which is already applied in several stocks in the NE Atlantic.

Both these efforts would benefit from cooperation across stocks and institutes related to the Celtic sea. That will also provide a common ground for assessing stocks that may promote more holistic approaches to ecosystem and mixed fisheries management.

Table 3.2.1 – Belgian landings of sole in VIIfg and VIIj-k, and the landings obtained by using a +40 kg/hour cpue threshold on the registered trips in area VIIj-k.

	VIIfg Total tonnes	VIIj-k Total tonnes	VIIj-k +40kg/h tonnes	%-misreported versus Total VIIfg	%-VIIfg +40kg/h	%-VIIj-k +40kg/h
1997	500	88	0	0	0	0
1998	520	86	0	0	0	0
1999	538	6	0	0	0	0
2000	667	2	0	0	0	0
2001	690	6	0	0	0	0
2002	809	62	38	5	4	62
2003	655	151	149	23	1	99
2004	669	145	143	21	2	99
2005	593	85	71	12	1	84
2006	499	31	26	5	1	86
2007	496	22	21	4	3	97
2008	380	9	8	2	5	89
2009	405	8	8	2	13	100
2010	516	17	14	3	8	80
2011	639	10	10	2	3	99
2012	740	16	15	2	4	95

Table 3.5.1.1 - Celtic Sea Sole (ICES Divisions VIIfg). Official Nominal landings and data used by the Working Group (t)

Year	Belgium	Denmark	France	Ireland	UK(E.&W,NI.)	UK(Scotland)	Netherlands	Total-Official	Unallocated	Used by WG	TAC
1986	1039 *	2	146	188	611	-	3	1989	-389	1600	
1987	701 *	-	117	9	437	-	-	1264	-42	1222	1600
1988	705 *	-	110	72	317	-	-	1204	-58	1146	1100
1989	684 *	-	87	18	203	-	-	992	0	992	1000
1990	716 *	-	130	40	353	0	-	1239	-50	1189	1200
1991	982 *	-	80	32	402	0	-	1496	-389	1107	1200
1992	543 *	-	141	45	325	6	-	1060	-79	981	1200
1993	575 *	-	108	51	285	11	-	1030	-102	928	1100
1994	619 *	-	90	37	264	8	-	1018	-9	1009	1100
1995	763 *	-	88	20	294	-	-	1165	-8	1157	1100
1996	695 *	-	102	19	265	0	-	1081	-86	995	1000
1997	660 *	-	99	28	251	0	-	1038	-111	927	900
1998	675 *	-	98	42	198	-	-	1013	-138	875	850
1999	604	-	61	51	231	0	-	947	65	1012	960
2000	694	-	74	29	243	-	-	1040	51	1091	1160
2001	720	-	77	35	288	-	-	1120	48	1168	1020
2002	703	-	65	32	318	+	-	1118	227	1345	1070
2003	715	-	124	26	342	+	-	1207	340	1547	1240
2004	735	-	79	33	283	-	-	1130	268	1398	1050
2005	645	-	101	34	217	-	-	997	121	1118	1000
2006	576	-	75	38	232	-	-	921	25	946	950
2007	582	-	85	32	244	-	-	943	2	945	890
2008	466	-	68	28	218	-	-	780	20	800	964
2009	513	-	74	26	194	-	-	807	-2	805	993
2010	620	-	45	27	179	-	-	871	5	876	993
2010	766	-	50	30	168	-	-	1013	16	1029	1241
2012 [1]	827	-	48	33	170	-	-	1078	18	1096	1060

1 Preliminar

* including VIIg-k

Table 3.5.1.2 - Sole in VIIfg. Catch numbers at age (in thousands)

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

YEAR	1971	1972
AGE		
1	0	0
2	386	541
3	270	902
4	1341	314
5	625	670
6	433	329
7	537	213
8	763	232
9	376	314
+gp	1220	730
0 TOTALNUM	5951	4245
TONSLAND	1861	1278
SOPCOF %	100	100

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

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	364	155	119	312	314	318	328	657	602	342
3	1882	438	287	834	438	741	560	972	675	831
4	748	863	336	560	349	339	747	876	792	309
5	305	411	638	611	271	154	208	584	399	467
6	352	209	304	559	244	159	154	180	377	280
7	119	239	110	261	404	99	197	62	150	207
8	110	97	102	131	120	198	124	96	120	92
9	116	109	67	197	28	71	153	100	94	111
+gp	644	541	372	463	365	174	169	352	380	326
0 TOTALNUM	4640	3062	2335	3928	2533	2253	2640	3879	3589	2965
TONSLAND	1391	1105	919	1350	961	780	954	1314	1212	1128
SOPCOF %	100	100	100	100	100	100	100	100	100	100

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

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	647	672	196	494	318	526	479	277	1458	433
3	1078	846	1473	1296	957	464	1164	994	690	1700
4	729	606	766	1173	797	879	601	1176	658	644
5	284	542	565	526	577	441	621	399	496	409
6	349	184	296	358	273	387	237	452	151	253
7	225	277	100	193	205	127	188	138	156	61
8	192	106	140	87	100	78	82	115	55	59
9	52	47	73	103	61	67	24	50	46	28
+gp	320	274	240	328	179	268	102	129	162	89
0 TOTALNUM	3876	3554	3849	4558	3467	3237	3498	3730	3872	3676
TONSLAND	1373	1266	1328	1600	1222	1146	992	1189	1107	981
SOPCOF %	100	100	100	100	100	100	100	100	100	100

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

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	354	295	129	177	245	197	608	1721	704	29
3	863	790	1156	1035	890	932	1718	1480	1918	1465
4	1104	739	1098	904	599	724	834	683	860	2202
5	332	864	420	424	400	297	282	241	436	660
6	186	283	483	229	252	171	143	60	242	249
7	161	149	133	192	127	108	80	56	65	95
8	63	65	112	57	126	51	31	43	39	54
9	83	42	65	43	45	52	23	19	26	36
+gp	99	146	109	106	106	87	44	51	81	51
0 TOTALNUM	3245	3373	3705	3167	2790	2619	3763	4354	4371	4841
TONSLAND	928	1009	1157	995	927	875	1012	1091	1168	1345
SOPCOF %	100	100	100	100	100	100	100	100	100	100

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

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AGE										
1	0	0	0	0	0	0	0	0	0	0
2	132	476	290	685	335	214	607	281	124	159
3	775	1926	916	1330	865	452	464	1317	1013	230
4	1260	886	896	715	743	559	426	744	1444	1033
5	2067	889	507	576	474	565	346	347	398	1329
6	447	807	426	163	325	277	292	258	273	363
7	248	128	373	148	157	198	173	164	194	205
8	89	67	51	178	145	76	103	118	133	136
9	29	38	44	44	184	109	44	66	66	89
+gp	84	55	45	51	70	172	193	118	199	242
0 TOTALNUM	5131	5272	3548	3890	3298	2622	2648	3413	3844	3786
TONSLAND	1547	1398	1118	946	945	800	805	876	1029	1096
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 3.5.1.3 - Sole in VIIfg. Catch weights at age (kg)

Run title : CELTIC SEA SOLE - WKCELT
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Table 2 Catch weights at age (kg)

YEAR	1971	1972
AGE		
1	0.039	0.106
2	0.106	0.147
3	0.167	0.186
4	0.222	0.226
5	0.272	0.264
6	0.315	0.302
7	0.352	0.34
8	0.383	0.376
9	0.408	0.413
+gp	0.4397	0.5384
0 SOPCOFAC	0.9999	1.0009

Table 2 Catch weights at age (kg)

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
AGE										
1	0.081	0.063	0.046	0.114	0.098	0.068	0.023	0.048	0.078	0.061
2	0.143	0.137	0.132	0.167	0.169	0.154	0.132	0.144	0.154	0.156
3	0.202	0.205	0.212	0.218	0.235	0.234	0.232	0.234	0.225	0.243
4	0.258	0.27	0.286	0.268	0.297	0.309	0.321	0.316	0.292	0.324
5	0.311	0.329	0.355	0.316	0.355	0.378	0.401	0.392	0.355	0.397
6	0.361	0.385	0.417	0.363	0.409	0.441	0.471	0.461	0.414	0.462
7	0.408	0.436	0.473	0.409	0.46	0.499	0.531	0.523	0.469	0.521
8	0.452	0.483	0.523	0.453	0.506	0.551	0.581	0.579	0.519	0.572
9	0.493	0.525	0.567	0.496	0.548	0.598	0.622	0.627	0.565	0.617
+gp	0.6021	0.6239	0.6715	0.6649	0.6681	0.7196	0.6636	0.7202	0.6654	0.7043
0 SOPCOFAC	1.0005	0.9995	0.9999	0.9988	0.9996	0.9979	1.0011	0.9992	0.9999	0.9994

Table 2 Catch weights at age (kg)

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	0.085	0.019	0.089	0.046	0.048	0.074	0.013	0.049	0.054	0.073
2	0.173	0.131	0.17	0.144	0.146	0.157	0.109	0.134	0.15	0.147
3	0.255	0.235	0.246	0.236	0.236	0.235	0.198	0.214	0.239	0.216
4	0.33	0.33	0.317	0.321	0.32	0.309	0.28	0.291	0.32	0.281
5	0.398	0.416	0.383	0.4	0.396	0.378	0.355	0.363	0.393	0.342
6	0.459	0.494	0.444	0.471	0.466	0.442	0.424	0.43	0.459	0.398
7	0.514	0.562	0.5	0.536	0.528	0.502	0.487	0.494	0.516	0.451
8	0.561	0.622	0.552	0.594	0.584	0.557	0.543	0.553	0.566	0.499
9	0.602	0.673	0.598	0.645	0.632	0.608	0.592	0.609	0.608	0.543
+gp	0.6786	0.7716	0.7026	0.7479	0.7404	0.7385	0.6909	0.7474	0.674	0.6402
0 SOPCOFAC	1.0004	0.9985	1.0016	1.0004	1.001	0.9993	0.9993	0.9993	0.9998	0.9995

Table 2 Catch weights at age (kg)

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
1	0.057	0.081	0.068	0.027	0.074	0.079	0.015	0.078	0.066	0.054
2	0.134	0.151	0.147	0.124	0.156	0.163	0.122	0.166	0.148	0.13
3	0.207	0.216	0.22	0.214	0.234	0.244	0.222	0.248	0.225	0.202
4	0.275	0.276	0.288	0.296	0.307	0.32	0.315	0.322	0.296	0.271
5	0.338	0.331	0.351	0.372	0.376	0.393	0.4	0.39	0.363	0.336
6	0.396	0.38	0.409	0.439	0.44	0.462	0.478	0.451	0.425	0.399
7	0.45	0.425	0.462	0.5	0.5	0.528	0.549	0.506	0.482	0.457
8	0.5	0.465	0.51	0.552	0.555	0.589	0.613	0.553	0.533	0.513
9	0.545	0.5	0.553	0.598	0.605	0.647	0.67	0.594	0.579	0.564
+gp	0.6445	0.5626	0.6429	0.6773	0.7071	0.7809	0.7655	0.6649	0.6773	0.7045
0 SOPCOFAC	0.9994	0.9996	0.9982	1.0008	0.9997	0.9994	1.0005	1	0.9954	1.0001

Table 2 Catch weights at age (kg)

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AGE										
1	0.123	0.066	0.068	0.085	0.075	0.128	0.128	0.127	0.14	0.11
2	0.171	0.13	0.145	0.139	0.139	0.164	0.179	0.16	0.162	0.162
3	0.218	0.194	0.219	0.192	0.2	0.198	0.221	0.186	0.184	0.211
4	0.266	0.256	0.288	0.245	0.258	0.258	0.252	0.23	0.223	0.245
5	0.313	0.317	0.354	0.297	0.313	0.309	0.32	0.31	0.272	0.277
6	0.361	0.377	0.415	0.349	0.365	0.305	0.394	0.346	0.354	0.32
7	0.408	0.435	0.473	0.4	0.414	0.412	0.417	0.404	0.42	0.339
8	0.454	0.493	0.528	0.451	0.46	0.521	0.463	0.404	0.447	0.371
9	0.501	0.549	0.578	0.501	0.503	0.532	0.481	0.53	0.475	0.403
+gp	0.6386	0.7211	0.6898	0.6177	0.6087	0.5363	0.6216	0.5907	0.6222	0.5274
0 SOPCOFAC	1.0014	1.0003	1.0011	0.9992	0.9999	1.0009	0.9997	0.9994	0.9995	1.0008

Table 3.5.1.4 - Sole in VIIfg. Stock weights at age (kg)

Run title : CELTIC SEA SOLE - WKCELT
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Table 3 Stock weights at age (kg)

YEAR	1971	1972
AGE		
1	0.09	0.09
2	0.076	0.113
3	0.136	0.157
4	0.19	0.222
5	0.239	0.298
6	0.406	0.351
7	0.472	0.352
8	0.389	0.593
9	0.346	0.417
+gp	0.5826	0.6005

Table 3 Stock weights at age (kg)

YEAR	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
AGE										
1	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
2	0.113	0.113	0.113	0.113	0.145	0.113	0.113	0.113	0.113	0.113
3	0.142	0.159	0.141	0.16	0.174	0.167	0.163	0.157	0.159	0.164
4	0.203	0.221	0.215	0.21	0.236	0.257	0.255	0.238	0.232	0.255
5	0.263	0.305	0.295	0.269	0.366	0.36	0.392	0.354	0.306	0.356
6	0.334	0.45	0.353	0.354	0.392	0.413	0.437	0.394	0.385	0.487
7	0.322	0.448	0.593	0.432	0.454	0.521	0.485	0.622	0.462	0.543
8	0.4	0.464	0.423	0.462	0.505	0.508	0.595	0.556	0.551	0.61
9	0.539	0.624	0.465	0.425	0.907	0.56	0.657	0.704	0.737	0.766
+gp	0.5822	0.6707	0.7112	0.728	0.7006	0.7826	0.6963	0.7714	0.6627	0.8561

Table 3 Stock weights at age (kg)

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
2	0.113	0.118	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
3	0.175	0.173	0.175	0.18	0.153	0.158	0.152	0.164	0.179	0.184
4	0.262	0.274	0.268	0.273	0.242	0.233	0.227	0.247	0.23	0.265
5	0.37	0.429	0.472	0.398	0.361	0.363	0.308	0.369	0.356	0.388
6	0.488	0.517	0.433	0.462	0.473	0.466	0.465	0.476	0.536	0.498
7	0.633	0.641	0.462	0.546	0.468	0.687	0.546	0.523	0.376	0.751
8	0.606	0.613	0.48	0.636	0.587	0.687	0.526	0.753	0.859	0.754
9	0.464	0.836	0.944	0.89	0.82	0.676	0.542	0.847	0.735	0.475
+gp	0.823	0.9784	0.7983	0.8435	0.8378	0.818	0.7522	0.9732	0.6789	0.8963

Table 3 Stock weights at age (kg)

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
1	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
2	0.148	0.113	0.113	0.104	0.113	0.113	0.11	0.062	0.113	0.113
3	0.196	0.135	0.143	0.186	0.178	0.195	0.204	0.169	0.187	0.189
4	0.267	0.227	0.233	0.284	0.276	0.282	0.317	0.306	0.312	0.289
5	0.392	0.329	0.335	0.387	0.386	0.371	0.433	0.434	0.434	0.403
6	0.47	0.43	0.441	0.486	0.495	0.454	0.541	0.534	0.538	0.512
7	0.492	0.521	0.54	0.573	0.598	0.529	0.635	0.603	0.619	0.609
8	0.576	0.599	0.629	0.647	0.689	0.593	0.712	0.648	0.68	0.691
9	0.636	0.661	0.705	0.708	0.766	0.644	0.772	0.677	0.725	0.757
+gp	0.7272	0.7572	0.8447	0.808	0.8923	0.7318	0.8525	0.707	0.7835	0.873

Table 3 Stock weights at age (kg)

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AGE										
1	0.09	0.09	0.09	0.09	0.09	0.108	0.113	0.112	0.13	0.08
2	0.158	0.116	0.149	0.143	0.117	0.141	0.151	0.143	0.143	0.151
3	0.205	0.176	0.213	0.188	0.177	0.176	0.19	0.183	0.172	0.185
4	0.258	0.248	0.275	0.235	0.236	0.232	0.223	0.226	0.204	0.212
5	0.317	0.329	0.337	0.284	0.294	0.274	0.287	0.28	0.25	0.249
6	0.381	0.415	0.399	0.334	0.35	0.261	0.349	0.333	0.331	0.295
7	0.449	0.502	0.459	0.386	0.406	0.389	0.357	0.399	0.381	0.346
8	0.521	0.587	0.52	0.441	0.46	0.542	0.437	0.41	0.425	0.395
9	0.594	0.667	0.579	0.496	0.513	0.526	0.501	0.495	0.438	0.424
+gp	0.8123	0.8683	0.7369	0.6414	0.6622	0.495	0.5814	0.5789	0.5913	0.5532

Table 3.5.1.5 - Sole in VIIfg. Tuning series

Indices in bold are used in the assessment

BE-CBT		**Belgium Beam trawl (Effort = Corrected formula)**												
	1971	**1996**												
	1	**1**	**0**	**1**										
	2	**14**												
11.06		**111**	**77**	**384**	**179**	**124**	**154**	**218**	**108**	**32**	**107**	**76**	**21**	**40**
8.44		**132**	**220**	**76**	**163**	**80**	**52**	**57**	**76**	**39**	**23**	**14**	**38**	**14**
17.39		**179**	**926**	**368**	**150**	**173**	**58**	**54**	**57**	**108**	**32**	**23**	**21**	**45**
18.83		**102**	**287**	**565**	**270**	**136**	**156**	**64**	**79**	**90**	**75**	**38**	**39**	**37**
16.38		**69**	**167**	**195**	**370**	**176**	**64**	**59**	**39**	**33**	**29**	**37**	**18**	**23**
28.07		**199**	**533**	**357**	**391**	**357**	**167**	**84**	**125**	**40**	**17**	**21**	**51**	**35**
24.11		**220**	**307**	**244**	**190**	**170**	**283**	**84**	**20**	**35**	**39**	**36**	**18**	**52**
18.09		**173**	**403**	**185**	**84**	**86**	**54**	**108**	**38**	**11**	**21**	**61**	**8**	**9**
18.9		**222**	**379**	**506**	**141**	**104**	**133**	**84**	**103**	**35**	**12**	**16**	**4**	**6**
29.02		**438**	**647**	**583**	**389**	**119**	**45**	**63**	**66**	**92**	**22**	**25**	**16**	**10**
35.39		**429**	**481**	**565**	**286**	**268**	**107**	**86**	**67**	**86**	**74**	**33**	**13**	**13**
28.77		**245**	**594**	**221**	**334**	**200**	**148**	**66**	**80**	**54**	**19**	**41**	**16**	**25**
34.95		**363**	**605**	**409**	**159**	**196**	**127**	**108**	**29**	**44**	**32**	**15**	**12**	**12**
33.48		**372**	**467**	**334**	**300**	**102**	**153**	**59**	**26**	**26**	**16**	**24**	**19**	**18**
40.49		**52**	**909**	**471**	**372**	**208**	**75**	**104**	**46**	**68**	**15**	**29**	**16**	**10**
52.46		**377**	**900**	**823**	**359**	**230**	**140**	**49**	**58**	**65**	**29**	**50**	**6**	**9**
37.23		**247**	**664**	**438**	**344**	**191**	**119**	**47**	**29**	**20**	**4**	**14**	**2**	**16**
42.92		**362**	**293**	**603**	**250**	**197**	**77**	**51**	**36**	**26**	**19**	**19**	**13**	**16**
53.58		**244**	**680**	**428**	**471**	**179**	**145**	**62**	**13**	**24**	**10**	**19**	**3**	**17**
40.27		**231**	**742**	**663**	**181**	**240**	**70**	**59**	**17**	**26**	**12**	**2**	**4**	**12**
18.05		**1028**	**380**	**225**	**131**	**29**	**26**	**9**	**7**	**13**	**8**	**4**	**1**	**2**
25.47		**327**	**1062**	**376**	**210**	**98**	**14**	**14**	**7**	**9**	**5**	**0**	**0.3**	**2**
31.27		**296**	**615**	**629**	**161**	**81**	**75**	**38**	**36**	**19**	**4**	**2**	**1**	**1**
38.35		**205**	**524**	**523**	**530**	**176**	**71**	**20**	**15**	**16**	**11**	**6**	**5**	**7**
47.81		**77**	**827**	**838**	**277**	**250**	**78**	**48**	**21**	**17**	**8**	**1**	**5**	**2**
47.63		**104**	**737**	**579**	**258**	**130**	**88**	**29**	**17**	**9**	**12**	**3**	**3**	**0**

BE-CBT2	**Belgium Beam trawl (Effort = Corrected formula)**												
1997	**2012**												
1	**1**	**0**	**1**										
2	**14**												
19.55	**96**	**330**	**188**	**120**	**71**	**37**	**27**	**11**	**8**	**9**	**3**	**1**	**1**
23.06	**83**	**384**	**303**	**94**	**50**	**42**	**16**	**12**	**10**	**4**	**3**	**5**	**3**
28.51	**325**	**849**	**410**	**125**	**44**	**24**	**7**	**9**	**3**	**2**	**1**	**2**	**0**
33.52	**1061**	**826**	**306**	**87**	**14**	**11**	**10**	**4**	**1**	**6**	**2**	**1**	**1**
37.77	**462**	**1075**	**528**	**228**	**129**	**28**	**12**	**8**	**8**	**4**	**13**	**1**	**1**
43.19	**93**	**1091**	**1439**	**481**	**138**	**47**	**23**	**13**	**1**	**1**	**1**	**3**	**1**
31.84	**122**	**412**	**711**	**974**	**241**	**122**	**39**	**15**	**9**	**2**	**6**	**0**	**1**
33.38	**266**	**1061**	**461**	**410**	**284**	**38**	**11**	**7**	**2**	**2**	**1**	**0**	**0**
28.75	**122**	**478**	**420**	**265**	**206**	**106**	**17**	**12**	**3**	**4**	**2**	**0**	**1**
31.21	**360**	**644**	**302**	**215**	**58**	**42**	**30**	**11**	**4**	**2**	**1**	**1**	**0**
28.26	**172**	**417**	**338**	**199**	**113**	**61**	**47**	**41**	**4**	**4**	**1**	**3**	**2**
23.46	**104**	**181**	**219**	**250**	**107**	**64**	**25**	**33**	**28**	**8**	**1**	**0**	**0**
25.35	**263**	**178**	**150**	**114**	**96**	**63**	**29**	**13**	**17**	**24**	**6**	**2**	**0**
39.11	**175**	**739**	**405**	**169**	**116**	**70**	**56**	**23**	**19**	**6**	**5**	**10**	**0**
44.07	**76**	**615**	**837**	**220**	**144**	**105**	**69**	**30**	**50**	**11**	**14**	**5**	**0**
44.99	**96**	**126**	**562**	**740**	**198**	**104**	**66**	**43**	**27**	**32**	**11**	**16**	**19**

UK(E&W)-CBT		**UK(E+W) VIIf Beam trawl**													
	1991	**2012**													
	1	**1**	**0**	**1**											
	1	**14**													
40.81		0	**52**	**98**	**189**	**171**	**60**	**67**	**23**	**20**	**16**	**13**	**5**	**4**	**4**
35.78		0	**18**	**220**	**103**	**83**	**69**	**22**	**21**	**10**	**13**	**5**	**3**	**1**	**1**
39.64		1.9	**6**	**83**	**198**	**77**	**50**	**41**	**11**	**24**	**9**	**5**	**4**	**3**	**4**
37.03		0	**23**	**80**	**59**	**116**	**36**	**31**	**19**	**11**	**15**	**8**	**5**	**5**	**4**
37.59		0	**16**	**87**	**73**	**56**	**105**	**24**	**30**	**23**	**8**	**8**	**4**	**5**	**3**
39.78		0.2	**22**	**96**	**128**	**70**	**45**	**53**	**15**	**13**	**12**	**4**	**9**	**5**	**2**
43		0	**10**	**60**	**86**	**69**	**53**	**27**	**39**	**11**	**11**	**5**	**5**	**3**	**2**
47.84		0	**13**	**101**	**73**	**77**	**50**	**17**	**13**	**20**	**7**	**6**	**4**	**2**	**1**
50.87		0.4	**31**	**204**	**107**	**52**	**50**	**28**	**13**	**6**	**10**	**4**	**2**	**1**	**0**
51.19		0.1	**72**	**152**	**150**	**75**	**27**	**28**	**20**	**9**	**4**	**8**	**3**	**2**	**2**
49.32		0	**37**	**272**	**99**	**89**	**48**	**19**	**17**	**11**	**9**	**3**	**7**	**1**	**2**
37.53		0	**11**	**149**	**375**	**90**	**63**	**28**	**18**	**14**	**9**	**6**	**4**	**4**	**1**
40.71		0.1	**18**	**101**	**176**	**369**	**77**	**45**	**18**	**6**	**7**	**3**	**4**	**1**	**2**
32.37		0	**19**	**91**	**65**	**114**	**180**	**34**	**27**	**15**	**7**	**3**	**5**	**1**	**1**
27.73		0	**27**	**78**	**126**	**55**	**60**	**115**	**15**	**14**	**4**	**5**	**2**	**2**	**1**
18.57		0	**16**	**86**	**94**	**103**	**32**	**39**	**69**	**13**	**8**	**4**	**2**	**2**	**1**
15.37		0.9	**18**	**77**	**89**	**77**	**82**	**32**	**41**	**76**	**8**	**8**	**4**	**2**	**3**
13.83		0	**12**	**76**	**100**	**67**	**52**	**54**	**19**	**32**	**42**	**10**	**5**	**2**	**3**
12.31		0	**23**	**54**	**72**	**72**	**63**	**27**	**29**	**12**	**12**	**29**	**4**	**3**	**1**
14.44		0	**2**	**98**	**65**	**48**	**46**	**34**	**19**	**18**	**5**	**5**	**13**	**1**	**1**
13.79		0.4	**7**	**57**	**125**	**41**	**34**	**22**	**19**	**12**	**12**	**4**	**7**	**16**	**1**
13.39		0	**3**	**14**	**82**	**105**	**26**	**18**	**16**	**9**	**7**	**6**	**1**	**3**	**3**

Table 3.5.1.5 - Sole in VIIfg. Tuning series - continued

Indices in bold are used in the assessment

UK(E&W)-BTS-Q3 **UK(E+W) VIIf Corystes (automated indices since 1995)**

	1988	**2012**									
	1	**1**	**0.75**	**0.85**							
	0	**9**									
74.120		22	**60**	**242**	**36**	**14**	**4**	0	0	0	0
91.909		132	**204**	**304**	**162**	**18**	**14**	6	4	2	2
69.858		21	**269**	**219**	**35**	**11**	**3**	5	2	0	0
123.410		40	**297**	**638**	**83**	**21**	**18**	5	0	3	2
125.078		5	**493**	**325**	**174**	**37**	**23**	12	1	2	1
127.672		6	**207**	**436**	**52**	**28**	**3**	2	2	1	1
120.816		1	**424**	**430**	**133**	**23**	**11**	9	0	0	3
114.886		31	**142**	**255**	**60**	**13**	**7**	14	1	1	1
118.592		3	**178**	**251**	**64**	**27**	**7**	3	4	1	3
114.886		37	**498**	**207**	**21**	**13**	**14**	5	3	6	0
114.886		104	**885**	**472**	**57**	**11**	**9**	5	2	1	5
118.592		29	**2922**	**297**	**38**	**16**	**7**	4	5	1	0
118.592		16	**1086**	**1608**	**37**	**26**	**6**	0	2	1	1
118.592		26	**449**	**711**	**307**	**23**	**9**	6	2	0	2
118.592		9	**786**	**283**	**151**	**121**	**14**	7	2	3	0
118.592		14	**465**	**628**	**55**	**30**	**56**	9	3	3	0
114.886		63	**862**	**434**	**99**	**15**	**22**	42	4	3	0
118.592		44	**407**	**267**	**38**	**16**	**7**	5	17	1	2
118.592		13	**324**	**238**	**47**	**16**	**8**	0	2	12	0
118.592		104	**424**	**128**	**51**	**16**	**13**	7	3	4	14
118.592		6	**1232**	**124**	**15**	**18**	**7**	9	4	3	5
118.592		1	**604**	**377**	**29**	**8**	**10**	4	3	3	2
118.592		19	**101**	**558**	**144**	**20**	**2**	7	9	4	2
118.592		22	**596**	**62**	**163**	**82**	**8**	2	7	3	0
118.592		16	**643**	**274**	**9**	**63**	**28**	1	1	1	3

IR - GFS : Irish Groundfish Survey (IBTS 4th Qtr) - VIIb Sole number at age (Interim indices for new Celtic Explorer series)

	2003	2012									
	1	1	0.79	0.92							
	1	10									
832		1.0	5.2	1.1	3.2	3.0	4.1	4.0	0.0	1.0	0.0
980		1.0	8.0	6.0	5.0	1.0	2.0	1.0	0.0	0.0	1.0
845		0.0	0.0	6.0	2.0	4.0	2.0	2.0	0.0	0.0	0.0
1046		0.0	0.0	4.0	4.0	6.0	4.0	1.0	0.0	0.0	0.0
1168		0.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0
1139		2.0	9.0	7.0	3.0	2.0	0.0	2.0	0.0	1.0	0.0
1018		0.0	15.0	3.0	4.0	1.0	1.0	2.0	1.0	0.0	2.0
1381		0.0	12.0	24.7	9.1	8.2	1.0	3.0	3.9	0.0	2.1
1392		2.0	0.0	20.1	8.0	6.1	3.1	0.0	1.0	1.0	3.7
1470		0.0	7.0	3.0	3.0	3.0	1.0	0.0	0.0	0.0	0.0

UK (E+W) TRAWL 107F. (Processed as unsexed - from 2001WG)

1991	2012									
1	1	0	1							
1	10									
18.57	0	1.7	6.4	13	11.2	3.5	3.3	1.1	0.8	0.8
16.00	0	8.4	29.4	10.4	6.9	5.9	1.5	1.8	0.8	0.9
13.79	0.1	0.8	3.7	10.2	3.8	2	1.4	0.3	0.6	0.2
9.48	0	1.7	4.3	2.5	4.9	1.7	1.5	1.1	0.6	0.7
8.46	0	2.3	12	5.3	2.5	4.5	0.9	1.2	0.7	0.2
8.67	0.1	2.8	4.3	4.9	2.4	1.4	1.4	0.3	0.5	0.2
8.14	0	2	8	6.8	4.1	2.1	0.7	1.2	0.4	0.3
7.13	0	2	4	2.7	2.1	1.3	0.4	0.3	0.5	0.1
5.69	0.1	8.5	12.4	3.5	1.5	1.2	0.8	0.4	0.1	0.3
4.05	0	0.9	1.8	1.6	0.7	0.2	0.2	0.2	0.1	0
4.42	0	1.5	10.1	2.3	1.7	0.6	0.3	0.2	0.2	0.1
6.10	0	0.5	4.8	8.2	1.8	1	0.3	0.2	0.2	0.1
9.94	0.1	1.6	2.8	3.3	6.7	1	0.7	0.3	0.1	0.1
9.42	0	1	4.8	2.9	3.3	4.9	0.9	0.6	0.4	0.2
12.09	0	2.6	4.9	6.1	2.3	2.6	4.9	0.7	0.7	0.2
12.97	0	0.4	7.1	7.7	9.5	3	3.9	6.9	1.3	0.9
10.66	0	0.5	2.6	3.5	3.2	3.2	1.2	1.5	2.6	0.3
10.13	0	0.4	3.5	**5**	3.8	2.9	2.7	0.9	1.6	2.2
9.00	0	0	0	0	0	0	0	0	0	0
7.70	0	0.2	5.3	3.7	2.3	2.1	1.1	0.8	0.9	0.2
7.4	0	0.7	5.7	8.6	3.2	3.2	2.4	1.3	1.2	0.9
7.7	0	3.8	2.9	9.6	10	3.4	2.5	1.5	1.3	0.8

Table 3.5.2.1 - Sole VIIfg - XSA diagnostics

Lowestoft VPA Version 3.1

6/02/2014 11:28

Extended Survivors Analysis

CELTIC SEA SOLE

CPUE data from file S7FGTUN.txt

Catch data for 42 years. 1971 to 2012. Ages 1 to 10.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BE-CBT	1971	2012	2	9	0	1
BE-CBT2	1997	2012	2	9	0	1
UK(E&W)-CBT	1991	2012	2	9	0	1
UK(E&W)-BTS-Q3	1988	2012	1	5	0.75	0.85

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 7

Terminal population estimation :

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

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

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

Prior weighting not applied

Tuning converged after 72 iterations

1

Regression weights

1	1	1	1	1	1	1	1	1	1

Fishing mortalities

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0	0	0	0	0	0	0	0	0	0
2	0.022	0.111	0.059	0.173	0.117	0.066	0.075	0.053	0.122	0.053
3	0.26	0.45	0.287	0.371	0.305	0.205	0.178	0.208	0.244	0.311
4	0.393	0.47	0.346	0.338	0.325	0.295	0.27	0.424	0.329	0.374
5	0.57	0.471	0.477	0.347	0.35	0.39	0.267	0.328	0.375	0.505
6	0.747	0.403	0.383	0.245	0.3	0.315	0.318	0.291	0.411	0.613
7	0.69	0.433	0.293	0.198	0.349	0.268	0.295	0.265	0.329	0.548
8	0.62	0.352	0.272	0.198	0.27	0.253	0.195	0.3	0.317	0.359
9	0.535	0.52	0.366	0.355	0.287	0.298	0.204	0.165	0.243	0.323

1

XSA population numbers (Thousands)

YEAR \ AGE	1	2	3	4	5	6	7	8	9
2003	5.26E+03	6.31E+03	3.56E+03	4.08E+03	5.00E+03	8.93E+02	5.23E+02	2.02E+02	7.35E+01
2004	5.84E+03	4.76E+03	5.59E+03	2.49E+03	2.49E+03	2.56E+03	3.83E+02	2.37E+02	9.85E+01
2005	5.02E+03	5.29E+03	3.86E+03	3.22E+03	1.41E+03	1.41E+03	1.55E+03	2.25E+02	1.51E+02
2006	3.52E+03	4.54E+03	4.51E+03	2.62E+03	2.06E+03	7.90E+02	8.68E+02	1.04E+03	1.55E+02
2007	3.90E+03	3.19E+03	3.45E+03	2.81E+03	1.69E+03	1.32E+03	5.60E+02	6.44E+02	7.75E+02
2008	9.70E+03	3.53E+03	2.57E+03	2.30E+03	1.84E+03	1.08E+03	8.84E+02	3.57E+02	4.45E+02
2009	6.33E+03	8.78E+03	2.99E+03	1.89E+03	1.55E+03	1.13E+03	7.11E+02	6.12E+02	2.51E+02
2010	1.25E+03	5.72E+03	7.37E+03	2.26E+03	1.31E+03	1.08E+03	7.41E+02	4.79E+02	4.56E+02
2011	3.55E+03	1.13E+03	4.91E+03	5.41E+03	1.34E+03	8.52E+02	7.27E+02	5.15E+02	3.21E+02
2012	7340	3220	905	3480	3520	833	511	474	339

Estimated population abundance at 1st Jan 2013

0	6640	2760	600	2170	1930	409	267	299

Taper weighted geometric mean of the VPA populations:

4860	4370	3560	2470	1480	874	535	341	216

Standard error of the weighted Log(VPA populations) :

0.4087	0.4041	0.4115	0.3706	0.4186	0.4508	0.5489	0.7213	0.8916

Table 3.5.2.1 - Sole VIIfg - XSA diagnostics - continued

Log catchability residuals.

Fleet : BE-CBT

Age	1971	1972
1	No data for this fleet at this age	
2	0.07	-0.01
3	-0.51	0.16
4	0.26	-0.18
5	0.3	0.15
6	0.1	0.27
7	0.45	-0.03
8	0.29	0.18
9	0.02	-0.1

Age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	No data for this fleet at this age									
2	0.4	-0.04	-0.29	0.39	0.05	0.22	0.25	1.02	0.38	0.05
3	0.37	-0.11	-0.35	0.39	0.13	0.05	0.06	0.03	0.19	0.09
4	0.12	-0.04	-0.31	-0.02	0	0.05	0.39	0.25	-0.11	-0.17
5	0.16	0.12	0	0.25	-0.09	-0.45	0.11	0.17	-0.16	0.02
6	-0.12	0.43	0.22	-0.21	0.05	-0.25	0.03	-0.09	0.14	0.15
7	-0.32	0.12	0.31	0.12	0.18	-0.4	0.6	-0.87	0.13	0.36
8	-0.42	-0.02	-0.43	0.53	-0.03	-0.15	0.3	-0.17	-0.12	0.35
9	-0.2	0.17	-0.09	0.11	-0.3	-0.22	0.05	0.01	0.11	0.48

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	No data for this fleet at this age									
2	0.28	0	-1.82	-0.26	0.25	-0.11	-0.47	-0.08	1.44	0.62
3	-0.05	-0.22	-0.09	-0.02	-0.2	-0.57	-0.51	0.15	0.38	0.38
4	-0.27	-0.36	-0.15	-0.11	-0.02	-0.22	-0.17	0.1	0.06	0.28
5	-0.26	-0.01	0.08	-0.07	-0.03	-0.08	-0.14	-0.07	-0.03	0.21
6	-0.24	-0.16	0.01	0.04	0.32	-0.09	0.04	0.16	-0.4	-0.05
7	0.1	0.17	-0.1	0.01	0.64	-0.02	0.14	0.18	-0.49	-0.89
8	0.47	-0.1	0.17	-0.28	-0.15	0.58	0.16	0.24	-0.37	-0.98
9	-0.19	-0.29	-0.04	-0.05	0.2	0.06	-0.21	-0.1	-0.34	-0.36

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	No data for this fleet at this age									
2	0.24	-0.34	-1.29	-0.95	99.99	99.99	99.99	99.99	99.99	99.99
3	0.25	-0.24	0.06	0.2	99.99	99.99	99.99	99.99	99.99	99.99
4	-0.07	0.19	0.37	0.13	99.99	99.99	99.99	99.99	99.99	99.99
5	-0.24	0.13	-0.02	-0.04	99.99	99.99	99.99	99.99	99.99	99.99
6	-0.4	0.26	-0.14	-0.08	99.99	99.99	99.99	99.99	99.99	99.99
7	0.18	-0.13	0.01	-0.45	99.99	99.99	99.99	99.99	99.99	99.99
8	0.43	-0.75	-0.04	-0.37	99.99	99.99	99.99	99.99	99.99	99.99
9	0.31	0.04	-0.25	-0.27	99.99	99.99	99.99	99.99	99.99	99.99

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	No data for this fleet at this age									
2	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

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

Age	2	3	4	5	6	7	8	9
Mean Log q	-6.202	-5.0674	-4.8528	-4.865	-4.8904	-4.9801	-4.9801	-4.9801
S.E(Log q)	0.6535	0.2788	0.2077	0.1705	0.213	0.3838	0.3909	0.2184

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.66	1.154	6.93	0.32	26	0.43	-6.2
3	0.81	1.31	5.66	0.65	26	0.22	-5.07
4	0.92	0.627	5.08	0.73	26	0.19	-4.85
5	0.82	2.376	5.3	0.88	26	0.13	-4.86
6	0.95	0.486	4.99	0.8	26	0.21	-4.89
7	0.83	1.335	5.21	0.73	26	0.32	-4.98
8	0.97	0.297	5.04	0.79	26	0.38	-5.01
9	0.94	1.53	5.07	0.96	26	0.19	-5.04
1							

Table 3.5.2.1 - Sole VIIfg - XSA diagnostics - continued

Fleet : BE-CBT2

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	No data for this fleet at this age									
2	99.99	99.99	99.99	99.99	0.1	-0.52	0.52	0.69	0.33	-0.83
3	99.99	99.99	99.99	99.99	0.57	0.33	0.66	0.34	-0.45	0.04
4	99.99	99.99	99.99	99.99	0.4	0.78	0.56	-0.17	0.06	-0.13
5	99.99	99.99	99.99	99.99	0.45	0.19	0.47	-0.58	-0.09	0.39
6	99.99	99.99	99.99	99.99	0.74	0.27	0.02	-1.15	0.4	-0.06
7	99.99	99.99	99.99	99.99	0.81	1.03	0.05	-0.89	-0.05	-0.05
8	99.99	99.99	99.99	99.99	0.31	0.52	-0.28	-0.46	-0.5	0.17
9	99.99	99.99	99.99	99.99	0.65	-0.08	0.34	-0.48	-0.3	-0.05

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	No data for this fleet at this age									
2	-0.71	0.34	-0.41	0.79	0.48	0.04	-0.02	-0.44	0.26	-0.61
3	-0.12	0.42	0.06	0.16	0.06	-0.34	-0.6	-0.49	-0.37	-0.26
4	0.14	0.19	-0.07	-0.28	-0.15	-0.21	-0.48	-0.03	-0.34	-0.29
5	0.32	0.06	0.35	-0.38	-0.16	0.19	-0.56	-0.4	-0.26	0.02
6	0.91	-0.18	0.24	-0.6	-0.32	0.02	-0.21	-0.42	-0.03	0.38
7	0.88	-0.14	-0.42	-0.9	0.08	-0.18	-0.04	-0.43	-0.09	0.33
8	0.66	-0.94	-0.34	-1.42	-0.36	-0.22	-0.71	-0.2	-0.17	-0.13
9	0.67	-0.43	-0.24	-0.44	-0.67	-0.14	-0.62	-1.1	-0.57	-0.24

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

Age	2	3	4	5	6	7	8	9
Mean Log q	-6.6342	-5.3222	-5.1096	-5.1029	-5.2856	-5.4245	-5.4245	-5.4245
S.E(Log q)	0.524	0.3937	0.3438	0.359	0.5068	0.5553	0.5862	0.5296

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.92	0.316	6.77	0.56	16	0.5	-6.63
3	1.04	-0.221	5.19	0.64	16	0.42	-5.32
4	1.59	-2.049	3.47	0.47	16	0.5	-5.11
5	1.01	-0.069	5.08	0.69	16	0.38	-5.1
6	0.96	0.169	5.34	0.55	16	0.5	-5.29
7	1.48	-1.421	5.07	0.38	16	0.8	-5.42
8	1.5	-1.887	5.69	0.5	16	0.73	-5.68
9	1.52	-2.647	5.94	0.65	16	0.61	-5.66

Fleet : UK(E&W)-CBT

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	No data for this fleet at this age									
2	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.38	0.13
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.01	0.27
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.49	0.07
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.52	0.04
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.39	0.14
7	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.38	-0.03
8	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.5	-0.17
9	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	0.64	0.4

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	No data for this fleet at this age									
2	-1.15	0.26	0.12	0.43	-0.63	-0.78	-0.09	-0.11	-0.15	-0.51
3	-0.19	-0.28	-0.15	0.15	-0.37	-0.17	0.2	-0.23	-0.54	-0.26
4	-0.04	-0.52	-0.4	0.23	0.01	-0.19	-0.19	-0.13	-0.71	-0.17
5	-0.11	-0.25	-0.28	-0.06	-0.03	0.13	-0.13	-0.29	-0.44	-0.29
6	-0.24	-0.41	0.11	-0.08	0.14	0.03	0.05	-0.44	-0.37	-0.22
7	0.09	-0.17	-0.18	-0.04	0.01	-0.3	-0.07	-0.08	-0.4	-0.12
8	-0.3	-0.02	0.48	-0.1	0.19	-0.1	0.06	0.06	-0.12	0.36
9	0.42	0.52	0.83	0.39	0.16	0.01	-0.34	0.21	0.05	0.47

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	No data for this fleet at this age									
2	-0.56	0.05	0.43	0.51	1.15	0.72	0.58	-1.6	1.35	-0.55
3	-0.22	-0.46	-0.16	0.22	0.53	0.88	0.49	0.03	-0.04	0.31
4	-0.33	-0.57	-0.07	0.24	0.3	0.71	0.68	0.31	0.1	0.17
5	-0.03	-0.33	-0.32	0.26	0.36	0.26	0.56	0.2	0.08	0.14
6	0.01	-0.13	-0.48	-0.19	0.45	0.31	0.58	0.14	0.17	0.04
7	-0.06	0.08	0	-0.15	0.35	0.48	0.14	0.15	-0.19	0.09
8	-0.06	0.29	-0.12	0.24	0.42	0.34	0.31	0.02	0.01	-0.03
9	-0.18	0.66	0.25	0.55	0.86	0.66	0.33	-0.04	-0.02	-0.29

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

Age	2	3	4	5	6	7	8	9
Mean Log q	-8.9503	-6.8734	-6.2814	-5.9649	-5.769	-5.7282	-5.7282	-5.7282
S.E(Log q)	0.7136	0.3505	0.381	0.2833	0.2912	0.215	0.2546	0.4616

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	1.89	-1.535	9.42	0.13	22	1.31	-8.95
3	1.41	-1.961	6.32	0.54	22	0.46	-6.87
4	1.14	-0.574	6.07	0.47	22	0.44	-6.28
5	0.95	0.4	6.03	0.77	22	0.27	-5.96
6	0.91	0.735	5.85	0.78	22	0.27	-5.77
7	0.85	2.127	5.78	0.91	22	0.17	-5.73
8	0.91	1.222	5.62	0.91	22	0.21	-5.63
9	0.94	0.607	5.4	0.83	22	0.33	-5.43

Table 3.5.2.1 - Sole VIIfg - XSA diagnostics - continued

Fleet : UK(E&W)-BTS-Q3

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	99.99	99.99	99.99	99.99	99.99	-1.4	-0.21	-0.5	-0.26	0.17
2	99.99	99.99	99.99	99.99	99.99	0.02	0.3	0.39	0.15	0.11
3	99.99	99.99	99.99	99.99	99.99	0.32	1.08	0.13	0.49	0.56
4	99.99	99.99	99.99	99.99	99.99	-0.17	0.51	-0.11	0.13	0.74
5	99.99	99.99	99.99	99.99	99.99	-0.13	0.41	-0.05	0.68	1.01
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	-0.71	0.32	-0.69	-0.69	0.07	0.5	0.8	0.41	0.16	0.25
2	0.3	0.33	0.09	0.09	-0.26	0.24	-0.34	0.5	0.26	-0.11
3	-0.06	0.79	0.16	0.47	-0.6	0.15	-0.49	-0.7	0.42	0.34
4	-0.24	0.32	-0.2	0.61	0.12	0.08	0.07	0.2	-0.12	0.46
5	-1.05	-0.26	0.06	0.09	0.95	0.63	0.58	-0.2	-0.13	0.23
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.01	0.55	-0.08	0.05	0.22	0.37	0.09	-0.08	0.65	0
2	0.23	0.25	-0.41	-0.29	-0.6	-0.77	-0.56	0.24	-0.28	0.1
3	-0.16	0.16	-0.59	-0.47	-0.17	-1.18	-0.69	0.03	0.59	-0.56
4	-0.24	-0.35	-0.67	-0.47	-0.55	-0.26	-0.9	-0.03	0.43	0.64
5	0.55	0.27	-0.33	-0.69	0	-0.67	-0.24	-1.63	-0.23	0.16
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									

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

Age	1	2	3	4	5
Mean Log q	-7.1311	-7.2202	-8.4948	-9.0501	-9.2843
S.E(Log q)	0.5003	0.3448	0.5517	0.4267	0.6056

Regression statistics :

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

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.75	1.605	7.48	0.64	25	0.36	-7.13
2	0.85	1.2	7.4	0.73	25	0.29	-7.22
3	0.73	1.58	8.42	0.6	25	0.39	-8.49
4	1	0.014	9.05	0.46	25	0.43	-9.05
5	1.1	-0.341	9.49	0.33	25	0.68	-9.28

Terminal year survivor and F summaries :

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

Year class = 2011

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	1	0	0	0	0	0	0
UK(E&W)-CBT	1	0	0	0	0	0	0
UK(E&W)-BTS-Q3	6644	0.51	0	0	1	1	0
F shrinkage mean	0	1.5				0	0

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
6644	0.51	0	1	0	0

Table 3.5.2.1 - Sole VIIfg - XSA diagnostics - continued

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

Year class = 2010

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	1502	0.54	0	0	1	0.194	0.096
UK(E&W)-CBT	1598	0.73	0	0	1	0.106	0.09
UK(E&W)-BTS-Q3	3650	0.29	0.255	0.88	2	0.674	0.041
F shrinkage mean	1666	1.5				0.026	0.087

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2758	0.24	0.23	5	0.956	0.053

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

Year class = 2009

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	551	0.325	0.243	0.75	2	0.277	0.334
UK(E&W)-CBT	981	0.322	0.397	1.23	2	0.287	0.201
UK(E&W)-BTS-Q3	446	0.258	0.119	0.46	3	0.417	0.399
F shrinkage mean	851	1.5				0.018	0.229

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
600	0.17	0.16	8	0.952	0.311

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

Year class = 2008

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	1537	0.241	0.041	0.17	3	0.328	0.494
UK(E&W)-CBT	1964	0.25	0.36	1.44	3	0.302	0.406
UK(E&W)-BTS-Q3	3210	0.224	0.129	0.58	4	0.356	0.267
F shrinkage mean	2517	1.5				0.014	0.33

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2167	0.14	0.14	11	1.017	0.374

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

Year class = 2007

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	1588	0.207	0.123	0.59	4	0.333	0.586
UK(E&W)-CBT	2194	0.197	0.063	0.32	4	0.387	0.455
UK(E&W)-BTS-Q3	1978	0.214	0.203	0.95	5	0.266	0.494
F shrinkage mean	3093	1.5				0.013	0.343

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1925	0.12	0.08	14	0.682	0.505

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

Year class = 2006

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	375	0.201	0.158	0.78	5	0.306	0.652
UK(E&W)-CBT	477	0.172	0.088	0.51	5	0.492	0.544
UK(E&W)-BTS-Q3	292	0.215	0.187	0.87	5	0.186	0.781
F shrinkage mean	890	1.5				0.016	0.328

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
409	0.11	0.09	16	0.77	0.613

Table 3.5.2.1 - Sole VIIfg - XSA diagnostics - continued

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 2005

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	233	0.196	0.153	0.78	6	0.283	0.609
UK(E&W)-CBT	347	0.155	0.12	0.77	6	0.562	0.446
UK(E&W)-BTS-Q3	116	0.214	0.251	1.17	5	0.141	0.989
F shrinkage mean	553	1.5				0.015	0.302

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
267	0.11	0.12	18	1.125	0.548

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

Year class = 2004

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	243	0.194	0.121	0.62	7	0.264	0.427
UK(E&W)-CBT	338	0.142	0.121	0.85	7	0.62	0.324
UK(E&W)-BTS-Q3	238	0.218	0.034	0.16	5	0.104	0.434
F shrinkage mean	422	1.5				0.012	0.268

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
299	0.11	0.07	20	0.703	0.359

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

Year class = 2003

Fleet	Es Su	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1	0	0	0	0	0	0
BE-CBT2	190	0.203	0.073	0.36	8	0.287	0.368
UK(E&W)-CBT	254	0.142	0.098	0.69	8	0.62	0.288
UK(E&W)-BTS-Q3	152	0.218	0.188	0.86	5	0.08	0.443
F shrinkage mean	137	1.5				0.013	0.481

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
222	0.11	0.07	22	0.623	0.323

Table 3.5.2.2- Sole in VIIfg. Fishing mortality

Run title : CELTIC SEA SOLE - WKCELT
At 6/02/2014 11:29

	1971	1972
1	0.0000	0.0000
2	0.0839	0.0694
3	0.1470	0.2563
4	0.3943	0.2275
5	0.4046	0.3105
6	0.3222	0.3427
7	0.4169	0.2315
8	0.3570	0.2837
9	0.2709	0.2171
+gp	0.2709	0.2171
FBAR 4- 8	0.3790	0.2792

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000
2	0.1067	0.0558	0.0427	0.1320	0.0733	0.0839	0.0726	0.2457	0.1476	0.086
3	0.3235	0.1621	0.1249	0.4123	0.2470	0.2213	0.1868	0.2831	0.3802	0.278
4	0.3116	0.2151	0.1616	0.3382	0.2691	0.2740	0.3228	0.4385	0.3492	0.267
5	0.3205	0.2510	0.2183	0.4347	0.2424	0.1632	0.2405	0.3993	0.3244	0.318
6	0.2375	0.3371	0.2656	0.2695	0.2748	0.1959	0.2181	0.3012	0.4310	0.353
7	0.1784	0.2246	0.2655	0.3406	0.2838	0.1529	0.3513	0.1148	0.3911	0.396
8	0.1610	0.1935	0.1264	0.5111	0.2309	0.1957	0.2598	0.2571	0.3014	0.392
9	0.2000	0.2123	0.1779	0.3392	0.1715	0.1862	0.2041	0.3070	0.3816	0.446
+gp	0.2000	0.2123	0.1779	0.3392	0.1715	0.1862	0.2041	0.3070	0.3816	0.446
FBAR 4- 8	0.2418	0.2443	0.2075	0.3788	0.2602	0.1964	0.2785	0.3022	0.3594	0.345

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.1679	0.1227	0.0499	0.1076	0.1253	0.1131	0.1330	0.0904	0.2184	0.1271
3	0.3735	0.3068	0.3803	0.4687	0.2788	0.2424	0.3467	0.3950	0.3019	0.3777
4	0.3718	0.3304	0.4453	0.5229	0.5215	0.3952	0.4985	0.6211	0.4376	0.4517
5	0.3716	0.4622	0.5165	0.5546	0.4676	0.5423	0.4755	0.6428	0.5130	0.4734
6	0.3697	0.3889	0.4379	0.6414	0.5536	0.5831	0.5580	0.6728	0.4735	0.4745
7	0.4709	0.4982	0.3362	0.5040	0.8417	0.4784	0.5534	0.6555	0.4558	0.3153
8	0.6892	0.3757	0.4474	0.4850	0.4704	0.8101	0.5758	0.6925	0.5241	0.2763
9	0.3567	0.3125	0.4262	0.6139	0.6610	0.5884	0.5524	0.7438	0.5825	0.4904
+gp	0.3567	0.3125	0.4262	0.6139	0.6610	0.5884	0.5524	0.7438	0.5825	0.4904
FBAR 4- 8	0.4546	0.4111	0.4366	0.5416	0.5710	0.5618	0.5322	0.6569	0.4808	0.3982

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0962	0.0799	0.0445	0.0639	0.0728	0.0427	0.1182	0.1426	0.1051	0.0077
3	0.3547	0.2865	0.4468	0.5163	0.4563	0.3822	0.5459	0.4119	0.2092	0.2941
4	0.3995	0.5157	0.7124	0.6671	0.5661	0.7338	0.6169	0.3843	0.3965	0.3500
5	0.3936	0.5529	0.5514	0.5858	0.6234	0.5400	0.6276	0.3181	0.4014	0.5323
6	0.3628	0.6057	0.6090	0.5857	0.7405	0.5256	0.4796	0.2298	0.5373	0.3735
7	0.5570	0.4898	0.5663	0.4595	0.6695	0.7332	0.4424	0.3098	0.3701	0.3691
8	0.5500	0.4044	0.7444	0.4476	0.5501	0.5501	0.4203	0.4013	0.3278	0.5297
9	0.6826	0.7770	0.8003	0.6328	0.6784	0.4072	0.4550	0.4367	0.4004	0.5037
+gp	0.6826	0.7770	0.8003	0.6328	0.6784	0.4072	0.4550	0.4367	0.4004	0.5037
FBAR 4- 8	0.4526	0.5137	0.6367	0.5492	0.6299	0.6165	0.5174	0.3287	0.4066	0.4309

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	FBAR 10-12
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0222	0.1110	0.0594	0.1728	0.1171	0.0659	0.0755	0.0530	0.1225	0.0534	0.0763
3	0.2598	0.4501	0.2873	0.3714	0.3055	0.2048	0.1782	0.2082	0.2444	0.3107	0.2544
4	0.3931	0.4697	0.3458	0.3384	0.3252	0.2946	0.2702	0.4243	0.3291	0.3740	0.3758
5	0.5705	0.4707	0.4766	0.3474	0.3496	0.3901	0.2670	0.3275	0.3746	0.5048	0.4023
6	0.7467	0.4032	0.3833	0.2446	0.2998	0.3152	0.3182	0.2907	0.4109	0.6125	0.4380
7	0.6901	0.4327	0.2926	0.1976	0.3495	0.2683	0.2953	0.2647	0.3290	0.5477	0.3805
8	0.6202	0.3521	0.2724	0.1976	0.2700	0.2533	0.1947	0.2997	0.3169	0.3593	0.3253
9	0.5354	0.5200	0.3657	0.3545	0.2871	0.2978	0.2039	0.1652	0.2434	0.3226	0.2437
+gp	0.5354	0.5200	0.3657	0.3545	0.2871	0.2978	0.2039	0.1652	0.2434	0.3226	
FBAR 4- 8	0.6041	0.4257	0.3541	0.2651	0.3188	0.3043	0.2691	0.3214	0.3521	0.4797	

Table 3.5.2.3 - Sole in VIIfg. Stock numbers at age (start of year, in thousand)

Run title : CELTIC SEA SOLE - WKCELT
At 6/02/2014 11:29

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	9372	4180	3318	3308	2932	5158	4590	5443	3504	5098	4838
2	5041	8480	3783	3002	2993	2653	4667	4153	4925	3170	4613
3	2077	4194	7158	3076	2569	2595	2104	3925	3456	4144	2244
4	4326	1622	2937	4687	2367	2051	1555	1487	2846	2594	2825
5	1974	2639	1169	1946	3420	1822	1324	1075	1023	1865	1514
6	1653	1192	1751	768	1370	2487	1068	940	826	728	1132
7	1656	1084	766	1249	496	951	1719	734	699	601	487
8	2672	987	778	580	903	344	612	1171	570	445	485
9	1665	1692	673	599	432	720	187	439	871	398	311
+gp	5390	3924	3727	2967	2395	1687	2430	1075	960	1396	1255
0 TOTAL	35826	29994	26059	22183	19877	20469	20255	20441	19680	20438	19704

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	4863	6760	4675	5624	3138	5713	4467	3722	8634	4214	4484
2	4378	4400	6116	4230	5089	2839	5169	4042	3368	7812	3813
3	3601	3636	3366	4895	3641	4134	2266	4177	3202	2784	5682
4	1388	2468	2264	2241	3028	2062	2831	1609	2672	1952	1863
5	1803	962	1540	1473	1299	1624	1108	1725	885	1299	1140
6	990	1187	600	878	795	675	921	583	970	421	704
7	666	630	742	368	512	379	351	465	302	448	237
8	298	405	356	408	238	280	148	197	242	142	257
9	325	182	184	221	236	133	158	59	100	110	76
+gp	949	1118	1070	724	747	387	630	251	257	384	240
TOTAL	19261	21748	20914	21062	18724	18226	18050	16831	20632	19565	18496

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	4462	3445	3325	4052	5472	6335	15044	8200	4383	6976
2	4057	4038	3117	3008	3666	4952	5732	13612	7420	3966
3	3038	3334	3373	2698	2554	3084	4293	4608	10680	6044
4	3524	1928	2265	1952	1457	1464	1904	2250	2762	7839
5	1073	2139	1042	1005	907	748	636	930	1386	1681
6	643	655	1113	543	506	440	395	307	612	840
7	396	405	323	548	274	219	235	221	221	324
8	157	205	224	166	313	127	95	137	147	138
9	176	82	124	96	96	163	66	56	83	96
+gp	209	282	207	236	225	272	126	151	257	135
TOTAL	17735	16513	15113	14305	15470	17804	28526	30473	27951	28039

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	GMST 71-10	AMST 71-10
1	5263	5842	5015	3523	3898	9704	6326	1250	3553	7343	0	4846	5264
2	6312	4762	5286	4538	3187	3527	8780	5724	1131	3215	6644	4552	4861
3	3561	5586	3856	4507	3454	2565	2988	7367	4912	905	2758	3656	3913
4	4076	2485	3222	2618	2813	2303	1891	2262	5413	3481	600	2397	2567
5	4998	2489	1406	2063	1689	1839	1552	1306	1339	3525	2167	1454	1588
6	893	2557	1407	790	1319	1077	1126	1075	852	833	1925	875	973
7	523	383	1546	868	560	884	711	741	727	511	409	532	623
8	202	237	225	1044	644	357	612	479	515	474	267	334	451
9	74	99	151	155	775	445	251	456	321	339	299	211	330
+gp	212	142	154	179	294	700	1098	813	966	920	825		
TOTAL	26115	24582	22268	20284	18634	23402	25335	21474	19730	21546	15895		

Table 3.5.2.4 - Sole in VIIfg. Summary

Run title : CELTIC SEA SOLE - WKCELT
At 6/02/2014 11:29

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 4- 8
1971	9372	9011	7575	1861	0.2457	0.3790
1972	4180	7586	5965	1278	0.2143	0.2792
1973	3318	6321	5018	1391	0.2772	0.2418
1974	3308	6294	5299	1105	0.2085	0.2443
1975	2932	5546	4711	919	0.1951	0.2075
1976	5158	5084	4072	1350	0.3315	0.3788
1977	4590	5687	4437	961	0.2166	0.2602
1978	5443	4836	3529	780	0.2210	0.1964
1979	3504	4842	3643	954	0.2618	0.2785
1980	5098	5010	3798	1314	0.3460	0.3022
1981	4838	4421	3253	1212	0.3725	0.3594
1982	4863	4606	3362	1128	0.3355	0.3451
1983	6760	4972	3502	1373	0.3921	0.4546
1984	4675	5211	3761	1266	0.3366	0.4111
1985	5624	4669	3195	1328	0.4157	0.4366
1986	3138	4495	3249	1600	0.4925	0.5416
1987	5713	3647	2437	1222	0.5014	0.5710
1988	4467	3800	2612	1146	0.4388	0.5618
1989	3722	3173	2042	992	0.4859	0.5322
1990	8634	3806	2327	1189	0.5110	0.6569
1991	4214	3529	2053	1107	0.5392	0.4808
1992	4484	3790	2373	981	0.4135	0.3982
1993	4462	3810	2444	928	0.3798	0.4526
1994	3445	3241	2224	1009	0.4536	0.5137
1995	3325	3079	2141	1157	0.5403	0.6367
1996	4052	3067	2083	995	0.4776	0.5492
1997	5472	3018	1863	927	0.4975	0.6299
1998	6335	3117	1679	875	0.5210	0.6165
1999	15044	4328	1872	1012	0.5405	0.5174
2000	8200	3984	2001	1091	0.5453	0.3287
2001	4383	5521	3191	1168	0.3660	0.4066
2002	6976	6074	4147	1345	0.3243	0.4309
2003	5263	5734	3843	1547	0.4026	0.6041
2004	5842	5078	3446	1398	0.4057	0.4257
2005	5015	5009	3313	1118	0.3375	0.3541
2006	3523	4265	2839	946	0.3333	0.2651
2007	3898	4073	2976	945	0.3176	0.3188
2008	9704	4434	2636	800	0.3035	0.3043
2009	6326	5154	2927	805	0.2750	0.2691
2010	1250	4730	3076	876	0.2848	0.3214
2011	3553	4397	3192	1029	0.3223	0.3521
2012	7343	4118	2915	1096	0.3760	0.4797
Arith. Mean	5273	4680	3262	1132	0.3752	0.4118
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

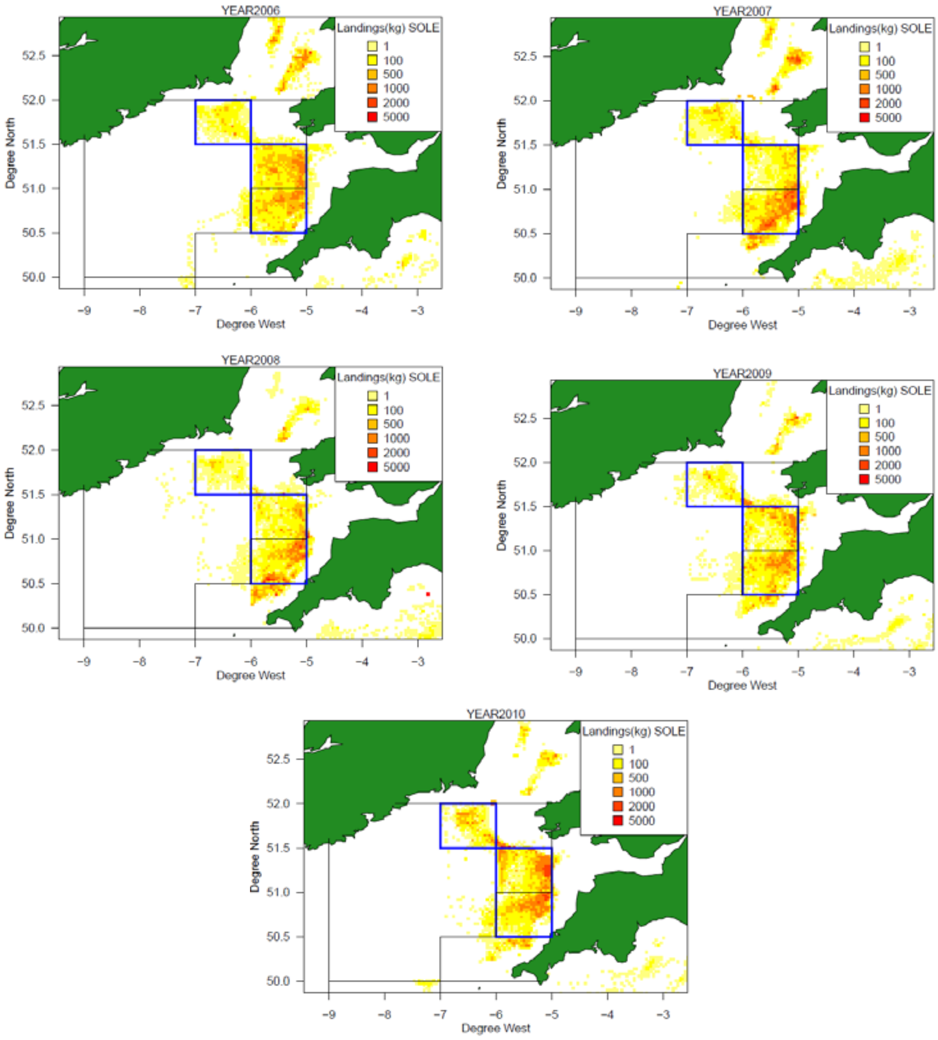


Figure 3.1.1 – Landings distribution (year) of sole in the Celtic Sea by ICES rectangle for the Belgian beam trawl fleet (2006-2012). Blue rectangles is Trevose box.

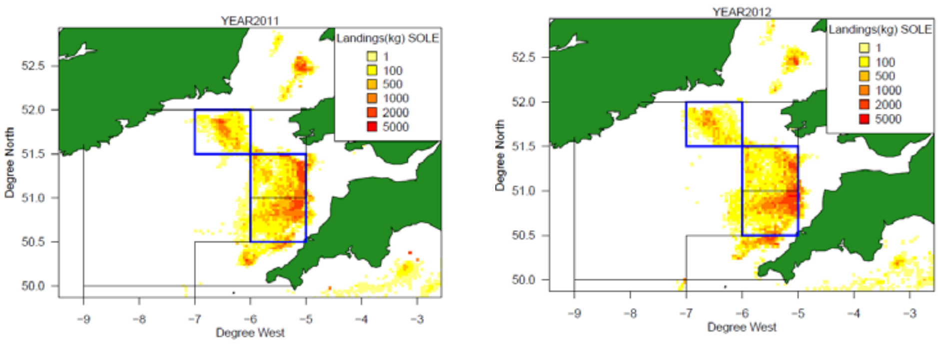


Figure 3.1.1 –-Continued Landings distribution (year) of sole in the Celtic Sea by ICES rectangle for the Belgian beam trawl fleet (2006-2012). Blue rectangles is Trevose box

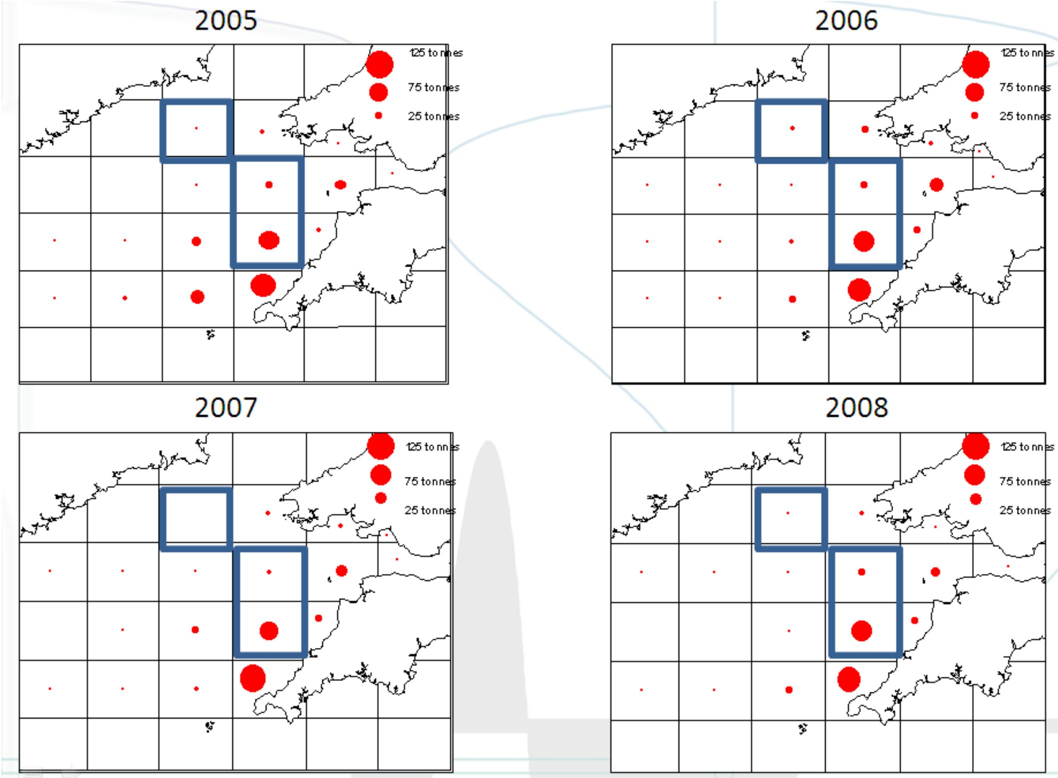


Figure 3.1.2 – Landings distribution (year) of sole in the Celtic Sea by ICES rectangle for the UK (E and W) beam trawl fleet (2005-2012). Blue rectangles is Trevose box.

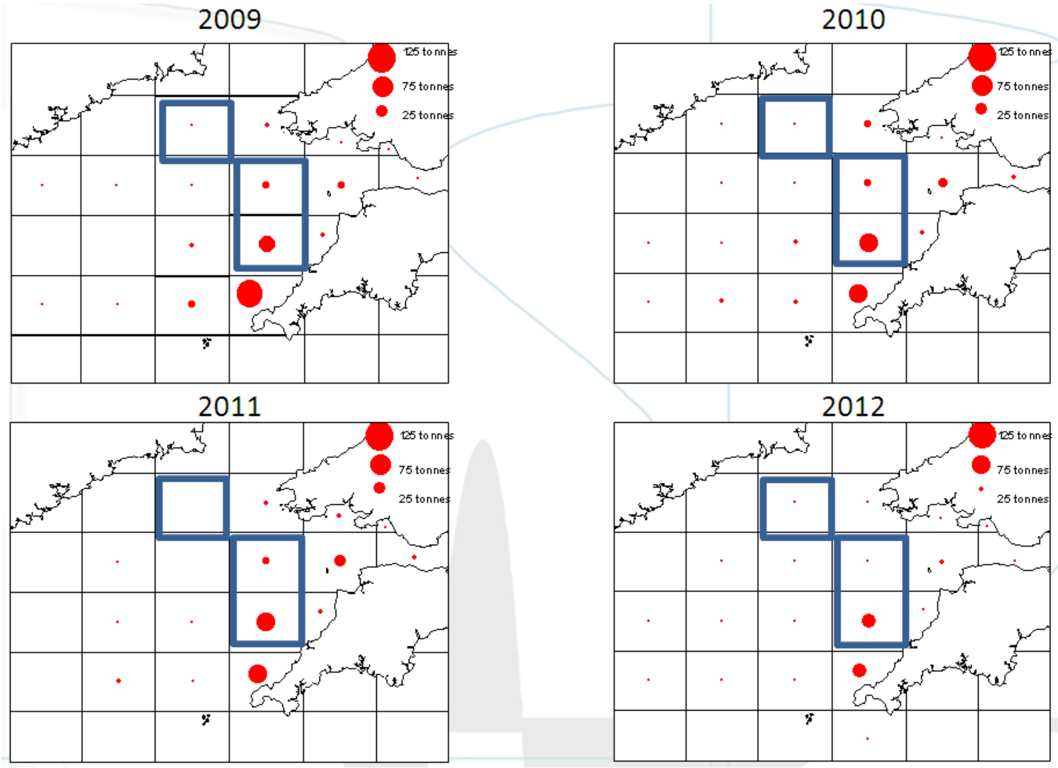


Figure 3.1.2 - Continued. Landings distribution (year) of sole in the Celtic Sea by ICES rectangle for the UK (E and W) beam trawl fleet (2005-2012). Blue rectangles is Trevose box

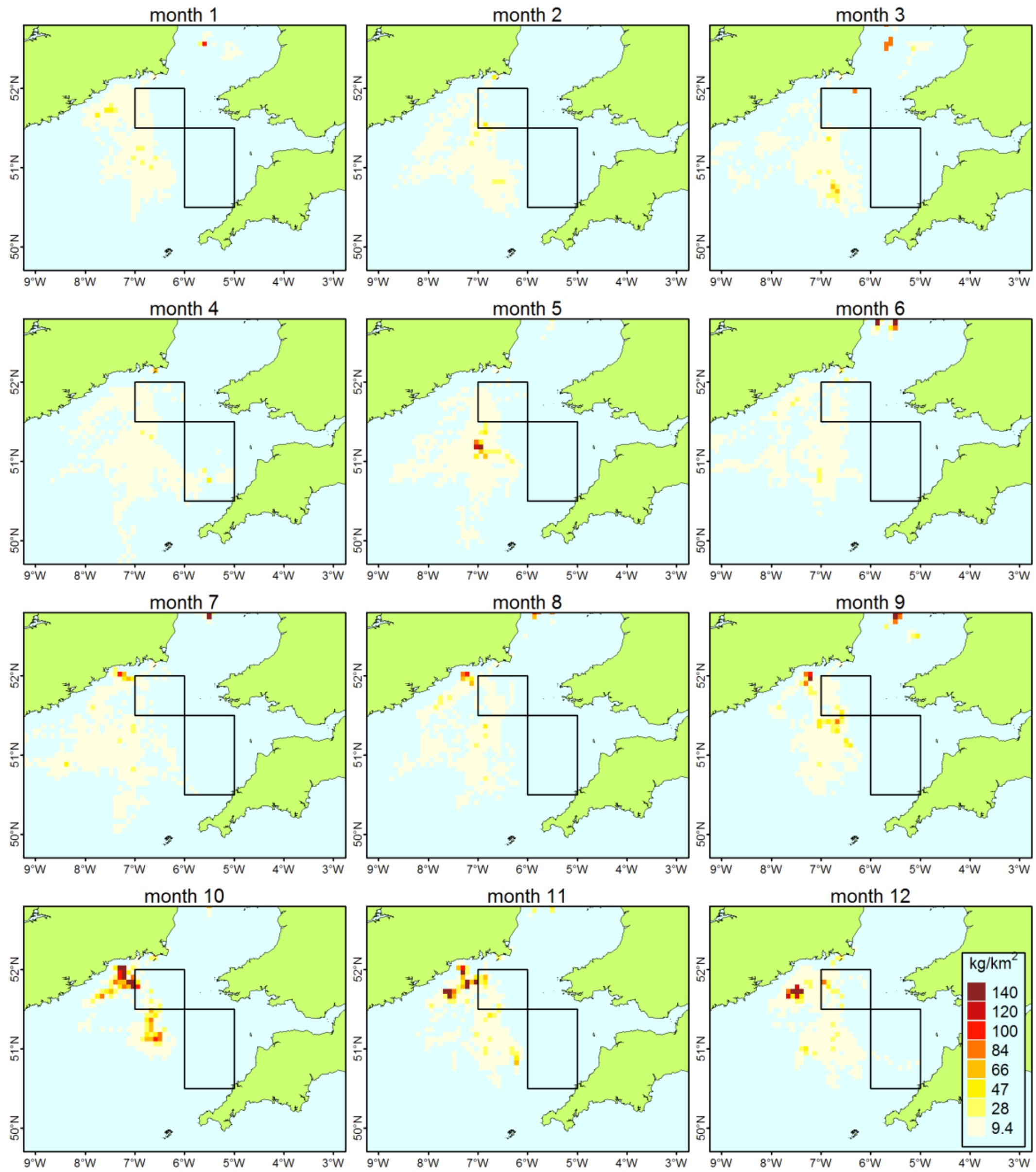


Figure 3.1.3 – Landings distribution (month) of sole in the Celtic Sea by ICES rectangle for the Irish beam trawl fleet (2012). Black rectangles is Trevose box.

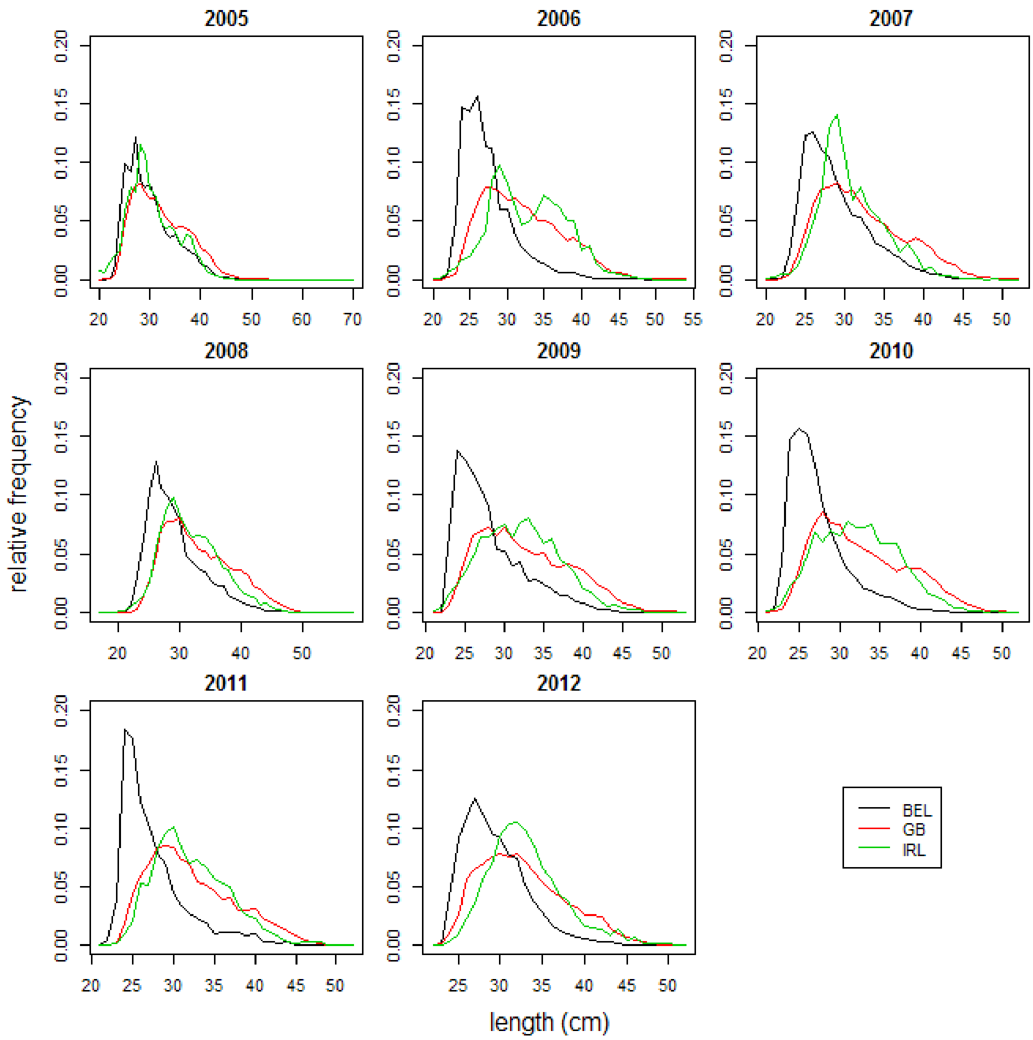


Figure 3.1.4 – Relative length frequency distributions of Belgian, UK (E and W) and Irish landings samples.

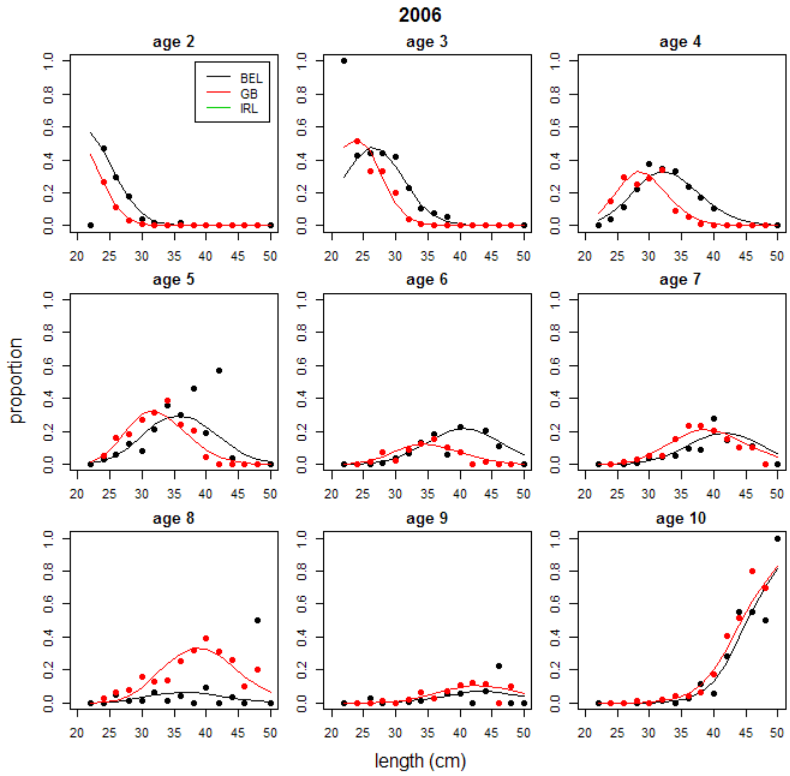


Figure 3.1.5 – Comparison of the proportions-at-age from Belgian and UK (E and W) age-length-keys in 2006.

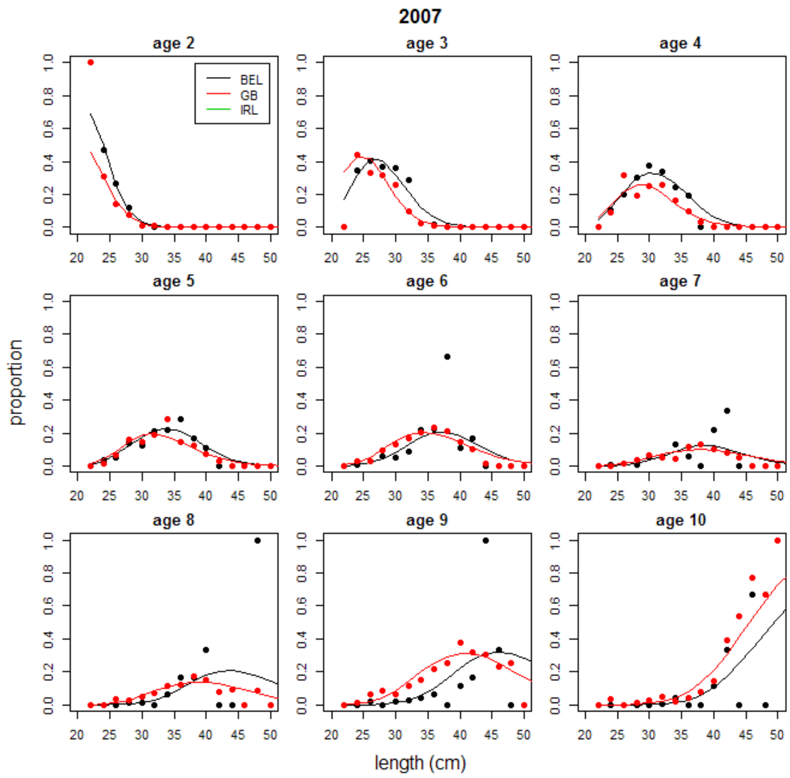


Figure 3.1.6 – Comparison of the proportions-at-age from Belgian and UK (E and W) age-length-keys in 2007.

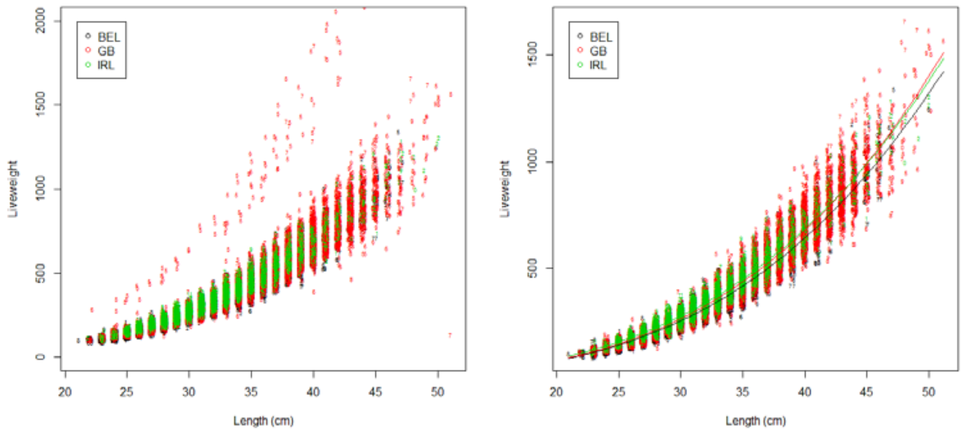


Figure 3.1.71. Length-weight data by country; the numbers represent the year (i.e. 5 for 2005). The UK data showed some strange outliers, mainly in 2005. The plot on the right shows the length-weight models after removing the outlying values (coloured lines). No obvious differences exist between countries.

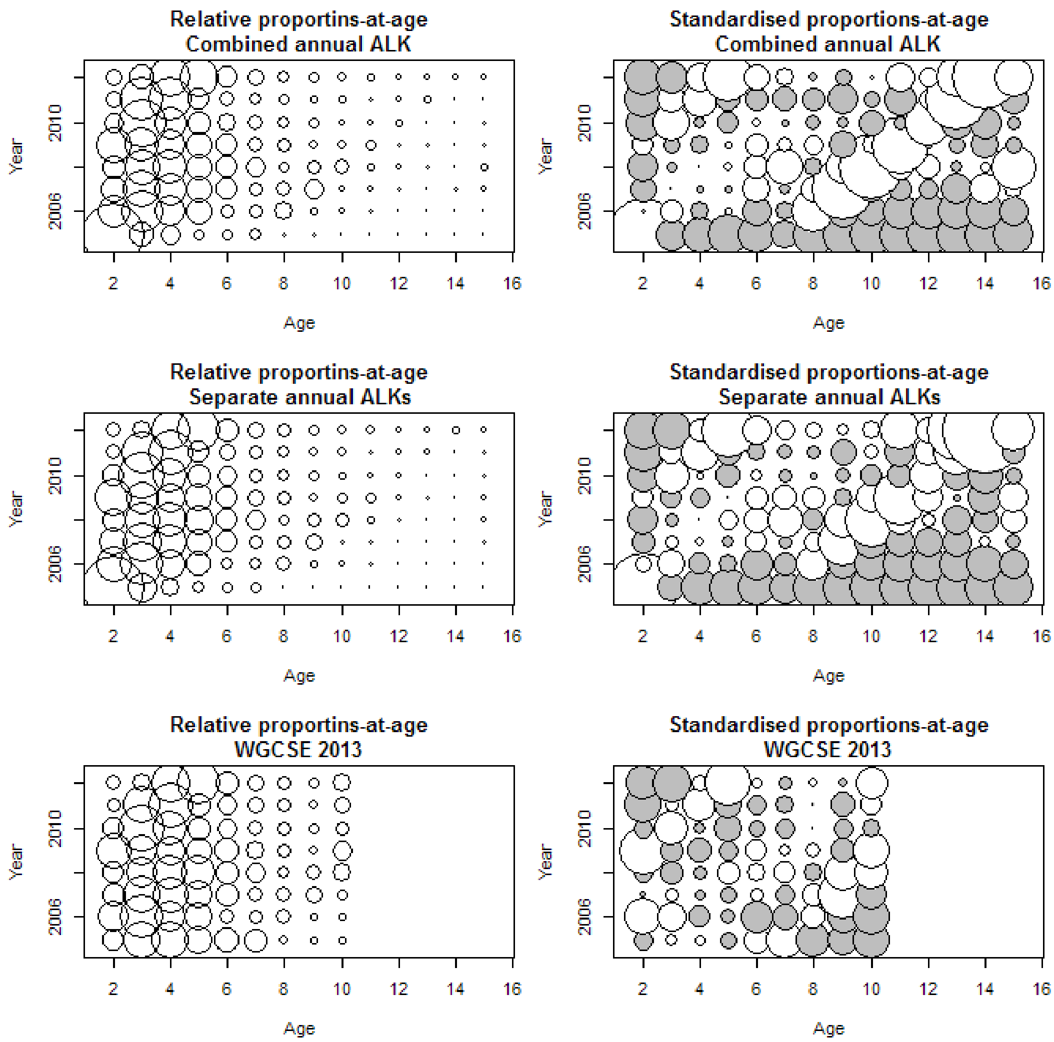


Figure 3.1.8. Relative and standardized proportions-at-age resulting from the combined annual ALK; separate annual ALK's by country and the data submitted to WGCSE2013.

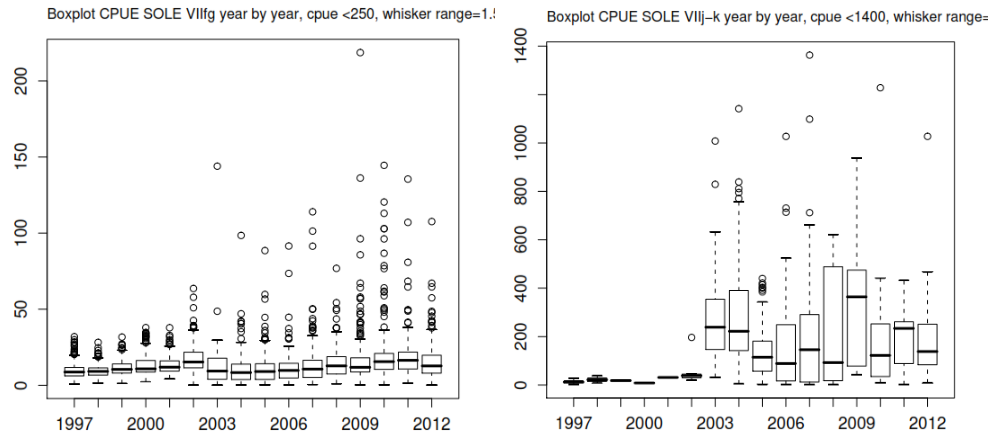


Figure 3.2.1 – Boxplots of cpue (kg/hour) from the Belgian beam trawl trips by year over the period 1997-2012 in area VIIfg (left panel) and area VIIj-k (right panel).

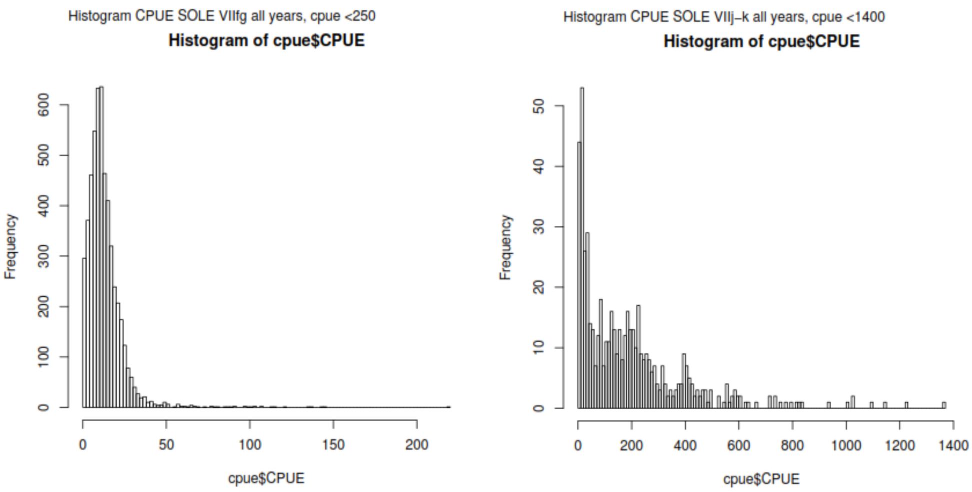


Figure 3.2.2 – Frequency histograms of cpue (kg/hour) from the Belgian beam trawl trips by year over the period 1997-2012 in area VIIfg (left panel) and area VIIj-k (right panel).

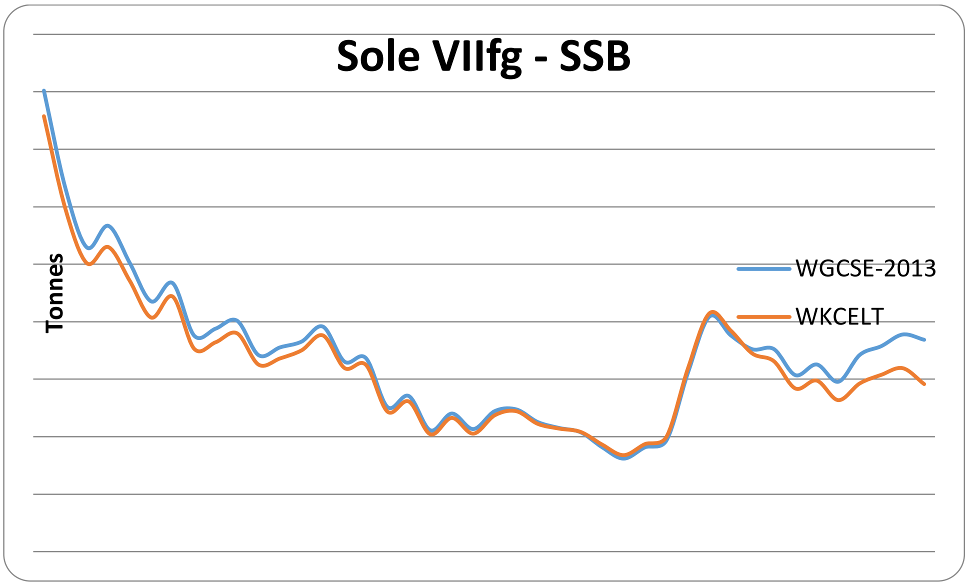


Figure 3.3.1 – Comparison of SSB between the 2013 WGCSE assessment and the proposed revisions of catch- and stock weights by WKCELT.

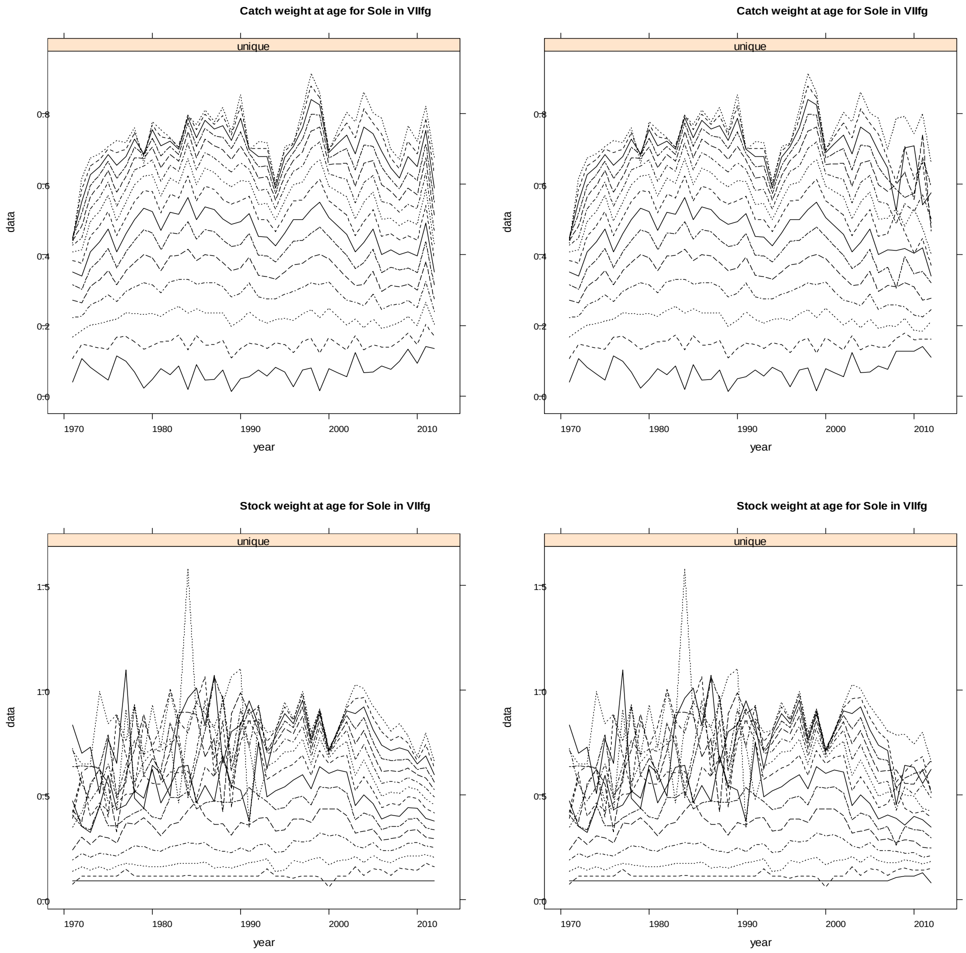


Figure 3.3.2 – Smoothed catch- and stock weights at age for the whole time-series as used by WGCSE up to 2013(two left panels). Original catch weights at age and Rivard calculated stock weights (2008-2012) as proposed to be used by WKCELT (two right panels).

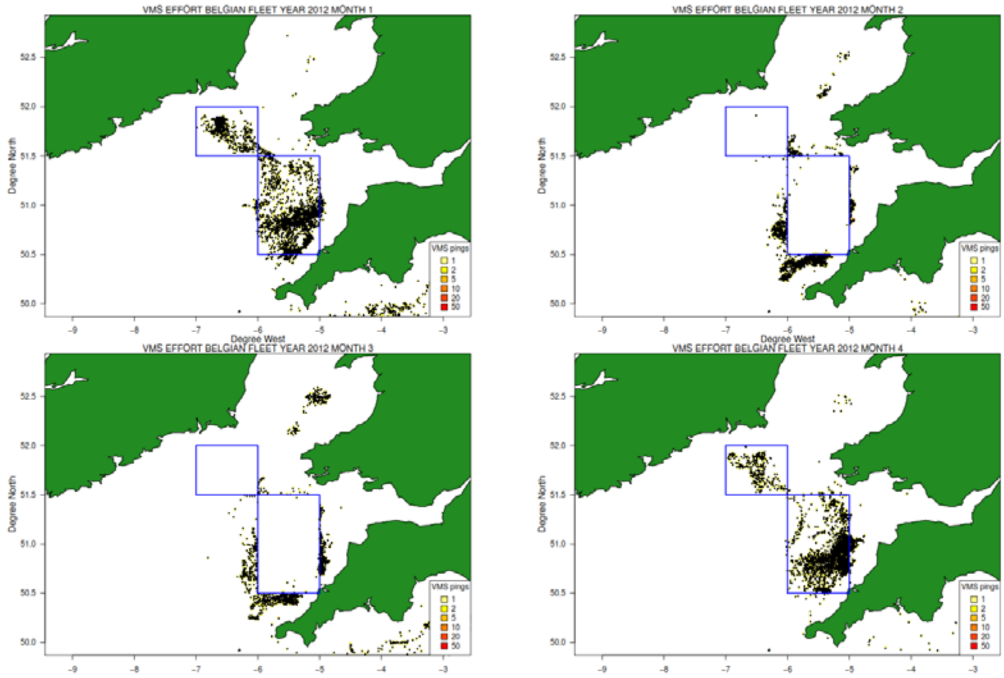


Figure 3.4.1 – Effort deployed in the first 4 months of 2012 for fishing activity of the Belgian beam trawl fleet (speed between 1.5 and 7 knots), based on VMS data.

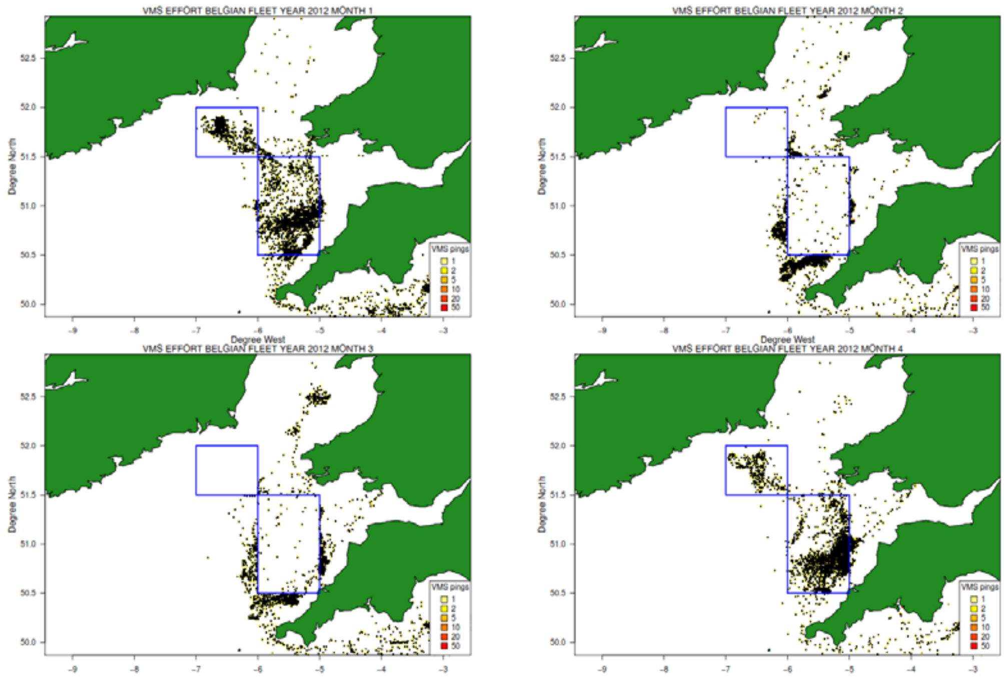


Figure 3.4.2 – Effort deployed in the first 4 months of 2012 of the Belgian beam trawl fleet (all speeds), based on VMS data.

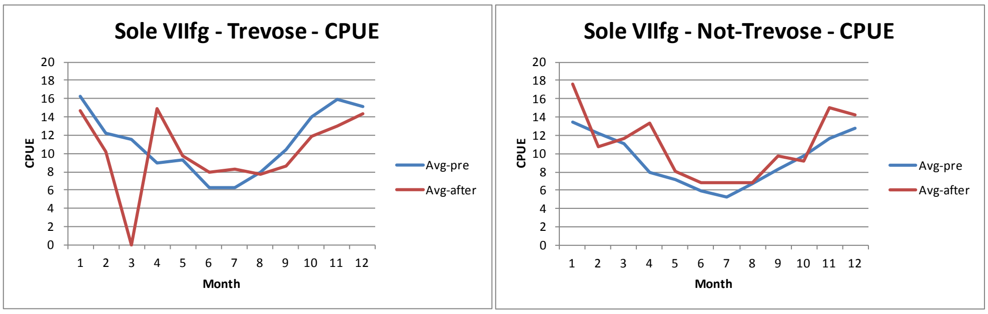
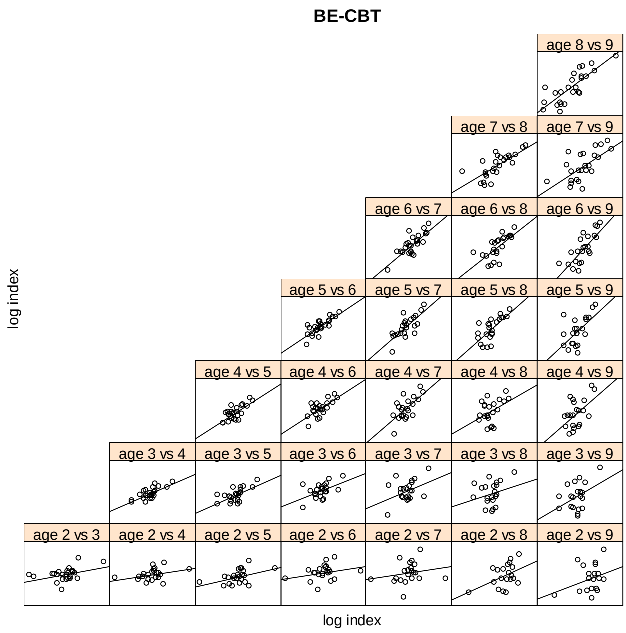
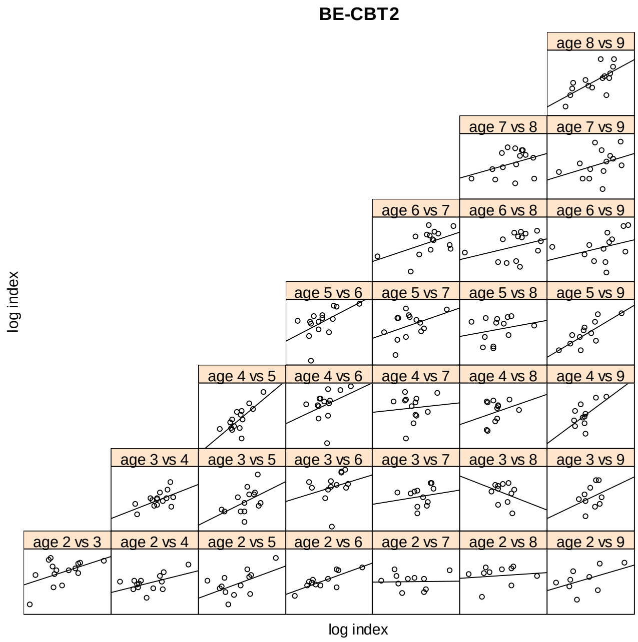
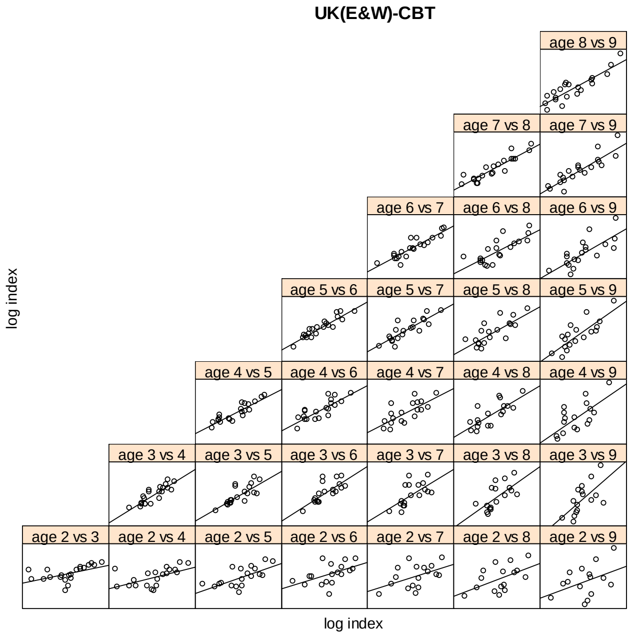


Figure 3.4.3 – Average cpue for trips fishing in the box and outside the box, before and after the introduction of the Trevose box (1997-2012 data).

Figure 3.4.4 – Average cumulative Belgian quota uptake before and after the introduction of the Trevose box for trips catching sole inside and outside the box (1997-2012 data).


BE-CBT
age 8 vs 9
age 7 vs 8
age 7 vs 9
age 6 vs 7
age 6 vs 8
age 6 vs 9
age 5 vs 6
age 5 vs 7
age 5 vs 8
age 5 vs 9
age 4 vs 5
age 4 vs 6
age 4 vs 7
age 4 vs 8
age 4 vs 9
age 3 vs 4
age 3 vs 5
age 3 vs 6
age 3 vs 7
age 3 vs 8
age 3 vs 9
age 2 vs 3
age 2 vs 4
age 2 vs 5
age 2 vs 6
age 2 vs 7
age 2 vs 8
age 2 vs 9
log index
log index


BE-CBT2
age 8 vs 9
age 7 vs 8
age 7 vs 9
age 6 vs 7
age 6 vs 8
age 6 vs 9
age 5 vs 6
age 5 vs 7
age 5 vs 8
age 5 vs 9
age 4 vs 5
age 4 vs 6
age 4 vs 7
age 4 vs 8
age 4 vs 9
age 3 vs 4
age 3 vs 5
age 3 vs 6
age 3 vs 7
age 3 vs 8
age 3 vs 9
age 2 vs 3
age 2 vs 4
age 2 vs 5
age 2 vs 6
age 2 vs 7
age 2 vs 8
age 2 vs 9
log index
log index



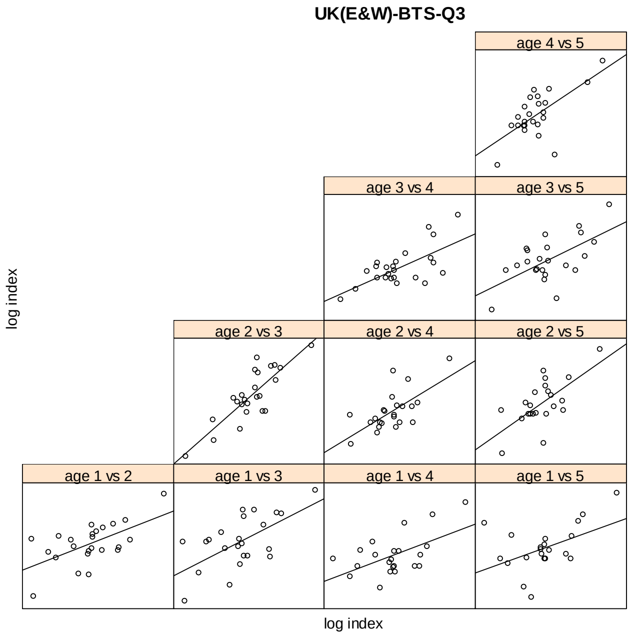


Figure 3.5.1.1 – Consistency plots of the Belgian beam trawl (BE-CBT 1971-1997) upper left, the other Belgian beam trawl (BE-CBT2 1997-2012) upper right, the UK (E and W) beam trawl (1991-2012) lower left and the UK(E and W)-BTS-Q3 survey (1998-2012) lower right.

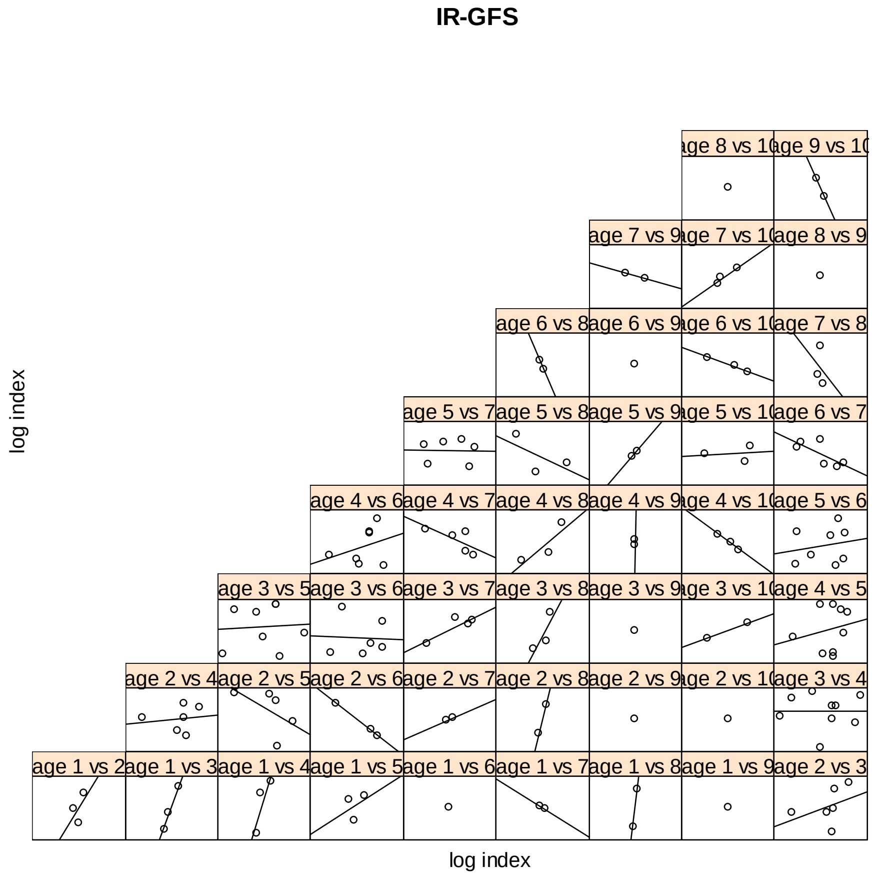


Figure 3.5.1.2 – Consistency plots of the Irish Groundfish survey (IR-GFS 2003-2012)

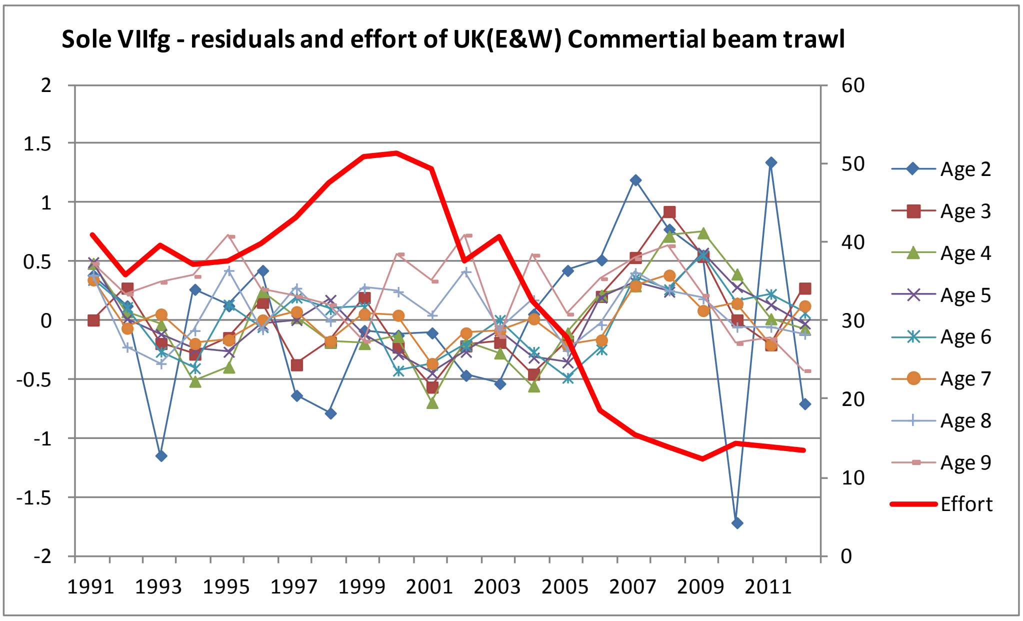


Figure 3.5.2.1 – Effort (red solid line) series and catchability residuals from the UK (E and W) commercial beam trawl tuning fleet.

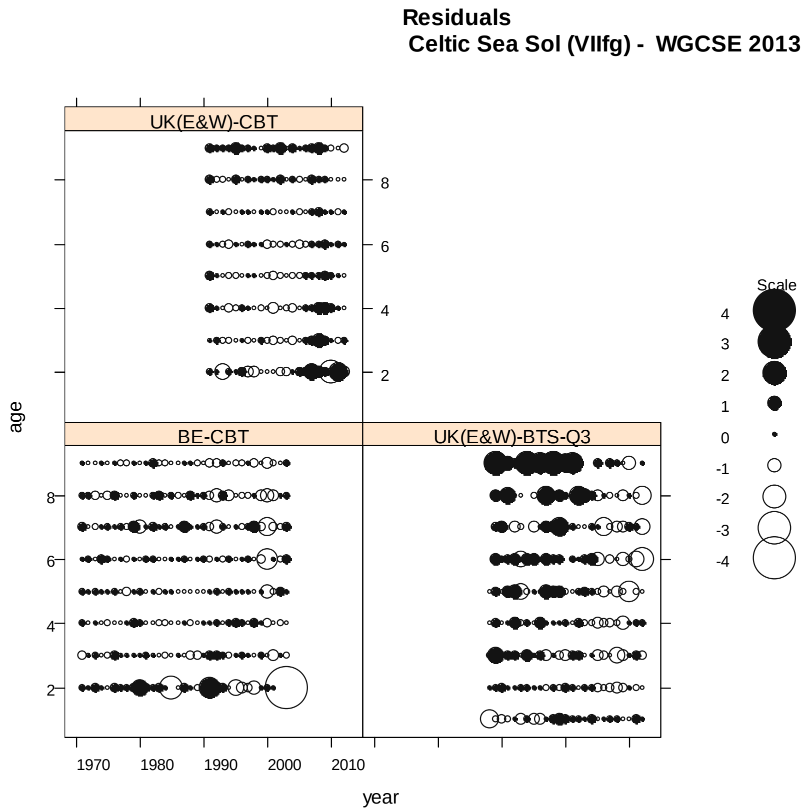


Figure 3.5.2.2 – Catchability residuals from WGCSE-2013.

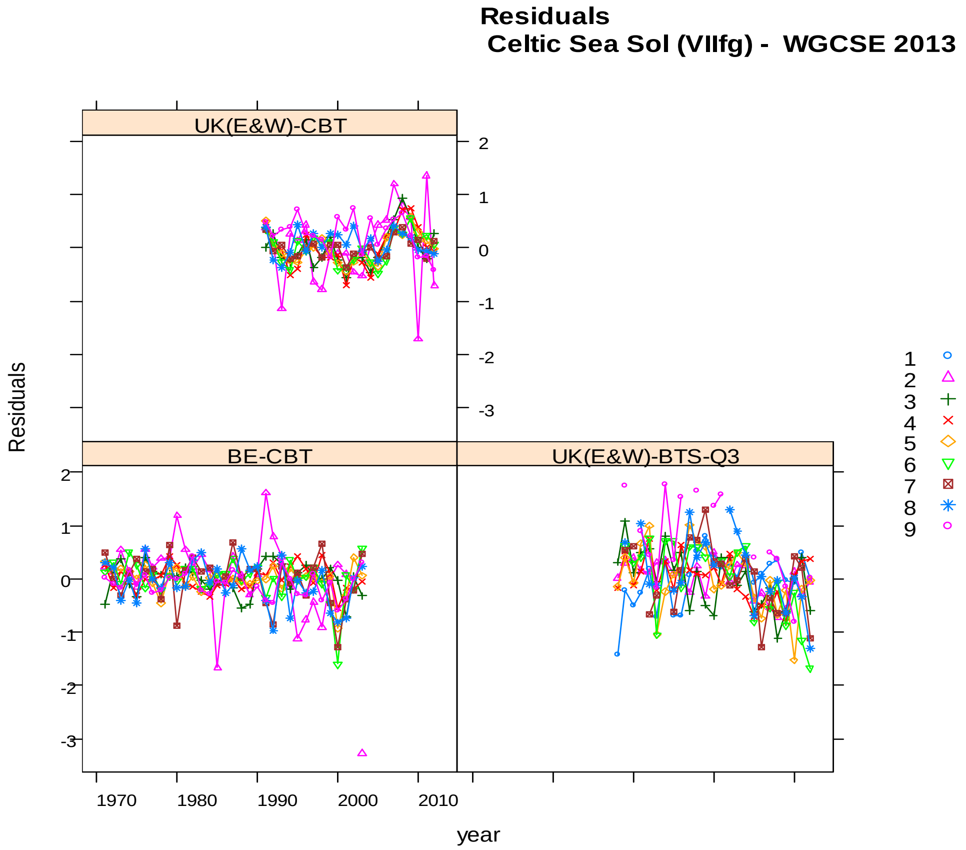


Figure 3.5.2.2 Continued – Catchability residuals from WGCSE-2013.

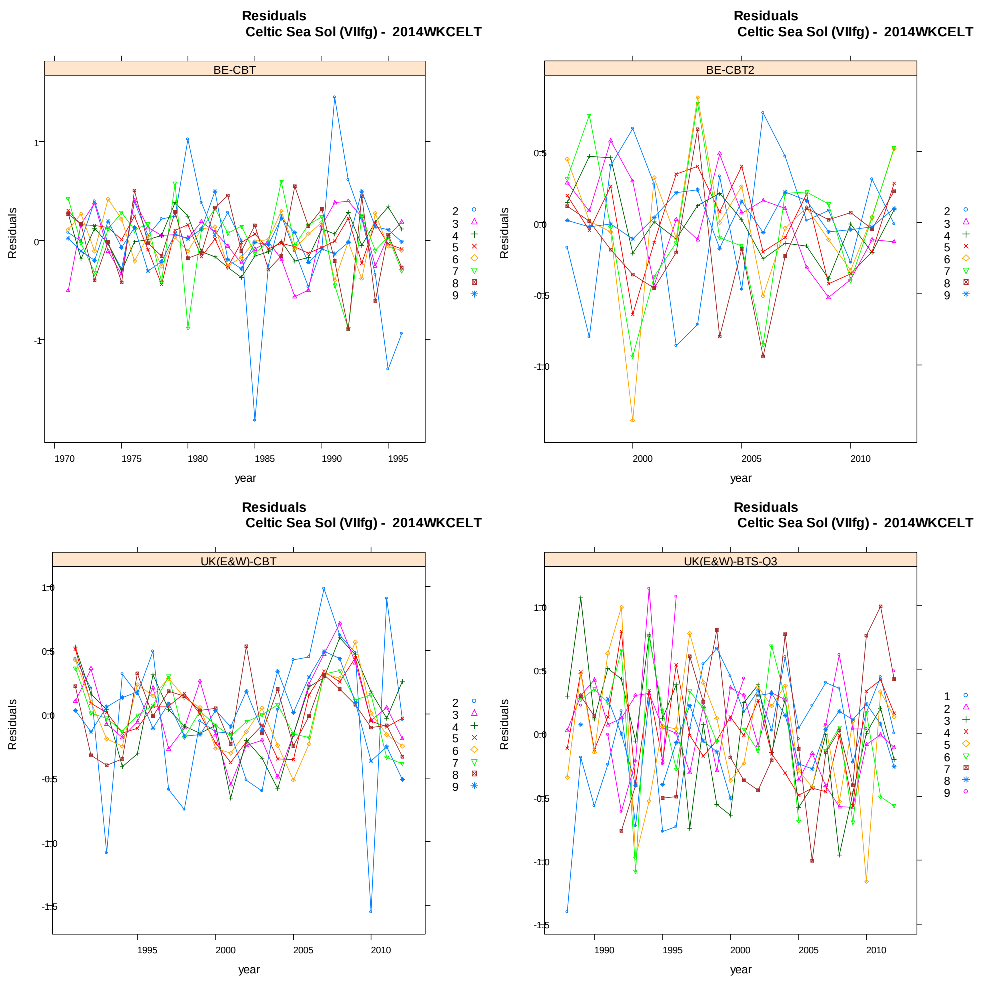


Figure 3.5.2.3 – Catchability residuals from single fleet XSA runs. BE-CBT (1971-1996), BE-CBT2 (1997-2012), UK (E and W)-CBT (1991-2012) and UK (E and W)-BTS-Q3 (1988-2012).

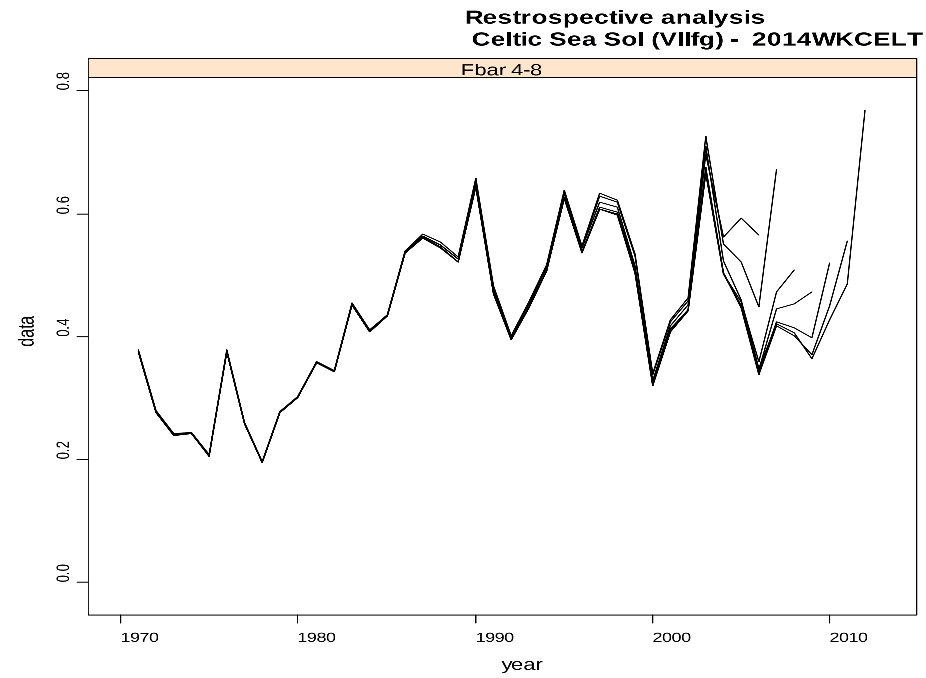


Figure 3.5.2.4 – Retrospective Fbar (4-8) using a split in the UK (E and W) commercial tuning series (19991-2004 and 2005-2012). Other tuning files are BE-CBT, BE-CBT2 and UK (E and W)-BTS-Q3 as adopted for final XSA run by WKCELT.

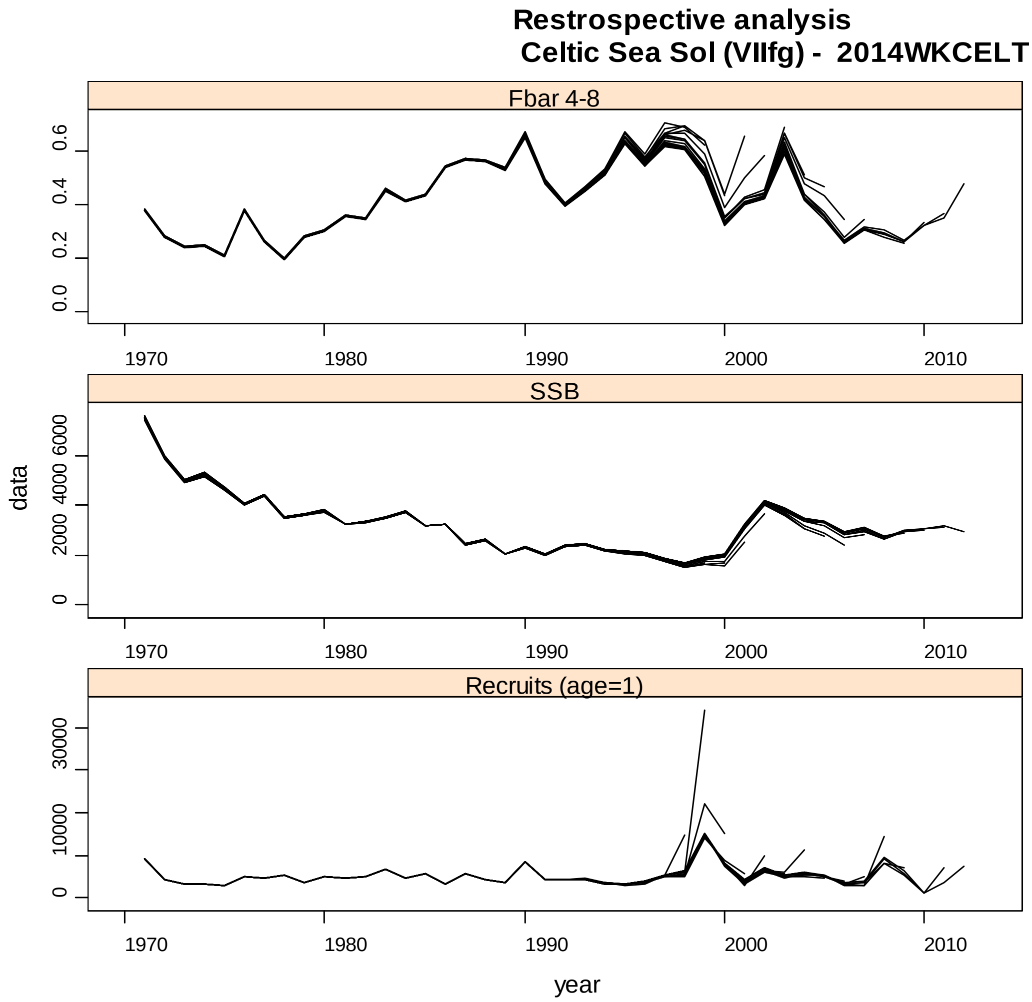
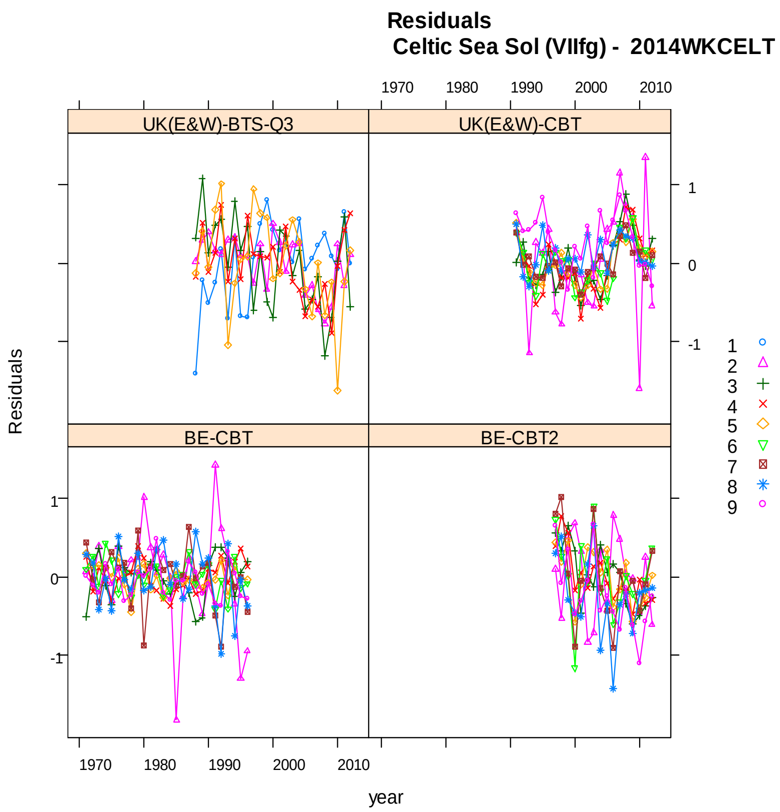


Figure 3.5.2.5 – Retrospective of the final XSA run using UK (E and W)-CBT (1991-2012), BE-CBT (1971-1996), BE-CBT2 (1997-2012) and UK(E and W)-BTS-Q3 (1988-2012).



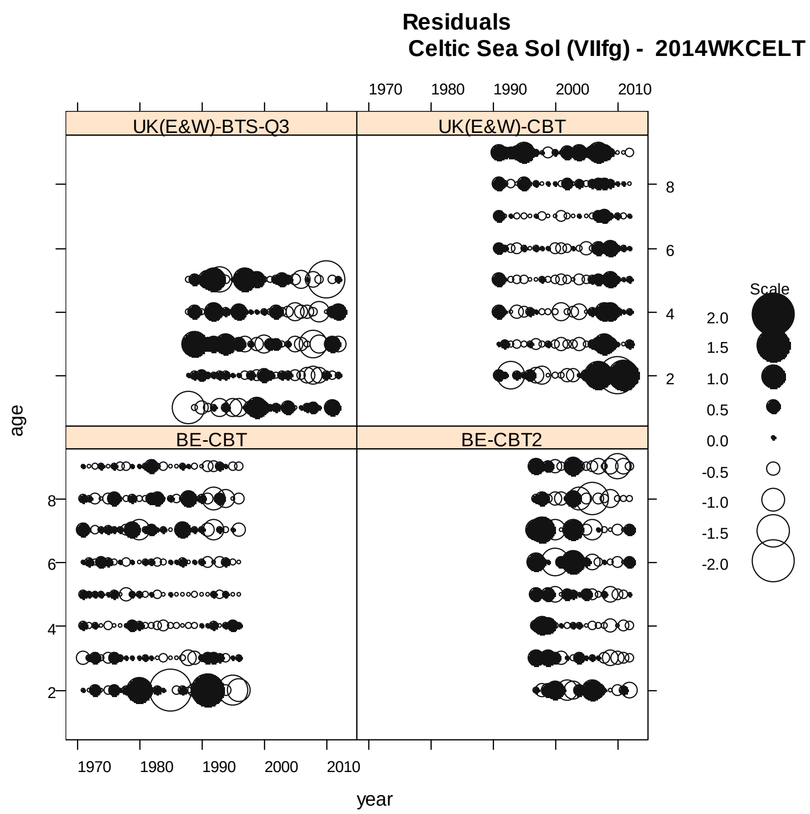


Figure 3.5.2.6 – Catchability residuals of the final XSA (WKCELT).

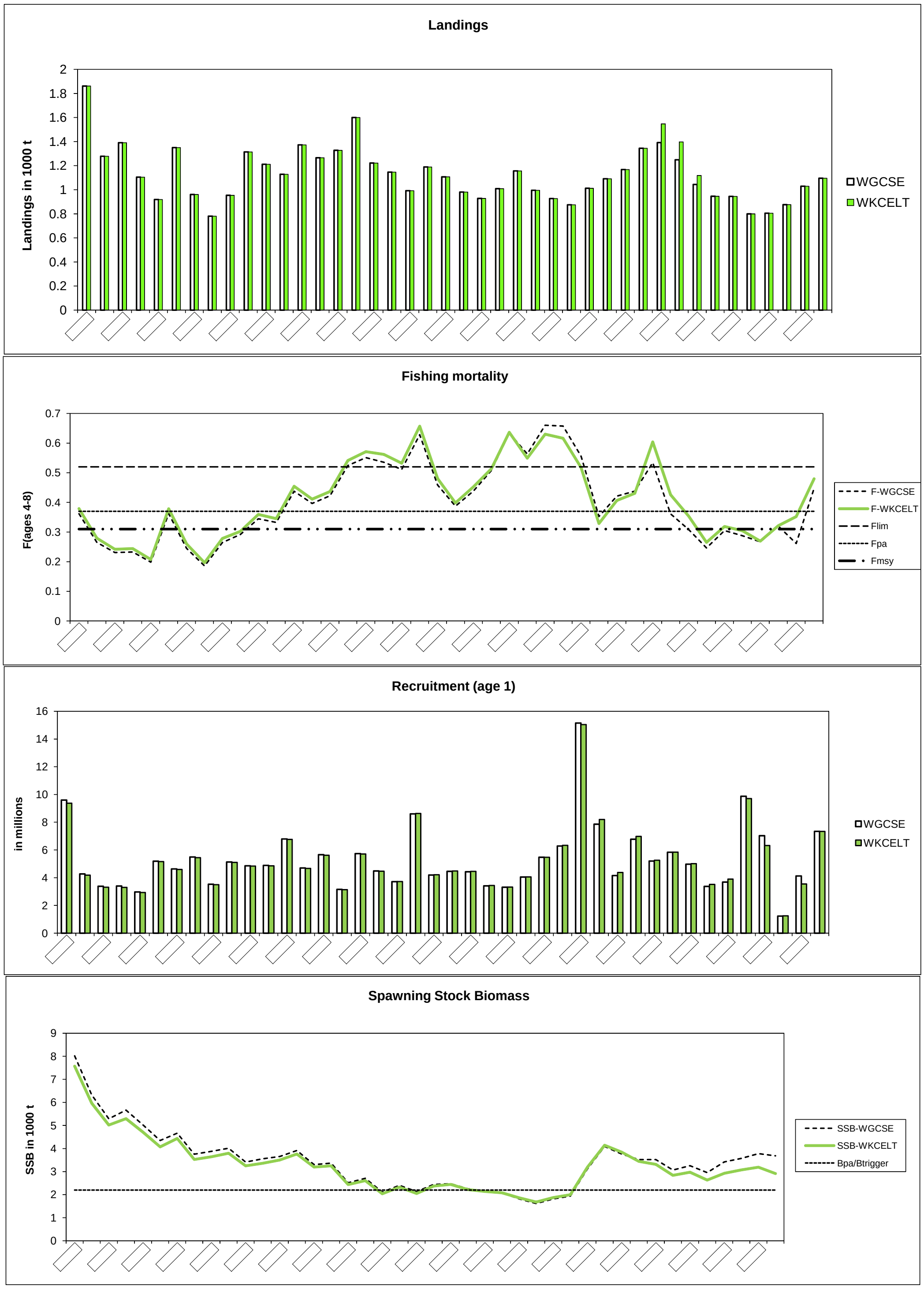


Figure 3.5.2.7 – Sole in VIIfg. Summary plots – Comparison WGCSE-2013 and WKCELT-2014

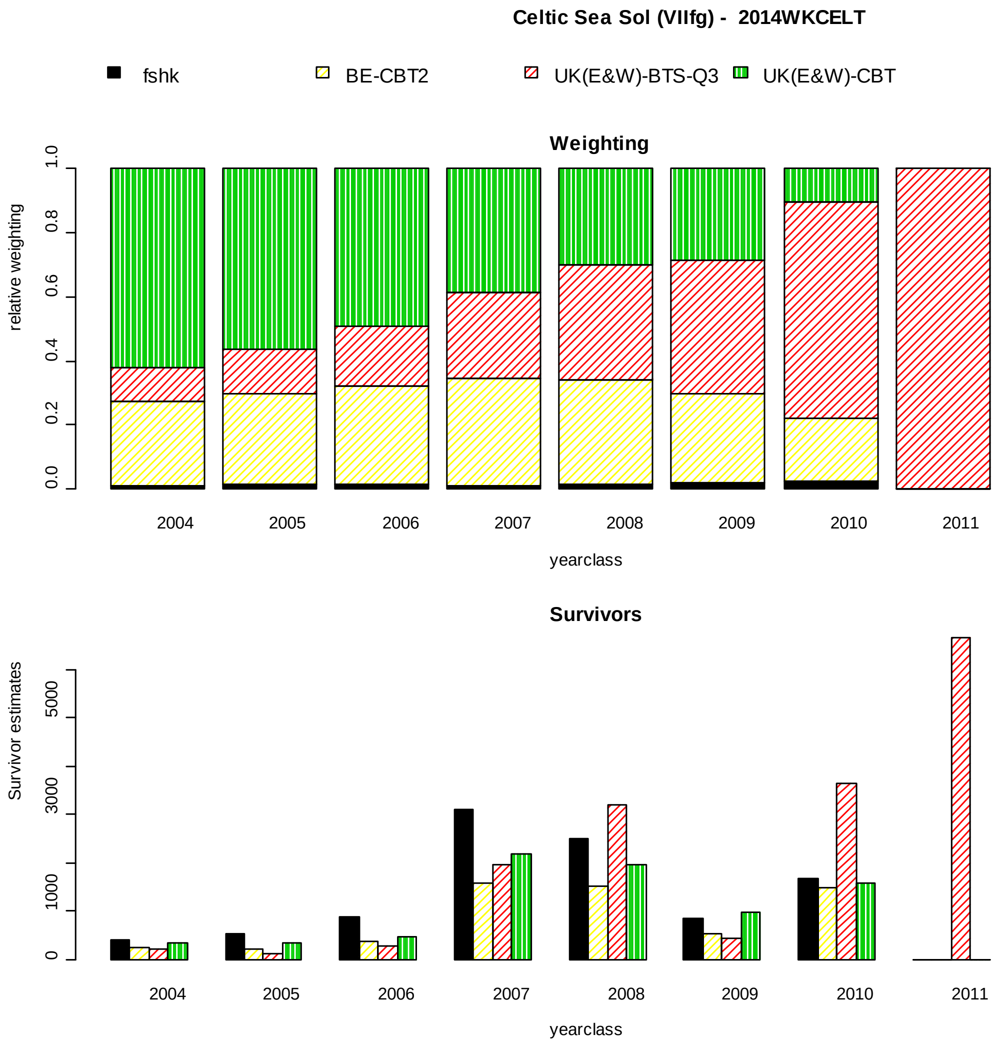


Figure 3.5.2.8 – Sole in VIIfg. Estimates of survivors from different fleets and shrinkage.

4 Celtic Sea whiting

4.1 Stock ID and substock structure

Whiting in the NE Atlantic extend from the Barents Sea and Iceland down to the southern Bay of Biscay. There are population genetics and tagging studies in the literature relating to stock structure and migrations, but the degree of separation between the Celtic Sea and surrounding stock(s) is not wholly conclusive.

4.1.1 Spawning Areas

English Channel ichthyoplankton surveys in June 1974 indicated that whiting larvae were present at inshore sites throughout the Channel (Pawson, 1995). They were most abundant around Beachy Head in the east and Start Point in the west, the areas where eggs were most concentrated in February, March and April. In September and October 1974, whiting larvae were not captured at coastal sites during ichthyoplankton surveys but small beam trawl surveys caught 0-group whiting at shallow inshore sites throughout the Channel. This indicates that whiting post-larvae adopt a coastal demersal existence by September and has been closely linked to Crangon abundance inshore and in estuaries (Henderson and Holmes, 1989).

Whiting was the most abundant whitefish larvae in abundance and frequency of occurrence during a large-scale larval survey around Ireland (Dransfeld *et al.*, 2004). Occurrence was mostly coastal with highest concentrations on the Saltees, Smalls and Fastnet in the Celtic Sea as well as Stanton to the north. No whiting larvae were recorded on the Porcupine Bank or much beyond the 200 m contour (Figure 4.1.1).

Juvenile Areas: Data from IBTS Q4 surveys show whiting juveniles in VIIb–k predictably around the west and southwest coast of Ireland as well as the south coast of Wales (Figure 4.1.2.). Survey catches occur persistently along the Irish west and southwest coastlines in area VIIb–k, as well as the southeast coast of Wales. Areas VIIb, g and j in Q4 at least are all therefore important juvenile areas for whiting.

By late summer 0-group fish settle out of the plankton, overwinter in more coastal shallow habitat and have been closely associated with inshore abundance of *Crangon crangon* (Henderson and Holmes, 1989). The same authors found in late spring many of these 0-group juveniles in estuarine habitats moved offshore never to return, while in more open marine habitats they often spent a further year in situ before recruiting to the adult stock as 1-group fish.

Adults are found in IBTS Q4 surveys around the British Isles coast and throughout the Celtic Sea shelf area, but generally in larger numbers on the Smalls commercial fishing grounds in VIIg (Figure 4.1.3).

Compared to haddock there is generally a higher signal to noise ratio for whiting from the same surveys, particularly in the area of the English channel, as well as higher variability in stock weights at age. This may suggest some stock mingling between the Celtic Sea, North Sea and/or Irish Sea in this area is a possibility.

4.1.2 Migrations

Pawson (1995) states there was "little indication of any migration" based on tagging of ~4000 individual in the western channel (1958-1960) with a return rate of 12-13% within 3 months. The main spawning areas of whiting in the Western Channel and Celtic Sea are off Start Point, off Trevose Head and southeast of Ireland (Anon, 2001).

The spawning season is from February to May, and the larvae are found in midwater before moving to live near the seabed by September. For the next two years, juvenile whiting are found in shallow coastal and estuarine areas, being particularly abundant around Start Point. Nearly 4000 adult whiting were tagged and released off Start Point during August 1958 and 1960. Most returns were within three months of release and demonstrated little indication of movement. Subsequent recaptures indicated more movement of whiting into the Celtic Sea than between the western and eastern Channel. Whiting released in summer between 1957 and 1961 near Carmarthen Bay moved south and west towards the two spawning grounds off Trevose and southeast of Ireland. There was no evidence of emigration out of the Celtic Sea area. Returns of whiting tagged and released in the County Down spawning area in the Irish Sea demonstrate more movement south into the Celtic Sea than north to the west of Scotland (Anon, 2001).

4.1.3 Genetics

A recent review by Reiss (Reiss, Hoarau, Dickey-Collas, and Wolff, 2009) of genetic population studies suggest there is little evidence of heterogeneity within the NE Atlantic whiting stock including the northern North Sea. In contrast differentiation within the North Sea has been reported upon as well some evidence of small-scale population structure of whiting within the Irish Sea.

Charrier *et al.,* 2007 using 7 microsatellites detected a low level of genetic structuring in Atlantic waters (compared with the North Sea) and found:

1. Genetic homogeneity from the Celtic Sea to the western Hebrides;
2. Whiting from the Bay of Biscay and especially those from the most southerly sampling site (Cape Breton) appeared genetically differentiated from more northern samples.

This latter low level genetic isolation is attributed to a weak anticyclonic gyre breaking off from the main North Atlantic Current west of Biscay (Charrier, Coombs, McQuinn, and Laroche, 2007). Stock differences are reported again by the same authors between NE Atlantic and the Irish Sea as well as potentially three distinct populations in the North Sea.

4.1.4 Transport routes

A recent review of 10+ years of ADCP, CTD and satellite tracked drifter data were combined with numerical modelling to highlight the importance of surface jet currents (Hill *et al.,* 2008). In contrast to tidal and episodic storm mixing, these thermohaline density driven currents are now thought the most significant contributor to shelf retention and transport systems (Figure 4.1.4) and in turn likely implications for stock isolation/mixing.

In summary, there are no strong justification to regard the whiting in VIIIe-k as a distinct closed stock. Rather, it seems this stock is linked at least to VIIb–c, perhaps even wider.

4.1.5 WKCELT decision on Assessment area

So far, the assessment unit for Whiting in the Celtic sea has been VIIIe–k, as indicated in Figure 4.1.5. The Divisions VII b-c have been regarded as a separate stock, for which no assessment or advice has been provided. The proposal from WKCELT was to merge the two areas to define the area as VII b–c and e–k. The reasons for that were the following:

- The management area is VIIb-c and e-k.
- There are no indications that whiting in VIIb-c is isolated from VIIe-k. Rather, both the studies outlined above and the length composition in surveys indicate that the VIIb-c is a juvenile area for fish that later on spreads into VIIe-k.
- The Irish Groundfish survey performs better in terms of consistency within year classes, when VII b-c is included. Merging the Irish Groundfish survey and the French EVHOE survey would include the VIIb-c as well.

4.2 Sampling and landings – revision of data

4.2.1 Historical landings

The spatial distribution of whiting 2012 landings data from the STECF database is mapped in Figure 4.2.1a. This shows that whiting landings were concentrated in several discrete areas in western waters and the North Sea. Within this stock area there are two main areas with higher volume of landings i.e. VIIg and the east part of VIIj (Celtic Sea Shelf) and VIIe (western Channel). The landings in VII b-k are mostly taken by Ireland (northern part) and France (southern part) Figure 4.2.1b.

For the current benchmark officially reported whiting landings were reconstructed back to 1904 from the ICES database (Figure 4.2.3). This shows that landings over time have fluctuated considerably. The underlying trend has been an increase in landings from less than 5000 tonnes in the 1950s to a peak of around 20 000 tonnes in the late 1980s and 1990s. Since then landings have shown a declining trend.

The composition by country of the landings is shown in Figure 4.2.4. Historically France has accounted for the majority of the landings. Since the mid-1990s the Irish proportion of the landings has increased significantly. French landings are made mainly by gadoid trawlers, which prior to 1980 were mainly fishing for hake in the Celtic Sea. Irish demersal trawlers from Dunmore East and Castletownbere and other ports in southwest Ireland have traditionally targeted Celtic Sea whiting in a mixed trawl fishery. In response to poor catches in other areas vessels have been attracted into this fishery in recent years from County Donegal.

4.2.2 Ageing quality

WKCELT discussed the Report of the Whiting (*Merlangius merlangus*, L) Otolith Exchange Scheme 2004 and Workshop 2005 (Easey, M., Henderson, G., and Shanks, A.M., 2005, http://ices.dk/community/Documents/PGCCDBS/whg.agewk2005.pdf). The workshop highlighted that whiting is one of the most difficult gadoid species to age because of difficulties in distinguishes true annual rings from background otoliths structure. This is particularly the case with Q4 otoliths where inclusion of the newly forming translucent edge zone as part of this year's growth, or new winter growth for the following year remains problematic. Overall the results indicated some tendency to over-age ages 2-3 and under-age ages 5-7, but that the age reading of whiting in the Celtic Sea was acceptable.

A further Age Validation workshop in 2013 (ICES, 2013; http://archimer.ifremer.fr/doc/00179/29052/27489.pdf) confirmed that high variability in growth of whiting from the same area confounds interpretation of the annular ring structure, but the ageing methods evaluated or final results were not significantly different. In addition confusion in some fish over the first annual zone as well as the limited area of whiting otoliths suitable for age determination further complicates this species.

In conclusion therefore any questions around quarterly age determination will have implications for internal consistency of indices. Studies at this point suggest ageing is reasonably consistent and reliable, but knowing the context trends in other biological parameters such as stock weights should be monitored closely to ensure data quality.

4.3 Discards

Discard data were provided to the benchmark meeting back to 1995 for Ireland and 2004 for France. The details of the Irish discard data are described in (Gerritsen, Irish whiting discards in VIIbgj – Evaluation of raising methods: Working Document to WKCELT 2014).

Post 2002 discard sampling for most countries within the EU Common Fisheries Policy (CFP) improved with the introduction of the Data Collection Regulation (DCR: 2002-2008) and associated funding. The DCR was then superseded by the Data Collection Framework (DCF: 2009-present). Despite improved sampling levels there was insufficient data to produce robust quarterly discards at age. Likewise applying an annual ALK was inappropriate given the growth rate of juvenile whiting. Therefore a knife-edge length split of length classes was used as a proxy for age.

The method of length split was applied to both the Irish and French datasets for input into the assessment. In order to extend the French time-series and take a slightly longer view in the assessment the French catch was estimated back to 1999 by proportion of landings to discards at age over the known time-series. The assumption of constant proportionality was discussed and seemed reasonable for this fleet and period.

The strong 1999 and weak 2005 year class is somewhat apparent in the Irish discards (Table 4.3.1). There appears to be a decline in 0-group and 1-group discards in the last 4-5 years. There is also a year effect in 2006.

French discards (Table 4.3.2) were significantly higher in the first 3 years of the time series. This is likely to be largely a function of the method of reconstruction back in time with limited data. The 2005 year class is again apparently weak. There is a slight increase in 3 and 4 year old discards towards the end of the time series.

4.4 Biological data

4.4.1 Maturity

Ogives for whiting from a working document to WGCSE 2013 on Maturity-at-age estimates for Irish Demersal Stocks in VIa and VIIabgj 2004-12 were presented and are given in Table 4.4.1, disaggregated by sex (Gerritsen WD01: WGCSE2013). Most fish appear mature at age 2, while maturity-at-age 1 is different between males and females, and between areas. To avoid undue fluctuations in SSB estimation due to uncertain maturity-at-age 1, it was decided to consider age2+ biomass as a proxy for SSB. This is in line with the practice for several other whiting stocks.

4.4.2 Weights at Age

Mean weight-at-age in the stock had been taken as mean weights-at-age in the quarter 1 landings. Where age 1 was poorly represented in quarter 1 landings, quarter 2 values were used as estimates of mean weight-at-age 1 in the stock. Stock weights-at-age were smoothed using a three year rolling average across ages to dampen the noise exhibited by the stock weight dataset.

With the inclusion of discards and consequential difficulty in generating quarterly mean weights at age, it was decided to use the NOAA NFT Calculator Utility (v2.1) which applies a Rivard correction to annual weights at age data to produce the January 1st whiting stock weights for the catch.

Mean and Rivard corrected stock weights are presented in Figure 4.4.1 with the latter showing a very stable pattern over the shortened time series up to age 4.

4.4.3 Natural mortality.

WKCELT decided to change the assumed natural mortality from the fixed value of 0.2 for all ages to values depending on the mean weight at age according to the Lorenzen power function. These values are probably more realistic, and bring the practice for this stock in line with the practice for other gadoid stocks in the area. The values are given in the text table below.

Age	0	1	2	3	4	5	6	7+
Nat.mortality	1.22	0.86	0.65	0.5	0.43	0.40	0.38	0.36

4.5 Tuning series

Historically several tuning series have been used in the assessment, both survey derived and commercial cpue. Those available are listed in Table 4.5.1. Some of these have been quite local, some have been discontinued and cpue series overall have tended to be sensitive to changes in fishing practices.

Both commercial fleets have been truncated at 2008 due to difficulties in generating effort data, while the UK survey series was formally discontinued. This left just the separate Irish and French surveys tuning the assessment which showed increasing noise in the older ages particularly.

The approach taken by WKCELT was to concentrate on a small number of tuning series that could represent the stock as a whole and that gave reasonably consistent representation of the year classes. In particular, local survey series were combined to provide series that cover most of the area. The final outcome of this process was two tuning series:

1. A combined groundfish survey index. This index is obtained by combining the Q4 IBTS survey of Irish Groundfish Survey (IGFS) in areas VIIb, g and j with the French EVHOE survey in VIIeh and j into the resulting index - IGFSEVHOE.

Both surveys extend to different areas within VIIbk, but overlap significantly in the Celtic sea and use a similar depth stratified random survey design. Notwithstanding that, effort is different between the surveys in different areas so to minimize any spatial or temporal bias within or between surveys and keep the index calculation as simple as possible it was decided to combine the survey data using a simple spatial grid (Figure 4.5.1).

The grid cell size was generated to maximize the number of paired survey data within a grid cell in the area of overlap. By applying an ALK per haul the average number-at-age per grid cell can be estimated. Thereafter the average number-at-age over the entire grid is used to provide the index. The effect of any within cell changes in effort are therefore dampened out by use of cell mean.

The grid method and cell size was based on a previous analysis used for Celtic Sea cod (WD 12, WKROUND 2012).

2. The FrOTB is a commercial otter trawl tuning fleet derived with effort in hours fished reported in logbooks and with the landings age structure for France scaled to the landings of that fleet (which is the main fleet landing whiting).

In addition an Irish commercial Otter trawl fleet (6) was examined. This fleet was derived using landings and effort for non-Nephrops directed fishing effort for a group of rectangles on the shelf in VIIb, j, g. The LPUE series shows marked changes in LPUE from year to year. The series has not been standardized to take account of changing fishing pattern or vessel characteristics and may not be an accurate representation of underlying abundance of whiting. The log catch ratios also show some very large values and fluctuations. Although an exploratory XSA was carried out with this fleet included this resulted in unsatisfactory residuals and WKCELT concluded that it should not be used for tuning the assessment.

4.6 Stock assessment

4.6.1 Revisions made

The following major changes could be made at this benchmark:

1. Including Divisions VIb-c in the assessment unit;
2. Including discards data;
3. Merging the Irish Groundfish survey and the French EVHOE survey to provide one annual survey (IGFSEVHOE) that covers the whole management area;
4. Revised natural mortalities;
5. Revised weights at age;
6. Knife edge maturity-at-age 2. Essentially, the 2+ biomass is used as a proxy for SSB.

For the time being, it was decided to maintain XSA (FLXSA software) as the standard assessment tool. Some preliminary exploration was done with SAM, which were promising, but did not reach a stage where this approach could be considered as an alternative for the immediate future. Other methods were discussed briefly, but due to lack of time, manpower and expertise, these could not be pursued further.

4.6.2 Exploratory XSA runs

Several exploratory XSA runs were made, mostly to explore inclusion of various tuning fleets.

At the end, WKCELT concentrated on XSA runs with three options for tuning series:

Run 1: Both IGFSEVHOE and FrOTB
Run 2: IGFSEVHOE only
Run 3: FrOTB only

The runs were made with FLR, with the conditioning tabulated in Section 4.6.3.

Previous explorations of the XSA settings by WGCSE indicated that age 5 was the most appropriate age for the q plateau. Catchabilities after that age were relatively similar and setting it at 5 reduced the number of model parameters slightly. Using an F Shrinkage of 1.0 over the 3 oldest ages for the last 5 years resulted in scaled weights in the order of 20-30% for most ages. This helped to stabilize the assessment whilst not being overly dominant in the survivor estimates. There was insufficient time at WKCELT to explore the XSA settings further with the revised catch-at-age matrix but WKCELT suggests that this is something that could be examined further in future.

Diagnostic results from the XSA runs are presented in Figures 4.6.1 and 4.6.5. The main estimates for these runs (and FLSAM) are presented in Figure 4.6.6.

These exploratory studies indicated that the FrOTB series performed less well with respect to year class consistency, and it created problematic residuals and retrospective errors. Therefore, it was decided to use Run 2, i.e. tuning with only the IGFSEVHOE survey series as the final assessment.

4.6.3 Final run

The final settings for Run 2 were:

- Catch data for 14 years 1999 to 2012. Ages 0 to 7.
- cpue (Survey) data:

  Fleet First age Last ageFirst yearLast yearalphabeta

1: IGFSEVHOE0520032012<NA> <NA>

- Tapered time weighting not applied
- Catchability independent of size for all ages
- Catchability independent of age for ages >5
- Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages.
- S.E. of the mean to which the estimates are shrunk =1
- Minimum standard error for population estimates derived from each fleet =0.5
- Prior weighting not applied
- Regression weights: 1 for all years and ages

The WKCELT considered that the revised XSA including discards, revising the M, using only IGFSEVHOE for tuning and with the conditioning above, behaved well enough with respect to residuals and retrospective error to propose it as a provisional assessment method for the coming years. Accordingly, the assessment can be a basis for a Category 1 advice.

FLSAM

An exploratory state space assessment model (SAM: Nielsen and Berg, 2014)) was performed using a combination of the FLR wrapper FLSAM (Payne and Hintzen, 2013) and directly via the sam.tpl file in the command line. SAM treats population abundance and fishing mortality-at-age as unobserved latent states and treats catches and survey/fleet indices as observations. The parameters to be estimated in the state space model are generally: process side: parameters of the transition equations of the latent variables (e.g. autoregressive parameters for an AR process on the states) and accompanying process error variances; and measurement-side: the measurement equation parameters (e.g. catchabilities, non-linear exponents) and measurement error variances.

The exploratory run conducted for whiting VIIbc, e-k was based on the combined EVHOE and IGFS survey and FR-OTB tuning index (run 1 of XSA runs). The SAM settings used for the run were:

1. Independent random walks on the F-states by age
2. Independent process variance on the F random walks by age
3. Independent process variance on the abundance random walks by age
4. Independent catchabilities by age by index
5. Independent observation error variances by age by index

This implementation is almost certainly over-parameterized (46 parameters fit using short series). The model did converge (as indicated by small final gradients and a positive-definite Hessian matrix), yet some parameters remain at the boundary of their settings in the returned .std parameter file produced by ADMB. Extensive further work is required to fix these fitting issues and expand the model structure to better represent the nature of the whiting fishery. Model inference is also possible with SAM via AIC or alternative measures of goodness-of-fit. It should therefore be possible to obtain a best fitting model, which balances increases in the likelihood with the number of parameters estimated.

Residual diagnostics are similar for the FR-OTB fleet and arguably better for the combined survey index (Figure 4.6.7.), as compared with the XSA equivalents.

A summary comparison with the XSA fits is given previously in Section 4.6.2 above and shows a somewhat similar -though more smoothed- trend in SSB and recruitment and a vastly smoothed Fbar trajectory. Inspection of the estimated parameters showed that the measurement error variances were high on the catches from the young ages (0-2), which when coupled with low process error variance smoothes the fitted F values. These are clear indications that more work is needed on these fits, including detailed explorations of the process equation, perhaps including mixture process errors (e.g. a mixture of Gaussian and t-distributed errors, Kitagawa (1987)) that would admit large sudden changes in F, which are harder to achieve under a simpler Gaussian random walk assumption. Such approaches may be particularly suited to the whiting fishery in the region.

Notwithstanding the fit issues, SAM has many advantages over traditional approaches in explicitly modelling sources of process and measurement error variance and balancing flexibility with tractability and the benchmark working group recommends further development work on a SAM model for Whiting VIIb, c, e-k.

In conclusion, FLSAM model has the potential to handle the observed noise in the input in a more satisfactory way than XSA. The trends in F, SSB and recruitment are broadly similar to those by XSA, although the trend in F in particular is almost flat and may be driven by model assumptions. The SAM approach looks promising and should be pursued further, but has not yet reached a stage for this stock where it can be recommended as a standard assessment.

As a final note, using FLR greatly facilitated inter-run comparisons across settings and methods. Without this valuable framework the main and exploratory runs would not be possible given the short time available.

4.7 Reference points

Since there is now an acceptable, although provisional assessment, and the conditioning has been revised, a revision of the reference points was needed.

4.7.1 Blim

There is no apparent stock–recruit relationship in the short period that is covered by the assessment (Figure 4.7.1). The lowest observed, rounded to the nearest thousand tonnes, is proposed as Blim. The value is 25 000 tonnes.

4.7.2 Yield and biomass per recruit.

Stochastic equilibrium values were obtained with the HCS software (Skagen 2013), with the following conditioning:

Recruitment: Hockey stick model with breakpoint at 25 000 tonnes, and level at 903 million, which is the geometric mean of the time series. Sigma =0.435, which is the SD of the log transformed recruitments in the period. The underlying stock–recruit data are shown in Figure 4.7.1

Weights at age: Weights have fluctuated over time (Figure 4.7.2). The assumed weights are averages over the years 2010–2012. The variability is the SD in a lognormal distribution covering the whole period.

Maturity-at-age. Knife-edge maturity-at-age 2.

Selection at age: The selection has been relatively stable (Figure 4.7.3), although with some recent reduction at age 2. The mean and CV over the whole period was used. HCS accounts for variable selection indirectly, as noise to the realized catches-at-age in the implementation step.

Natural mortality. Lorenzen estimates as in the assessment.

Simulations. The stock was projected forward for 98 years, with a range of fixed fishing mortalities, and with recruitment, weights and selection as stochastic variables. In Figure 4.7.4, statistics of 1000 iterations of catch and SSB are presented for year 98, which are taken to represent a stochastic equilibrium. Also, the risk to Blim, a deterministic yield and SSB per recruit raised to the mean recruitment as well as the F0.1 are presented. The risk is the percentage of bootstrap trajectories that were below Blim in year 98.

4.7.3 Proposed reference points

Blim: As noted above, Bloss (25 000 tonnes) is proposed for Blim. The risk to Blim starts to rise at F around 0.5, which could be a Flim. For FMSY, F0.1 would be a candidate. The 10 - percentile of SSB at F0.1 is 40 000 tonnes, which could be a candidate for BMSY trigger. That would represent a level of SSB that is unexpectedly low if F is maintained at FMSY, and give BMSY trigger at 60% above Blim.

It should be noted that these values have been derived assuming the relatively high weights at age that have been seen in recent years. If growth changes in future, reference points that have been derived from yield and biomass per recruit calculations may have to be revised.

The text table below summarizes the proposed values

	Value	Basis
Blim	25 000	Bloss
BMSY trigger	40 000	Lower bound of expected range at F0.1
Flim	0.5	Increasing risk to Blim
FMSY	0.32	F0.1

4.8 Multispecies and mixed fisheries issues

The VIIb–k whiting stock is primarily targeted by otter trawlers and to a lesser extent Scottish seines and beam trawls. Effort of otter trawlers has remained relatively stable within the Celtic Sea as a whole. Several main species groups are targeted by otter trawlers catching whiting as part of a targeted mixed gadoid fishery and also as by-catch within hake, anglerfish, and megrim fisheries as well as the smaller mesh Nephrops targeted fleet.

4.9 Ecosystem drivers

A summary document of the physical and biological features of the Celtic sea ecosystem is available (Anon, 2013)

- Long-term datasets (1958) from the Malin shelf indicate a steady increase in SSTs.
- Time series dataset (1990–2010) of phytoplankton species are increasing in coastal waters south and southwest of Ireland.
- Long-term time series since 1958 show a decline in overall zooplankton abundance and a northward shift of warm-water zooplankton Calanus into Celtic Sea.

The general increase in sea surface temperature is expected to increase larval development rates during the pelagic phase and as a consequence larval mortality may decline. However the larval retention mechanisms may also be impacted so the cumulative impact on recruitment maybe difficult to forecast. UWTV surveys offer and opportunity to monitor oceanographic variables using a sled mounted CTD. This information is relatively easy to collect and over time will augment the knowledge base on the oceanographic regime in FU19.

4.10 Impact of the Fishery on the Ecosystem

Demersal trawling modifies the benthic community structure and also has the potential to modify the physical habitat. The frequency of this demersal trawl impact has been assessed using VMS data (Gerritsen *et al.*, 2013). In the Irish EEZ of the Celtic Sea, 68% was impacted at least once by trawling, a considerable portion of the area (46%) was impacted at least twice, 13% of the area was impacted at least five times, particularly along the continental shelf. Some regions (<2%) were impacted ten times or more. While there are no direct studies on the impact of trawling on the benthic communities it might be expected that these grounds are highly modified environments.

Table 4.3.1 Irish discard numbers-at-age.

Discards No At Age Ireland

	0	1	2	3	4
1995	10,131	14,784	2,665	84	-
1996	615	4,150	2,657	927	41
1997	660	4,414	11,050	1,813	152
1998	1,347	4,980	9,295	1,273	15
1999	4	1,206	5,421	411	-
2000	1,376	3,793	3,685	209	-
2001	1,180	3,799	23,740	467	-
2002	1,717	4,302	21,602	1,260	6
2003	2,785	9,203	6,785	1,082	73
2004	2,170	22,778	9,533	715	25
2005	262	5,977	23,120	3,803	86
2006	4,812	27,024	34,976	2,468	293
2007	903	12,853	28,608	3,229	44
2008	719	5,112	7,610	876	14
2009	347	6,129	13,793	1,372	6
2010	288	2,390	7,000	2,255	404
2011	371	3,305	3,563	1,251	110
2012	120	4,233	3,786	1,664	232

Table 4.3.2 French discard numbers-at-age.

Discards No At Age France

	0	1	2	3	4
1999	4898	14133	9018	1482	134
2000	6040	17428	11120	1384	83
2001	6925	19985	12751	1456	61
2002	2514	7254	4628	2464	78
2003	608	1755	1120	813	199
2004	56	1016	246	53	0
2005	1069	3341	1717	250	18
2006	22	293	824	187	25
2007	36	83	10	0	0
2008	725	1558	909	122	1
2009	122	478	391	78	5
2010	23	829	1053	170	14
2011	293	650	948	245	23
2012	17	421	1011	333	32

Table 4.4.1 Estimated proportions mature (sample numbers in brackets) by stock, sex and age. Maturity ogives used by the WG are also given.

Stock	Sex/WG	1	2	3	4	5	6	7
whg-7b-c	F	0.23 (195)	0.94 (176)	1.00 (79)	1.00 (17)	1.00 (10)	1.00 (1)	1.00 (1)
	M	0.52 (197)	0.82 (127)	1.00 (62)	1.00 (18)	1.00 (8)	1.00 (2)	1.00 (1)
whg-7e-k	F	0.34 (231)	0.99 (195)	0.96 (137)	0.96 (66)	1.00 (19)	1.00 (4)	1.00 (1)
	M	0.60 (265)	0.94 (187)	0.95 (129)	0.88 (41)	0.87 (17)	1.00 (4)	
	WGCSE	0.39	0.90	0.99	0.99	1.00	1.00	1.00

Table 4.5.1. Tuning fleets used in whiting VIIek assessment at WGCSE 2013.

Fleet	First year	Last year	First age	Last age
"FR-GADOID-late": Fra Commercial	1993	2008	3	6
"FR-NEPHROPS-Late": Fra Commercial	1993	2008	3	6
"FR-EVHOE": Fra Survey	1997	2012	0	4
"UK-WCGFS": UK Survey	1987	2001	1	6
"IR-GFS-7G-SweptArea": Irl Survey	1999	2012	0	6

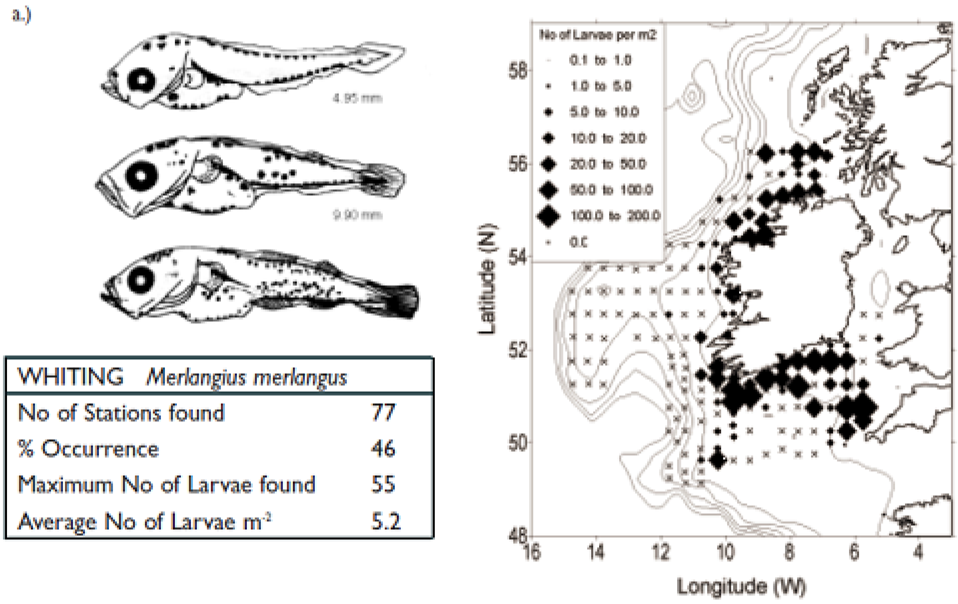


Figure 4.1.1 Distribution of whiting larvae from *Dransfeld et al.*, 2004.

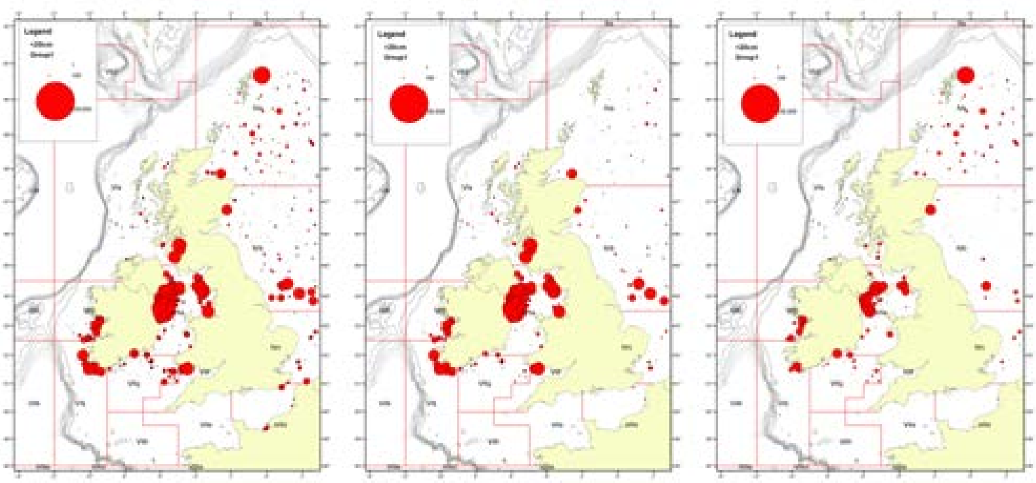


Figure 4.1.2 IBTS Q4 catches of juvenile whiting 2010–2012. Juveniles classed as those <20 cm. Catches occur consistently along the Irish and Welsh southwest coastlines in area VIIb-k, as well as the southeast coast of Ireland.

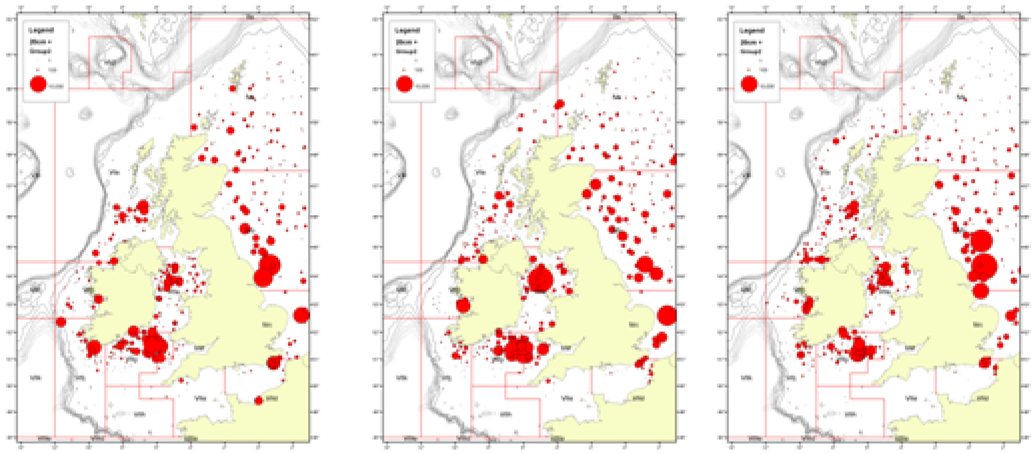


Figure 4.1.3 IBTS Q4 catches of adult whiting 2010–2012. Adults are classed as those ≥20 cm and are generally found in larger numbers on the Smalls commercial fishing grounds in area VIIg.

Fig 4.1.4 Schematic map of principal summer thermohaline transport pathways on the northwestern European shelf and the cold and salt pools that drive them. Orange shaded areas, regions where seasonally formed bottom dense pools are influenced by both cool winter temperatures and salty oceanic water which has penetrated the outer shelf. Light blue shaded areas, regions where only temperature is responsible for the density of dense water trapped below the seasonal thermocline. Green arrow, European slope current. Red arrows, frontal jets associated with bottom fronts at boundaries of dense cold and salt pools.

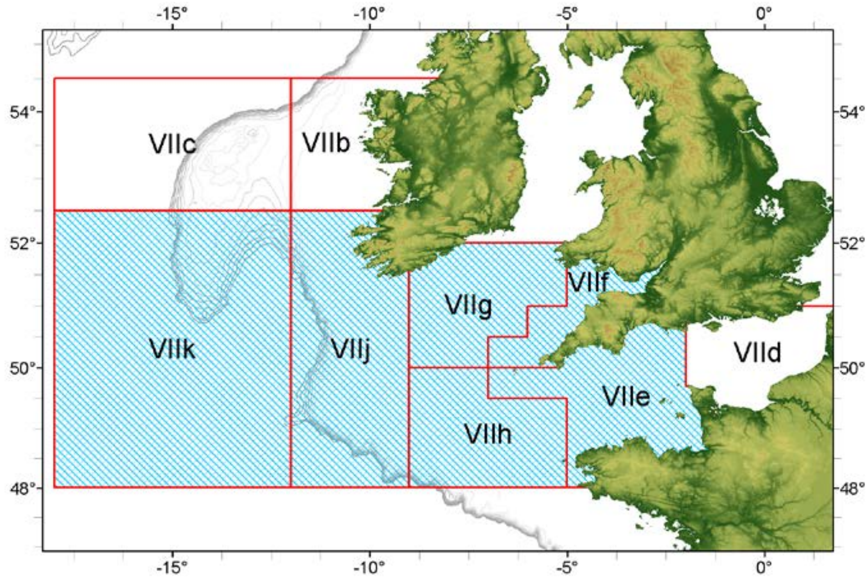


Figure 4.1.5 Red Boxes-TAC Management Area; Blue Shading - Historic Assessment Area.

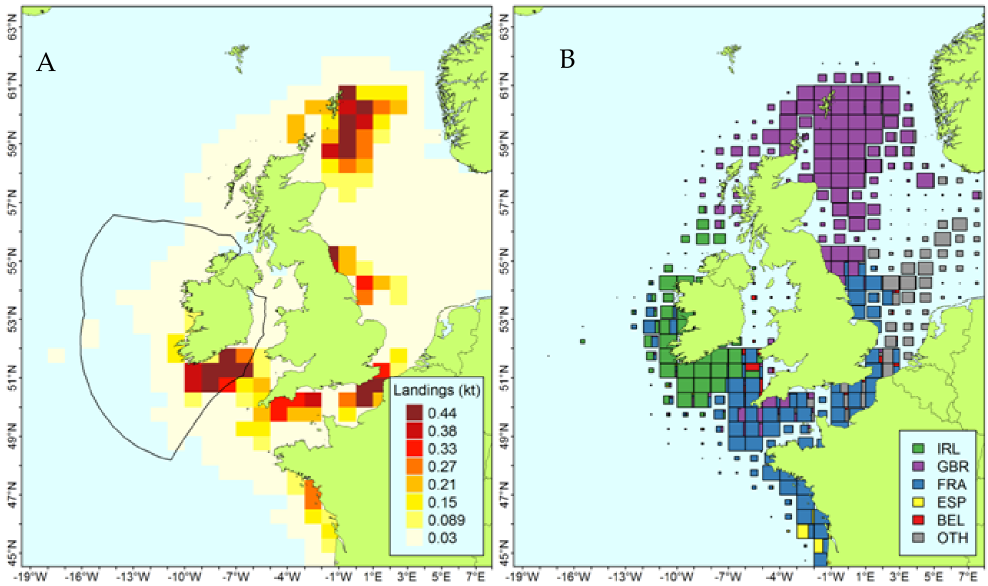


Figure 4.2.1 STECF Landings in Kt are given in panel A, with landings by country given in panel B.

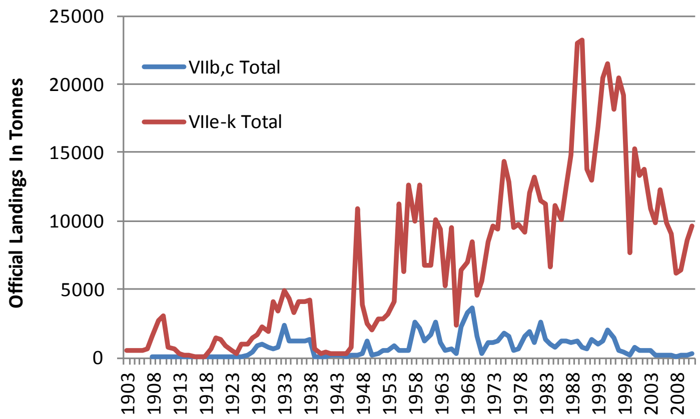


Figure 4.2.3 Historic landings for whiting in Area VIIek and VIIbc from ICES database.

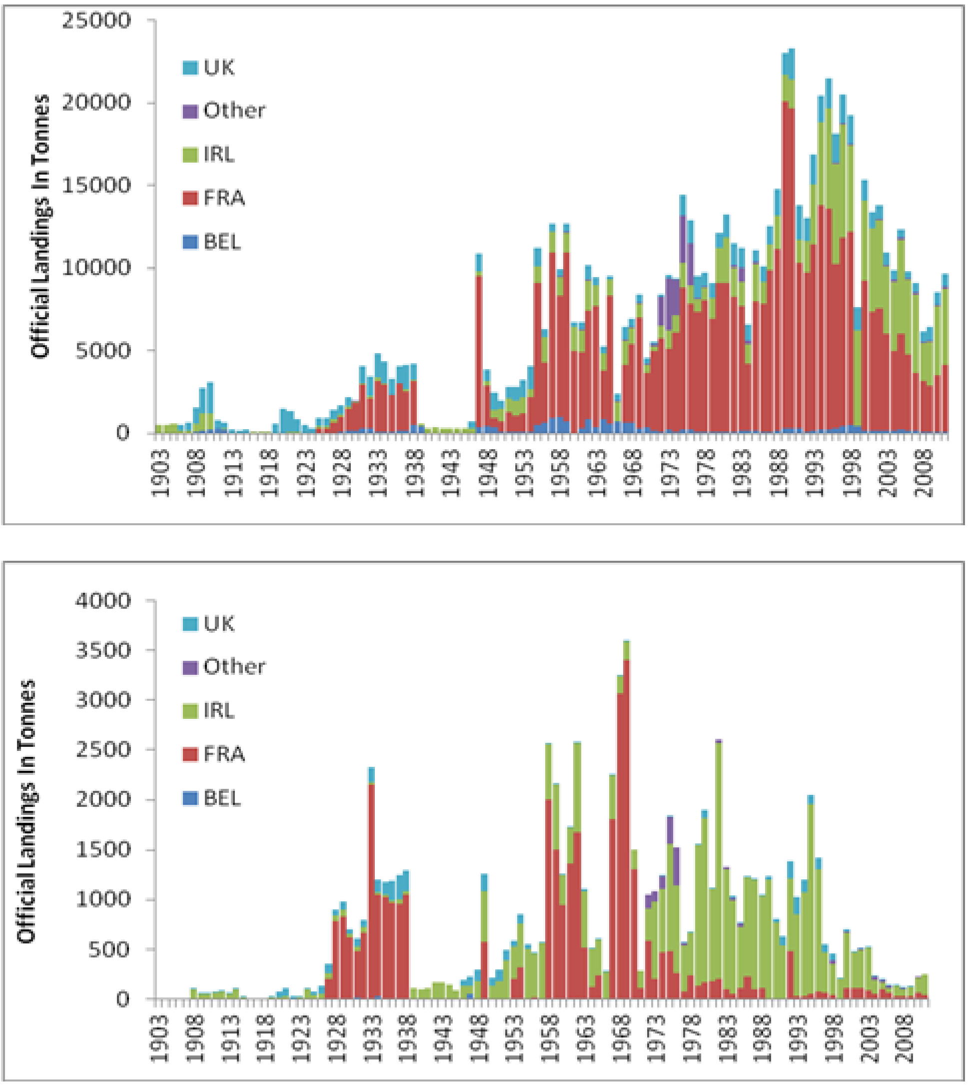
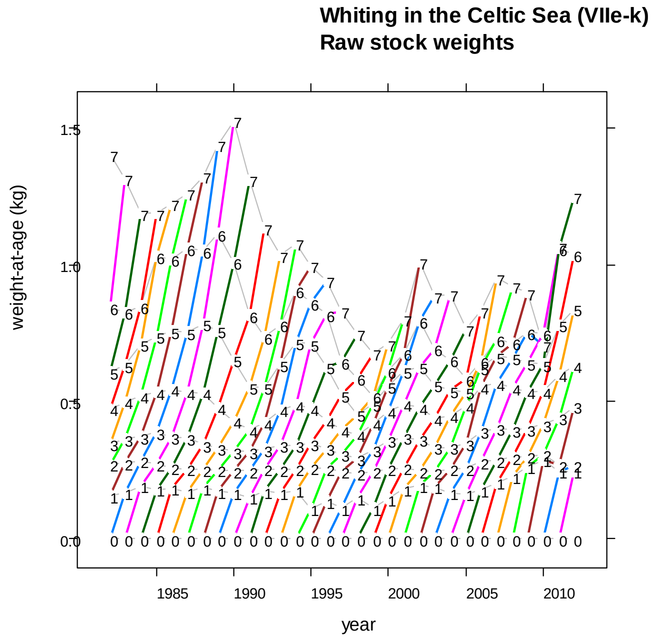


Figure 4.2.4 Time series of landings by country from ICES showing VIIek above and VIIbc in lower panel.



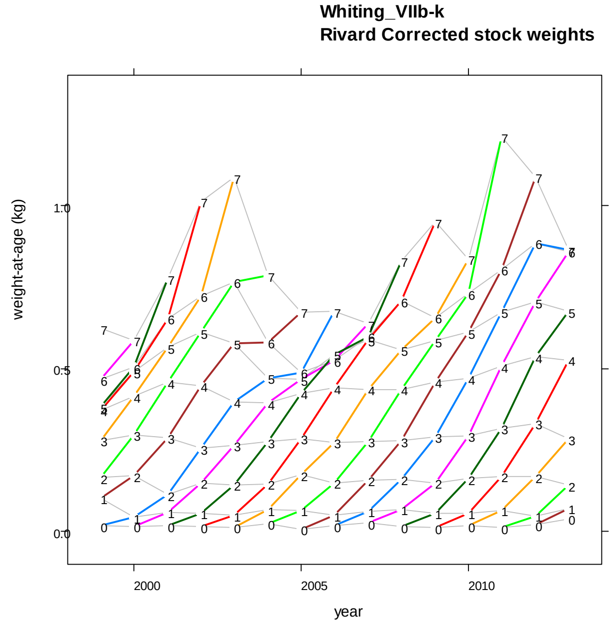


Figure 4.4.2.1 Stock weights for whiting landings in VIIek are given in upper panel, raw weights smoothed to 3 year average. Lower panel presents the stock weights for whiting catches in VIIbc, e-k from Rivard corrected annual mean catch weights at age.

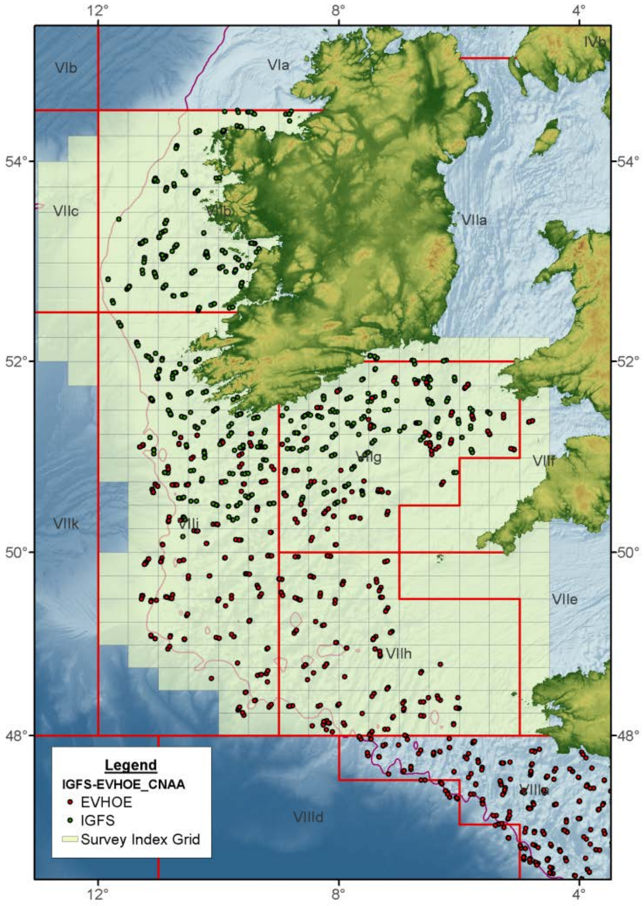


Figure 4.5.1 Spatial distribution of the IGFS and EVHOE survey series of whiting data used to produce the IGFSEVHOE combined survey index. Grid cell size is 0.25° Latitude by 0.5° Longitude.

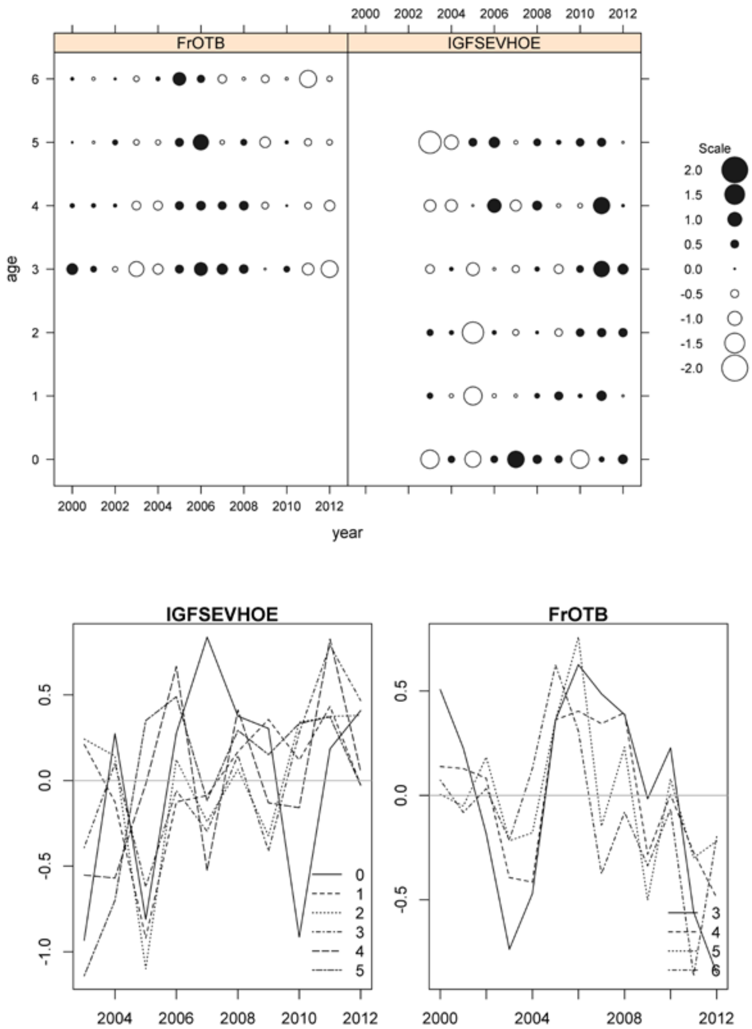


Figure 4.6.1 Bubble residual plots (Upper panel) and line plots (Lower panel) for the two tuning fleets in the XSA (Run 1). Left panel is the combined IGFSEVHOE survey index, right panel is the French commercial OTB tuning fleet. A significant trends can be seen in the commercial data.

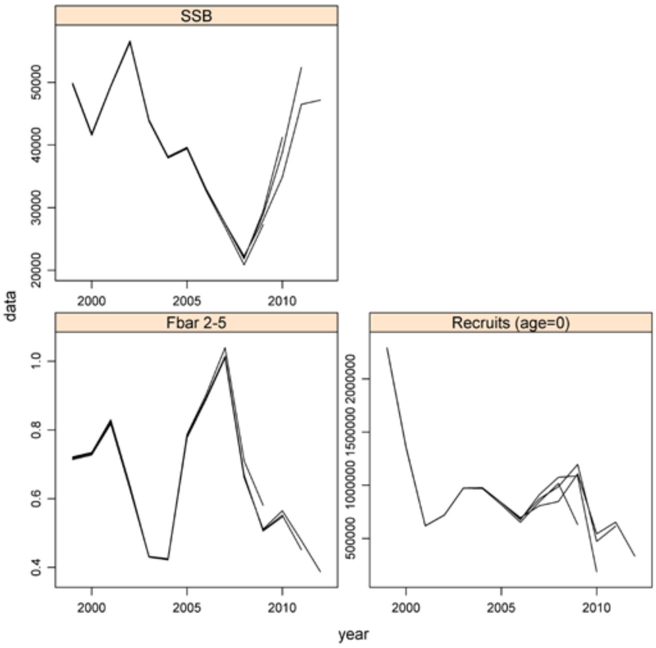


Figure 4.6.2 Retrospective plots for Run 1.

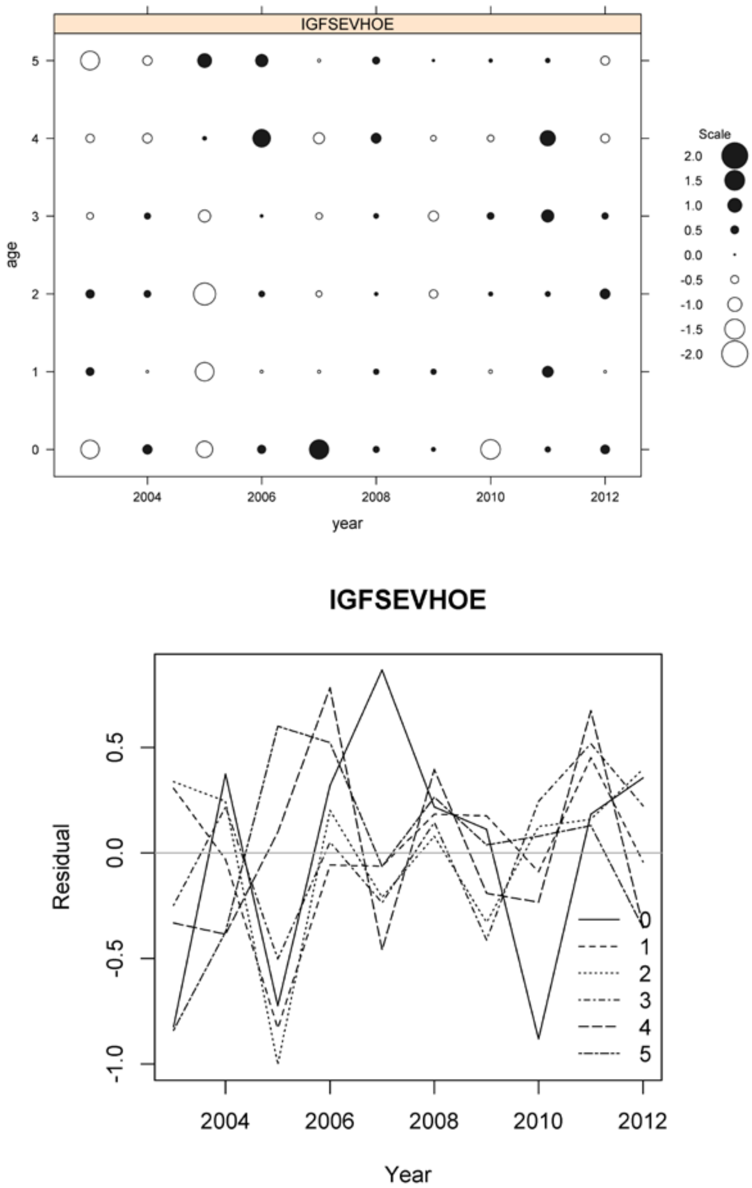


Figure 4.6.3 Bubble residual plots (Upper panel) and line plots (Lower panel) for the XSA run using the survey tuning fleet only – IGFSEVHOE (Run 2). There doesn't appear to be a significant trend in the residuals.

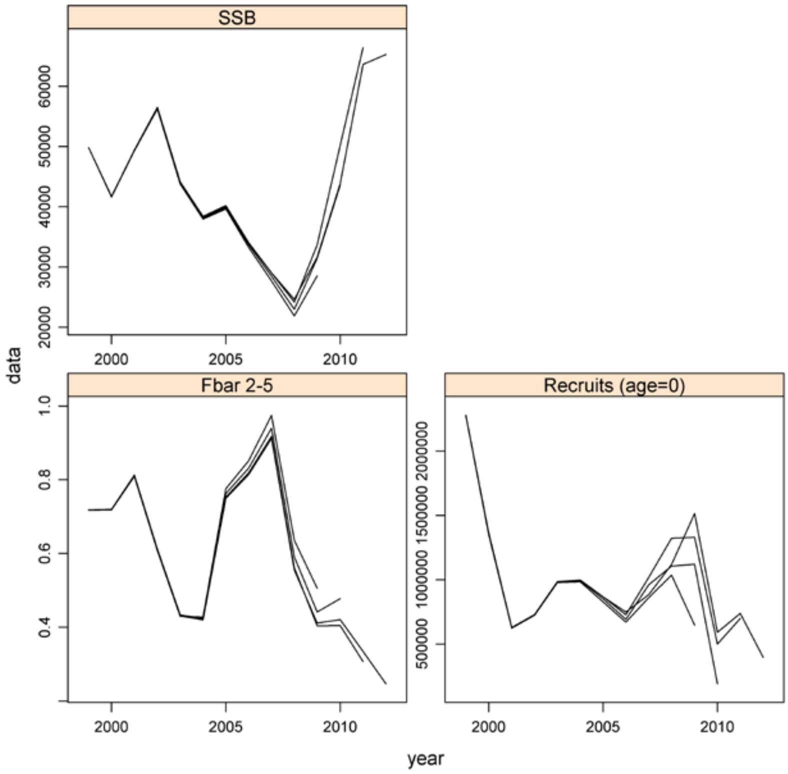
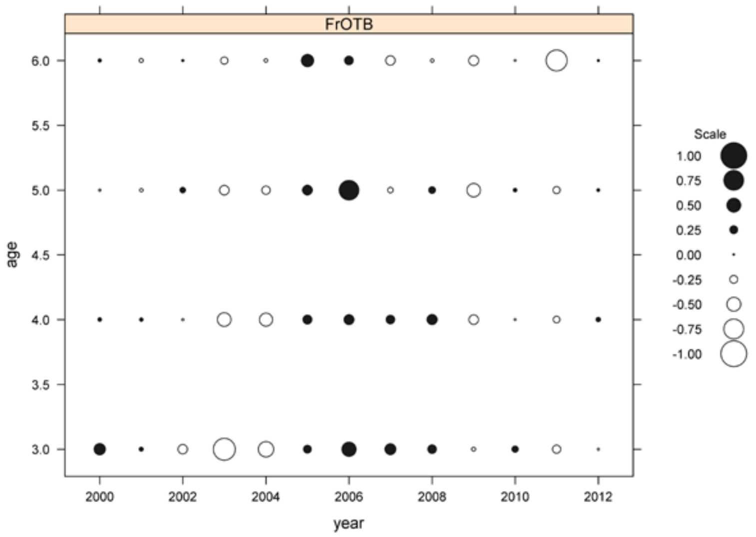


Figure 4.6.4 Retrospective plots for Run 2. Revisions to SSB and Fbar are small and random, while recruitment tends to be revised consistently upwards.



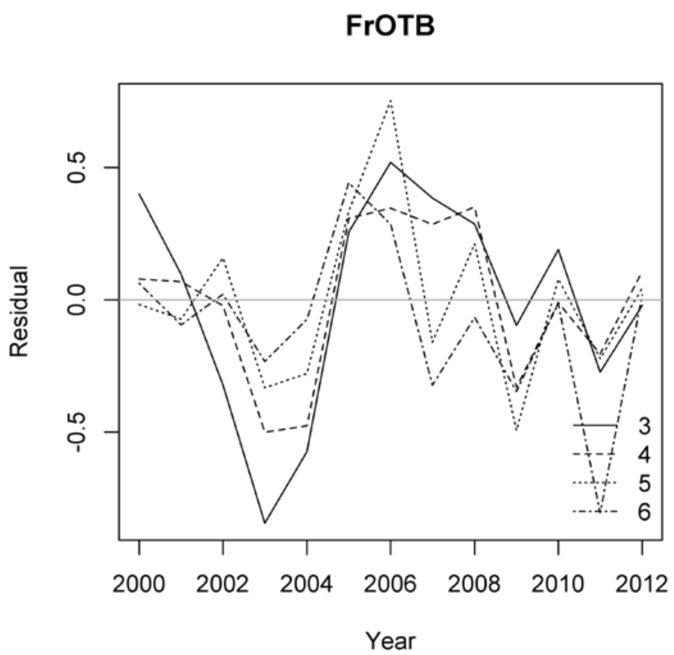


Figure 4.6.5 Bubble residual plots (Upper panel) and line plots (Lower panel) for the XSA Run 3 using the commercial tuning data. There are significant positive and negative trends in the residuals.

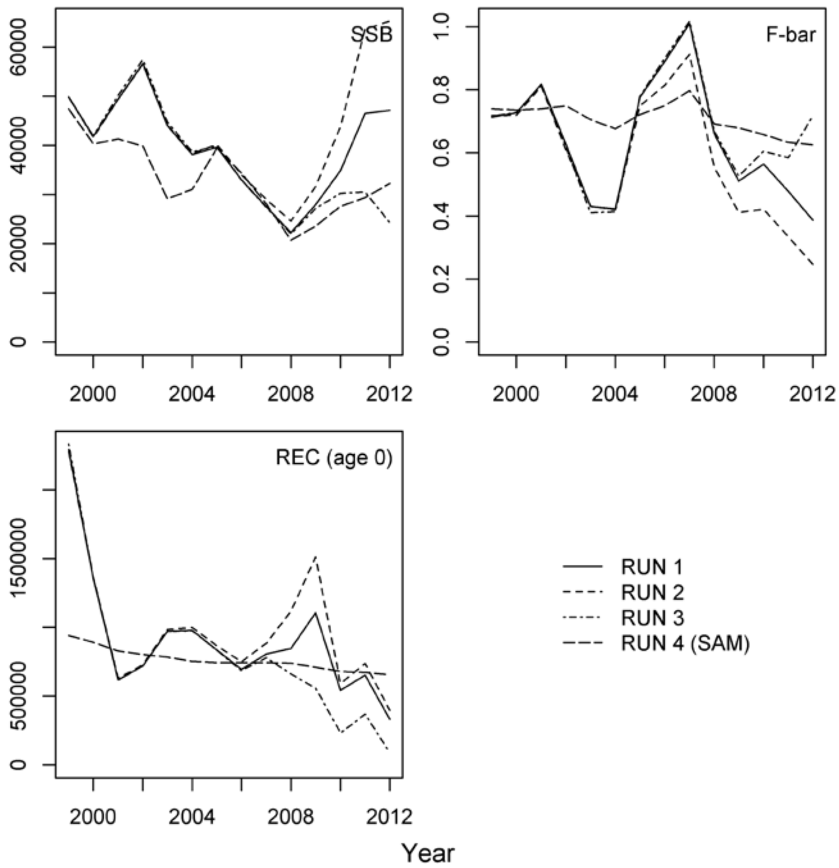


Figure 4.6.6 Inter run comparisons of combined and the two single fleet runs as well as SAM.

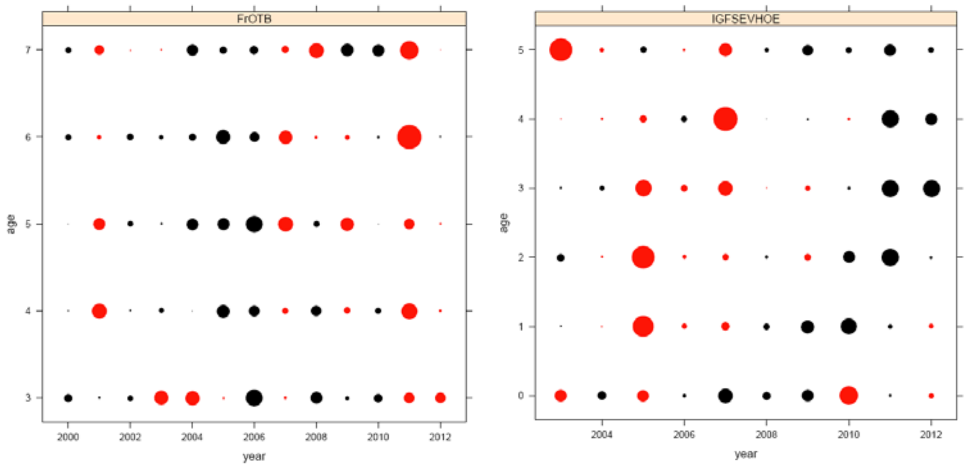


Figure 4.6.7. Residual plots from SAM Run 4. Commercial tuning FrOTB data are presented in the left panel, the combined survey index IGFSEVHOE is in the right panel.

Figure 4.7.1 Stock recruit data used in deriving reference points.

Figure 4.7.2. Weights at age used in deriving reference points.

Figure 4.7.3. Historic selection at age.

Figure 4.7.4. Long-term equilibrium Yield and SSB

4.11 References

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5 Nephrops in FU 19

5.1 Stock ID

VMS and Seabed mapping Data

In FU19 Nephrops are caught on a large number of spatially discrete small inshore grounds and on some larger grounds further offshore (Figure 5.1.1.). These grounds have been named as Bantry Bay, Galley Grounds 1-4, Cork Channels and Helvick 1-2. WKCELT redefined the area of these discrete polygons using 2006–2011 integrated VMS-logbook databased on the methods described in Gerritsen and Lordan (2011) where Nephrops directed activity was defined for VMS pings where >30% of daily operational landings was reported to be Nephrops (Figure 5.1.1). Available MBES backscatter (multibeam echosounder) and bathymetry data from the Irish National seabed mapping programme (www.infomar.ie) was overlaid on the VMS data to further refine the areas (Figure 5.1.2). The MBES backscatter data indicates sediment hardness where soft substratum produces light grey colouration whereas harder sub-strata appears darker as acoustic signal returns strongly from a hard surface and is absorbed in soft ground. Bathymetry data also aids in defining channels which comprise of soft sediments.

Other ancillary data such as groundfish survey stations with *Nephrops* catches from Irish and French surveys, sediment PSA data – (particle size analysis) from infomar surveys were mapped to check boundaries of these polygons (Figure 5.1.1). The locations of these grab samples have been mainly determined by the seabed classification made from the multibeam data. Table 5.1.1 shows the data sources available. The revised polygons were manually drawn and the area calculated using different projections in Arc GIS 10.

VMS and backscatter data overlays and how this is interpolated to redefine Galley Ground 1 are depicted in Figure 5.1.3. The distinct area of light grey indicates softer sediment and links well with the VMS pattern of high *Nephrops* landings. Figure 5.1.4 of Galley Ground 2 was revised using VMS data only .The available backscatter data does not cover the entire patch and indicates a general soft sediment type in the area. Figure 5.1.5 of the Galley Ground 3 shows the variation in the backscatter data where the dark and light grey patches indicate variability in the sediment and also the VMS picks up this to some degree. Figure 5.1.6 of the offshore Galley Ground 4 was revised using VMS data where the blue patterns indicates *Nephrops* landings of about 50–60 %. There are some channels of blue patterns which are more than likely trawl tracks corresponding to soft sediment type.

Figure 5.1.7 of the data overlays for Helvick 1 illustrates that there is a sharp transition from soft to hard sediment in the SW of this patch which also corresponds to the VMS data. For Helvick 2-3 grounds only VMS data are available (Figure 5.1.8). This shows a striking pattern of *Nephrops* landings. The collapsing of these two areas into one is sensible as it is highly likely to be a channel of mud corresponding to a trawl track. Bathymetry data overlay highlighted the channels of soft mud in the Cork Channels ground (Figure 5.1.9). These channels are thought to be remnants of fluvial channels related to the deglaciation of the Irish ice sheet at the end of the last ice age. Available data for Bantry Bay (Figure 5.1.10) shows a harder type sediment close to the shore and the VMS pattern of *Nephrops* landings extends into the inner bay.

The revised areas of each discrete polygon is shown in Table 5.1.2 using different projections in Arc GIS 10 and the average value is taken as the final area. The re-definition of the polygons in FU19 resulted in a 16% increase in overall area from 1653 km² to 1973 km² (Table 5.1.3). From other data sources such as groundfish surveys and observer data there are catches of *Nephrops* outside the defined discrete patches, however, these are deemed to be minor at present. WKCELT concluded that the current area estimation of 1973 km² is acceptable as the total area of this stock. WKCELT recommended that the area is subject to refinement when additional backscatter data becomes available, further sediment sampling and improved VMS data to include vessels of size 12 metres. Also any future area revisions are to be considered by WGNEPs.

Larval Tracking Models

Adult *Nephrops* are territorial and not thought to undergo much movement on the seabed so that adult populations can be considered as separate stocks. Recent larval tracking studies using both Regional Ocean Modelling System (ROMS) and a larval transport model (LTRANS) for *Nephrop*s in the Celtic Sea has explored the potential connectivity between proximal and distant *Nephrops* grounds (O'Sullivan *et al.*, *in press*). This study differentiated between larval retention and dispersal as there are important consequences for stock connectivity. The study demonstrated that the *Nephrops* grounds in FU 19 are linked in a metapopulation state whereby some grounds are donors of larvae and others retainers. A connectivity matrix table presented by O'Sullivan et al describes the percentage of larvae that are retained over the same ground from which they are hatched or transported to adjacent grounds following the pelagic larval phase. From this the Galley Ground 4 retains larvae but also donates to the Labadie grounds (FU 2021), Cork Channels grounds donates larvae to three other grounds, Helvick patches donate to 4 grounds in FU 19. WKCELT concluded that the results from this study were important to stock assessment demonstrating the inter-connectivity of the *Nephrops* grounds in FU 19 and the *Nephrops* grounds in the wider Celtic sea. WKCELT recommends that this research be revised when updates to annual oceanography data are available.

5.2 Issue list

For this FU the benchmark process considered the following issues identified by WGCSE 2013:

- Spatial extent of the *Nephrops* grounds could be improved.
- Inputs to Separable Cohort Analysis (SCA) Bell model should be investigated.
- Growth and natural mortality parameters should be examined.
- The utility of the Irish groundfish survey and other survey information for this stock should be examined
- The reference points would also need reconsideration based on the update assessment information.

5.3 Scorecard on data quality

The WKACCU scorecard approach was followed to quantify bias in fisheries data, evaluate the quality of data sources used and identify steps in data collection process that must be improved (ICES, 2008a). The text table below is the scorecard of the key parameters that are scored to evaluate potential bias in data used for stock assessment.

	No bias	Potential bias	Confirmed bias	Comment
A. SPECIES IDENTIFICATION				
1. Species subject to confusion and trained staff				
2. Species misreporting				
3. Taxonomic change				
4. Grouping statistics				
5. Identification Key				
Final indicator	No bias			

B. LANDINGS WEIGHT	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on species identification	No bias			
1. Missing part				Not Checked statistically
2. Area misreporting				Area misreporting corrections have been applied
3. Quantity misreporting				Logbook data assumed to be accurate
4. Population of vessels				
5. Source of information				
6. Conversion factor				Standard Nep CF of 3 is used from tail to live weight
7. Percentage of mixed in the landings				
8. Damaged fish landed				
Final indicator		Potential bias		Landings information are derived from logbooks and assumed to be accurate

C. DISCARDS WEIGHT	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on species identification	No bias			
1. Sampling allocation scheme				
2. Raising variable				
3. Size of the catch effect				Catch samples are decomposed into landings and discard fractions using an onboard selection ogive
4. Damaged fish discarded				
5. Non response rate				
6. Temporal coverage				
7. Spatial coverage				
8. High grading				
9. Slipping behaviour				
10. Management measures leading to discarding behaviour				
11. Working conditions				
12. Species replacement				
Final indicator		Potential bias		

D. EFFORT	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on species identification	No bias			
1. Unit definition				Derived from logbook data
2. Area misreporting				
3. Effort misreporting				
4. Source of information				
Final indicator		Potential bias		

E. LENGTH STRUCTURE	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on discards/landing weight		Potential bias		Landings information are derived from logbooks and assumed to be accurate
1. Sampling protocol				Sampling protocol could be described as "convenience sampling" which has the potential for bias
2. Temporal coverage				Temporal changes in size and sex ratio in the catches require frequent temporally stratified samples which is not achieved in all years
3. Spatial coverage				Sampling mainly focused on Bantry
4. Random sampling of boxes/trips				Industry self-sampling is mainly used in this area and catch samples are assumed to be randomly selected
5. Availability of all the landings/discards				
6. Non sampled strata				
7. Raising to the trip				
8. Change in selectivity				
9. Sampled weight				
Final indicator		Potential bias		

F. AGE STRUCTURE	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on length structure		Potential bias		
1. Quality insurance protocol				
2. Conventional/actual age validity				
3. Calibration workshop				
4. International exchange				
5. International reference set				

F. AGE STRUCTURE	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on length structure		Potential bias		
6. Species/stock reading easiness and trained staff				
7. Age reading method				
8. Statistical processing				
9. Temporal coverage				
10. Spatial coverage				
11. Plus group				
12. Incomplete ALK				
Final indicator		Potential bias		Nephrops cannot yet be directly aged.Growth parameters are assumed in line with other areas and studies.The accuracy and bias associated with these assumptions is not known

G. MEAN WEIGHT	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on length/age structure		Potential bias		
1. Sampling protocol				
2. Temporal coverage				
3. Spatial coverage				
4. Statistical processing				
5. Calibration equipment				
6. Working conditions				
7. Conversion factor				
8. Final indicator				Length-weight parameters are used to estimate mean weight.

H. SEX RATIO	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on length/age structure		Potential bias		
1. Sampling protocol				
2. Temporal coverage				
3. Spatial coverage				
4. Staff trained				
5.Size/maturity effect				
6. Catchability effect				There is a strong variation in female catchability for Nephrops
Final indicator		Potential bias		

I. MATURITY STAGE	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on length/age structure		Potential bias		
1. Sampling protocol				
2. Appropriate period				
3. Spatial coverage				
4. Staff trained				
5. International reference set				
6. Size/maturity effect				
7. Histological reference				
8. Skipped spawning				
Final indicator				Not relevant to the current assessment method
Final indicator		Potential bias		

5.4 Multispecies and mixed fisheries issues

The *Nephrops* fisheries in this FU target different areas, and *Nephrops* catches and landings show different size structures. In recent years FU 19 has accounted for around 14% or 834 t of the total landings (~4500 t) from the wider Celtic Sea (FU19, 20, 21 and 22) (ICES, 2013b). The Galley Ground 4 represents around 47% of the total area where *Nephrops* are currently fished in FU19 based on areas shown in Figure 5.1.1, Table 5.1.3.

Figure 5.4.1 shows the proportion of *Nephrops* in the Irish landings overlaid on international OTB effort. There are distinct areas where *Nephrops* are specifically targeted in FU 19. Davie and Lordan (2011) examined the species composition in a *Nephrops* targeting métier in VIIj. They defined two separate métiers a "clean" and more "mixed" depending on the proportions of *Nephrops* in the landings. They found that the median number of species landed on trips targeting *Nephrops* was ~7 with and IQR of 5-9.The main species landed with *Nephrops* by weight were anglerfish, megrim, haddock, whiting and cod.

Gerritsen *et al.*, (2012) used hierarchical cluster analysis to define spatial regions with relatively homogenous species compositions in the waters around Ireland. They identified 1 *Nephrop*s cluster within FU 19 where the retained catches from the Cork cluster was more mixed with ~37% *Nephrops,* ~15% haddock and 13% anglerfish. The percentage of the total otter trawl effort expended on this ground was ~3%, with similar percentages in the total landings (2%) and total surface area fished (1%).

5.5 Ecosystem drivers

Underlying Ecosystem trends

A summary document of the physical and biological features of the Celtic sea ecosystem is available (Anon, 2013)

- Long-term datasets (1958) from the Malin shelf indicate a steady increase in SSTs.
- Time series dataset (1990-2010) of phytoplankton species are increasing in coastal waters south and southwest of Ireland.
- Long-term time series since 1958 show a decline in overall zooplankton abundance and a northward shift of warm-water zooplankton Calanus into Celtic Sea.

The general increase in sea surface temperature is expected to increase larval development rates during the pelagic phase and as a consequence larval mortality may decline. However the larval retention mechanisms may also be impacted so the cumulative impact on recruitment maybe difficult to forecast. Uwtv surveys offer and opportunity to monitor oceanographic variables using a sled mounted CTD. This information is relatively easy to collect and over time will augment the knowledge base on the oceanographic regime in FU19.

Impact of the Fishery on the Ecosystem

Demersal trawling, which is the main catching method in FU19, modifies the benthic community structure and also has the potential to modify the physical habitat. The frequency of this demersal trawl impact has been assessed using VMS data (Gerritsen *et al.,* 2013). In the Irish EEZ of the Celtic Sea, 68% was impacted at least once by trawling, a considerable portion of the area (46%) was impacted at least twice, 13% of the area was impacted at least five times, particularly along the continental shelf edge and on the mud patches such as those in FU19 where *Nephrops* occur. Some regions were even impacted ten times or more, although this occurred in <2% of the area. While there are no direct studies on the impact of trawling on the benthic communities in FU19 it can be expected that these grounds are highly modified environments.

In addition to estimating *Nephrops* stock abundance UWTV surveys can be used to monitor the presence of certain benthic fauna. Sea-pens and burrowing megafauna communities have been included in the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2010). For each minute of the UWTV footage the occurrence of trawl marks, fish species and other species are recorded. Distributions maps from the 2011 to 2013 surveys show that sea-pens were identified from the video footage as *Virgularia mirabilis* and *Pennatula phosphorea* and these species were also present at stations where trawl marks were recorded (Lordan *et al.*, 2013).

5.6 Stock Assessment

5.6.1 Catch – quality, misreporting, discards

Commercial landings data are supplied by Ireland, France and the UK.

The quality of historic landings data are not well known but they are perceived to be reasonably accurate. Landings statistics for the Irish fleet are obtained from EU logbooks since 1995. Vessels record daily retained catches in operations and make a declaration of total landings on return to port. Since 2012, most vessels in the fleet have been using electronic logbooks (EC Regulation 1224 of 2009 and 404 of 2011).

Disaggregated effort and lpue data are available for the Irish *Nephrops* directed fleet in FU19 from 1995 for all vessels >18 metres total length is reported by WGCSE. Effort and lpue data are not standardized, and hence do not take into account vessel capabilities, efficiency, seasonality or other factors that may bias perception of lpue abundance trend over the longer term.

In recent year landings in FU 19 have been adjusted to take account of minor area misreporting from FU16 to FU19.This correction is perceived to be reasonably accurate.

Fish and other bycatches in the fishery have been collected by on board observers since 1994. Discarding by the *Nephrops* trawl fleet is around 55% of the total catch by weight. The main discards are small whole *Nephrops*. The main fish species discarded are haddock, boarfish and dab (Anon, 2011).

5.6.2 Groundfish Survey

Length–frequency data of the *Nephrops* catches on the Irish groundfish survey (IGFS-WIBTS-Q4) (2003–2013) are available. Figure 5.6.1. depicts the positions of the IGFS stations in FU19 and it is shows that the majority of the stations occur outside the discrete polygons. However, these data are useful for trends in indicators such as mean size and mean weights and these were investigated at this meeting. Mean weights were calculated using the parameters derived from Scottish weight–length relationships (Pope and Thomas, 1955), (Stock Annex).

The mean size and weight of males and females from the survey was fairly stable over time (Figure 5.6.2 and 5.6.3). It must be noted that there will be some differences in catchability and selectivity between the survey and the commercial fishery and also spatial coverage differences.

WKCELT concluded that although these data are not used directly in the benchmark process for this stock that the data are useful for trends and recommended that *Nephrops* length frequency data from this groundfish survey to be investigated for trends in indicators.

5.6.3 TV survey

In 2006 Ireland conducted the first underwater television survey (UWTV) in FU19, however only 6 stations were completed. From 2011 to 2013 an average of 38 stations have been completed annually. All grounds except Galley Ground 4 in 2011 and Galley Ground 1 in 2012 were covered by the TV survey. The survey design is based on randomly picked stations from the ground polygons and the sampling effort on each ground was determined by relative area. The methods used during the survey were similar to those employed for UWTV surveys of *Nephrops* stocks around Ireland and elsewhere and are documented by WKNEPHTV (ICES, 2007), SGNEPS (ICES, 2009, 2010, 2012) and WGNEPS (2013).Given the scale of the area and the number of distinct patches it is unrealistic to expect sufficient stations (~10) in each individual patch to estimate densities separately. The random stratified approach may cause problems in years where the planned survey coverage is not achieved. In which case WGCSE or WGNEPS should make recommendations on the most appropriate fill in procedure to be adopted.

In order to use the survey abundance estimate as an absolute it is necessary to correct for potential biases. For FU19 the field of view of the camera was 0.75 m and expert judgment of the mean burrow diameter was in the range of 0.25–0.4 m. The edge effect is estimated at 1.25 which is similar to FUs of moderate density. In future it may become possible to quantitatively estimate burrow diameter from mosaics of the footage from this and other areas. Burrow detection rates were thought to be relatively high due to good water clarity and few other burrow systems of similar size. Burrow identification could be slightly overestimated since a few fish and crab species were observed at burrow entrances. The proposed cumulative correction factor for the area was 1.3 (Table below). When compared to with the correction factors applied in other areas it is quite close to the average used on other grounds.

The biases associated with the estimates of *Nephrops* abundance in FU19 are:

	Period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU19:						
S and SW Ireland	2011	1.25	0.9	1.15	1	1.3

WKCELT concluded that the full UWTV approach is appropriate to this stock. WKCELT recommended that WGCES or WGNEPS to decide on appropriate fill in procedure if any ground has not be surveyed by TV.

5.6.4 Weights, maturities, growth

Commercial Catch Data

Length and sex composition of the annual landings for this FU are estimated from port sampling. Sampling has been collected on an irregular basis in the years 1996 to 1997, 1999 and 2002 to 2006. A catch self-sampling programme is in place. This involves unsorted catch and discard samples being provided by vessels or collected by observers at sea on discard trips. The catch sample is partitioned into landings and discards using an on board discard selection ogive derived for the discard samples. Sampling effort is stratified monthly but quarterly aggregations are used to derive length distributions.

The sampling intensity and coverage has varied over the time-series (See Stock Annex, Table B.2.1 and B.2.2). Since 2007 sampling has improved although the majority of the samples come from Bantry Bay. Also sampling of the discards has quite sparse over the time series. WKCELT concluded that adequate sampling intensity for all grounds is difficult to obtain given the spatial distribution of the patches and the irregular patter in the fishery.

WKCELT recommended that future efforts to be directed at improvements in spatial coverage and sampling of the discards.

Length-weight parameters

Mean weights for this stock are estimated using parameters derived from Scottish weight–length relationships (Pope and Thomas, 1955). These parameters were compared statistically with data collected for the nearby FU17 ground and found not to be significantly different from L/W data collected in 2013 (Lordan, *et al.*, 2013). As a sensitivity test WKCELT compared the total catch weight estimates for pooled FU 19 length frequency samples (2003–2013) using weight–length parameters from *Nephrops* grounds with similar mean burrow density (i.e. FU 6 Farn Deeps and FU 11-12 North and South Minch). There was a ±7% difference in the total estimated weight (Table 5.6.4.1). WKCELT concluded that currently there is no strong basis to revise the weight–length relationship currently in use for this stock. However, WKCELT recommended length–weight data be collected to validate the parameters used for this area.

Mean Weight

The annual mean weight in the landings is calculated from the length–frequency data and Pope and Thomas (1955) length–weight relationship. Figure 5.6.4.1. shows the mean weight by sex for all grounds over the time series shows a declining trend and this is also evident for Bantry Bay data only (Figure 5.6.4.3).Explorations of the mean weight in the catch samples by sex displayed a strong cyclical pattern in the females from Bantry Bay (Figure 5.6.4.3). This corresponds to the emergence of mature females from the burrows to mate in summer. The male data shows a reduction in both level and variability in mean weight since 2011. There are also indications of cyclical patterns. This implies that the sampling design should take into account a temporal stratification probably at a monthly scale.

Sex Ratio

Previous *Nephrops* working groups have highlighted stability in sex ratio as an important indicator for *Nephrops* stocks. As for mean weight a cyclical pattern is evident which is linked to female emergence behaviour. In 2013 more females than usual were observed in the unsorted catch samples and this was confirmed by the industry (Figure 5.6.4.4).

WKCELT recommend that sex ratio indicators be updated and reviewed annually by WGCSE.

Maturity

Maturity data for females have been recorded during the *Nephrops* catch sampling programme, by month and year and the maturity stage of females is recorded based on a visual examination of the gonads. The size at which 50% of the female animals were mature (L50) was investigated for FU 19 based on 3 datasets for months May-July based on maturity schedules observed (Figure 5.6.4.5):

- All grounds and all years 2002–2013.
- All grounds pooled for years 2009–2013.
- Bantry Bay ground and years 2009–2013.

WKCELT concluded that the Bantry Bay dataset was the most appropriate to this stock at present. This gives L50 of 24 mm CL for females (Table 5.6.4.2).

No update to male maturity was made at WKCELT 2014 and the same L50 should be assumed for males. Estimation of male maturity using a segmented regression model fitted to a scatterplot of carapace versus appendix masculine length was proposed by McQuaid *et al*., 2006 and ICES (2006). This approach has been examined for other FUs around Ireland and is sensitive to outliers. The biological significance of the observed breakpoint is not known since males are mature at smaller size but may not be able to functionally mate. The assumption that males mature at the same CL as females may well be reasonably accurate. Ultimately this only impacts on the calculation of the SPR male component and will no impact on the F0.1 a harvest rate for this stock.

Discard Selection

WKCELT examined the need to update the discard ogive selection for FU 19. Previously to partition the catch lengths into landings and discards a selection ogive from FU 22 based on 2006 was used. Discard observations from Bantry Bay 2008 (Q1), 2013 (Q2-3) were available. These discard ogives were are shown in Figure 5.6.4.6. The estimated L50 (Table 5.6.4.3) from the Bantry Bay datasets were quite similar except for quarter 2 in 2013 (33 CL mm). The L50 for WGCSE was considerably (26 CL mm). The data for Bantry Bay shows that the smaller size *Nephrops* are not landed. This is because the vessels are mainly <18 metres and do not have sufficient crew to spend significant time tailing small *Nephrops*. It was decided to average the Bantry Bay data excluding 2013 Q2 dataset to estimate a discard selection ogive which gives a L50 of 30 CL mm.

WKCELT concluded that the averaged discard selection ogive was acceptable to split unsorted catch lengths into landings and discards. WKCELT recommended that WGCSE keep the discard selection ogive under reviewed revise as necessary based on improved information.

5.6.5 Assessment model

In 2009 WKNEPH debated the use of the surveys as either an absolute measure of abundance or a relative index (ICES, 2009a). Ultimately this led to a consensus that bias corrected survey abundance estimates could be used directly in the formulation of catch advice. Two modelling approaches were used to estimate sustainable stock specific Harvest Ratio reference points; SCA (a separable LCA model Bell) and Age Structured Simulation model (Dobby) (ICES, 2009a). The F_{MSY} proxy harvest rate values were updated at WKCELT2014 (see Section 5.8) using the most recent data available for FU19 using the Separable Cohort Analysis model Bell in r.

Final options decided are as follows:

3 year average length–frequency distributions reference period 2011–2013.

Discard survival: 25%

FemMature<-c(23,24) L_{25} /L_{50} for female maturity.

MalMature<-c(23,24) L_{25}/L_{50} for male maturity.

n.indivs<-c(484) TV survey index: 3 year average reference period 2011-2013.

surv.time<-c(0.66) Fraction of year surveys occurs.

TV.sel<-c(16.5,17) TV selectivity.

alpha<-0.001 Survey weighting: 0.001 (low).

f.range<-c(0, 0.01, seq(0.05, 4, 0.05)) F.range for estimating the Yield-per-recruit.

discard.weight<-c(1) discard weighting.

initial.parameters <- c(1.5,21.5, 1.15,0.4,0.3).

The model also has five initial parameters to estimate:

1. Initial population size at the smallest length class equal sex distribution assumed.
2. Length at 25% selection.
3. Multiplier on L_{25} to give L_{50}.
4. Fishing mortalities at full selection for males and immature females.
5. Fishing mortality at full selection for mature females.

Additional parameters required such as the von Bertalanffy growth parameters, natural mortality and weight-length parameters by sex are required. These parameters are given in text table below and were chosen as final from model run 2 (Table 5.6.4.1): The final selected values for these are in lines with those for other *Nephrops* stocks (See Stock Annex Table C.1).

PARAMETER	MALES	IMMATURE FEMALES	MATURE FEMALES
L_{∞}	60	60	56
K	0.16	0.16	0.08
Natural Mortality	0.3	0.3	0.2
Discard Survival	25%	25%	25%
A	0.000322	0.000684	0.000684
B	3.207	2.963	2.963

Table 5.6.4.1 gives the model runs and input parameters carried out by WKCELT and estimates of the three stock-specific candidates for F_{MSY} ($F_{0.1}$, $F_{35\%SPR}$, and F_{MAX}) for each. For run 1 (Figure 5.6.5.1) the model fits well to the landings but not to discards and the estimate of female catchability (q) is very low. Model run 2 (Figure 5.6.5.1) does not fit as well to landings as the previous run, the fit to the discards is improved and the estimate of female catchability is more realistic. The residuals showed that the males at smaller sizes were overestimated and females underestimated for both these runs but the residuals for run 2 were modest.

WKCELT concluded that SCA run 2 was the most appropriate on the basis of the female q and modest residuals. The run 2 outputs and residuals are in line with those presented at WKNEPH 2009 for various other FUs. Also the difference between the TV survey estimate and the model estimate of a TV survey ratio of 0.72 is within the range presented at the WKNEPH 2009 (Table 5.6.5.2).

WKCELT recommended that the SCA model is to be used to generate F_{MSY} proxies and that WGCSE should revise as necessary the reference points based on an updated SCA and per recruit analysis provided if there are indications of changes to fisheries or biological factors.

5.7 Short-term projections and how the advice is derived

An estimate of mean weight in the landings is required to calculate catch options using the methodology developed by WK*NEPH* (ICES, 2009). If there is no firm evidence of a recent change in mean weight then a 3 year average is used. It may be necessary to deviate from this procedure in cases where there are changes to mean weight related to recruitment or sampling issues. This should be reviewed annually by WGCSE.

Discard selection ogive is used to split the catches into retained landings and discards. This should be reviewed annually as sampling improves.

5.8 Appropriate Reference Points (MSY)

Under the ICES MSY framework, exploitation rates which are likely to generate high long-term yield (and low probability of overfishing) have been evaluated and proposed for each *Nephrops* functional unit. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{MSY} directly and hence proxies for F_{MSY} have been determined. Three stock-specific candidates for F_{MSY} ($F_{0.1}$, $F_{35\%SPR}$, and F_{MAX}) were derived from a length-based per recruit analysis (these may be modified following further data exploration and analysis).

Density of *Nephrops* in FU 19 is considered moderate (~0.33 burrow/m^2). For this FU the exploitation rate on males is usually higher than on females except in 2013.

$F_{0.1}$ (combined between sexes) is expected to deliver high long-term yield with a low probability of recruitment overfishing and therefore is chosen as a proxy for F_{MSY}. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm and that the supplied length frequencies represented the population in equilibrium.

Using the ICES decision framework for F_{MSY} proxies in *Nephrops* a harvest ratio consistent with a combined sex $F_{0.1}$ is accepted by WKCELT 2014.

WKCELT reiterate that all F_{MSY} proxy harvest rate remain preliminary and recommend that these may be modified following further data exploration and analysis.

FU 19 Harvest ratio reference points:

	Male	Female	Combined
F0.1	8.1	9.0	8.1
FMAX	12.3	13.0	12.3
F35%SpR	13.0	15.2	14.5

	Type	Value	Basis
MSY Approach	FMSY	8.1%	F0.1 Combined.

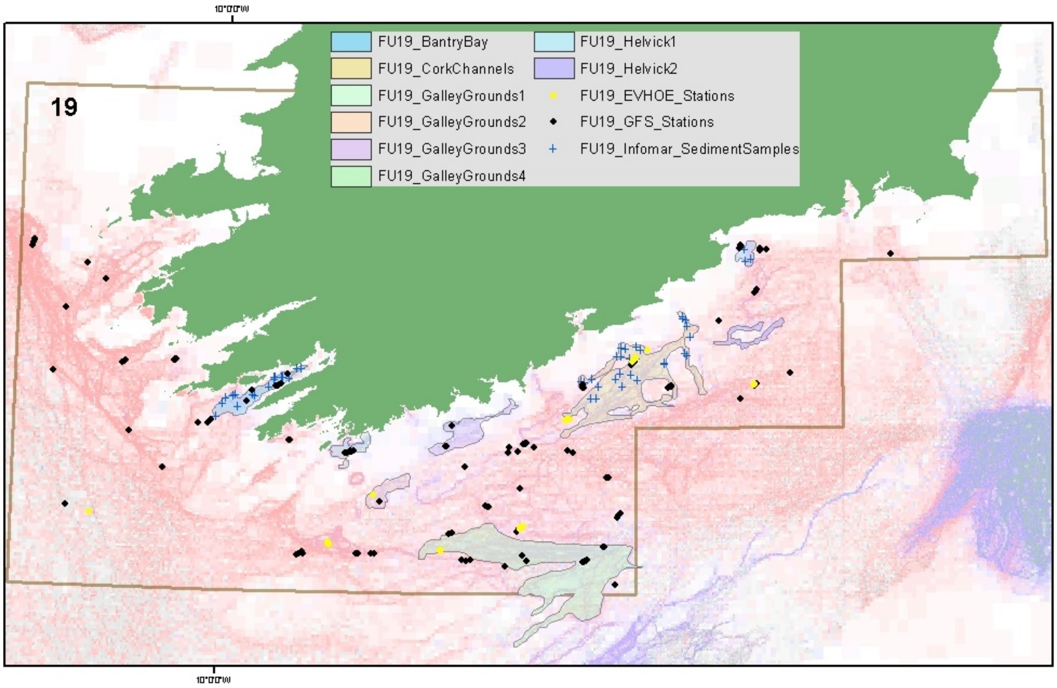

Figure 5.1.1 *Nephrops* in FU19 (S and SW Ireland).Positions of groundfish stations with *Nephrops* catches (black circle = Irish groundfish survey, yellow circle = French groundfish survey) and sediment samples (blue crosses) from infomar surveys overlaid on proportion of *Nephrops* in the Irish landings overlaid on international OTB effort (red=0% *Nephrops*; blue=50-60% *Nephrops*; grey=unknown (no Irish landings).

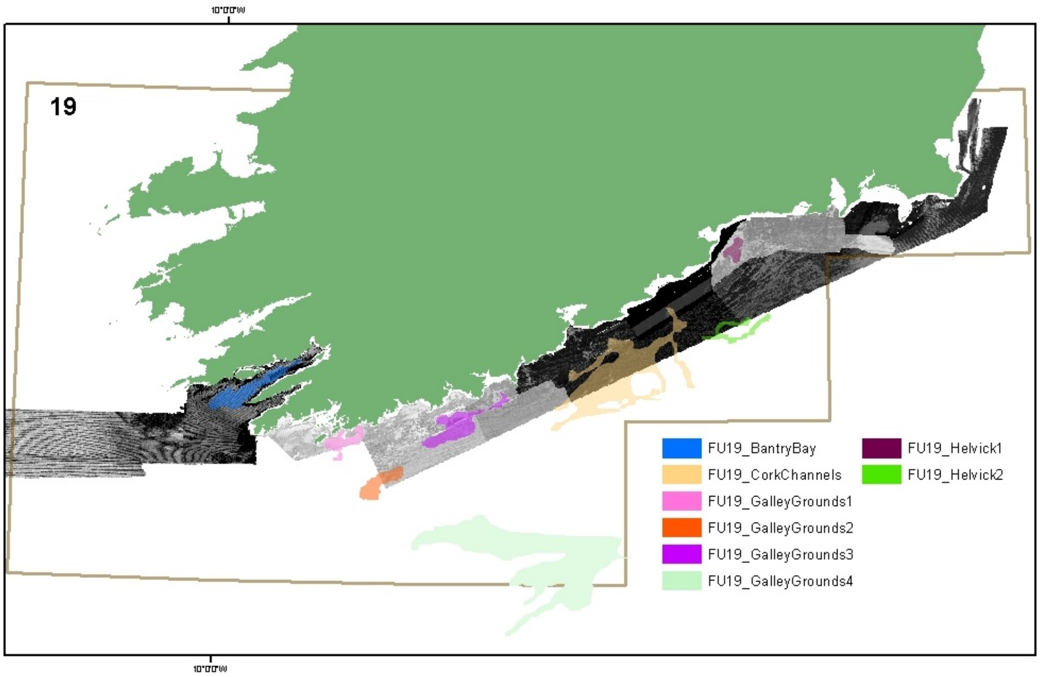

Figure 5.1.2 *Nephrops* in FU19 (S and SW Ireland).Available MBES backscatter data from infomar surveys and revised polygons.

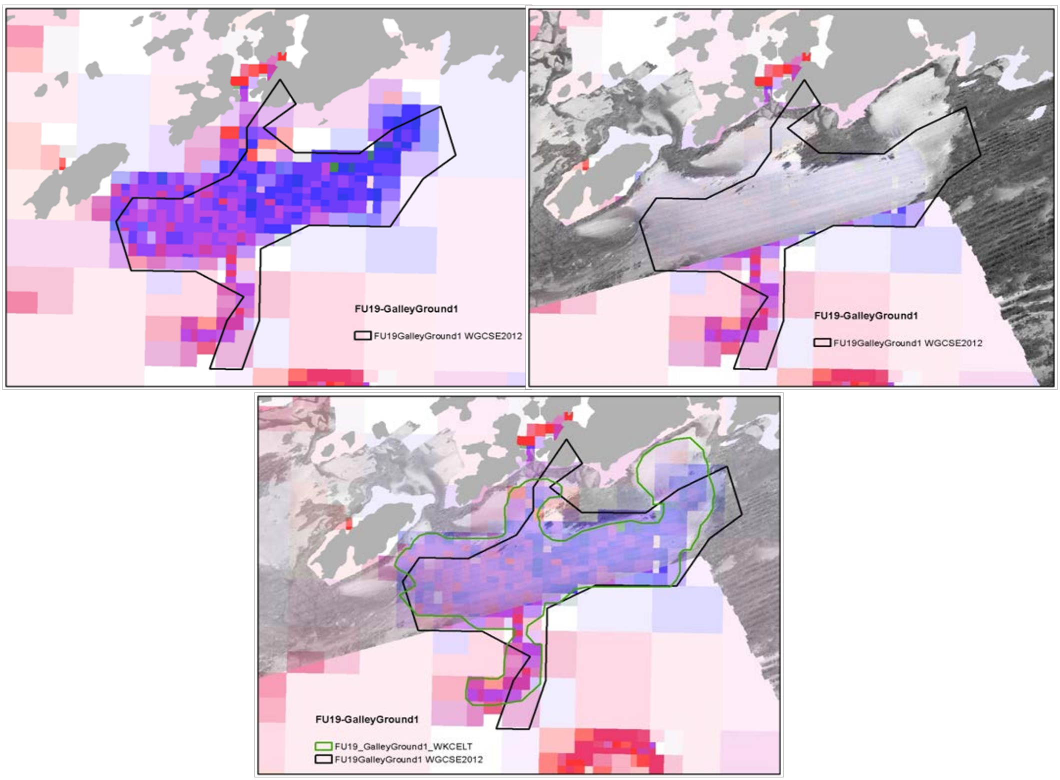

Figure 5.1.3 ***Nephrops*** **in FU19 (S and SW Ireland). Galley Ground 1: Top left panel: VMS and original polygon (black line). Top right panel: available backscatter and VMS data overlay. Bottom panel: Revised polygon (green line) and original polygon (black line).**

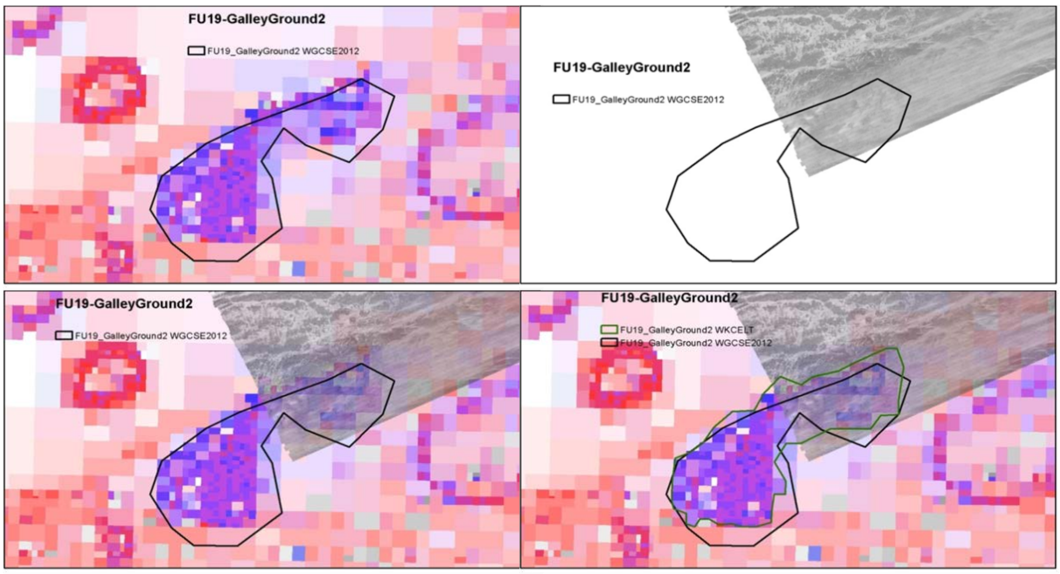

Figure 5.1.4 ***Nephrops*** **in FU19 (S and SW Ireland). Galley Ground 2: Top left panel: VMS and original polygon (black line). Top right panel: available backscatter and VMS data overlay. Bottom left panel: Data overlays and original polygon. Bottom right panel: Revised polygon (green line) and original polygon (black line).**

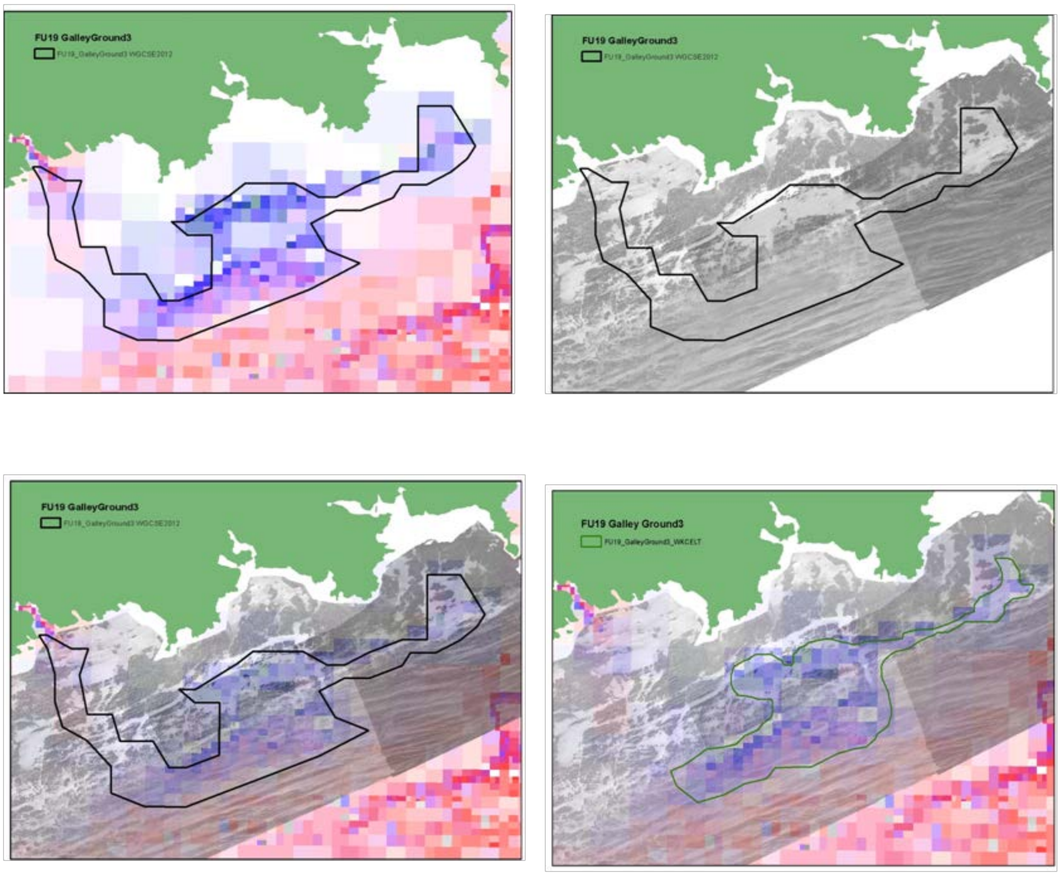

Figure 5.1.5 ***Nephrops*** **in FU19 (S and SW Ireland). Galley Ground 3: Top left panel: VMS and original polygon (black line). Top right panel: available backscatter and original polygon. Bottom left panel: Data overlays and original polygon. Bottom right panel: Revised polygon (green line).**

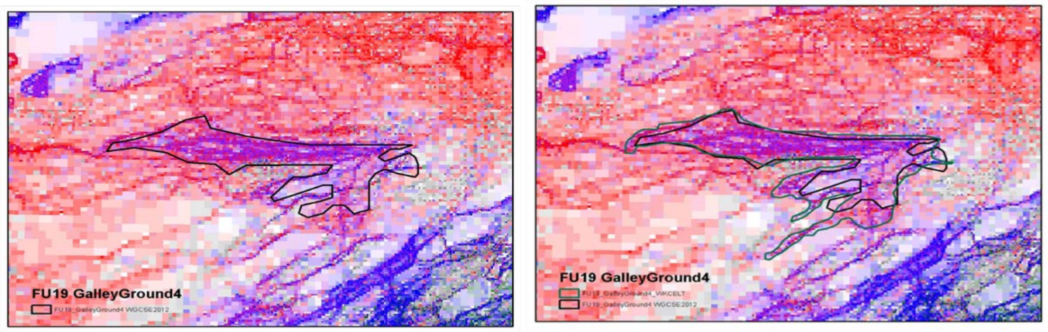

Figure 5.1.6.***Nephrops*** **in FU19 (S and SW Ireland). Galley Ground 4: Left panel: VMS and original polygon (black line). Right panel: VMS data and revised polygon (green line).**

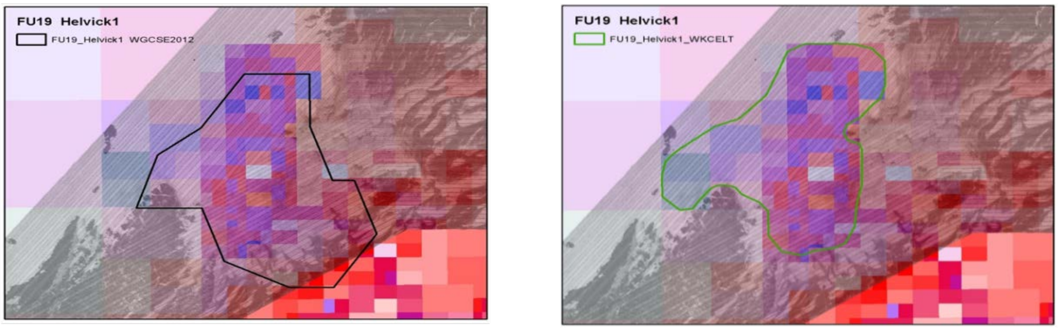

Figure 5.1.7 ***Nephrops*** **in FU19 (S and SW Ireland). Helvick Head 1: Left panel: VMS and backscatter overlay with original polygon (black line). Right panel: Revised polygon (green line).**

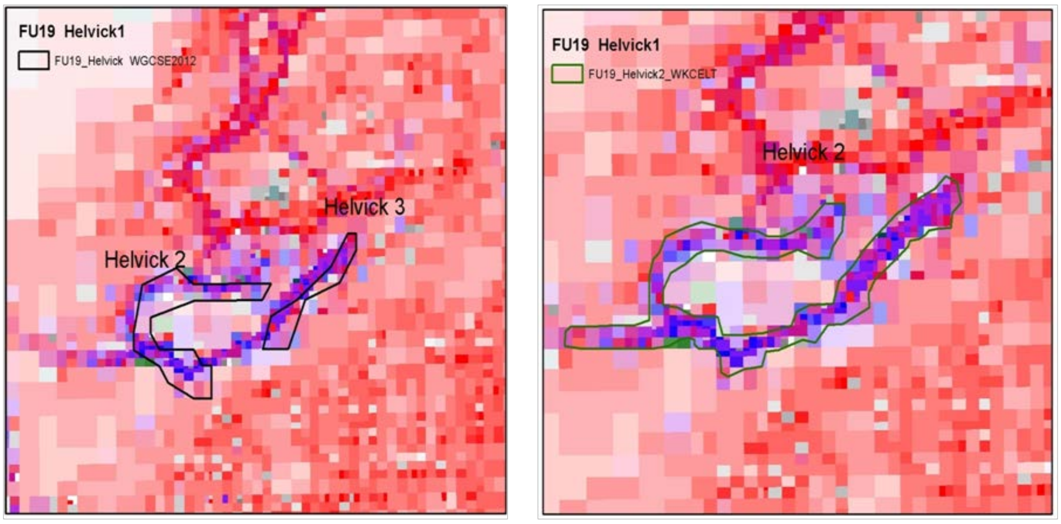

Figure 5.1.8 ***Nephrops*** **in FU19 (S and SW Ireland). Helvick Head 2-3: Left panel: VMS and backscatter overlay with original polygon (black line). Right panel: Revised polygon (green line).**

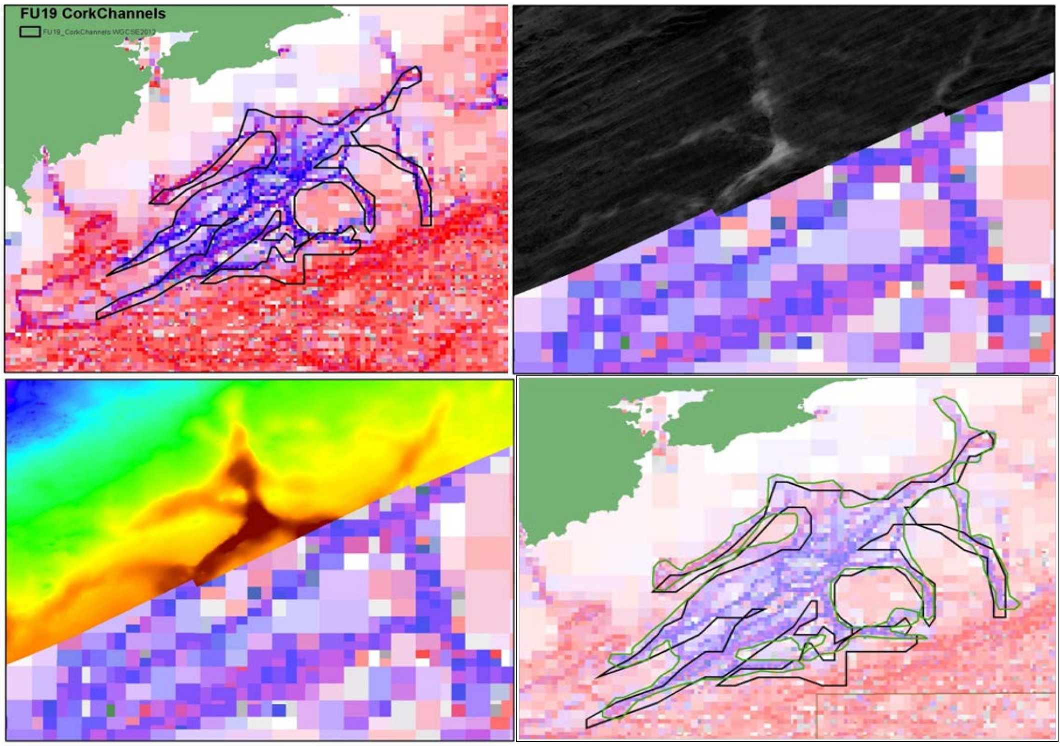

Figure 5.1.9 *Nephrops* in FU19 (S and SW Ireland). Cork Channels. Top left panel: VMS and original polygon (black line). Top right panel: available backscatter and VMS data overlay. Bottom left panel: Bathymetry and VMS data. Bottom right panel: Revised polygon (green line) and original polygon (black line).

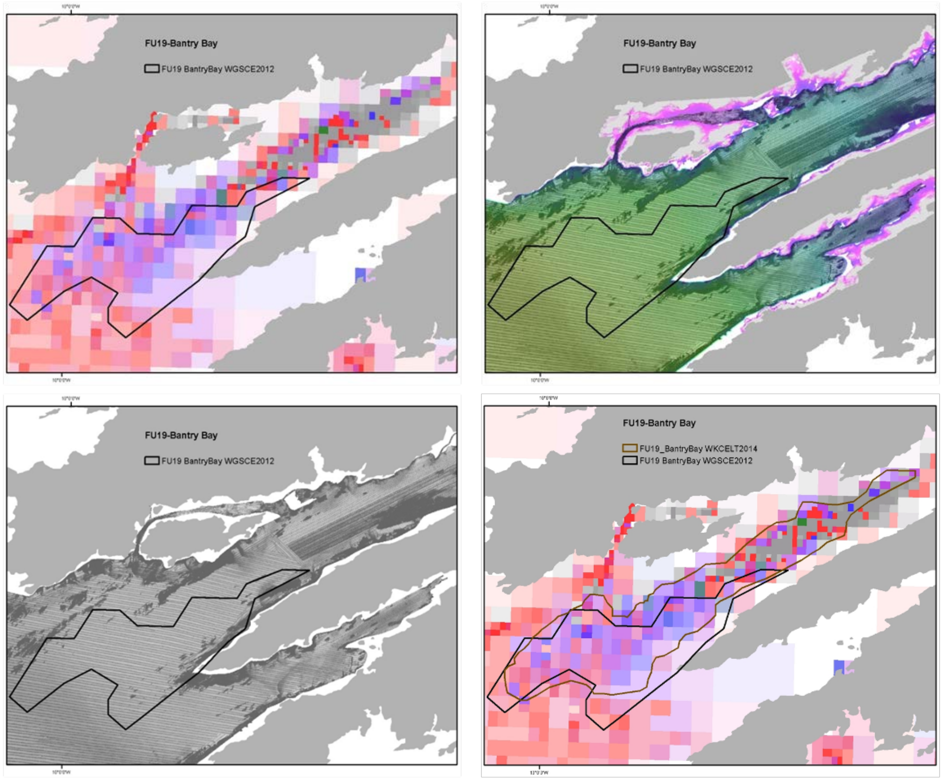

Figure 5.1.10 ***Nephrops*** **in FU19 (S and SW Ireland). Bantry Bay. Top left panel: VMS and original polygon (black line). Top right panel: available backscatter and bathymetry data overlay. Bottom left panel: Backscatter data. Bottom right panel: Revised polygon (brown line) and original polygon (black line).**

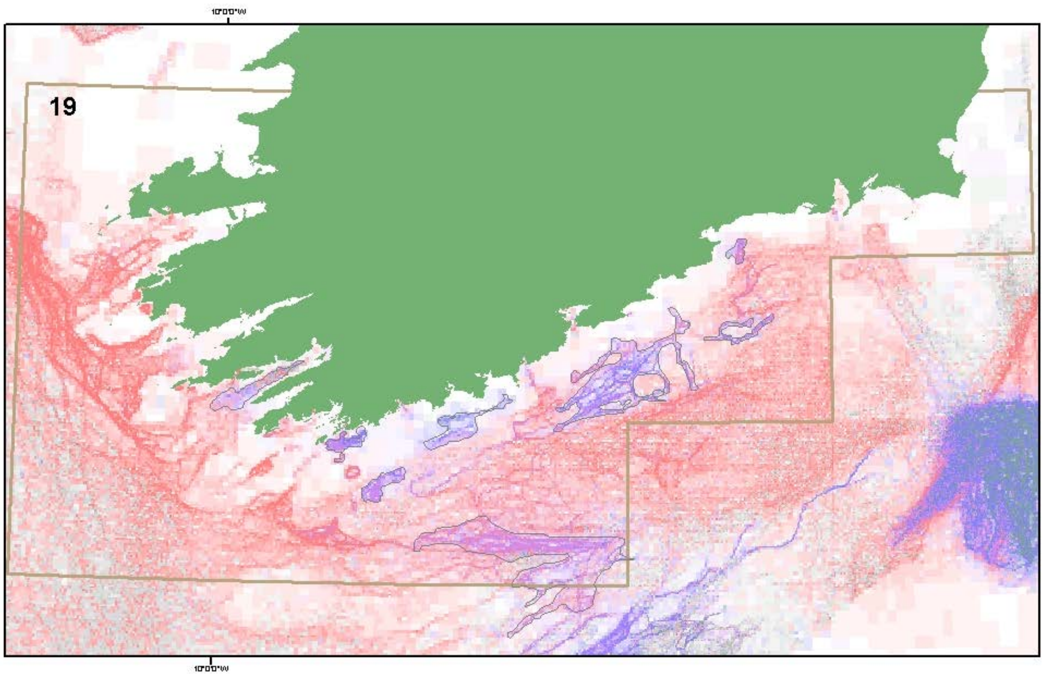

Figure 5.4.1. Proportion of ***Nephrops*** **in the Irish landings overlaid on international OTB effort (red=0%** ***Nephrops*****; blue=50-60%** ***Nephrops*****; grey=unknown (no Irish landings).**

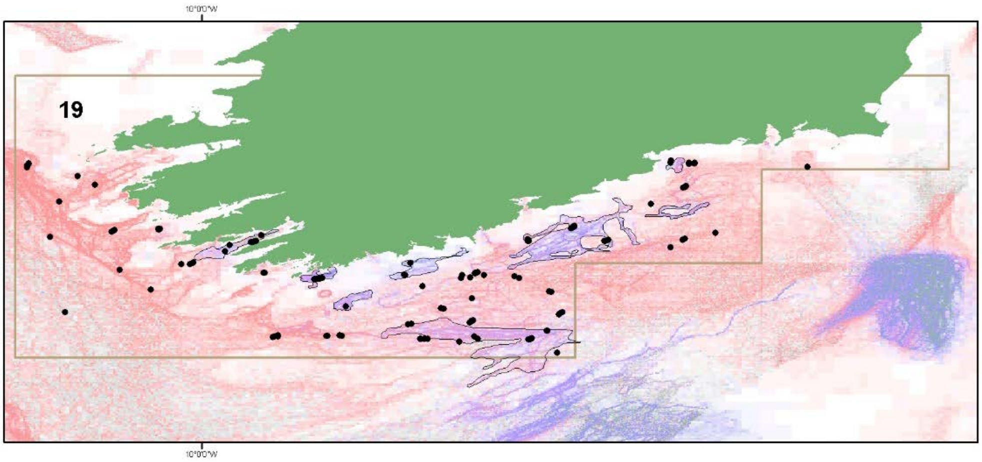

Figure 5.6.1. ***Nephrops*** **in FU19 (SW and SE Ireland). Station positions with N*ephrops* catches from Irish groundfish from 2003 to 2013 and revised ground polygons**

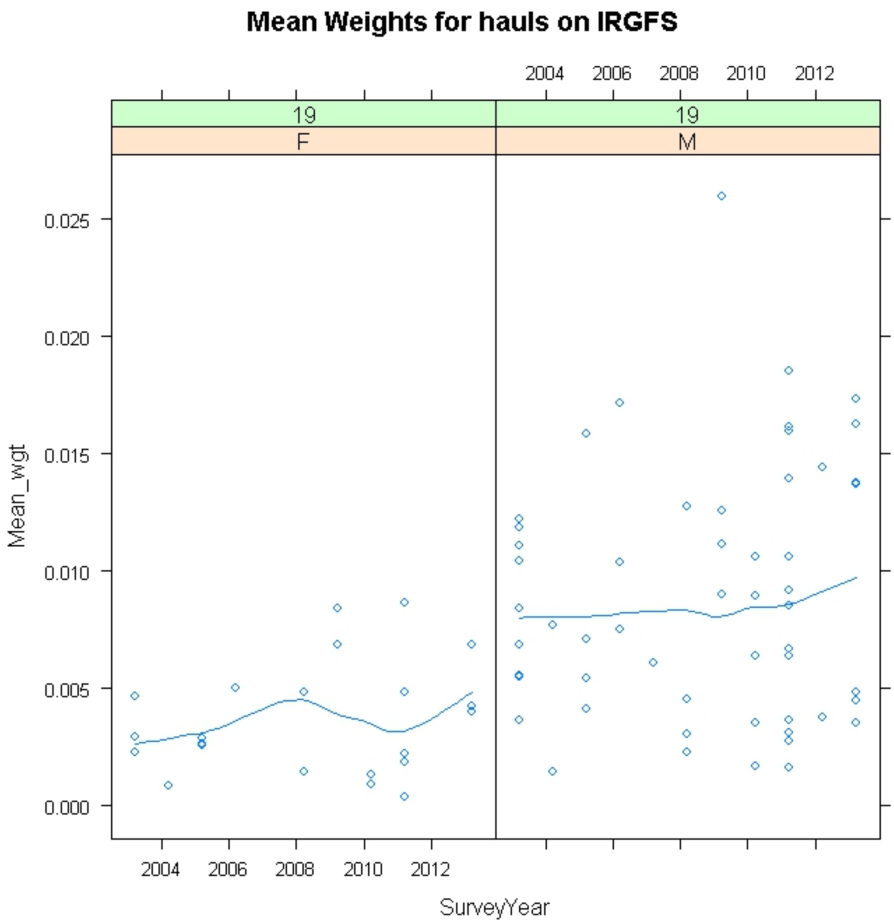

Figure 5.6.2. ***Nephrops*** **in FU19 (S and SW Ireland). Mean weights (gr) by sex for Irish Groundfish survey time series.**

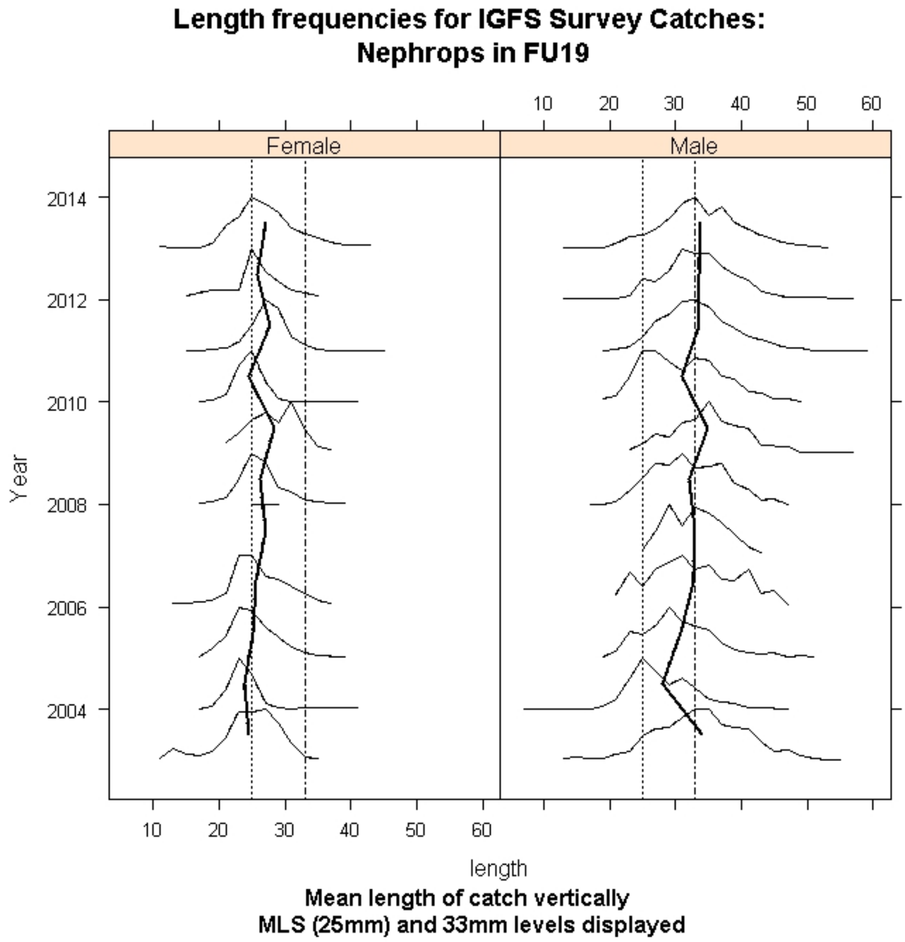

Figure 5.6.3. ***Nephrops*** **in FU19 (S and SW Ireland). Mean length CL mm by sex for Irish Groundfish survey time series.**

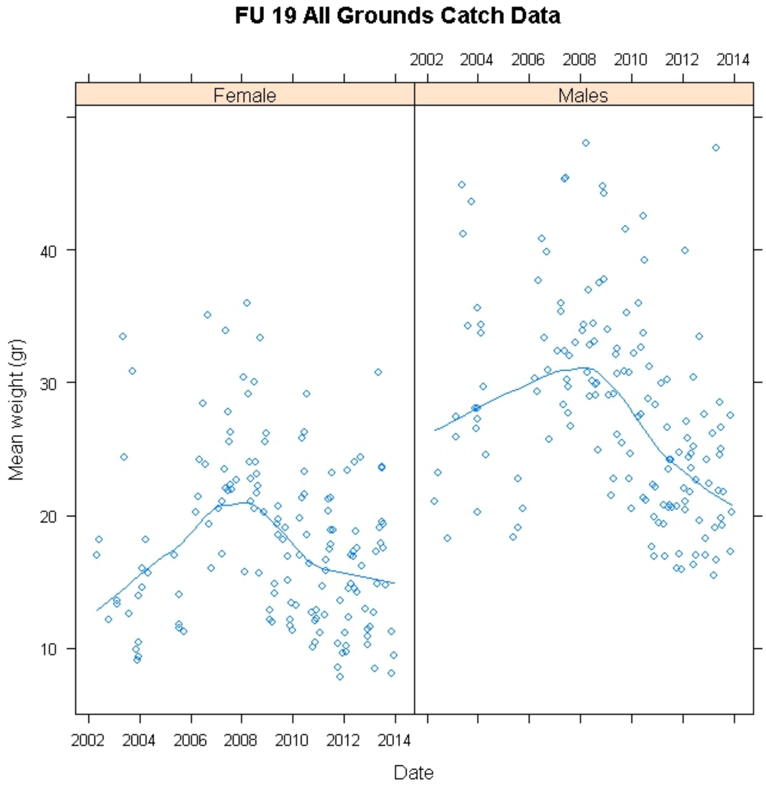

Figure 5.6.4.1. ***Nephrops*** **in FU19 (S and SW Ireland). Mean weight (kg) for males and females catches from all grounds.**

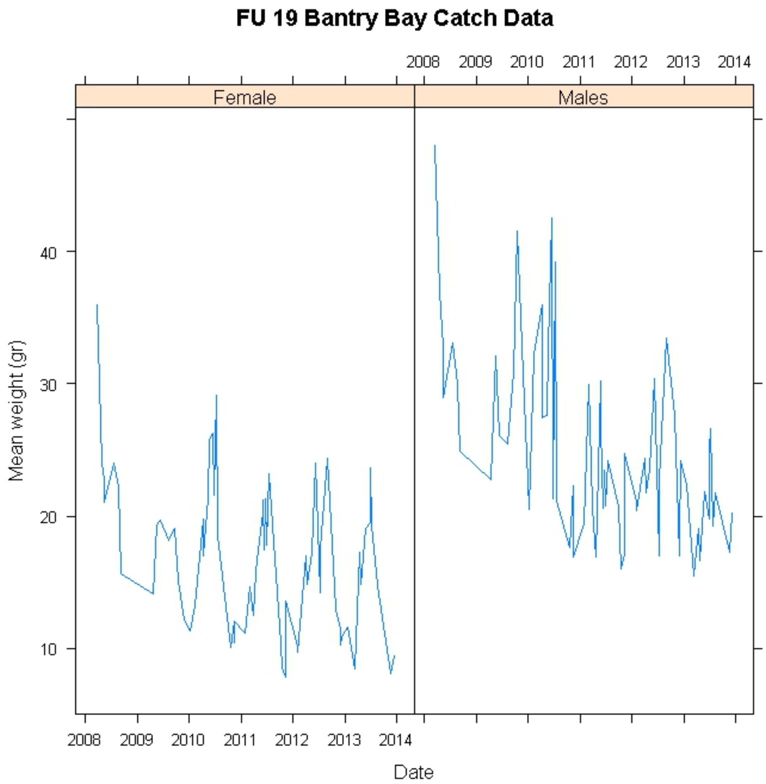

Figure 5.6.4.2. ***Nephrops*** **in FU19 (S and SW Ireland). Mean weight (kg) for males and females catches from Bantry Bay sampling showing female seasonal trend.**

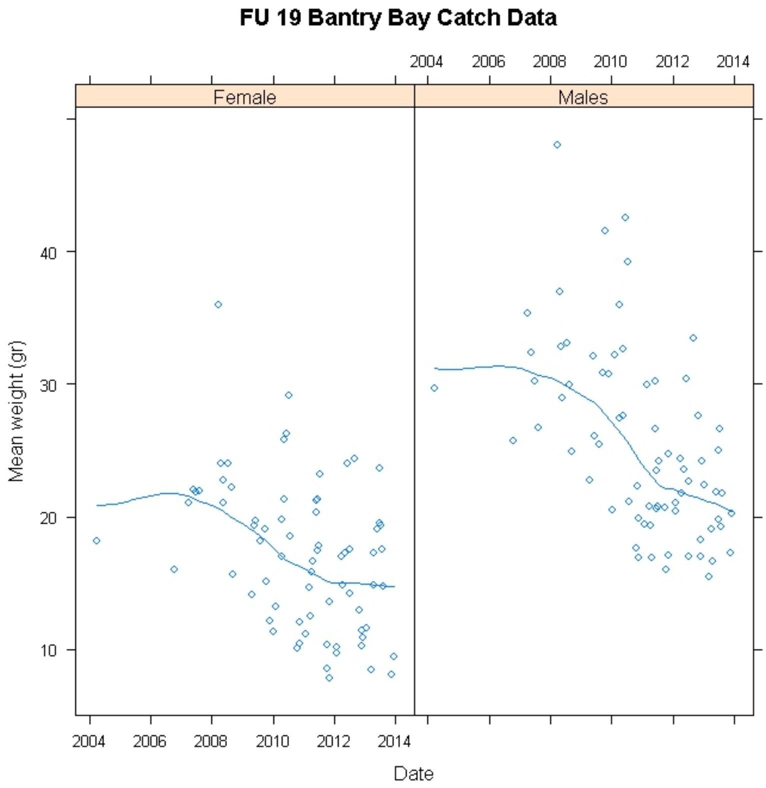

Figure 5.6.4.3. ***Nephrops*** **in FU19 (S and SW Ireland). Mean weight (kg) for males and females catches from Bantry Bay.**

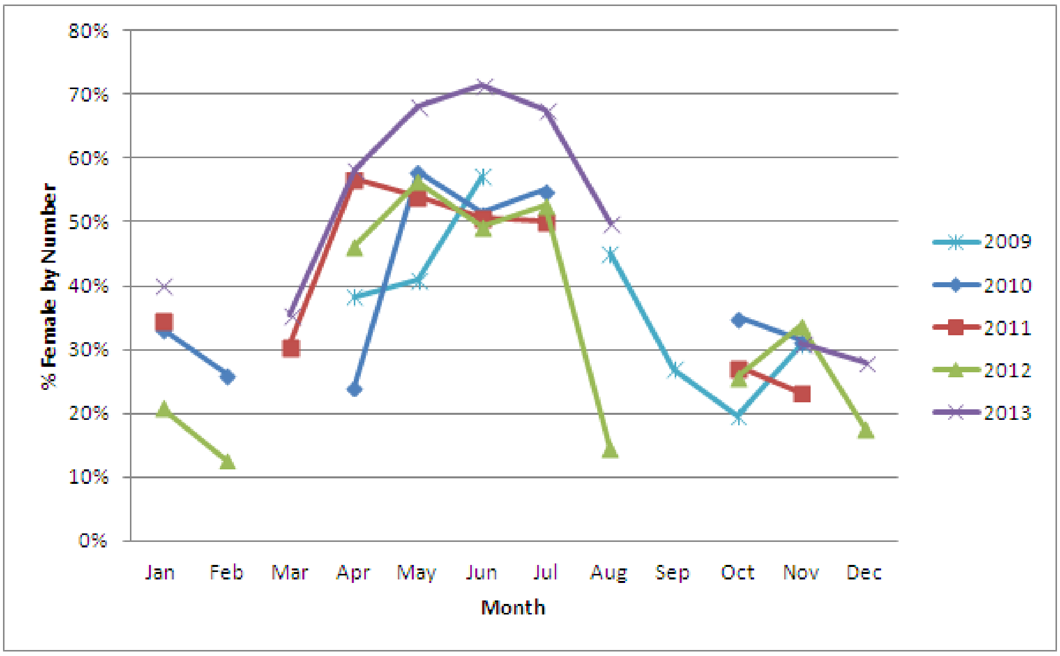

Figure 5.6.4.4. ***Nephrops*** **in FU19 (S and SW Ireland). Percentage females by number in the catches from Bantry Bay catch sampling.**

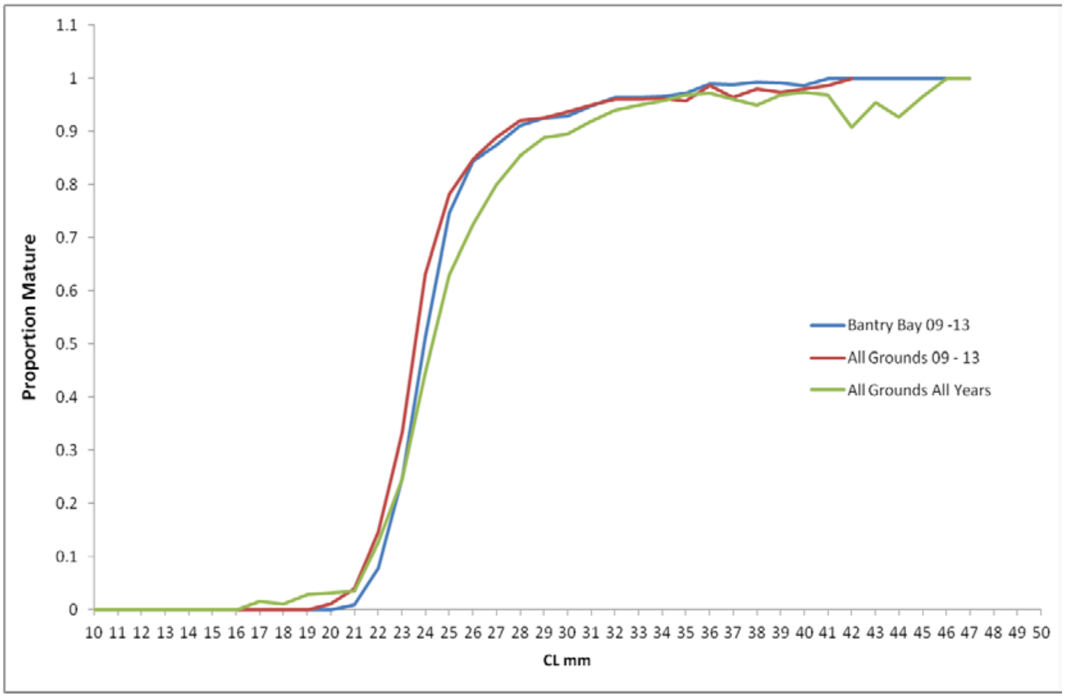

Figure 5.6.4.5. ***Nephrops*** **in FU19 (S and SW Ireland). Maturity ogives investigated.**

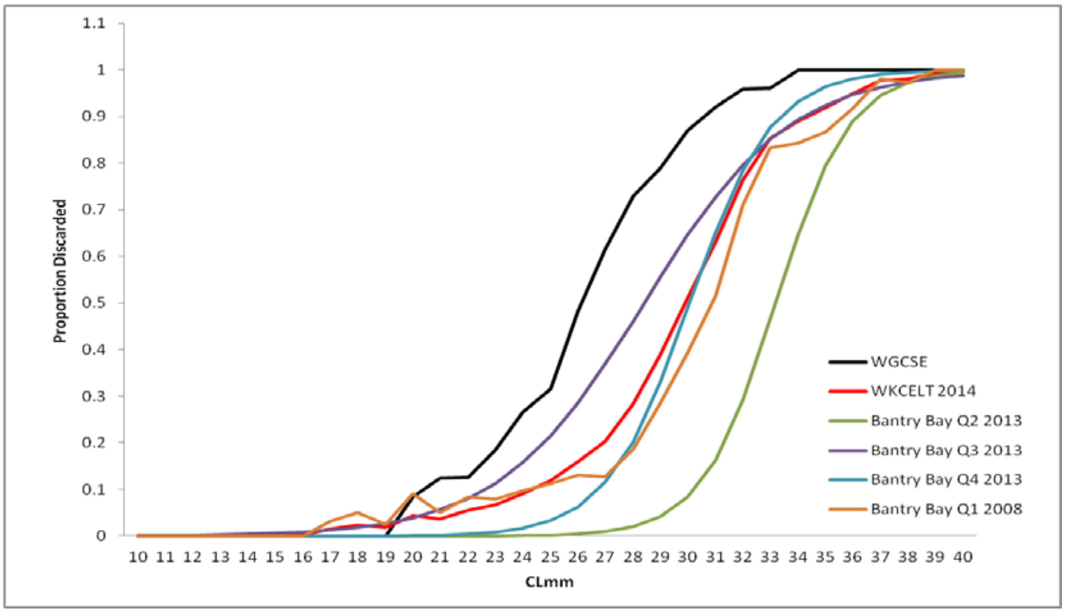

Figure 5.6.4.6. ***Nephrops*** **in FU19 (S and SW Ireland).Discard selection ogives.**

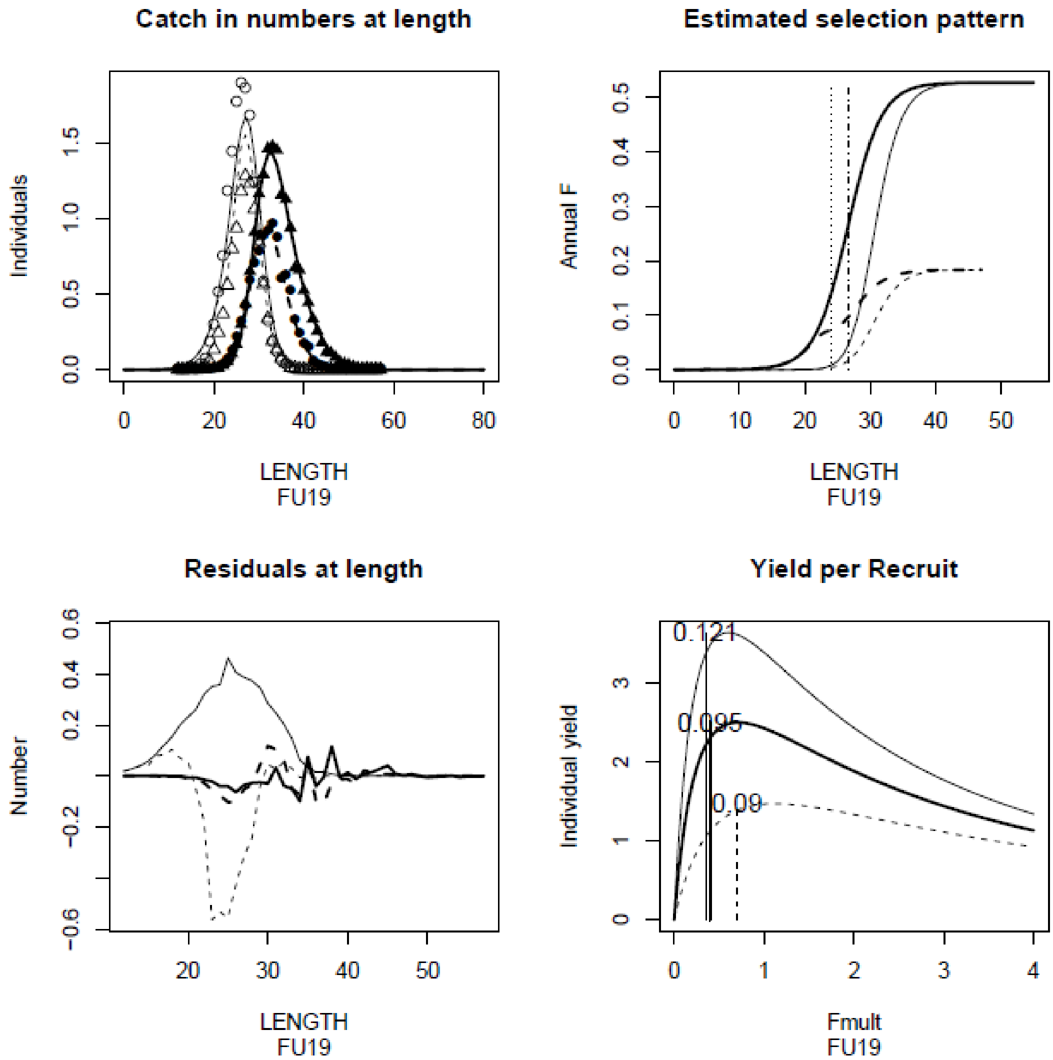

Figure 5.6.5.1. ***Nephrops*** **in FU19 (S and SW Ireland). Separable Cohort Analysis model fit Run 1.Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards and landings, top right gives the fishing mortality at length with the vertical lines representing length at 25% selection and 50% selection. Bottom left shows residual numbers (observed-expected) at length. The bottom right gives the Yield-per-recruit against fishing mortality, the thick solid line gives the combined value and vertical lines represent F0.1 for the three curves.**

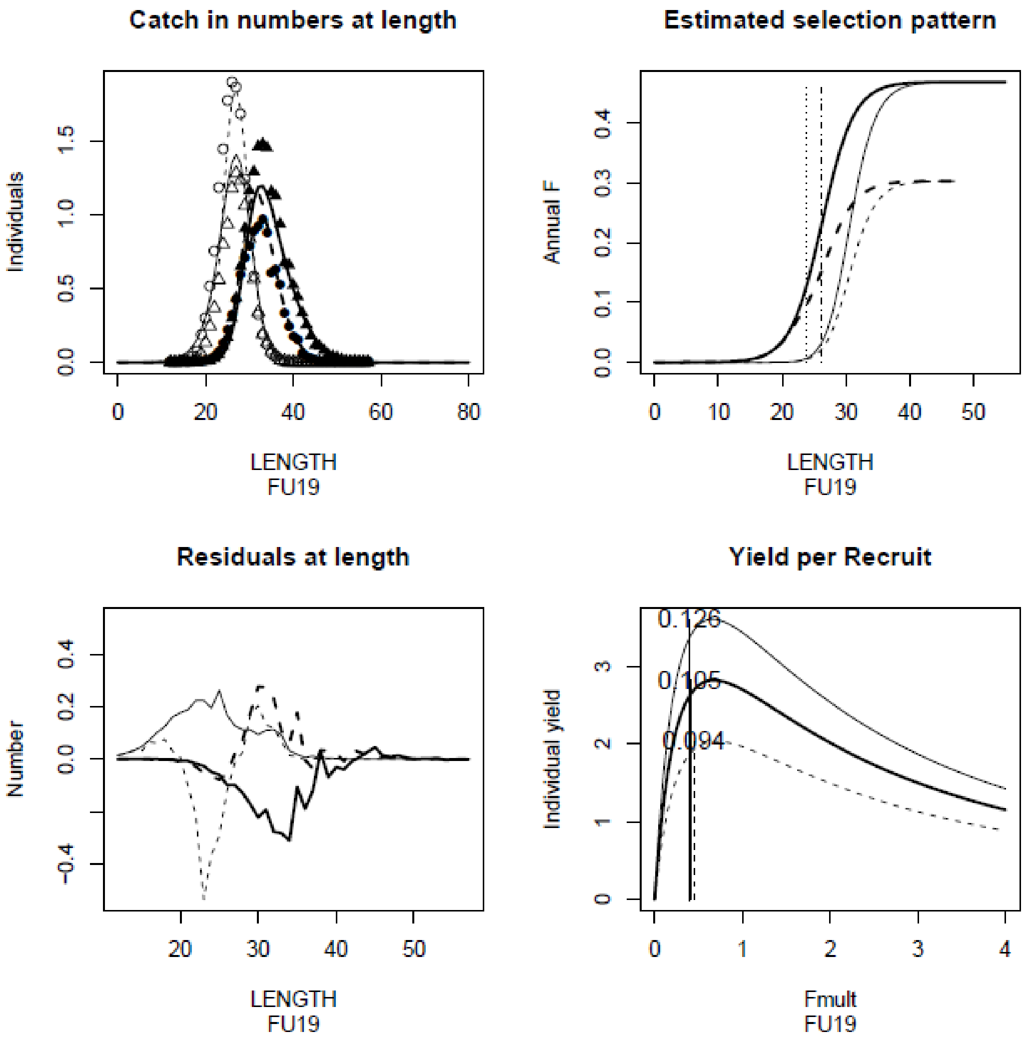

Figure 5.6.5.2. *Nephrops* in FU19 (S and SW Ireland). Separable Cohort Analysis model fit Run 2. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards and landings, top right gives the fishing mortality at length with the vertical lines representing length at 25% selection and 50% selection. Bottom left shows residual numbers (observed-expected) at length. The bottom right gives the Yield-per-recruit against fishing mortality, the thick solid line gives the combined value and vertical lines represent F0.1 for the three curves.

Table 5.1.1. *Nephrops* in FU19 (S and SW Ireland). Data sources available to revise the ground boundaries.

	WKCELT 2014						
	Commercial Data		Seabed Mapping Data			Survey Data	
Ground	VMS 2006-2011	Observer Trip Data	Backscatter	Bathymetry	Sediment Samples	UWTV	GroundFish
Bantry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cork Channels	Yes	Yes	Partial	Partial	Yes	Yes	Yes
Galley Grounds1	Yes	Yes	Partial	Partial	No	Yes	Yes

Galley Grounds2	Yes	Yes	Partial	Partial	No	Yes	Yes
Galley Grounds3	Yes	Yes	No	No	No	Yes	Yes
Galley Grounds4	Yes	Yes	No	No	No	Yes	Yes
Helvick 1	Yes	No	Yes	Yes	Yes	Yes	Yes
Helvick 2	Yes	Yes	Partial	Partial	No	Yes	No
Helvick 3	Yes	No	No	No	No	Yes	No
Kenmare Bay	No	Yes	Yes	Yes	Yes	No	Yes

Table 5.1.2. ***Nephrops*** **in FU19 (S and SW Ireland). Area (km²) calculation for each ground by projection method in Arc GIS 10.**

	WKCELT 2014			
	Integrated VMS 2006-2011			
	Irish National Grid (km²)	Eckert VI (world) (km²)	Cylindrical Equal Area (km²)	Average (km²)
Bantry	121.75	121.54	121.27	121.52
Cork Channels	562.93	562.17	560.91	562.01
Galley Grounds1	60.97	60.88	60.74	60.86
Galley Grounds2	76.87	76.76	76.59	76.74
Galley Grounds3	134.16	133.98	133.68	133.94
Galley Grounds4	926.56	925.40	923.33	925.10
Helvick 1	33.15	33.10	33.03	33.09
Helvick 2	59.62	59.53	59.40	59.52
Total	1976.02	1973.36	1968.95	1972.78

Table 5.1.3. ***Nephrops*** **in FU19 (S and SW Ireland). Final areas (km²) by grounds calculated.**

	WGCSE 2012	WKCELT 2014
	Area (km²)	
Bantry	90.91	121.52
Cork Channels	484.75	562.01
Galley Grounds1	61.88	60.86
Galley Grounds2	77.95	76.74
Galley Grounds3	202.75	133.94
Galley Grounds4	652.33	925.10
Helvick 1	38.56	33.09
Helvick 2	31.47	59.52
Helvick 3	12.66	na
Total	1653.26	1972.78

Table 5.6.4.1. ***Nephrops*** **in FU19 (S and SW Ireland). Total weight of female and male catch using different length- weight relationships.**

L-W parameters	Female (kg)	Male (kg)	Total (kg)
FU19	520.97	1376.08	1897.06
FU6	571.35	1459.26	2030.61
FU11/12	468.98	1346.93	1,815.91

Table 5.6.4.2. ***Nephrops*** **in FU19 (S and SW Ireland).Estimates of L25/L50 of female maturity.**

	Female	
	L25 CL mm	L50 CL mm
all grounds: all years	23	24.5
all grounds: 2009-2013	22.5	23.5
BantryBay: 2009-2013	23	24

Table 5.6.4.3. ***Nephrops*** **in FU19 (S and SW Ireland).L50 of each discard selection ogive.**

Discard Ogive	L50 CL mm
WGCSE	26
Bantry Bay Q1 2008	31
Bantry Bay Q2 2013	33
Bantry Bay Q3 2013	28.5
Bantry Bay Q4 2013	30
WKCELT 2014	30

Table 5.6.4.1. ***Nephrops*** **in FU19 (S and SW Ireland). Separable Cohort Analysis model runs and outputs.**

Run	HR0.1. Comb	HR35%spr Comb	HRmax Comb	Male.k	Male. L.inf	Female.k	Female. L.inf	Discard Weight	Estimated survey abundance	Male.f	Female.f
1	6.8%	13.7%	10.8%	0.16	60	0.06	56	1	432.21	0.5274	0.1835
2	8.1%	14.5%	12.3%	0.16	60	0.08	56	1	346.59	0.4688	0.3036
3	8.1%	16.1%	11.7%	0.16	60	0.08	56	0.5	387.92	0.5206	0.2046
4	7.4%	17.6%	12.4%	0.16	66	0.08	56	0.5	288.27	0.7148	0.2408
5	8.5%	19.3%	13.6%	0.16	60	0.1	56	0.5	294.69	0.5177	0.4036
6	7.5%	22.3%	12.2%	0.16	60	0.1	56	0.1	355.79	0.5341	0.2158
7	9.0%	20.5%	13.3%	0.165	60	0.1	56	0.5	278.41	0.5422	0.4054
8	7.0%	14.2%	11.2%	0.165	60	0.07	56	0.5	416.85	0.5300	0.1813
9	8.1%	16.1%	11.7%	0.16	60	0.08	56	0.5	387.92	0.5206	0.2046

Table 5.6.4.2. *Nephrops* in FU19 (S and SW Ireland). Fitted and observed abundances (million burrows) from the TV survey for each model run. Observed abundance is 3 year average 2011-2013.

Model Run Number	Fitted	Observed	Ratio
1	432.213	484.384	0.89
2	346.590	484.384	0.72
3	387.921	484.384	0.80
4	288.269	484.384	0.60
5	294.688	484.384	0.61
6	355.786	484.384	0.73
7	278.406	484.384	0.57
8	416.851	484.384	0.86
9	387.921	484.384	0.80

5.9 Future Research and data requirements

There are a number of generic research questions (e.g. occupancy and edge effect bias) associated with the UWTV methodology which are not discussed here.These have been discussed in other EG reports (ICES, 2013a, ICES, 2009). There are also specific uncertainties and assumptions that need to be examined further for this particular FU before less conservative F_{msy} proxies could be considered. These include:

- More accurate mapping of the spatial extent of the grounds and fisheries.
- Better knowledge of the meta-population interactions between patches.
- Improvement spatial coverage and sampling of the landings and discards.
- Area specific length–weight data to validate the parameters used for this area.
- Better knowledge of the difference in growth and population structure across the area.

5.10 References

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6 Nephrops in FU 20-21

6.1 Stock ID

VMS Data

The knowledge of the distribution of suitable *Nephrops* habitat in this area is developing. Information so far suggests that *Nephrops* are found in complex channels, which are probably the remnants of fluvial channels related to the deglaciation of the Irish ice sheet at the end of the last ice age. Integrated VMS data has been used to define ground boundaries for a range of *Nephrops* stocks where there is limited data on sediment distribution.

The ground boundary of the Labadie, Jones and Cockburn Banks *Nephrops* grounds was revised based on French and Irish VMS data from 2008-2012, aggregated on a 3-minute (0.05 degree) grid linked to French and Irish landings (Figure 6.1.1), French and Irish lpue (Figures 6.1.2 and 6.1.3) and proportion of *Nephrops* in the Irish landings overlaid on international OTB effort (Figure 6.1.4). Figure 6.1.5 shows that French landings have decreased in recent years from this FU and the French spatial coverage is different from the Irish. The Irish lpue (Figure 6.1.6) may give a better indication of abundance than the combined French and Irish data.

The revised areas of the polygon is shown in Table 5.1.1 calculated using different projections in ArcGIS 10 and the average value is taken as the final area. The revision of the ground boundary has resulted in a 63% increase from 3170 km² a conservative minimum estimate used by WGCSE 2012 to 10,014 km² (Table 5.1.2). This is now the largest *Nephrops* ground in ICES area VII, followed by FU 16 Porcupine ground (6922 km²) and FU 15 western Irish sea (5820 km²). WKCELT concluded that the current area estimation of 10 014 km² is acceptable as the total area of this stock. WKCELT recommended that the area is subject to refinement when additional data becomes such as seabed mapping and that any future area revisions are to be considered by WGNEPS.

WKCELT also recommended that the Functional Unit 20-21 be revised to include ICES statistical rectangles (28-29 E0 and 29E3) to cover the revised ground boundary (Table 6.1.3 and Figure 6.1.5).

Table 6.1.1. *Nephrops* in FU 20-21. Area (km²) calculation by projection method in ArcGIS 10.

	Labadie FU 20-21			
	Irish National Grid (km²)	Eckert VI (world) (km²)	Cylindrical Equal Area (km²)	Average (km²)
Integrated VMS 2008-2012	10 028.27	10 018.02	9995.86	10 014

Table 6.1.2. *Nephrops* in FU 2021. Final areas (km²) calculated in ArcGIS 10.

FU 20-21	
WGCSE 2012	WKCELT 2014
Area (km²)	
3710	10 014

Table 6.1.3. *Nephrops* in FU 2021. ICES statistic al rectangles in revised FU20-21.

FU 20-21
28 E0-E2,
29 E0-E3,
30E1-E3,
31E2

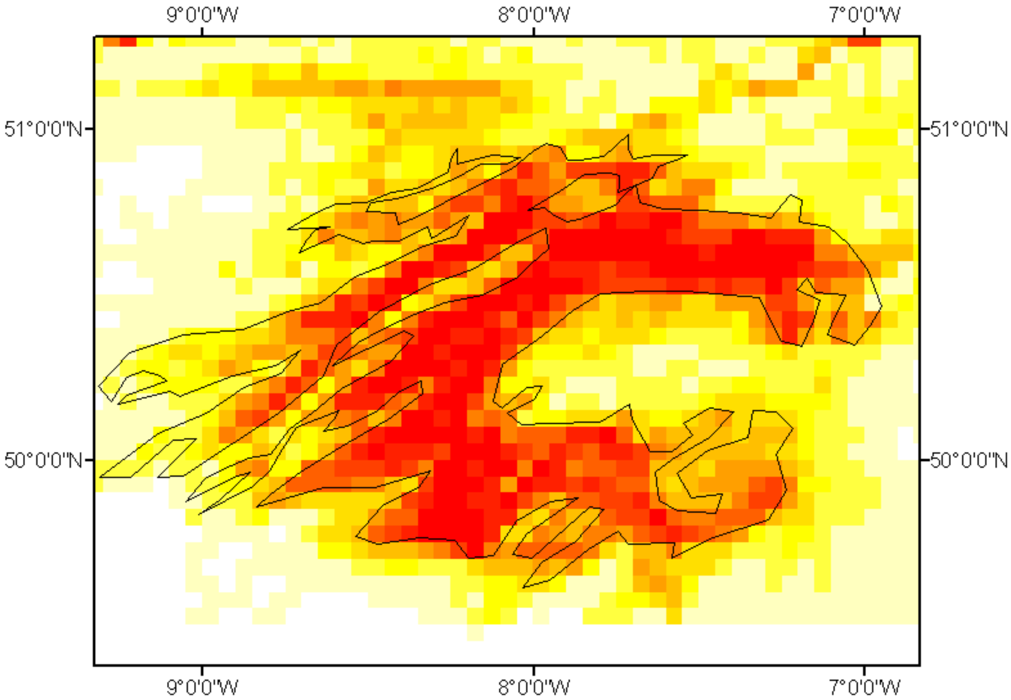


Figure 6.1.1. *Nephrops* in FU 20-21.Heatmap of Irish and French *Nephrops* landings (square root-transformed colour scale) with the revised ground outline in black.

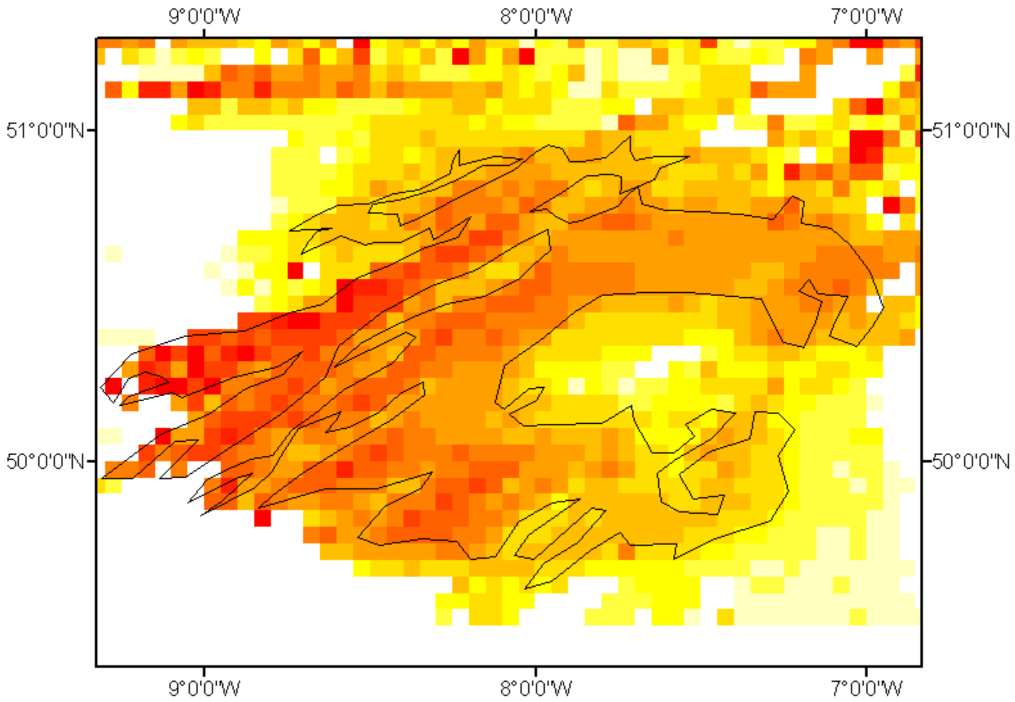


Figure 6.1.2. *Nephrops* in FU 20-21. Heatmap of Irish and French *Nephrops* LPUE with the revised ground outline in black.

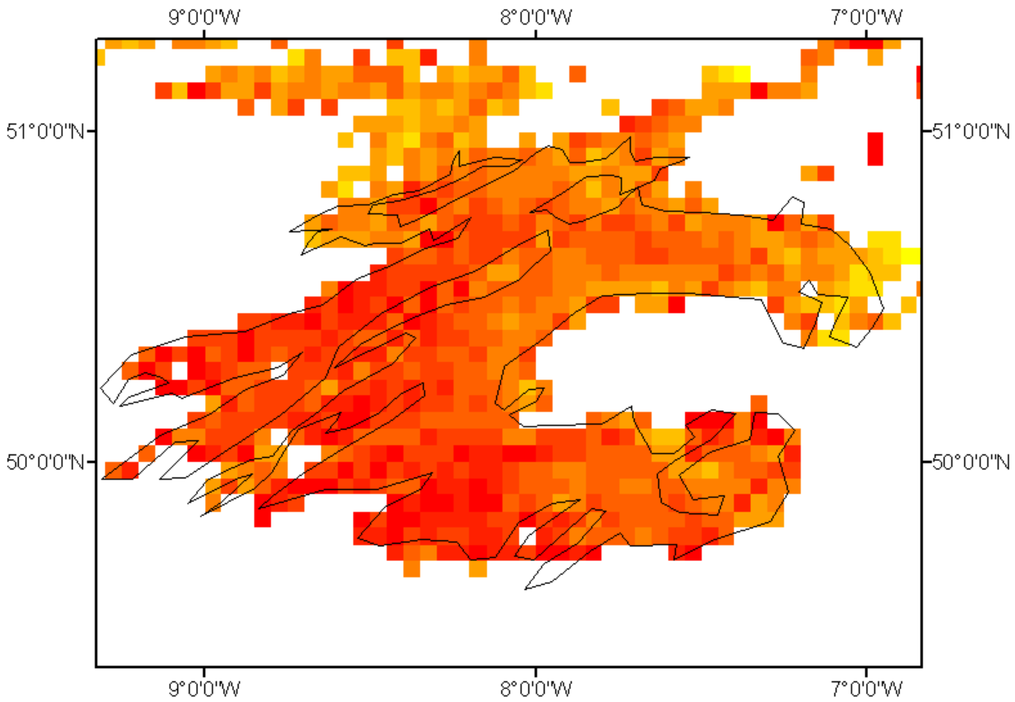


Figure 6.1.3. *Nephrops* in FU 20-21. Heatmap of Irish only *Nephrops* LPUE with the revised ground outline in black.

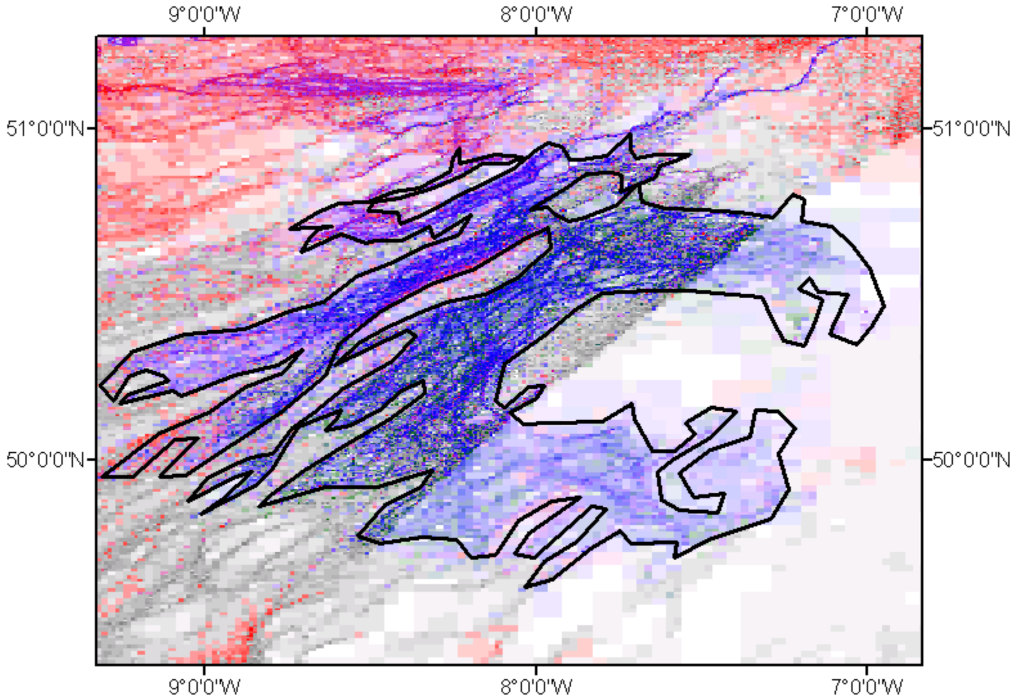


Figure 6.1.4. ***Nephrops*** **in FU 20-21. Proportion of** ***Nephrops*** **in the Irish landings overlaid on international OTB effort (red=0%** ***Nephrops*****; blue=50-60%** ***Nephrops*****; grey=unknown (no Irish landings). The revised ground outline is shown in black.**

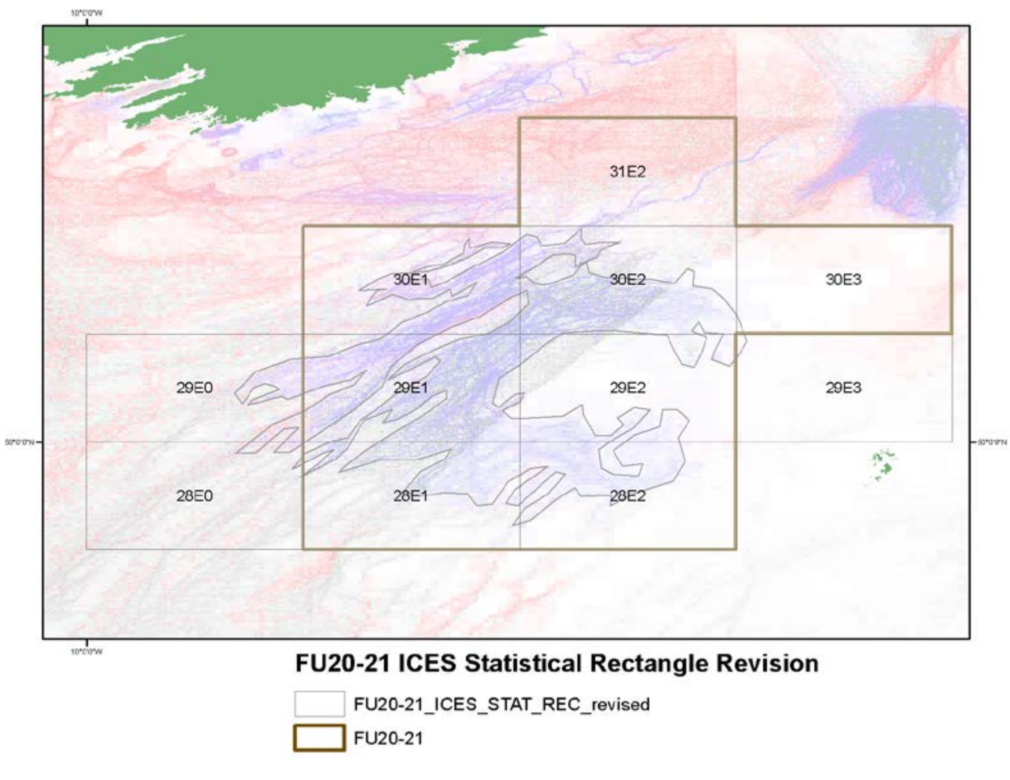
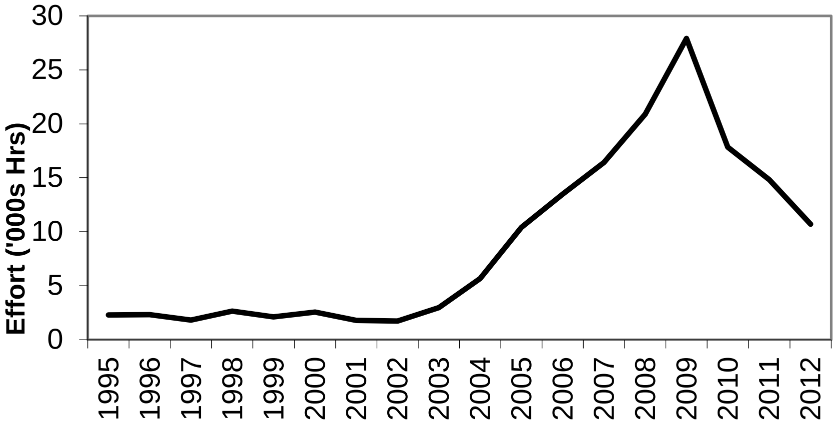
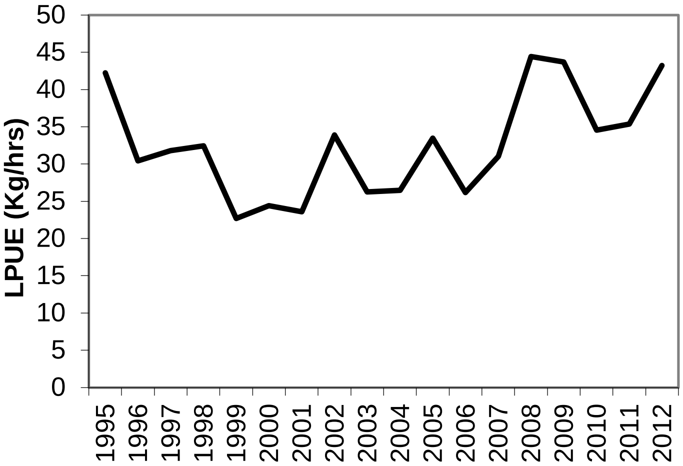


Figure 6.1.5. ***Nephrops*** **in FU 20-21. ICES statistical rectangles in FU20-21. The revised ICES statistical rectangles in grey which covers the revised ground boundary.**





Larval Tracking Models

Adult *Nephrops* are territorial and not thought to undergo much movement on the seabed so that adult populations can be considered as separate stocks. Recent larval tracking studies using both Regional Ocean Modelling System (ROMS) and a larval transport model (LTRANS) for *Nephrop*s in the Celtic Sea has explored the potential connectivity between proximal and distant *Nephrops* grounds (O'Sullivan *et al., in press*). This study differentiated between larval retention and dispersal as there are important consequences for stock connectivity. A connectivity matrix table presented by O'Sullivan *et al.,* describes the percentage of larvae that are retained over the same ground from which they are hatched or transported to adjacent grounds following the pelagic larval phase. The Labadie grounds had a high retention rate (~30%) in 2011 which was similar to that estimated for the western Irish Sea (FU 15). FU 20-21 and also donates some larvae to the Galley grounds (FU 19). WKCELT concluded that the results from this study were important to stock assessment demonstrating some inter-connectivity of the *Nephrops* grounds in the wider Celtic sea. WKCELT recommends that this research be continued and should explore the accuracy and precision of retention/exchange rates as well as interannual variability.

6.2 Issue list

For this FU the benchmark process considered the following issues identified by WGCSE 2012 to improve the inputs to the data limited approach which offers some potential to provide advice and management for this stock

- Spatial extent of the *Nephrops* grounds could be improved.
- Update mean weight from available sampling data
- Update discard selection pattern from available sampling data
- The utility of the Irish groundfish survey and other survey information for this stock should be examined.

6.3 Scorecard on data quality

The WKACCU scorecard approach was followed to quantify bias in fisheries data, evaluate the quality of data sources used and identify steps in data collection process that must be improved (ICES, 2008a). Table 6.3 is the scorecard of the key parameters that are used to evaluate potential bias in data used for stock assessment.

	No bias	Potential bias	Confirmed bias	Comment
A. SPECIES IDENTIFICATION				
1. Species subject to confusion and trained staff				
2. Species misreporting				
3. Taxonomic change				
4. Grouping statistics				
5. Identification Key				
Final indicator	No bias			

B. LANDINGS WEIGHT	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on species identification	No bias			
1. Missing part				Not Checked statistically
2. Area misreporting				Area misreporting corrections have been applied
3. Quantity misreporting				Logbook data assumed to be accurate
4. Population of vessels				
5. Source of information				

6. Conversion factor				Standard Nep CF of 3 is used from tail to live weight
7. Percentage of mixed in the landings				
8. Damaged fish landed				
Final indicator		Potential bias		Landings information are derived from logbooks and assumed to be accurate

C. DISCARDS WEIGHT	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on species identification	No bias			
1. Sampling allocation scheme				
2. Raising variable				
3. Size of the catch effect				Catch samples are decomposed into landings and discard fractions using an onboard selection ogive
4. Damaged fish discarded				
5. Non response rate				
6. Temporal coverage				
7. Spatial coverage				
8. High grading				
9. Slipping behaviour				
10. Management measures leading to discarding behaviour				
11. Working conditions				
12. Species replacement				
Final indicator		Potential bias		

D. EFFORT	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on species identification	No bias			
1. Unit definition				Derived from logbook data
2. Area misreporting				
3. Effort misreporting				
4. Source of information				
Final indicator		Potential bias		

E. LENGTH STRUCTURE	No bias	Potential Bias	Confirmed Bias	
Recall of bias indicator on discards/landing weight		Confirmed Bias		
1. Sampling protocol				
2. Temporal coverage				Very poor samplingby both countries
3. Spatial coverage				Very poor samplingby both countries
4. Random sampling of boxes/trips				
5. Availability of all the landings/discards				
6. Non sampled strata				
7. Raising to the trip				
8. Change in selectivity				
9. Sampled weight				
Final indicator		Confirmed Bias		

G. MEAN WEIGHT	No bias	Potential Bias	Confirmed Bias	
Recall of bias indicator on length/age structure		Confirmed		Very poor samplingby both countries
1. Sampling protocol				
2. Temporal coverage				
3. Spatial coverage				
4. Statistical processing				
5. Calibration equipment				
6. Working conditions				
7. Conversion factor				
8. Final indicator			Confirmed	Lenght-weight parameters are used to estimate mean weight.

H. SEX RATIO	No bias	Potential Bias	Confirmed Bias	
Recall of bias indicator on length/age structure		Potential bias		Very poor samplingby both countries
1. Sampling protocol				
2. Temporal coverage				
3. Spatial coverage				
4. Staff trained				
5.Size/maturity effect				
6. Catchability effect				There is a strong variation in female catchability for Nephrops
Final indicator			Confirmed	

I. MATURITY STAGE	No bias	Potential bias	Confirmed bias	Comment
Recall of bias indicator on length/age structure		Potential bias		
1. Sampling protocol				

2. Appropriate period		
3. Spatial coverage		
4. Staff trained		
5. International reference set		
6. Size/maturity effect		
7. Histological reference		
8. Skipped spawning		
Final indicator		Not relevant to the current assessment method
Final indicator	Potential bias	

6.4 Multispecies and mixed fisheries issues

The *Nephrops* fisheries in this FU target different areas, and *Nephrops* catches and landings show different size structures. In recent years FU 20-21 has accounted for around 48% or 2185 t of the total landings (~ 4500 t) from the wider Celtic Sea (FU19, 20, 21 and 22) (ICES, 2013b).

Figure 6.4.1 shows the proportion of *Nephrops* in the Irish landings overlaid on international OTB effort. Over most of the area *Nephrops* constitute between 50-60% of the retained landings.Davie and Lordan (2011) examined the species composition in a *Nephrops* targeting métiers in VIIg. They defined two separate métiers a "clean" and more "mixed" depending on the proportions of *Nephrops* in the landings. They found that the median number of species landed on trips targeting *Nephrops* was ~7 with and IQR of 5-10. The main species landed with *Nephrops* by weight were anglerfish, whiting, cod, megrim and haddock. The grounds to the North tend to have a more mixed species composition in the retained landings. Gerritsen *et al.*, (2012) used hierarchical cluster analysis to define spatial regions with relatively homogenous species compositions in the waters around Ireland. They identified 2 *Nephrops* clusters within FU20-21, retained catches from Labadie 1 was dominated by *Nephrops* ~60% with anglerfish (12%) and megrim (9%) also important. Labadie 2, which is the northwestern part of the ground was more mixed, ~28% *Nephrops*, ~17% anglerfish and 14% megrim. The percentage of the total otter trawl effort expended on these grounds was ~9%, with similar percentages in the total landings (8%) and total surface area fished (8%).

6.5 Ecosystem drivers

Underlying Ecosystem trends

A summary document of the physical and biological features of the Celtic sea ecosystem is available (Anon, 2013). This indicates that:

- Long-term datasets (1958) from the Malin shelf indicate a steady increase in SSTs.
- Time series dataset (1990-2010) of phytoplankton species are increasing in coastal waters south and southwest of Ireland.
- Long-term time series since 1958 show a decline in overall zooplankton abundance and a northward shift of warm-water zooplankton Calanus into Celtic Sea.
- ECOQO OSPAR report for seabirds in the Celtic Sea shows a downward trend since early 2000's.
- 65% of the landings in the Celtic sea region come from stocks which have analytical assessments.

The general increase in sea surface temperature is expected to increase larval development rates during the pelagic phase and as a consequence larval mortality may decline. However the larval retention mechanisms may also be impacted so the cumulative impact on recruitment maybe difficult to forecast. Uwtv surveys offer and opportunity to monitor oceanographic variables using a sled mounted CTD. This information is relatively easy to collect and over time will augment the knowledge base on the oceanographic regime in FU20-21.

Impact of the Fishery on the Ecosystem

Demersal trawling, which is the main catching method in FU20-21, modifies the benthic community structure and also has the potential to modify the physical habitat. The frequency of this demersal trawl impact has been assessed using VMS data (Gerritsen *et al.*, 2013). In the Irish EEZ of the Celtic Sea, 68% was impacted at least once by trawling, a considerable portion of the area (46%) was impacted at least twice, 13% of the area was impacted at least five times, particularly along the continental shelf edge and on the mud patches such as those in FU20-21 where *Nephrops* occur. Some regions were even impacted ten times or more, although this occurred in <2% of the area. While there are no direct studies on the impact of trawling on the benthic communities in FU20-21 it can be expected that these grounds are highly modified environments.

In addition to estimating *Nephrops* stock abundance UWTV surveys can be used to monitor the presence of certain benthic fauna. Sea-pens and burrowing megafauna communities have been included in the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2010). For each minute of the UWTV footage the occurrence of trawl marks, fish species and other species are recorded. Abundance categories of sea-pen species and distributions maps from the 2012 to 2013 surveys show that all sea-pens were identified from the video footage as *Virgularia mirabilis* and this species was also present at stations where trawl marks were recorded (Doyle *et al.*, 2012, 2013).

6.6 Stock Assessment

6.6.1 Catch – quality, misreporting, discards

Commercial landings data are supplied by Ireland, France and the UK.

The quality of historic landings data are not well known but they are perceived to be reasonably accurate. Landings statistics for the Irish fleet are obtained from EU logbooks since 1995. Vessels record daily retained catches in operations and make a declaration of total landings on return to port. Since 2012, most vessels in the fleet have been using electronic logbooks (EC Regulation 1224 of 2009 and 404 of 2011).

In recent year landings in FU 2021 have been adjusted to take account of minor area misreporting from FU16 to FU2021. This correction is perceived to be reasonably accurate.

Fish and other bycatches in the Irish fishery have been collected by on board observers since 1994.Discarding by the *Nephrops* trawl fleet is around 38% of the total catch by weight. The main discards are small whole *Nephrops*. The main fish species discarded are whiting, dogfish, haddock and poor cod (Anon, 2011).

Discard observations on Nephrops length distributions from Irish vessels have been very limited (See table: 6.6.3.) compared to other areas. The Irish fishery has expanded into this area from FU22 in recent years. Fishing trips tend to cover multiple areas and are seasonal making planning adequate sampling coverage difficult.

WKNEPH recommend that sampling coverage of this area be improved to allow the estimation of length compositions of landings and discards across fleets with reasonable accuracy and precision.

6.6.2 Groundfish Survey

Length–frequency data of the *Nephrops* catches on the Irish groundfish survey (IGFS-WIBTS-Q4) (2003–2013) and French groundfish survey (EVHOE-WIBTS-Q4 (1997–2012) are available. Figure 6.6.1. depicts the positions of the IGFS and EVHOE stations in FU2021 and shows that some of the stations occur outside the revised ground polygon. Also that the Irish stations are in the northern sector whereas the French stations are more dispersed over the ground. Trends in indicators such as mean size and mean weights were investigated at the meeting. For both the Irish and French groundfish survey mean weights were calculated using the parameters derived from Scottish weight–length relationships (Pope and Thomas, 1955), (Stock Annex). The mean size of males and females from the Irish groundfish survey was fairly stable over time (Figure 6.6.2), for the French survey data there are some fluctuations in male mean size which maybe a signal of recruitment (Figure 6.6.3). The Irish data shows a slight increasing trend in mean size for males in the latter years of the series (Figure 6.6.4) while the French data shows a stable or slightly decreasing trend (Figure 6.6.5). The mean weights for *Nephrops* caught on EVHOE survey are higher than those caught by Irish survey. It must be noted that there are spatial coverage differences between both surveys. WKCELT concluded that although these data are not used directly in the benchmark process nonetheless the data are useful for trends. WKCELT recommended that *Nephrops* length frequency data from the groundfish surveys to be investigated for trends in indicators annually.

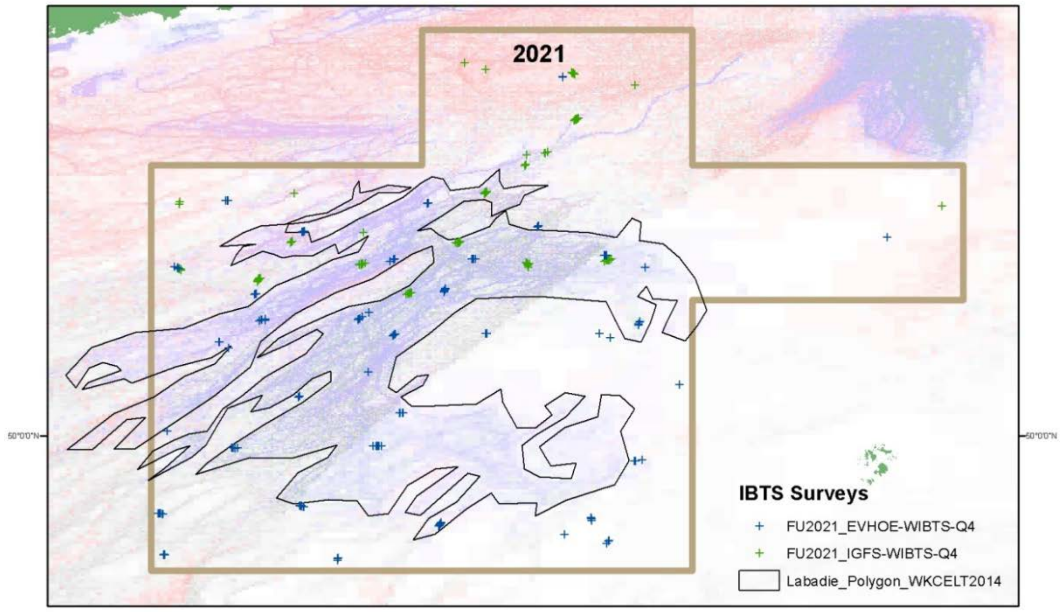


Figure 6.6.1. Nephrops in FU 20-21. Positions of stations with Nephrops catches on IBTS groundfish surveys. French stations (blue cross) and Irish stations (green cross).

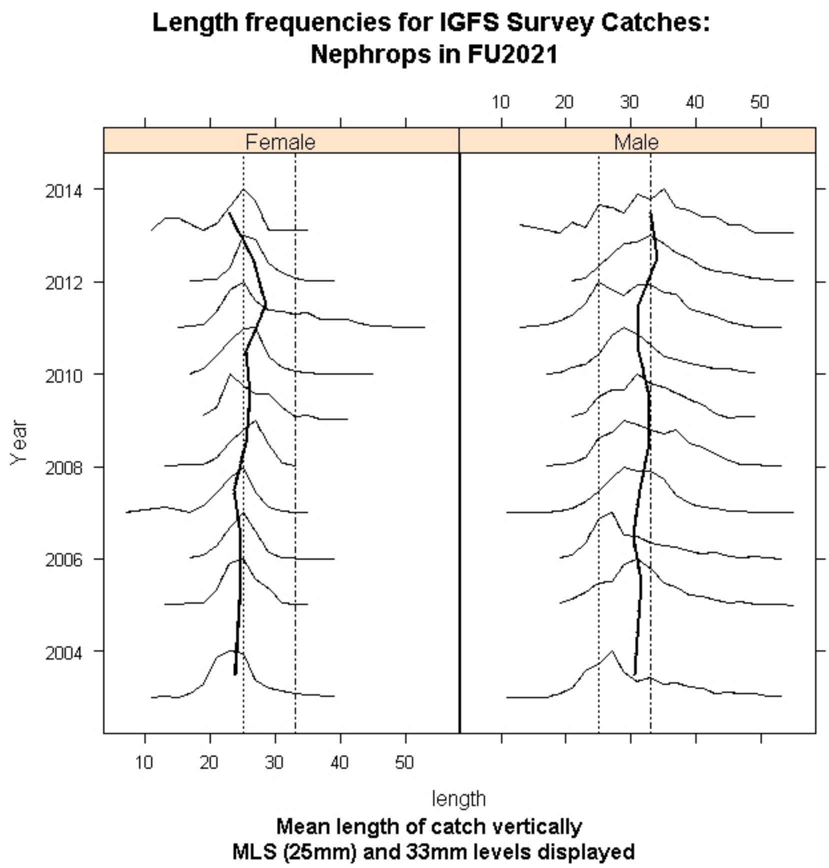


Figure 6.6.2. *Nephrops* in FU 20-21. Mean length CL mm by sex for Irish Groundfish survey time series.

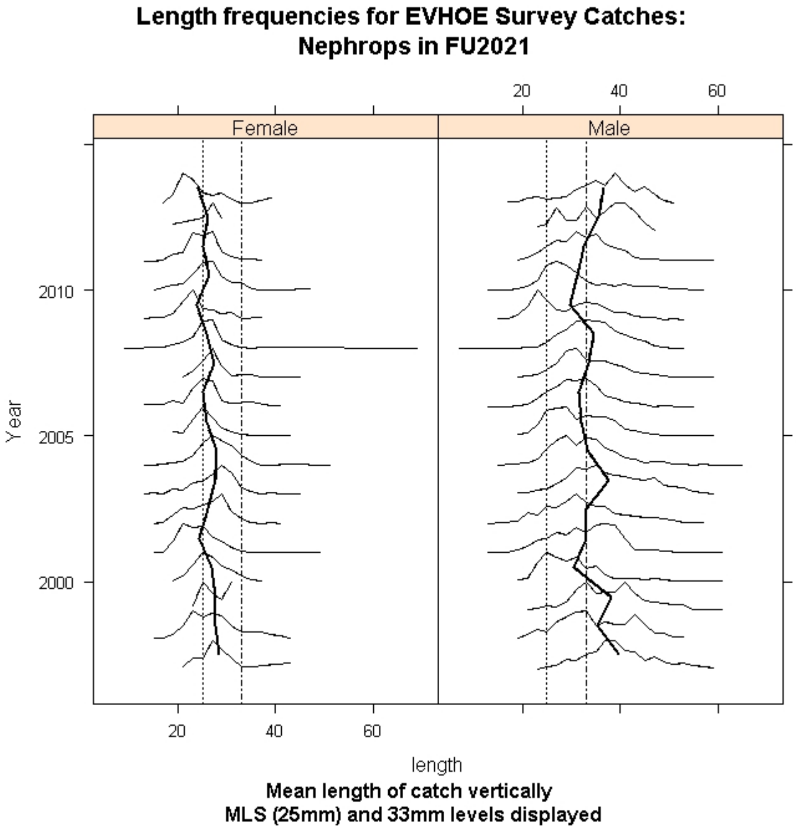


Figure 6.6.3. *Nephrops* in FU 20-21. Mean length CL mm by sex for French Groundfish survey time series available.

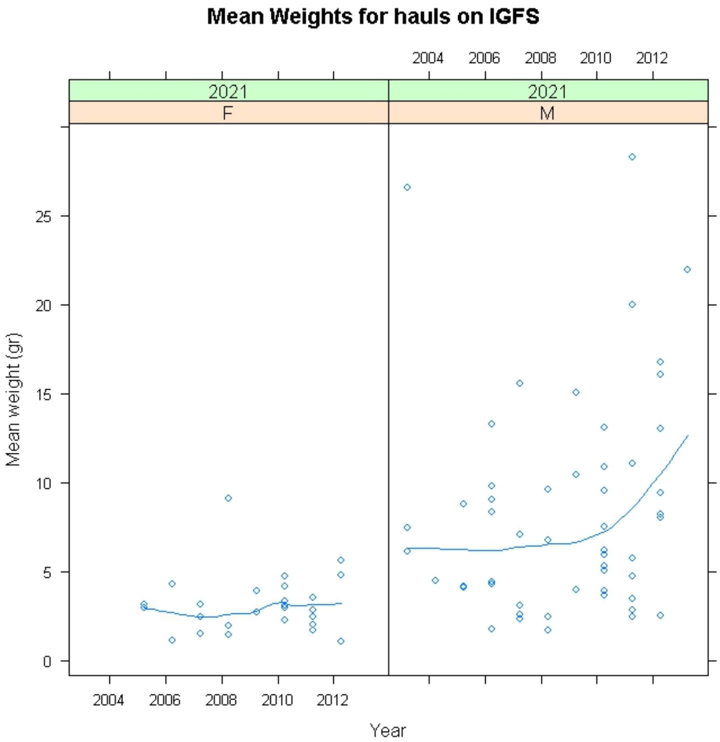


Figure 6.6.4. *Nephrops* in FU 20-21. Mean weights (gr) by sex for Irish Groundfish survey 2004–2013.

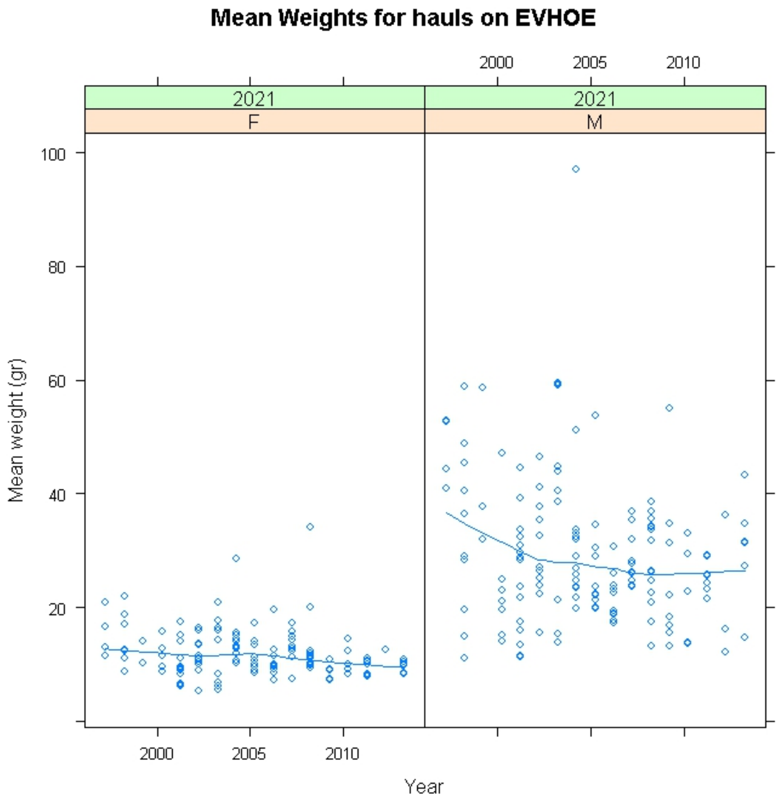


Figure 6.6.5. ***Nephrops*** **in FU 20-21. Mean weights (gr) by sex for French Groundfish survey 1997–2013.**

6.6.3 TV survey

Scientific knowledge of the heterogeneous habitat and spatial distribution of the *Nephrops* population in this area is developing. In 2006 Ireland conducted an exploratory underwater television survey (UWTV) in FU20-21. Nine stations in the northern part of the grounds were completed and these stations were chosen based on VMS data available at the time. In response to the WKNEPH 2012 recommendations Ireland reviewed survey effort in FU15, 17 and 22 and reallocated survey effort to FU16, 19 and 20-21 (ICES, 2012). In 2012, 52 stations were surveyed across the entire ground (Doyle *et. al*., 2012). In 2013, fifty-four stations were surveyed, all north of 50°N, along a randomized isometric grid with 6 nautical mile spacing (Doyle *et. al*., 2013).

The methods used during the survey were similar to those employed for UWTV surveys of *Nephrops* stocks around Ireland and elsewhere and are documented by WKNEPHTV (ICES, 2007), SGNEPS (ICES, 2009, 2010, 2012) and WGNEPS (2013). In order to use the survey abundance estimate as an absolute it is necessary to correct for potential biases. For FU 20-21 the field of view of the camera was 0.75 m and expert judgment of the mean burrow diameter was in the range of 0.25–0.4 m. The edge effect is estimated at 1.25 which is similar to FUs of moderate density. In future it may become possible to quantitatively estimate burrow diameter from mosaics of the footage from this and other areas. Burrow detection rates were thought to be relatively high due to good water clarity Burrow identification could be slightly overestimated since burrows with the classical *Nephrops* signatures are common but they are interspersed with burrows of various crab and other burrowing megafauna species. The proposed cumulative correction factor for the area was 1.3 (Table below). When compared to with the correction factors applied in other areas it is quite close to the average used on other grounds.

The biases associated with the estimates of *Nephrops* abundance in FU 20-21 are:

	Period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU 20-21:						
	2012	1.25	0.9	1.15	1	1.3

UWTV spatial coverage

In 2006, nine stations in the northern part of the grounds were surveyed using UWTV, these stations were placed more-or-less at random. In 2012, fifty-two stations were surveyed across the entire ground. However these stations were generally located along known fishing tracks, thereby potentially biasing the abundance estimate. In 2013, fifty-four stations were surveyed, all north of 50°N, along a random isometric grid with a 6.0 nautical mile spacing across an expanded area to that used previously. Because the southern part of the grounds is expected to have lesser abundance, extrapolating the 2013 survey over the whole ground may also result in bias.

In order to address these concerns, the distribution of Irish commercial LPUE from the aggregated VMS dataset was used as a proxy for stock density (Figure 6.1.3). The density distribution of LPUE over the whole ground is shown in Figure 6.1.7. The midpoints of each survey track were matched up with the grid cell of VMS data in which they fell, in order to estimate the mean LPUE for each of the survey stations. The distributions of these are also shown in Figure 6.1.6. The 2006 survey had a bimodal distribution with a group of stations with high LPUE (35–40kg/h) and another group of stations with lower LPUE (around 25–30kg/h), there were no stations with less than 20 or more than 45kg/h. The 2012 survey had a fairly narrow distribution around 30–35kg/h. The LPUE distribution of the 2013 survey was somewhat broader and closer to the overall LPUE distribution.

The average LPUE of each of the surveys was remarkably close to the average of the whole ground given in table below:

	LPUE (KG/H)
Whole ground	34.1
2006 survey	33.1
2012 survey	33.9
2013 survey	32.3

Therefore it seems likely that the bias due to the location of the sampling stations on any of the surveys is minor (assuming that the Irish LPUE is a reasonably approximation of stock density). It should be noted however that there are fine-scale patterns in the distribution of fishing effort (and presumably of *Nephrops*) that are lost at the scale on which the VMS data were aggregated (0.05 degrees). So, for example, it is possible that a survey station would be located on ground with no *Nephrops*, but the LPUE in the cell in which the survey station falls could be quite high.

WKCELT concluded that the survey design used in 2013 was the most appropriate to this stock. The preliminary surveys in 2006 and 2012 may not be an appropriate basis to estimate density across and extensive and heterogeneous area such as this. This example highlights the potential for bias that needs to be considered carefully if the "*Nephrops* data limited approach" is applied in this and other areas. Because survey coverage was 61% of the total area it was not possible to extrapolate density to the whole area. Future surveys should employ a strategy to maximize survey coverage to allow for some extrapolations in years where the number of stations is reduced due to time constraints.

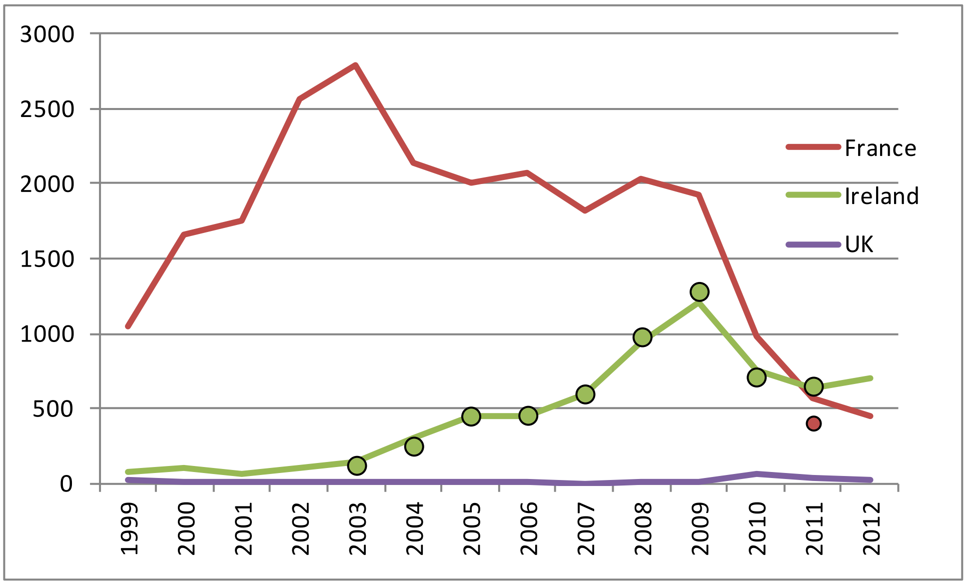
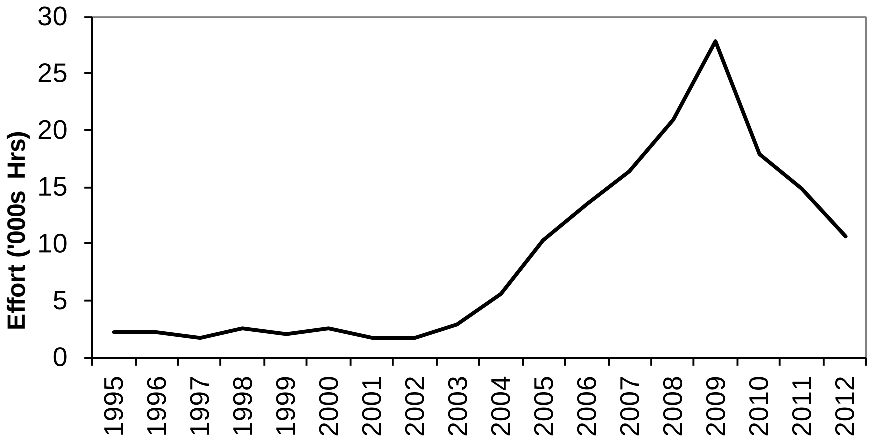


Figure 6.6.3.1. *Nephrops* in FU 20-21. International reported *Nephrops* landings. Dots are checks against STECF Database.



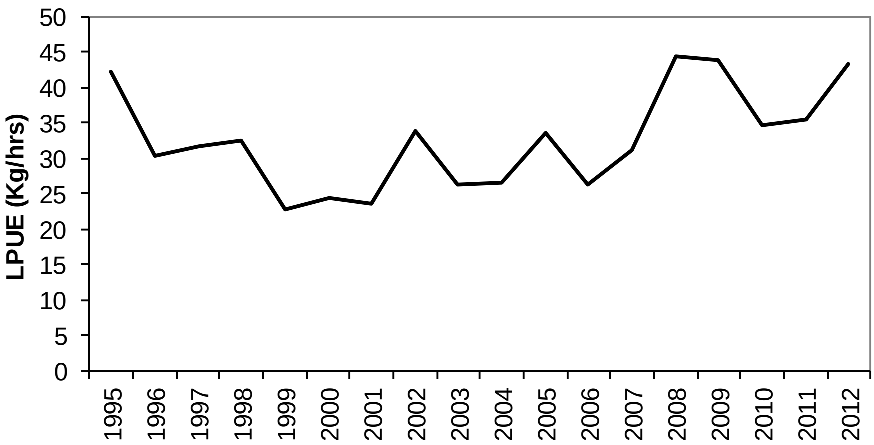


Figure 6.6.3.2. ***Nephrops*** **in FU 20-21. Irish effort and LPUE for** ***Nephrops*** **directed fleet**

6.6.4 Weights, maturities, growth

Commercial Catch Data

Ireland

Length and sex composition of the annual landings for this FU are estimated from port and at-sea sampling. Sampling levels have been very poor and collected on a very irregular basis in the years 2009–2013. The main difficulty is the nature of the fishery as it is a distant ground ~150 km offshore and the behaviour of the fleet where Irish and French vessels switch between *Nephrops* grounds to maintain catch rates.

In Ireland a catch self-sampling programme is in place. This involves unsorted catch and discard samples being provided by vessels or collected by observers at sea on discard trips. The catch sample is partitioned into landings and discards using an on board discard selection ogive derived for the discard samples. This is approach is needed because the landings are made as tails or graded whole prawns and the discards are known to be extensive. The numbers of samples and individuals measured is given in Table 6.6.3. In 2012 and 2013, data on graded landings were sampled on board. These data could in future be used to reconstruct the landings LFDs.

WKNEPH recommend that sampling coverage of this area be improved to allow the estimation of length compositions of landings and discards across fleets with reasonable accuracy and precision. Improved collaboration with industry could facilitate this by providing commercial grade information on landings and accommodating observers on FU20-21 fishing trips.

Table 6.6.3. Irish Sampling levels.

	Number of Samples			Numbers Measured		
	Catch	Discard	Landings	Catch	Discard	Graded Landings
2009	1			489		
2010	1			461		
2011	1			270		
2012	2	2	1	2654	2024	1747
2013	3	3	1	2514	2038	4552

Length-weight parameters

Ireland

The annual mean weight for Irish landings is calculated from the length–frequency data and a length–weight relationship from studies on Scottish stocks by Pope and Thomas (1955) (See Stock Annex). No update to this relationship was made at the meeting.

France

No update to this relationship was made at the meeting.

Mean Weight

The annual mean weight in the landings is calculated from the length–frequency data and a length–weight relationship as stated above. Mean weight in the landings and discards is needed in the UWTV approach. Previous investigations of this at WGCSE 2012 showed that the mean weight in the landings for French vessels is significantly higher than Irish vessels. A weighted mean weight was derived using the Irish and French mean weights and the proportions of the total landings by each country. This was considered to be the most realistic value although there have been strong trends in the proportions landed by each country. No alternative approach was developed at WKCELT.

Sex Ratio

Previous *Nephrops* working groups have highlighted stability in sex ratio as an important indicator for *Nephrops* stocks. Given the low levels of sampling it was not possible to extract information on this. WKCELT recommend that sex ratio indicators be reviewed when sampling data improves.

Maturity

L50 for females (22 CL mm) is borrowed from FU 22 as to date there has been no maturity ogive estimated for this FU. Use of data from groundfish surveys is not applicable as these take place in quarter 3 and 4 and the limited commercial samples are usually obtained in summer. WKCELT recommend that updated maturity ogives are calculated when sampling data improves for this FU.

Discard Selection

No new information

6.6.5 Assessment model

The *Nephrops* data-limited approach (ICES, 2012) approach was first used by WGCSE 2012 to provide advice. This method requires the following inputs to derive Harvest Ratios for given levels of density and landings:

1. Recent absolute (bias corrected) density estimate from the TV survey. Three exploratory surveys have been carried out and to date 60% of the area has been covered by the TV survey (Doyle *et al.*, 2013). The mean density adjusted estimates range from 0.18 to 0.58 burrow/m² (Table 6.6.4.1).
2. Spatial extent of the grounds.
   The area estimate was revised at WKCELT 2014 based on French and Irish VMS data and is now accepted as the best estimate.
3. Mean weight in the landings.
4. Percentage of dead discards.

Table 6.6.4.1. FU20-21 Summary of univariate statistics for the burrow density estimates (bias corrected).

Year	1st Quantile	Median	Mean burrow/m²	3rd Quantile	Max	No. of Stations	StDev	CV/Relative Standard error
2006	0.13	0.42	0.40	0.60	0.91	11	0.31	24%
2012	0.38	0.62	0.58	0.77	1.04	57	0.26	6%
2013	0.10	0.17	0.18	0.24	0.60	58	0.14	10%

6.7 Short-term projections and how the advice is derived

WKCELT concluded that if more complete spatial coverage of the newly defined area can be achieved using the standard UWTV survey approach and sampling data are sufficient to estimate the parameter required to calculate catch options the this method could be applied in the near future.

6.8 Appropriate Reference Points (MSY)

No specific reference points have been derived for this FU yet due to lack of sufficient length–frequency data to derive the inputs to separable cohort model analysis. WKCELT concluded that stock specific reference points should be estimated based on the most complete sampling data for this stock by WGCSE in order to use the standard UWTV approach.

6.9 Future Research and data requirements

There are still a number of outstanding issues that need to be addressed to improve the inputs to the data limited approach and also before this FU can be move to full UWTV survey category. WKCELT recommend the following

- Improved length frequency information. This could be obtained in collaboration with industry through enhanced observer sampling, self-sampling or using the grade approach where discards can also be estimated.
- Full coverage of the grounds by UWTV survey. This FU is geographically extensive and is challenging to complete. However, full coverage of the ground would provide a comprehensive picture of the population.

6.10 References

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7 Comments from the external reviewers

General Comments (External Expert):

The Celtic working group met to conduct 4 benchmark assessments; Sole VIIfg, Whiting VIIek, Nep 19 and Nep 20-21. General information regarding the specific stocks was provided to the working group either via presentation or made available on Sharepoint. Several problems were identified in the XSA formulations for sole and whiting due primarily to noisy data. Nep 19 was given a passing bill of health and moved forward to final report preparation and completion of the annex. The Irish team has been making great steps in integrating several sources of data into the assessment. The development of habitat mapping using multibeam sonar seabed classifications algorithms is showing promise and continued work in this area is encouraged. Whiting was postponed until later in the week due to the absence of discard data (a major source of concern). The initial run on Thursday afternoon, with the discard data in, identified several strong residual patterns, and a number of potential setting errors that needed to be corrected. However, combining the surveys, including the discards and changes to M in the improved the assessment to a point where it was informative. For sole, strong patterns in the residuals of two of the tuning indices and the sensitivity of F to minor changes were found to be main sources of uncertainty. A comprise model with a truncated age structure in the UK_BT-index was accepted as an interim solution, however, it was stressed that this assessment has problems that cannot be resolved with XSA. Both the Sole and the whiting teams were encouraged to pursue more advanced assessment models such State Space. In fact, an initial SAM run was made available to the participants. Nep 20-21 has some sampling issues, yet the benchmark concluded that the UWTV surveys were the best approach to assessing the stock, assuming some logistic and coverage problems can be overcome. A survey design with less intensity of stations than in other areas could not be completed in the time allocated. Only the northern portion of the fishing area was covered, potentially introducing a bias to the density estimates. The sampling design and intensity should be revisited if this continues to occur. A short presentation on mixed fisheries was made providing an overview of ongoing projects, but there was little discussion on the matter.

Overall the co-chairs did an excellent job of organizing the meeting and keeping the participants on track. The general information regarding specific stocks provided at the benchmark meeting was in good order. However, there was a fair amount of outstanding baseline data workup left until the actual framework meeting. While this was no reflection on the participants who worked late into the evening most days, it did limit the amount of time available to pursue new avenues or in-depth review of some models during the week. For example, the non-availability of the complete whiting discard data until Wednesday afternoon prevented the exploration of the assessment until the last few days of the meeting. Essentially there was limited time to investigate several aspects of the whiting assessment. This and several other factors reduced the amount of exploration time available during the meeting. The working group is strongly encouraged to have the input data prepared to a level that would allow use of the data in existing models and the exploration of new configurations. That being said, it is my opinion that the benchmarks were the best that could be done in the time allocated, but that the assessments could have moved forward more if efficiencies were made in the data preparations before the meeting.

8 Recommendations

For both **Celtic Sea sole and Celtic Sea whiting** it is strongly recommended to explore assessment methods that are less sensitive to noise in the data, for example state—space models like SAM.

Nephrops in FU 19,

WKCELT recommended that WGCSE and WGNEP consider refinement and revisions of area, parameters, discards, sex ratios and decide on appropriate fill in procedure if any ground has not be surveyed by TV.

Nephrops in FU 20-21:

The WKCELT recommended further development of the UWTV approach, in particular to ensure sufficient coverage. In the meantime, the data-poor approach, as outlined in the stock annex, should apply.

Annex 1 List of participants

Name	Country
Mette Bertelsen	ICES
Jennifer Doyle	Ireland
Spyros Fifas	France
Colm Lordan	Ireland
Gary Melvin	Canada
Cóilín Minto	Ireland
Sofie Nimmegeers	Belgium
Eibhlin O Sullivan	Ireland
Lionel Pawlowski	France
Dankert Skagen	Norway
David Stokes	Ireland
Willy Vanhee	Belgium

Annex 2 Stock annex Celtic Sea Sole

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sole (division VIIf,g)
Working Group:	Working Group for the Celtic Seas Ecoregion
Date:	7th February 2014
Last updated:	7th February 2014 – Willy Vanhee and Sofie Nimmegeers

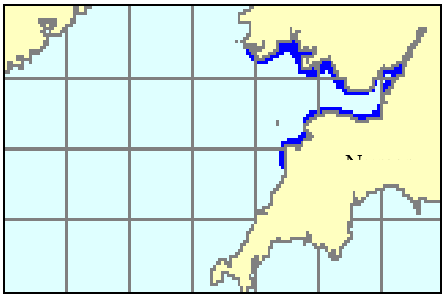
General

Stock definition

A description of the stock definition of sole in the Celtic Sea was given in the leaflet "Fisheries information – cod, sole, plaice and whiting in the south west of the British Isles" published by Cefas under a EU funded project (SAMFISH: EU Study Contract 99-009, Improving sampling of western and southern European Atlantic Fisheries) and is taken over here.

In the coastal waters of western England and Wales, sole are found in greatest abundance in the eastern Celtic Sea. The main spawning areas for sole in the Celtic Sea are in deep waters (40–75 m) off Trevose Head, where spawning usually takes place between March and May. Sole nursery grounds are generally located in shallow waters such as estuaries, tidal inlets and sandy bays. Juvenile sole (0 and 1 year old fish) are found chiefly in depths up to 40 m, and adult sole (fish aged 3 plus) are generally found in deeper water. Spawning and nursery grounds are well defined.

Over 6000 sole were tagged on the nursery grounds of the Bristol Channel and the Irish Sea between 1977 and 1988. The majority of fish tagged in Swansea Bay and Carmarthen Bay were between 15 and 24 cm in length. Most of the recaptures of these tagged fish occurred two or more years after release, which meant that many fish tagged as juveniles were recaptured as adults. The majority of returned fish were reported off the north coasts of Devon and Cornwall, and over a wide area in the eastern Celtic Sea and St George's Channel. These results suggest that once an adult sole has recruited to an area, it tends to remain there, and that there is only limited movement of sole between the Celtic Sea and adjoining areas.



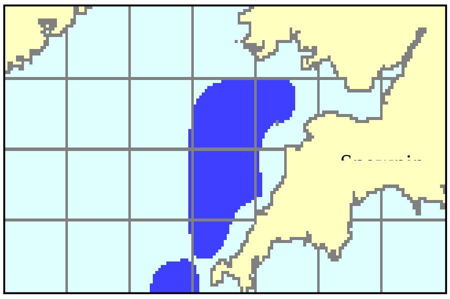


Figure A.1 Nursery and spawning areas of sole in the Celtic Sea (After Coull, K.A., Johnstone, R., and S.I. Rogers. 1998. Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOOA Ltd.)

Fishery

Fisheries for sole in VIIf, g involve vessels from Belgium, taking approx. three quarters, the UK taking approx. 15%, and France and Ireland taking minimal amounts of the total landings. Nominal landings are available from 1971 onwards. Sole are mainly targeted by beam trawlers and the fishery is concentrated on the north Cornish coast off Trevose Head and around Lands End. There is an average landing of 1100 tonnes throughout its history (See also figures A.2 and A.3).

Discard information is being collated since 2004 and it seems to be minor. Discarding of sole in the UK (E and W) fleet was estimated to fluctuate between 1% and 9%. Discard rates of sole in the Belgian beam trawl fleet (responsible for the main uptake of this stock) account for about 2%–5% in weight.

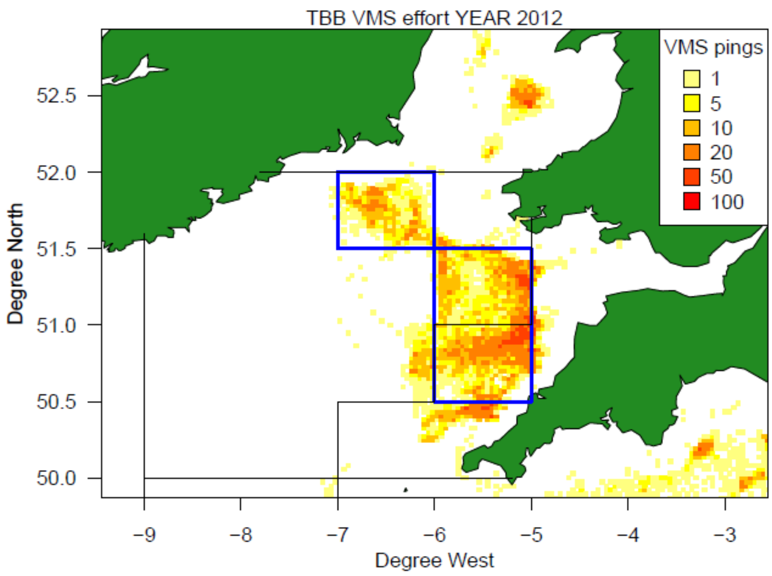


Figure A.2 Effort distribution of the Belgian beam trawl fleet operating in the Celtic Sea (VMS data 2012)

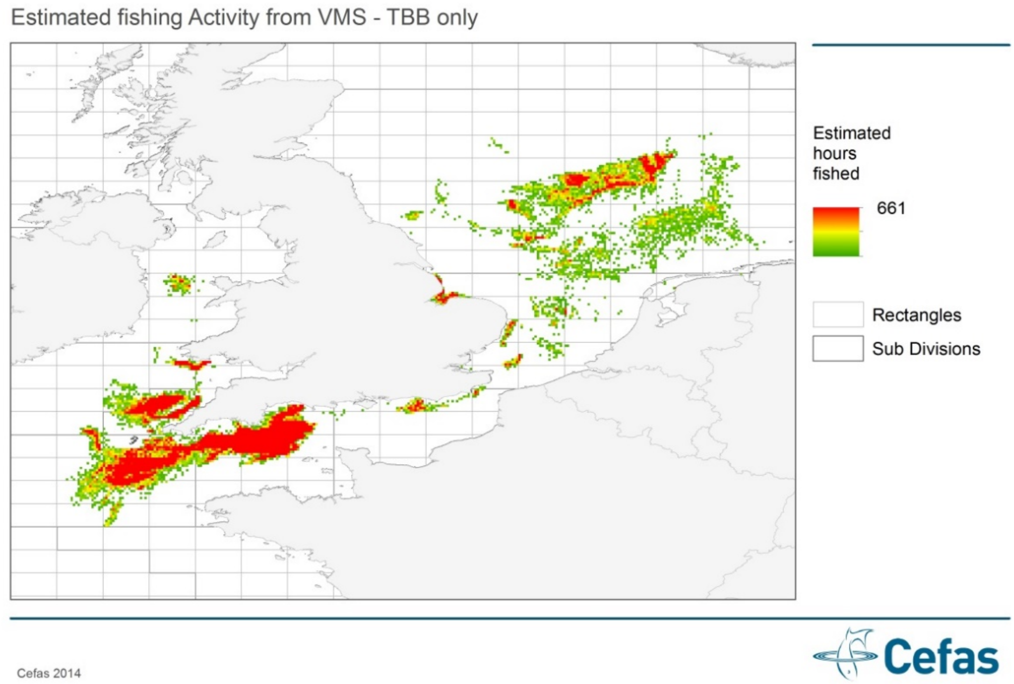


Figure A.2 Effort distribution of the UK (E and W) beam trawl fleet operating in the Celtic Sea (VMS data 2012)

Management

Celtic Sea sole has been managed by TAC since 1983. Other management measures are technical measures including minimum landing size (24 cm) and minimum mesh sizes (80 mm for beam trawlers).

Furthermore national authorities can impose additional management measures, such as temporal closures, trip catch controls and monthly catch controls.

The area referred to in this report as the Trevose box, consists of the ICES rectangles 30E4, 31E4 and 32E3.

Council Regulation (EC) No 27/2005, Annex III, part A 12 (b) prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during January-March 2005.This prohibition did not apply to Beam trawlers during March.

Council Regulation (EC) No 51/2006, Annex III, part A 4.2; (EC) No 41/2007, Annex III, part A 7.2; (EC) No 40/2008, Annex III, part A 6.2; (EC) No 43/2009, Annex III, part A 6.2 prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during February and March 2006-2009 with derogations for vessels using pots, creels or nets with less than 55 mm mesh size. The prohibition does not apply within 6 nautical miles from the baseline.

Council Regulation (EC) No 1288/2009, Article 1 stipulates that the prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during February and March referred to in Council Regulation (EC) No 43/2009, Annex III, part A 6.2 shall be applicable until 30 June 2011.

Council Regulation (EC) No 579/2011, Article 2 stipulates that the prohibited fishing in ICES rectangles 30E4, 31E4 and 32E3 during February and March stipulated in Council Regulation (EC) No 43/2009, Annex III, part A 6.2, and prolonged in Council Regulation (EC) No 1288/2009, Article 1, shall be applicable until 31 December 2012.

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No 1434/98 specifying conditions under which herring may be landed for industrial purposes other than direct human consumption

Ecosystem aspects

The following description of the ecosystem in the Celtic Sea is taken from the MEFEPO atlas (Connolly, P.L., *et al.* 2009).

Physics

Bathymetry: Shelf sea south of Ireland, limited to the west by the slope of the Porcupine seabight and the Goban Spur.

Circulation: Along the shelf edge, there is a poleward flowing „slope current"; on the shelf a weaker current flows north from Brittany across the mouth of the English Channel. Thermal stratification and tidal mixing generates the Irish coastal current which runs westwards in the Celtic Sea and northwards along the west coast of Ireland. Several rivers discharge freshwater into the ecoregion and influence the circulation patterns. These are notably the River Loire, the Severn and the Irish rivers Lee and Blackwater.

Fronts: The Irish Shelf Front is located to the south and west of Ireland (at c. 11°W), and consists of a tidal mixing front existing all year-round. On the shelf, there are the Ushant Front in the English Channel and the Celtic Sea front at the southern entrance to the Irish Sea.

Temperature: Sea surface temperatures measured in coastal stations northwest of Ireland since the 1960s show a trend of sustained positive temperature anomalies from 1990. An offshore weather buoy maintained off the southwest coast of Ireland (51.22°N 10.55°W) since mid-2002, indicated that 2003 and 2005 had the warmest summer temperatures of the record while 2007 saw the warmest winter temperatures. Temperatures in 2008 started above the time-series mean (2003–2008) until April and from July onwards, temperatures remained well below the time-series mean (WGOH 2009).

Biology

Phytoplankton: Productivity is reasonably high on the shelf with a rapid decrease west of the shelf break. Continuous Plankton Recorder (CPR) data suggests a steady increase in phytoplankton over at least the last 20 years. Toxic algal blooms occur around Irish coasts esp. along the southwest of Ireland.

Zooplankton: CPR data suggest an overall decline in the abundance of zooplankton in recent years. *Calanus* abundance is now below the long-term mean.

Benthos, larger invertebrate, biogenic habitats: The major commercial invertebrate species is Norway lobster (*Nephrops norvegicus*). Two epibenthic assemblages predominate in the Celtic Sea: one along the shelf edge and the slope, dominated by the anemone *Actinauge richardi* and a more widely distributed assemblage on the continental shelf, dominated by *Pagurus prideaux* and other mobile invertebrates (shrimps and echinoderms).

Fish Community: The area is a spawning area for key migratory fish species, notably mackerel *Scomber scombrus* and horse mackerel *Trachurus trachurus*. On the continental shelf the main pelagic species are herring *Clupea harengus*, sardine *Sardina pilchardus* and sprat *Sprattus sprattus*. The groundfish community consists of over a hundred species with the most abundant 25 making up 99% of the total biomass. Surveys revealed a downward trend in the biomass and abundance of cod, whiting and hake.

Birds, Mammals and Elasmobranchs: Basking shark (*Cetorhinus maximus*) is seen throughout the area but the stock seems to be severely depleted. Blue sharks (*Prionace glauca*) are found during summer. The Harbour porpoise *hocoena phocoena* is the most numerous cetacean in the region. Bottlenosed dolphins (*Tursiops truncates*) occur in large numbers while the common dolphin (*Delphinus delphis*) is also widely distributed in the area. White-beaked dolphin and White-sided dolphin (*Lagenorhynchus albirostris* and L. *acutus*) occur over much of the shelf area. Grey seals (*Halichoerus grypus*) are common in many parts of the area. Petrels (fulmar and storm-petrel) dominate the seabird populations in the west of Ireland and Celtic Sea region but there are also large breeding colonies of kittiwake, guillemot and gannet.

Environmental signals and implications: Increasing temperature and changes in zooplankton communities are likely to have an impact on the life histories of many species. Cod in the Celtic Sea are at the southern limit of the range of the species in the Northeast Atlantic. It is known that at the southern limits of their range, recruitment tends to decrease in warmer waters (above 8.5°C), and that cod are not found in waters warmer than 12°C. Celtic Sea cod has higher growth rates and mature earlier than other cod stocks. Although it is uncertain, Drinkwater (2005) has predicted that a sustained 1°C rise in seabed temperature, over the course of this century, could result in the disappearance of cod stocks from the Celtic Sea and the English Channel. Already there has been a northward shift in the distribution of some fish with an increase of sea bass *Dicentrarchus labrax* and red mullet *Mullus surmuletus* populations around British coasts. The region also recently experienced an unprecedented increase in the numbers of snake pipefish, *Entelurus aequoreus*. Abundance of herring *Clupea harengus* and pilchard *Sardina pilchardus* occurring off the south-west of England, has been shown to correspond closely with fluctuations in water temperature. Sardines were generally more abundant and their distribution extended further to the east when the climate was warmer, whilst herring were generally more abundant in cooler times. The migration timing of squid (*Loligo forbesi*) and flounder (*Platichthys flesus*) off the south-west of England has also been linked to temperature (Sims *et al*., 2001; 2004). Zooplankton abundance has declined in the region in recent years and the overall substantial decline in *Calanus* abundance, which is currently below the long-term mean, may have longer term consequences given the fish community shift towards smaller pelagic species feeding on zooplankton.

Fishery effects on benthos and fish communities: Temporal analyses of the effects of fishing and climate variation suggest that fishing has had a stronger effect on size-structure than changes in temperature. A marked decline in the mean trophic level of the fish community over time has been documented and this has resulted from a reduction in the abundance of large piscivorous fish such as cod and hake, and an increase in Nephrops and smaller pelagic species such as boarfish *(Capros aper*) which feed at a lower trophic level. In the Celtic Seas, discarding levels differ between the different fleets but can be as high as two thirds of the total catch with increasing trends in recent years. Discarding of undersized fish is a problem in several fisheries (e.g. cod, haddock, Nephrops and megrim). Improving the selection pattern should benefit the stocks and result in a higher long-term yield. Sole and plaice are predominantly caught by beam trawl fisheries. Beam trawling, especially using chain-mat gear, is known to have a significant impact on the benthic communities, although less so on soft substrata and in areas which have been historically exploited by this fishing method. Benthic drop-out panels have been shown to release around 75% of benthic invertebrates from the catches. Information from the UK industry (Trebilcock and Rozarieux, 2009) suggests that uptake in 2008 was minimal. The high mud content and soft nature of Nephrops grounds means that trawling readily marks the seabed, trawl marks remaining visible for some time. Despite the high intensity of fishing (some areas are impacted >7 times/year) burrowing fauna can be seen re-emerging from freshly trawled grounds, implying that there is some resilience to trawling. Cetacean bycatch has been noted in some fisheries, including the pelagic trawl fishery for mackerel and horse mackerel in the SW of Ireland, although the numbers caught were low.

Data

Commercial Catch

Before 2013

VIIfg	BEL	IRL*	UK(E and W)	Derivation of international landings in VIIfg
Length composition	VIIfg	VIIfg	VIIfg	
ALK	VIIfg	VIIfg	VIIfg	
Age Composition	VIIfg	VIIfg	VIIfg	The quarterly national catch numbers-at-age and catch weights at age were raised to the total international landings (including France, Northern Ireland and Scotland).

* From 2005 to 2009 no Irish Length compositions or ALK's therefore from 2005 to 2009, BEL+UK age composition raised to total international landing

Numbers-at-age 1 in the catch are low in most years, therefore these were not considered to add useful information and are replaced by zeros.

From 2013 onwards,

quarterly data (landing numbers and weight at age) from Belgium, Ireland and UK are provided under the ICES InterCatch format on a métier basis. These comprise about 90% of the international landings. Additionally, quarterly total landings from France, Northern Ireland and Scotland can be accessible. Allocation for the unsampled strata is based on a match between gear and mesh size. The remaining unsampled métiers are raised by all original age compositions. All raising is proportional to the catch numbers-at-age. Quarterly stratification has not been taken into account.

WKCELT 2014

For the period 2003–2005, the catch numbers-at-age and the total international landings were corrected for a substantial misreporting of Belgian landings into VIIj-k.

Biological

Weights at Age

Before 2013

The total international catch weights at age are calculated as the weighted mean of the annual weight at age data supplied by Belgium, UK (E and W) and Ireland, which account for about 95% of the total international landings (weighted by landed numbers).

From 2013 onwards,

The total international catch weights at age are calculated by applying the weighting algorithm for 'Mean weight weighted by numbers-at-age or length in InterCatch. This means that the mean weights at age of the sampled catches (supplied by Belgium, UK (E and W) and Ireland) and the allocated mean weights at age are weighted by their numbers-at-age. Note that the catch weights at age for the years before 2013 were not updated according to the InterCatch protocol.

In the recent assessments (upon 2013), the catch weights at age were smoothed using a quadratic fit where catch weights at age are mid-year values (age=1.5, 2.5 etc.). Stock weights-at-age were the first quarter catch weights smoothed by fitting a quadratic fit. Catch weights at age and stock weights at age have been scaled to give a SOP of 100%.

For the period 2002–2004 the stock weights at age are the catch weights of the Belgian beam trawl fleet (BEL-BEAM) in the first quarter, smoothed by fitting a Gompertz function. For the period 2005–2007, the stock weights were calculated as the weighted mean of the 1st quarter weights at age data supplied by Belgium and UK (E and W) (weighted by landed numbers) and smoothed using a quadratic fit through these points.

Stock and catch weights have no explicit trends. The values for 2001 showed a strange convergence and were replaced by the mean of the 2000 and the 2002 weights.

WKCELT 2014

For the period 2008-2012, the original total international catch weights at age were used. The stock weights were obtained using the Rivard weight calculator (http://nft.nefsc.noaa.gov./) that conducts a cohort interplolation of the catch weights. This protocol should be maintained in future assessments.

Natural Mortality and Maturity Ogives

Natural mortality was assumed to be 0.1 for all ages and years. This is consistent with the natural mortality estimates used for other sole stocks (IV, VIId, VIIa, VIIIab) and consistent with estimates of M reported in Horwood (1993).

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.

AGE	1	2	3	4	5	6 AND OLDER
	0.00	0.14	0.45	0.88	0.98	1.00

The proportion of M and F before spawning was set to zero.

Surveys

Target species

Flatfish species, particularly juvenile plaice and sole. Length data recorded for all finfish species caught; samples for age analysis taken from selected species.

Period

1988–2012: September (continuing)

Gear used

Commercially-rigged 4 m steel beam trawl; chain matrix; 40 mm codend liner.

Mean towing speed: 4 knots over the ground. Tow duration: 30 minutes. Tow duration for trips in 1988–1991 was 15 minutes; in 1992 comparative tows of 15 and 30 minutes length were carried out, and subsequent cruises used a standard 30 minute tow. The data from earlier years were converted to 30 minutes tow equivalent using relationships for each species derived from the comparative work in 1992.

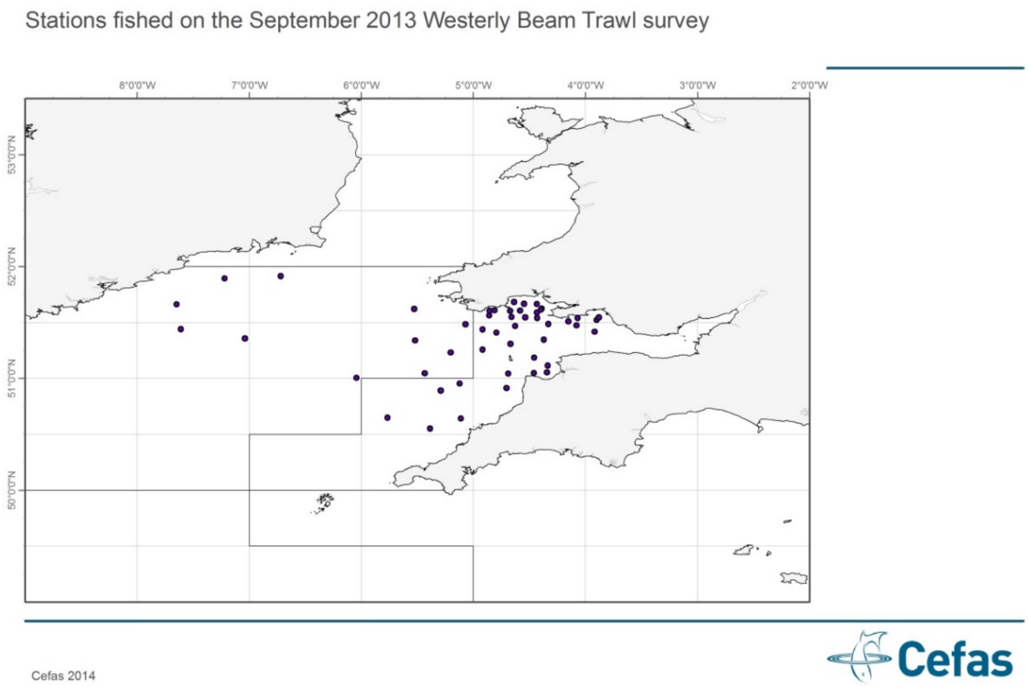
Vessel used: RV. *Endeavour* (Cefas).

Survey design

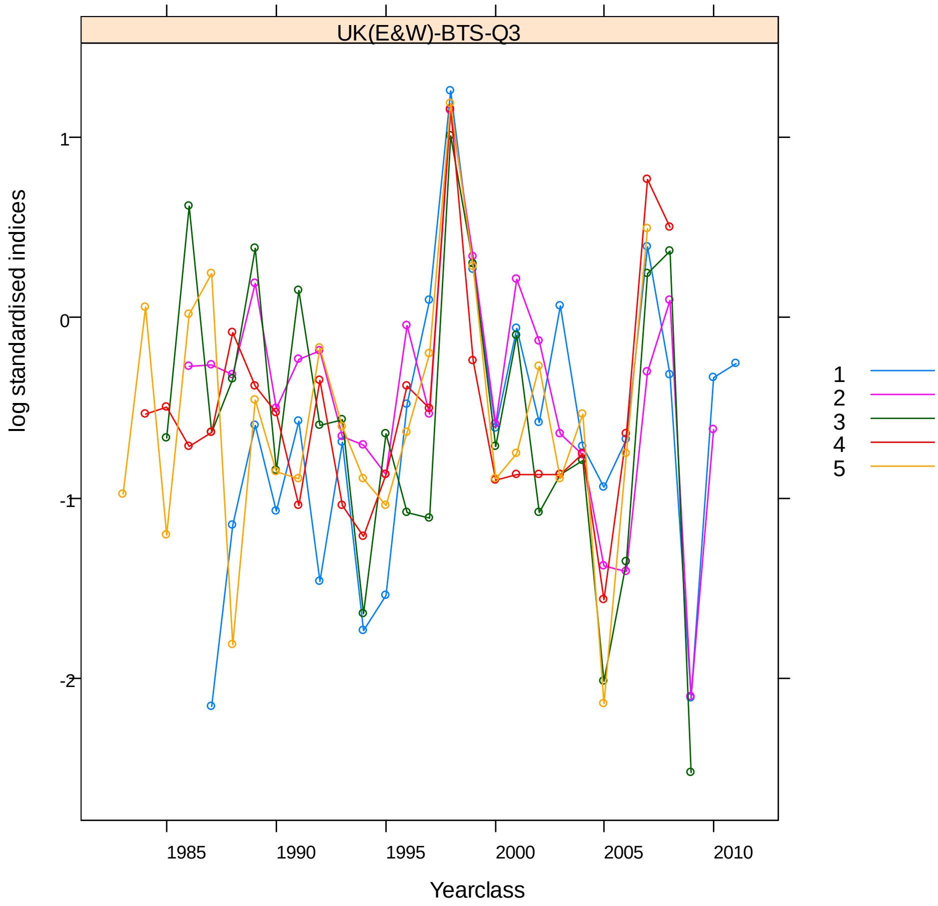
Survey design is stratified by depth band and sector (Depth bands are 0–20, 20–40, 40+). Station positions are fixed. There are 101 core fishing and hydrographic stations distributed around the Irish Sea, Bristol Channel and Celtic Sea between 50 to 55 deg. N and between the English, Welsh and Irish coasts.

Method of analysis

Raised, standardized length frequencies for each station combined to give total length distribution for a stratum (depth band/sector). Sector age length keys applied to stratum length distributions 1988–1994; stratum age–length keys applied 1995 onwards. Mean stratum cpue (kg per 100 km and numbers-at-age per 100 km) are calculated. Overall mean cpue values are simple totals divided by distance in metres (or hours fished). Population number estimates derived using stratum areas as weighting factors.



Abundance indices for all ages used in the assessment (standardized to the mean of the respective ages) are given in the figure below. The figure shows that the survey is able to track the strength of the year classes reasonably well.



The Irish Groundfish survey, held in the 4th quarter is available since 2003. The possible inclusion of the Irish Groundfish survey was examined at WKCELT2014, but not retained because the consistency between ages is very poor.

Commercial cpue

Commercial cpue data are available from the Belgian, the UK (E and W) and the Irish beam trawl fleets, as well as the UK (E and W) and Irish Otter trawl fleets. There is also information on the cpue of the hardly significant Scottish seine fleet for the sole fisheries.

The Belgian and the UK (E and W) beam trawl tuning fleets used for the assessment are described further down in the stock annex. There do exist other tuning data for this stock (e.g. UK otter trawl fleet), but these have not been included in the assessment as they were not considered to be representative for this stock.

Other relevant data

No information.

Historical stock development

During the eighties fishing mortality increased for this stock. In the following decades fishing mortality fluctuated around this higher level. However fishing mortality has decreased since the late 1990s and is estimated to be below F_{msy} (0.31) in 2008–2009. Fishing mortality in 2012 is estimated to be 0.48, above F_{pa} (0.37).

Recruitment has fluctuated around 5 million recruits with occasional strong year classes. The 1998 year class is estimated to be the strongest in the time series and the 2007 year class to be the second highest for this stock. The 2009 year class is by far the lowest in the time series. The incoming recruitment (year class 2011) is estimated to be above average.

SSB has declined almost continuously from the highest value of 8000 t in 1971 to the lowest observed in the time series in 1998. The exceptional year class of 1998 has increased SSB to above the long-term average. The good recruitment in 2008 and above average recruitment in 2009 and 2012 is predicted to keep SSB well above $B_{PA}/B_{trigger}$.

Tuning Data

The tuning data that are used in the assessment are:

Until 2013

- UK Corystes September beam trawl survey (UK(E and W)-BTS-Q3 survey) from1988 onwards
- Belgium commercial beam trawl fleet (BEL-CBT) from 1971-2003
- UK beam trawl fleet (UK-CBT), Division VIIf, from 1991 onwards.

WKCELT2014

- UK Corystes September beam trawl survey (UK(E and W)-BTS-Q3 survey) from1988 onwards
- Belgium commercial beam trawl fleet (BEL-CBT) from 1971-1996
- Belgium commercial beam trawl fleet (BEL-CBT) from 1997 onwards
- UK beam trawl fleet (UK-CBT), Division VIIf, from 1991 onwards.

The Belgian beam trawl tuning fleet was temporally discontinued in 2003. This is due to a change in the calculation of the effort statistics from the official logbooks and sale slip notes. At the 2014 benchmark assessment, a new derivation of the Belgium beam trawl data were available from 1997 onwards. The Belgian tuning series was split into two separate fleets (WKCELT2014 report): one with the original data from 1971 up to 1996 and the new series from 1997 up to 2012. The effort series used to calculate cpue for the index is HP corrected. For the period 2003–2005, a correction for a substantial misreporting of Belgian landings into VIIj-k, was introduced. For the UK (E and W)-BTS-Q3 tuning series, only ages 1 to 5 were retained.

Assessment Methods and Settings

Celtic Sea sole has been assessed with XSA. An overview of the changes in parameter settings of the XSA are given below:

	assessment 1998-1999			2000 assessment			assessment 2001-2002		
Fleets	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β
BEL-CBT commercial	71-asses-year-1	2-9	0-1	86-asses-year-1	2-9	0-1	86-asses-year-1	2-9	0-1
UK-CBT commercial	91-asses-year-1	2-9	0-1	87-asses-year-1	3-9	0-1	91-asses-year-1	2-9	0-1
UK(E&W)-BTS-Q3 survey	88-asses-year-1	1-4	0.75-0.85	88-asses-year-1	1-4	0.75-0.85	88-asses-year-1	1-4	0.75-0.85
-First data year	1989			1986			1986		
-Last data year	assessment year-1			assessment year-1			assessment year-1		
-First age	1			1			1		
-Last age	10+			10+			10+		
Time series weights	None			None			None		
-Model	Mean q model all ages			Power model (ages 1 & 2)			Power model (ages 1 & 2)		
-Q plateau set at age	7			7			7		
-Survivors estimates shrunk towards mean F	5 years / 5 ages			5 years / 5 ages			5 years / 5 ages		
-s.e. of the means	0.5			1.5			1.5		
-Min s.e. for pop. Estimates	0.3			0.3			0.3		
-Prior weighting	None			None			None		
Fbar (4-8)									

	2003 assessment			assessment 2004-2005			assessment 2006-2012		
Fleets	Years	Ages	α-β	Years	Ages	α-β	Years	Ages	α-β
BEL-CBT commercial	87-asses-year-1	2-9	0-1	71-asses-year-1	2-9	0-1	71-asses-year-1	2-9	0-1
UK-CBT commercial	91-asses-year-1	2-9	0-1	91-asses-year-1	2-9	0-1	91-asses-year-1	2-9	0-1
UK(E&W)-BTS-Q3 survey	88-asses-year-1	1-4	0.75-0.85	88-asses-year-1	1-4	0.75-0.85	88-asses-year-1	1-9	0.75-0.85
-First data year	1987			1971			1971		
-Last data year	assessment year-1			assessment year-1			assessment year-1		
-First age	1			1			1		
-Last age	10+			10+			10+		
Time series weights	None			None			None		
-Model	Power model (ages 1 & 2)			Power model (ages 1 & 2)			Mean q model all ages		
-Q plateau set at age	7			7			7		
-Survivors estimates shrunk towards mean F	5 years / 5 ages			5 years / 5 ages			5 years / 5 ages		
-s.e. of the means	1.5			1.5			1.5		
-Min s.e. for pop. Estimates	0.3			0.3			0.3		
-Prior weighting	None			None			None		
Fbar (4-8)									

	WKCELT2014		
Fleets	Years	Ages	α-β
BEL-CBT commercial 1	71-96	2-9	0-1
BEL-CBT commercial 2	97-asses-year-1	2-9	0-1
UK-CBT commercial	91-asses-year-1	2-9	0-1
UK(E&W)-BTS-Q3 survey	88-asses-year-1	1-5	0.75-0.85
-First data year	1971		
-Last data year	2012		
-First age	1		
-Last age	10+		
Time series weights	None		
-Model	Mean q model all ages		
-Q plateau set at age	7		
-Survivors estimates shrunk towards mean F	5 years / 5 ages		
-s.e. of the means	1.5		
-Min s.e. for pop. Estimates	0.3		
-Prior weighting	None		
Fbar (4-8)			

Short-term projection

Population numbers for ages 2 and older are taken from the XSA output (estimates of the year = the assessment year minus 1). If age 2, solely assumed by the UK(E and W)-BTS-Q3 survey is substantially high, the estimate is reduced by 23% (calculated as the average reduction from the first year estimate to the converged estimate – 4 years later).

The long-term geometric mean (starting year up to assessment year minus 3) is assumed for age 1 in the forecast.

Standard procedure for setting the fishing mortality in the forecast is to take the mean over the last three years, not rescaled. If a trend occurs in fishing mortality (3 consecutive higher or lower estimates), the Working Group may use a scaled F to the last year.

WKCELT 2014, decided as an interim solution to change the standard procedure for setting the fishing mortality. In case such as in 2012 the estimate of fishing mortality is considered to be uncertain, the fishing mortality should not be rescaled to the last year, but taken as the mean of the last three years.

Weights at age in the catch and in the stock are averaged over the last three years.

Medium term projections

No medium term projections were done since 2007.

Yield and biomass per recruit / long-term projections

Population numbers for ages 2 and older are taken from the prediction output (estimates of the year = the assessment year). The long-term geometric mean (starting year up to assessment year minus 3) is assumed for age 1.

Fishing mortality is set at the mean over the last three years, not rescaled. If a trend occur in fishing mortality (3 consecutive higher or lower estimates), the Working Group may use a scaled F to the last year.

Weights at age in the catch and in the stock are averaged over the last three years.

Biological reference points

Biological reference point values are given in the text table below:

	Type	Value	Technical basis
MSY	MSY Btrigger	2200 t	Bpa
Approach	FMSY	0.31	Provisional proxy based on stochastic simulations
	Blim	Not defined	
Precautionary Approach	Bpa	2200 t	There is no evidence of reduced recruitment at the lowest biomass observed and Bpa can therefore be set equal to the lowest observed SSB.
	Flim	0.52	Flim: Floss.
	Fpa	0.37	This F is considered to have a high probability of avoiding Flim and maintaining SSB above Bpa in 10 years, taking into account the uncertainty of assessments. Fpa: Flim × 0.72 implies a less than 5% probability that (SSBMT<Bpa).

(Unchanged since: 2010)

Other Issues

An evaluation of the Trevose box closure (ICES rectangles 30E4, 31E4 and 32E3) was based on Belgian data that accounts for about 75% of the total international landings. Furthermore, the Belgian fleet is predominantly active in the Trevose Box (see map in section A.2). This study showed that the cpue substantially increased in the month after the opening of the Trevose box. The quota uptake also increased substantially in that month, however as the Belgian fleet is subjected to a limited quota uptake by month, the overall uptake levels off at the end of the year. The annual quota has not been exceeded since the introduction of the closure.

References

Connolly, P.L., Kelly, E., Dransfeld, L., Slattery, N., Paramor, O.A.L., and Frid, C.L.J. (2009): MEFEPO North Western Waters Atlas. Marine Institute. ISBN 978 1 902895 45 1

Horwood, J. W. 1993a. The Bristol Channel Sole (Solea solea (L.)): A Fisheries Case Study. Advances in Marine Biology, 29: 215–367.

Annex 3 Stock Annex Whiting VIIb–c and e–k

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Whiting VIIb–c and e–k
Working Group	Celtic Sea Ecoregion
Date	4th Feb, 2014
Revised by	David Stokes

General

Historically this stock has been managed by TAC covering VIIb–k while the assessment area considered only VIIe–k. Having reviewed the available information, the WKCELT Benchmark proposed inclusion of VIIb–c within an overall VIIb–k assessment and management area, but excluding VIId.

Stock definition

Whiting in the NE Atlantic extends from the Barents Sea and Iceland down to the southern Bay of Biscay. There are population genetics and tagging studies in the literature relating to stock structure and migrations, but the degree of separation between the Celtic Sea and surrounding stock(s) is not wholly conclusive.

In particular, there are no strong justification to regard the whiting in VIIIe–k as a distinct closed stock. Rather, it seems this stock is linked at least to VIIb–c, perhaps even wider.

Fishery

Whiting in Divisions VIIe–k are taken as a component of catches in mixed demersal trawl and seine fisheries. The spatial distribution of whiting 2012 landings data from the STECF database is mapped in Figure A.2.1. This shows that whiting landings were concentrated in several discrete areas in western waters and the North Sea. Within this stock area there are two main areas with higher volume of landings i.e. VIIg and the east part of VIIj (Celtic Sea Shelf) and VIIe (western Channel). The landings in VII b–k are mostly taken by Ireland (northern part) and France (southern part; Figure A.2.2). For the current benchmark officially reported whiting landings were reconstructed back to 1904 from the ICES databases (Figure A.2.3). This shows that landings over time have fluctuated considerably. The underlying trend has been an increase in landings from less than 5000 t in the 1950s to a peak of around 20 000 t in the late 1980s and 1990s. Since then landings shown a declining trend.

The composition by country of the landings is shown in Figure A.2.4. Historically France has accounted for the majority of the landings. Since the mid-1990s the Irish proportion of the landings has increased significantly.

French landings are made mainly by gadoid trawlers, which prior to 1980 were mainly fishing for hake in the Celtic Sea. Irish demersal trawlers from Dunmore East and Castletownbere and other ports in southwest Ireland have traditionally targeted Celtic Sea whiting in a mixed trawl fishery. In response to poor catches in other areas vessels have been attracted into this fishery in recent years from County Donegal.

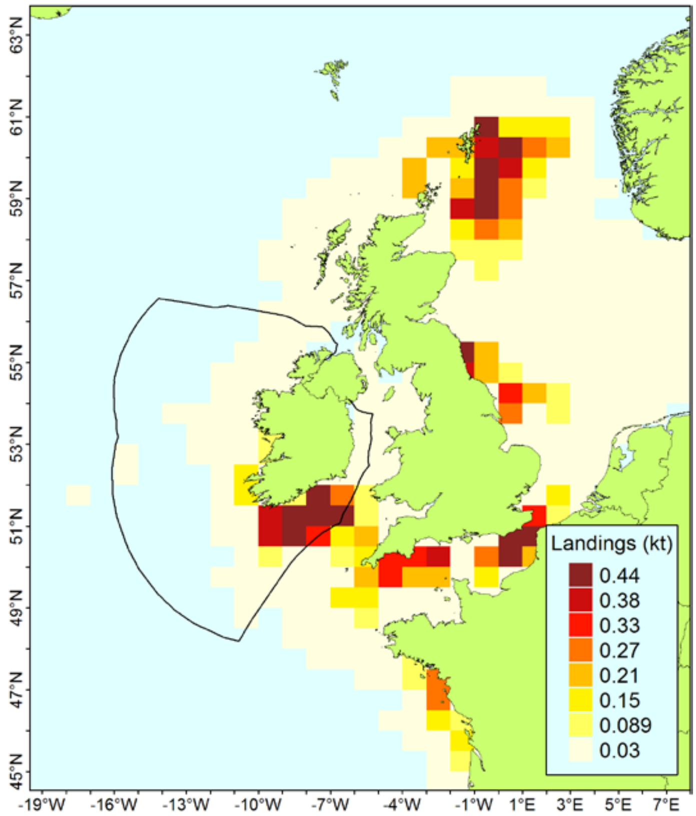


Figure A.2.1. Spatial distribution of whiting landings in 2012

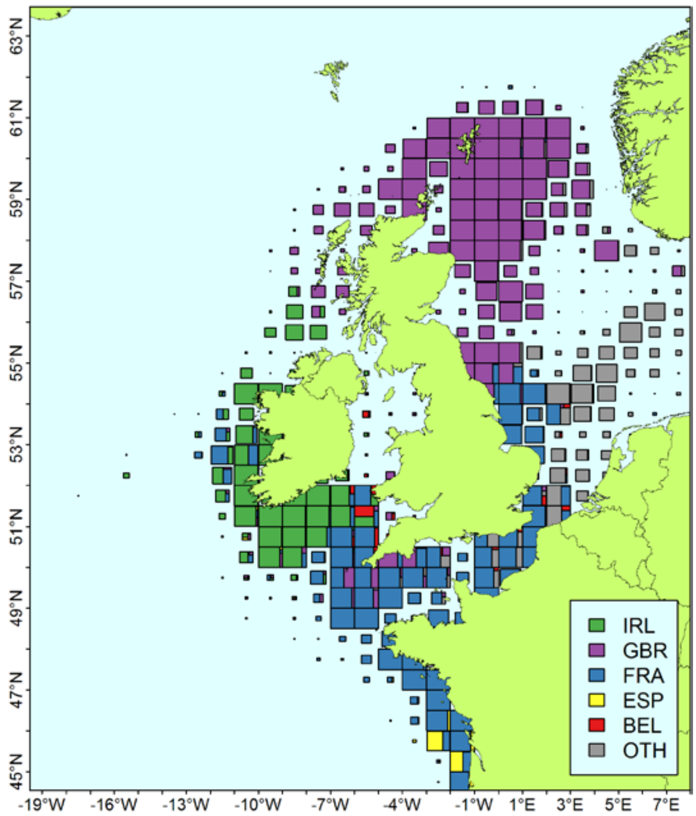


Figure A.2.2. Landings by country (2012)

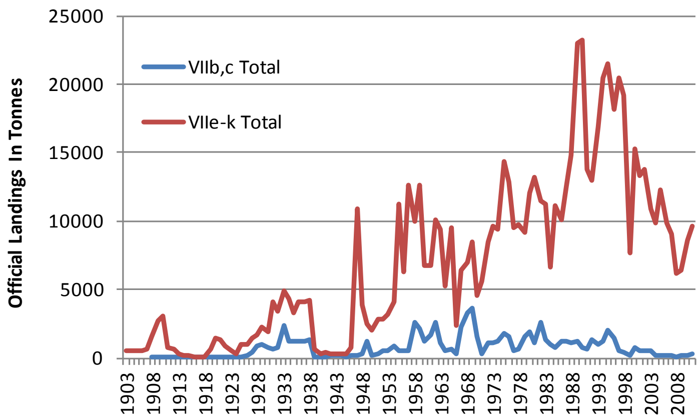


Figure A.2.3. Official landings in tonnes.

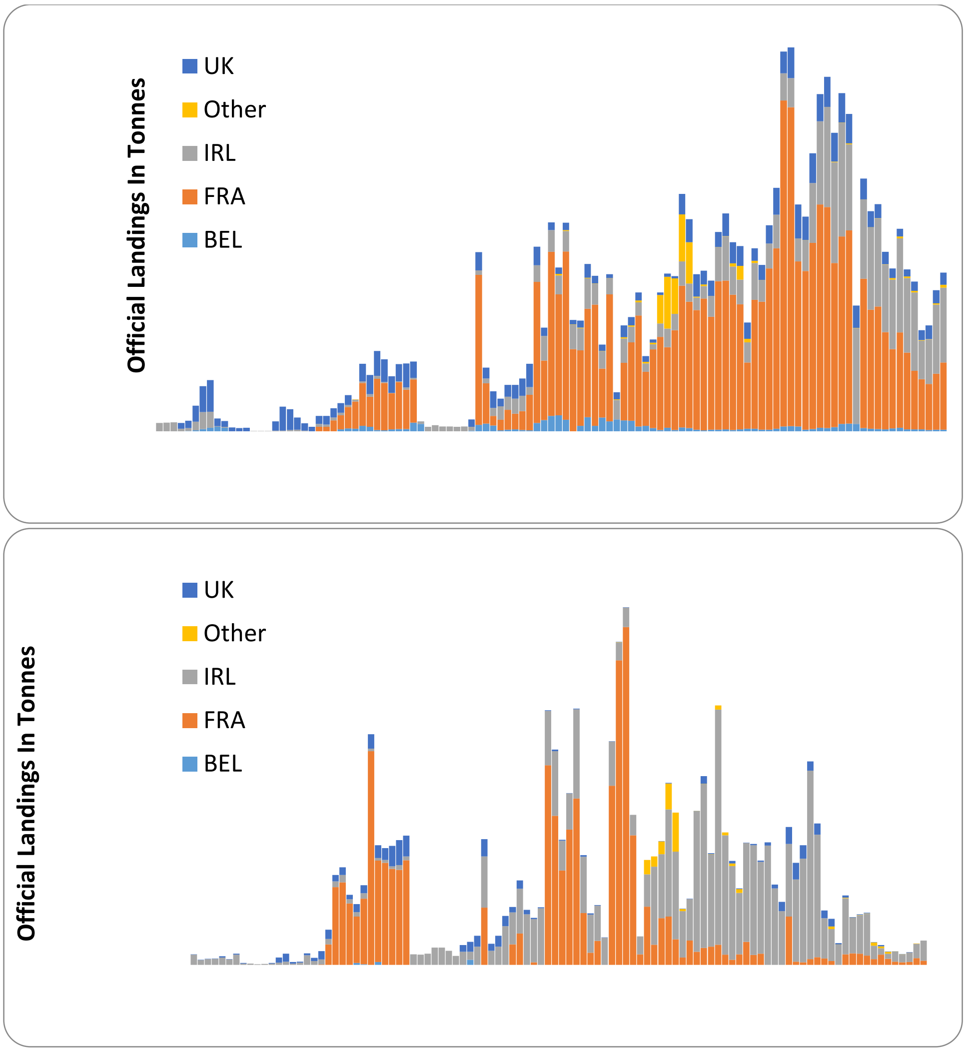


Figure A.2.4. Official landings in tonnes by nation.

Ecosystem aspects

No relevant information has been made available to the Working Group.

Data

Commercial catch

Data on international landings-at-age and mean weight-at-age are available for Irish, French and UK fleets from 1999 to present. Data made available through InterCatch from the fishing year 2012 is already raised to VIIe–k. The Table below presents the data available and the procedures used to derive quarterly length compositions, age compositions and mean weights-at-age.

National landings are used to raise the national length frequency and age data in the first instance. Thereafter, landings for countries without sampling are used to raise the sampling of another national fleet with similar dynamics. These allocations on average count for significantly less than 2% annually.

1. Annual quarterly length, age and mean catch weights data for each country is raised by ICES division to the total landings for that division.
2. Where countries have additional landings by ICES division for which they have no sampling, these landings are used to raise the national length weight and age data to the national annual landings figure.
3. A small number of countries with minimal landings have no sampling available. To reach a final international catch numbers-at-age figure these landings are used to scale the raised national numbers-at-age data from an appropriate other nation. Given the fleet characteristics landings from Belgium, Jersey and Guernsey have been allocated to the UK, landings from UK Scotland and UK Northern Ireland have been allocated to Ireland.

Division	Data	UK	France	Ireland	Belgium* /Other**	Derivation of international landings:
VII bk	Length composition	VIIb–k	VIIb–k	VIIb–k		VIIbk
	ALK	VIIb–k	VIIb–k	VIb–k		VIIbk
	Age Composition	VIIb–k	VIIb–k	VIIb–k		VIIbk
	Mean weight-at-age	VIIb–k	VIIb–k	VIIb–k		VIIbk Weighted by numbers caught
	Landings	VIIbk	VIIbk	VIIbk	VIIbk	VIIbk

*** Belgium landings used to raise quarterly length, age and weight at age data from the UK**

**** Others cover UK Scotland and UK Northern Ireland (allocated to Ireland) and Jersey and Guernsey (allocated to the UK).**

Biological

Age group 0 is included in the assessment data to allow inclusion of 0-group indices in the XSA, although in most years, no landings are recorded. Inclusion of discards for the recent time series (1999–present) has provided more significant 0-group data for the final catch numbers-at-age file. Mean weights-at-age in the catch were derived by combining landings and discards weight at age data, divided by the landed and discarded numbers at-age.

Mean weight-at-age in the stock are taken as mean weights-at-age in the quarter 1 catch. Where age 1 was poorly represented in quarter 1 landings, quarter 2 values were used as estimates of mean weight-at-age 1 in the stock. Stock weights-at-age are smoothed using a three year rolling average across ages to dampen the noise exhibited by the stock weight dataset. This approach is also used in Irish Sea whiting and Celtic Sea haddock.

Natural mortality is estimated according to Lorenzen's power function of weight model, the values applied are in the text table below.

Age	0	1	2	3	4	5	6	7+
Nat.mortality	1.22	0.86	0.65	0.5	0.43	0.40	0.38	0.36

Maturity data collected in the Irish Q1 Biological Groundfish Survey 2004–2009 survey were presented to the WG (Working Document 1: WGCSE 2013). Results indicated 34% of age 1 females and 60% of male fish are mature. For age 2 fish 99% female and 94% males were mature with full maturity occurring at approximately age 3 and older. However, since the estimates of proportions mature at age one and even more the estimates of abundance at age one, the decision was made by the 2014 WKCELT benchmark to use the 2+ biomass as a proxy for the SSB. This is in line with the practice for the other whiting stocks in the region. The proportions of F and M before spawning were both set to zero to reflect the SSB calculation date of 1 January.

Age	0	1	2	3	4	5	6	7+
Maturity	0	0	1.00	1.00	1.00	1.00	1.00	1.00

Surveys

The 2014 WKCELT benchmark decided to use a combined survey index as the only tuning index for the assessment. This index is obtained by combining the Q4 IBTS survey of Irish Groundfish Survey (IGFS) in areas VIIb,g and the French EVHOE survey in VIIeh and VIIj. The method used to combine the surveys is to apply an ALK to the raised whiting length frequency for each haul. The mean number-at-age within each grid cell of a 0.5 deg spatial grid were then summed to produce an annual combined survey index. The grid method and cell size was based on a previous analysis used for Celtic Sea cod (WD x, WKROUND 2012).

Commercial cpue

Information on effort, whiting landings and lpue are available from two French fleets (one gadoid and one *Nephrops* directed). These have been used in the assessment as separate fleets in the past, but being separated only by virtue of effort without independent age data being applied, it was decided at WKCELT 2014 to leave as an aggregated tuning fleet. LPUE and effort for this aggregated fleet was used to scale the overall historic French age structure available to WGCSE for the annual assessments to produce annual catch numbers-at-age. The cpue is not used for tuning the assessment at present.

Other relevant data

Discards

Discards were made available by Ireland (Gerritsen, WD to WKCELT 2014) and France, the two main exponents of the fishery. The discards for both countries were raised by taking the ratio of annual effort (Hrs) of discard trips proportional to the effort (Hrs) for the landings of the appropriate fleet. Resolution of the discard data for either country precluded stratification by quarter and age, and as such the numbers at length were raised by effort per year and further allocated to age by length split. The Irish length split was used for Irish and French data alike.

The time series for Irish discards is from 1995 to present, but truncated in WKCELT as 1999 to present. French data were available for 2004 to present. This was extrapolated back to 1999 based on the annual ratio of numbers-at-age between discards: landings within the discard time series for ages 2–4. Where historically age groups 0–1 would not be represented in the landings the ratio used to generate discards at age from the historical landings were based on age 1 discards: age 2 landings and age 0 discards: age 2 landings within the discard time series available.

French data have been revised to include historical discards back to 2004. Discards data were obtained from the French observer at sea OBSMER program. Data were mainly collected on otter trawlers belonging to a so-called 'Gadoid OTB French Fleet', a group of vessels where at least 40% of the landings per quarter are made of gadoids. Length distributions of the catch were raised to the fishing effort of the Gadoid fleet and then scaled according the ratio between the landings of the Gadoid fleet against those of whiting for the whole stock area. Due to lack of quarterly age length key data, length distributions were converted into numbers-at-age through a split procedure according to the following table giving for each quarter age according to fish length:

Quarter	Age 0	Age 1	Age 2	Age 3	Age 4
1	none	0-22 cm	23-32 cm	33-38 cm	>38 cm
2	0-12 cm	13-23 cm	24-32 cm	33-38 cm	>38 cm
3	0-18 cm	19-27 cm	27-32 cm	33-38 cm	>38 cm
4	0-21 cm	22-30 cm	31-34 cm	35-38 cm	>38 cm

Historical stock development

The assessment method was revised by WKCELT (2014)

Model used: XSA

Software used: FLR under R version 2.4.1 in conjunction with FLCore 1.4–3, FLAssess 1.4.1, FLXSA 1.4–2 and FLEDA 1.4–2

Lowestoft VPA95 software also for XSA and separable VPA

Model and data options:

- Catch data for 14 years 1999 to 2012. Ages 0 to 7.
- cpue (Survey) data:

Fleet	First age	Last age	First year	Last year	alpha	beta
1 IGFSEVHOE	0	5	2003	2012	<NA>	<NA>

- Tapered time weighting not applied
- Catchability independent of size for all ages
- Catchability independent of age for ages > 5

- Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages.
- S.E. of the mean to which the estimates are shrunk = 1
- Minimum standard error for population estimates derived from each fleet = 0.5
- Prior weighting not applied
- Regression weights: 1 for all years and ages

Input data types and characteristics:

Type	Name	Year range	Age range	Variable year to year
Caton	Catch in tonnes	1999–current	0–7+	Yes
Canum	Catch-at-age	1999–current	0–7+	Yes
Weca	Weight-at-age in the commercial catch	1999–current	0–7+	Yes
West	Weight-at-age of the stock at spawning time	1999–current	0–7+	Yes:
Mprop	Proportion of natural mortality before spawning	1999–current	0–7+	No
Fprop	Proportion of fishing mortality before spawning	1999–current	0–7+	No
Matprop	Proportion mature-at-age	1999–current	0–7+	No
Natmor	Natural mortality	1999–current	0–7+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	IGFSEVHOE (combined IBTS Q4 and EVHOE)	2003–current	0–5

Short-term projection

Model used: Multi Fleet Deterministic Projection

Software used: MFDP1a

Initial stock size: initial stock numbers derived from XSA analyses. Numbers-at-age 0 are not considered to be well estimated and are replaced with a geometric mean of the full time-series (1982–2007). Recruitment has been at a low level since 1995 with the exception of the 1999 year class. The two most recent years have displayed good recruitment, with last year's being revised downward. Recruitment is solely estimated from the FR-EVHOE and IR-GFS7gSweptArea surveys, in recent years the French survey estimates have been far higher than those of the Irish survey. Because of these reasons the geometric mean is used.

Natural mortality: That used in the assessment

Maturity: Maturity ogive used in the assessment

F and M before spawning: Those used in the assessment method

Weight-at-age in the stock: Unscaled 3 year arithmetic mean

Weight-at-age in the catch: Unscaled 3 year arithmetic mean

Exploitation pattern: Unscaled 3 year arithmetic mean (though alternative options may be used depending on recent F trajectories and the Working Group's perception of the fishery).

Intermediate year assumptions: *Status quo* F

Stock–recruitment model used: Geometric mean of full time-series (1982 to present-1) for age 0 recruitment

F_{bar}: That used in the assessment

Medium-term projections

None.

Long-term projections

Model used: Multi Fleet Yield-per-recruit

Software used: MFYPR2a

Yield-per-recruit calculations are conducted using the same input values as those used for the short-term forecasts.

Biological reference points

A summary of reference point proposals to date, their technical basis and currently adopted reference points is given in the text Table below:

	WG 1998	ACFM 1998	WG 2000	ACFM 2000
F_{lim}	No Proposal	No Proposal	1.18 (F_{lim}=F_{loss})	No Proposal
F_{pa}	No Proposal	No Proposal	0.72 (F_{pa}=F_{lim} x $e^{-1.645 \times 0.3}$)	No Proposal
B_{lim}	15,000 t	15,000 t	15 000 t (B_{lim}=B_{loss})	15,000 t (B_{lim}=B_{loss})
B_{pa}	18,000 t	21,000 t	21 000 t (B_{pa}=B_{loss} x 1.4)	21,000 t (B_{pa}=B_{loss} x 1.4)

The technical basis of ACFM's 1998 Bpa proposal is given below (1999 WG text):

Bpa = Blim x 1.4 = 21 000 t. In the past the WG have selected MBAL as 18 000 t based on evidence of reduced recruitment at SSB's <18 000 t. However this MBAL is driven by a period of low recruitments at low SSB in the earlier years of the time-series (1982–1985) when the data are probably not reliable. Examination of the stock–recruit plot provides no compelling evidence of reduced recruitment below SSB of 18 000 t.

The technical basis of the WG's 2000 Flim and Fpa proposals are given below:

On the basis of results obtained from a LOWESS fitted non-parametric stock and recruitment relationship and the derived equilibrium SSB and yield curves with the original data trajectories the 2000 Working Group considered that Fpa and Flim could be defined because Floss appeared reasonably estimated. However, taking into account the uncertainties in the data the 2000 Working Group decided to use 0.3 as the SE in calculation of Fpa from Floss. The technical basis for the proposed reference points are defined below:

Flim = Floss (1.18 in this year’s assessment)

Fpa = Flim x e-1.645*0.3 = 0.72

Due to the revision of the assessment conditioning by WKCELT in 2014, where *inter alia* discards are included in the assessment and the natural mortalities revised, WKCELT (2014) proposed revised reference points.

Proposed new reference points:

The Table below summarizes the proposed values by WKCELT (2014)

	Value	Basis
Blim	25 000	Bloss
BMSYtrigger	40 000	Lower bound of expected range at F0.1
Flim	0.5	Increasing risk to Blim
FMSY	0.32	F0.1

Other issues

No other issues.

Table 1. Model settings/Input data/Tuning data.

		1999	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Catch date range:	***Years***	82-98	82-99	82-00	82-01	82-02	82-03	82-04	82-05	82-06	82-07	82-08
	Ages	1-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+	0-7+
Assmnt Method:		XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA	XSA
Fbar Age Range:		2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5	2-5
Time taper:		No	No	No	No	No	No	No	No	No	No	No
Q plateau age:		4	4	4	4	4	4	4	4	5	5	5
F shrinkage S.E:		0.8	2.5	1.5	1.5	1.5	1.5	1.5	1.5	1	1	1
	Num yrs	5	5	5	5	5	5	5	5	5	5	5
	Num ages	3	3	3	3	3	3	3	3	3	3	3
Fleet S.E:		0.2	0.2	0.2	0.2	0.2	0.2	0.5	0.5	0.5	0.5	0.5
Commercial Tuning Fleets:												
FR-Gadoid	*Yrs*	89-98	90-99	93-00	82-92	82-92	82-92	83-92	83-05			
	Ages	3-6	3-6	3-6	3-6	3-6	3-6	3-6	3-6			
FR-Gadoid Late	*Yrs*				93-01	93-02	93-03	93-04		93-06	93-07	93-08
	Ages				3-6	3-6	3-6	3-6		3-6	3-6	3-6
FR-Nephrops	*Yrs*	89-98	90-98	93-00	93-01	87-02	87-03	87-04	87-05	93-06	93-07	93-08
	Ages	2-6	4-6	2-6	2-6	2-6	2-6	2-6	3-6	3-6	3-6	3-6
IR-7g&j-OT	*Yrs*			95-00	95-01	95-02	95-03	95-04	95-05			
	Ages			1-6	1-4	1-4	1-4	1-4	3-4			
Survey Tuning series:												
FR-EVHOE	*Yrs*			97-00	97-01	97-02	97-03	97-04	97-05	97-06	97-07	97-08
	Ages			0-4	0-4	0-4	0-4	0-4	0-4	0-4	0-4	0-4
UK-WCGFS	*Yrs*	92-98	92-99	93-00	92-01	92-02	92-03	92-04	92-04	87-01	87-01	87-01
	Ages	1-6	1-6	2-6	2-4	2-4	2-4	2-4	1-6	1-6	1-6	1-6
UK-BCCSBTS	*Yrs*	89-98	90-99	89-00	89-01	89-02	89-03	89-04	89-05			
	Ages	0-1	0-1	0-1	0-1	0-1	0-1	0-1	0-1			
IR WCGFS	*Yrs*			93-00								
	Ages			1-1								
IR-IGFS Swept area	*Yrs*								99-05	99-06	99-07	99-08
	Ages								0-6	0-6	0-6	0-6

Annex 4 Stock Annex South and Southwest Ireland *Nephrops* FU19

Stock specific documentation of standard assessment procedures used by ICES.

Stock	South and SW Ireland, *Nephrops* (FU19)
Date	February 2014 (WKCELT 2014)
Revised by	Jennifer Doyle and Colm Lordan

General

Stock definition

Nephrops is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution.

There are several discrete grounds in FU19 and have been named as: Bantry Bay, Galley Grounds 1-4, Cork Channels and Helvick 1-2 and are shown in Figure A.1.1.

The spatial extent of the *Nephrops* grounds in FU19 has been re-defined using 2006–2011 integrated VMS-logbook data using the methods described in Gerritsen and Lordan (2011) and also incorporating available backscatter and bathymetry data from the Irish National seabed mapping programme (www.infomar.ie). Nephrops directed activity was defined for VMS pings where >30% of daily operational landings was reported to be Nephrops. Table A.1.2. shows the data available to redefine the ground boundaries in FU19. The revised polygons were manually drawn and the area calculated using different projections in ArcGIS 10. The average of these calculations was accepted as the area of each ground (Table A.1.2). Positions of the polygons are in Table A.1.3 based on WKCELT calculations. The discrete grounds areas are subject to revision as more seabed mapping and new VMS data becomes available. Any revisions to survey area are to be considered by WGNEPS.

The Functional Unit for assessment includes some parts of the following ICES Divisions VIIj, g, a. The fishery data for this includes the following ICES Statistical rectangles: 31–33D9–E0; 31E1; 32E1–E2; 33E2–E3 (Figure A.1.1).

Adult *Nephrops* probably only undertake very small-scale movements (a few 100 m). Recent studies in larval tracking models show that larval transfer may occur between the separate mud patches in FU19 as some patches are donors of larvae to adjacent grounds (O'Sullivan *et al., in press*).

Fishery

Ireland

The Irish fleet has been the main participant in this fishery. Vessels <18 metre total length operate out of many local ports and fish the inshore *Nephrops* patches in periods of good emergence and weather. These smaller vessels account for approximately 70% of the landings from this FU.Vessels >18 m tend to fish the offshore *Nephrops* and target *Nephrops* on several in other FUs to optimize catch rates depending on tides and weather. These larger vessels freeze the catches at sea and have become increasingly prevalent since 2006.

France

French trawlers operating in this area fish also in the Celtic Sea (FU22 and FU20–21) and switch to FU19 depending on weather conditions. The fleet operating here has dwindled since the 90's.

UK

Landings are minor from this FU.

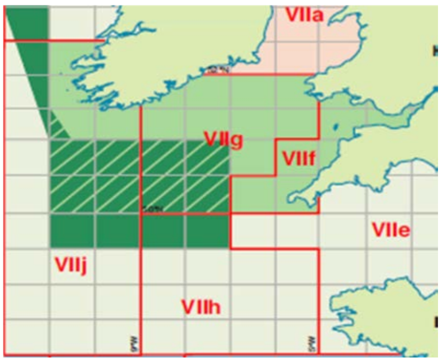
Technical Measures

The following TCMs are in place for *Nephrops* in VII (excluding VIIa) after EC 850/9 in operation since 2000: Minimum Landing Sizes (MLS); total length >85 mm, carapace length >25 mm, tail length >46 mm. This regulation is applied by the Irish and UK fleets whereas a more restrictive regulation adopted by the French Producers' Organizations (35 mm CL i.e. 11.5 cm total length) is applied by the French trawlers.

The French fleet uses a mesh size of 100 mm for codend since January 2000 (in order to not be constrained by bycatch composition).

The mesh size, catch composition and square mesh panel requirements in the Celtic Sea after EU 737/2012 are shown below in the table and maps below. The majority of Irish *Nephrops* vessels operating in the area use 70–89mm mesh and are obliged to have a 120 mm square mesh panel (SMP) since 2012. Some Irish vessels and most French Nephrops vessels use >100 mm cod end mesh with a 100 mm SMP.

	VII (Celtic Sea & West of Ireland)								
	Area VII Outside restricted areas				Celtic Sea Protection Zone				HAKE BOX
Mesh size (mm)	70-79	80-89	90-99	100+	70-79	80-89	90-99	100+	100+
Twine thickness	4mm double or single 6mm								
Headline Panel (mm) (Beam Trawlers see footnote 1)	-	-	-	-	-	-	-	-	-
Square mesh panel (mm)	80	-	-	-	110	110	110	100	-
Maximum number of meshes in codend circumference	120	120	100	100	120	120	100	100	100
Catch Composition	-	Either - Or		-	Either - Or		-	-	-
Maximum % of cod allowed. (Council Reg 39/2013)	-	-	-	-	-	-	-	-	-
Maximum % cod, haddock, saithe allowed	-	-	30	-	-	-	30	-	-
Maximum % of hake allowed	20	20	20	-	20	20	20	-	-
Minimum % of saithe required	-	-	-	-	-	-	-	-	-
Minimum % of Nephrops required	35	30	-	-	35	30	-	-	-
Minimum % of Annex I List (see footnotes)	-	-	70 2	-	-	-	70 2	-	-
Minimum % of haddock, hake, whiting, megrim, monkfish, rays, saithe and Nephrops	-	-	-	-	-	-	-	-	-



Source:http://www.bim.ie/media/bim/content/newsandevents/BIM_Fisheries_Management_Map_2013.PDF

Ecosystem aspects

Physical oceanography

The larval tracking study has shown that in the Celtic Sea fast moving water is apparent around the southwest coast of Ireland in summer and water velocity increases moving south around the west coast of Ireland and clockwise along the south coast. Surface water consistently moves quickly through the northern channel of the Irish Sea and into the Clyde and through Georges Channel in the south. This is forced by strong tides in both areas (O'Sullivan *et al., in press*).

Sediment distribution

Information on the spatial extent of the sediment suitable for *Nephrops* from UWTV surveys, seabed mapping programmes and the fishing industry is growing. There is insufficient sediment and burrow density data to explore relationships between burrow density and sediment for these *Nephrops* grounds and to provide detailed sediment maps. There is limited sediment data from seabed mapping of Bantry Bay suggesting the presence of suitable *Nephrops* substratum where samples contain 60–90 % mud shown in Figure A.3.1 (O' Sullivan *et al., in press*).

Bathymetry

UWTV station depths ranged from 18 metres in Bantry Bay to 114 metres on the offshore Galley Grounds 4. Coastal bathymetry data are available from INSS programme and is updated regularly (www.infomar.ie) and these show some channels of soft sediment which correlate to patterns in the VMS integrated data.

Data

Commercial catch

Commercial landings data are supplied by Ireland, France and the UK.

The quality of historic landings data are not well known but they are perceived to be reasonably accurate. Irish landings data are available from 1989. The time-series of French landings commences in the late 1980s. UK landings are also available from 1989.

Landings statistics for the Irish fleet are obtained from EU logbooks since 1995. Vessels record daily retained catches in operations and make a declaration of total landings on re-turn to port. Since 2012, most vessels in the fleet have been using electronic logbooks (EC Regulation 1224 of 2009 and 404 of 2011). Vessels are required to electronically report catches on board in each 24 hour period.

Similarly landings from UK Scotland and England, Wales and Northern Ireland are available from the logbooks. Landings from France are obtained from EU logbooks.

Sampling Data

Length frequency data of the landings were collected on an irregular basis in the years 1996 to 1997, 1999 and 2002 to 2006. Since 2002 a new catch self-sampling programme was put in place. This involves unsorted catch and discard samples being provided by vessels or collected by observers at sea on discard trips. The catch sample is partitioned into landings and discards using an on board discard selection ogive derived for the discard samples (Table B.2.1). Sampling effort is stratified monthly but quarterly aggregations are used to derive length distributions.

The sampling intensity and coverage has varied over the time-series (Table B.2.2). Since 2007 sampling has been good although the majority of the samples come from Bantry Bay recently. Also sampling of the discards has quite sparse over the time series.

Previously to split the catch numbers into landings a discard ogive from FU22 2006 had been used as discard sampling data has been minimal in FU19. This was explored at WKCELT where discard data observations from 2008 and 2013 from Bantry Bay were used to derive a selection ogive. An averaged discard selection ogive (2008 quarter 1 only and 2013 quarter 3 and 4) was accepted by WKCELT and used to partition the catch data for the reference period 2011-2013. Figure B.2.1. shows the average discard selection ogive accepted at WKCELT. Figure B.2.2. shows the partitioned length frequency data for the reference period 2011-2013.

Fish and other bycatches in the fishery have been collected by on board observers since 1994. Discarding by the *Nephrops* trawl fleet is around 55% of the total catch by weight. The main discards are small whole *Nephrops*. The main fish species discarded are haddock, boarfish and dab (Anon, 2011).

Biological

Biological parameters for this stock are outlined in Table B.1.

Length–weight

The annual mean weight in the landings is calculated from the length–frequency data and a length–weight relationship from studies on Scottish stocks by Pope and Thomas (1955). No changes in these parameters were made at WKCELT 2014.

Mean weights over the time series 2009 to 2013 for Bantry Bay (Figure B.3.1) displayed a seasonal trend in the females where this is related to emergence of females from the burrows in summer to mate (Figure B.3.2).

Natural mortality

A natural mortality rate of 0.3 was assumed for all length classes and years for males and immature females, with a value of 0.2 for mature females. The lower value for mature females reflects the reduced burrow emergence while ovigerous and hence an assumed reduction in predation. The accuracy of these assumptions is unknown but the same assumptions are made for most Nephrops stocks (WKNEPH 2009 and 2013a). No changes in these parameters were made at WKCELT 2014.

Maturity

Female

The L_{50} in May to July was chosen as the most appropriate estimate given the maturity schedules observed. An updated analysis was available at WKCELT 2014 and the female L_{25}/L_{50} were estimated as 23/24 CL mm from 2008–2013 sampling data (Table B.3.1 and Figure B.3.3).

Male

No update to male maturity was made at WKCELT 2014.The same maturity is assumed as for female L_{25}/L_{50}.

Discard survival

Given the trip durations (1–2 days typically) and behaviour of this fleet means the majority of discards are returned to the sea over suitable sediment. The proportion scavenged by birds is probably quite low. Tow durations, volume of catches, prolonged sorting on deck and moderate density of *Nephrops* on the seabed probably results in relatively low discard survival. This is assumed to be around 25% in line with other *Nephrops* stocks in the Celtic Sea. No changes in these parameters were made at WKCELT 2014.

Surveys

UWTV Survey

In 2006 Ireland conducted the first underwater television survey (UWTV) in FU19, however only 6 stations were completed. From 2011 to 2013 an average of 38 stations have been completed and the majority of the discrete patches surveyed on an annual basis. The survey design is based on randomly picked stations from the ground polygons and the sampling effort on each ground was determined by relative area. The methods used during the survey were similar to those employed for UWTV surveys of *Nephrops* stocks around Ireland and elsewhere and are documented by WKNEPHTV (ICES, 2007), SGNEPS (ICES, 2009, 2010, 2012) and WGNEPS (2013b). Up to date UWTV survey reports are available at: http://oar.marine.ie/handle/10793/911.

UWTV Survey relative to absolute conversion factors

In order to use the survey abundance estimate as an absolute it is necessary to correct for potential biases. For FU19 the field of view of the camera was 0.75 m and expert judgment of the mean burrow diameter was in the range of 0.25–0.4 m. The edge effect is estimated at 1.25 which is similar to FUs of moderate density. In future it may become possible to quantitatively estimate burrow diameter from mosaics of the footage from this and other areas. Burrow detection rates were thought to be relatively high due to good water clarity and few other burrow systems of similar size. Burrow identification could be slightly overestimated since a few fish and crab species were observed at burrow entrances. The proposed cumulative correction factor for the area was 1.3 (Table below). When compared to with the correction factors applied in other areas it is quite close to the average used on other grounds.

The biases associated with the estimates of *Nephrops* abundance in FU19 are:

	Established	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU19:						
S and SW Ireland	2011	1.25	0.9	1.15	1	1.3

WKCELT 2014 concluded that an UWTV based approach should apply for this stock and that WGCSE and WGNEPS review survey results when available.

IBTS Groundfish Survey

There are two IBTS- GFS catching *Nephrops* in FU1 19: Irish groundfish survey-Q4: IGFS-WIBTS-Q4 commenced in 2003 and French groundfish survey EVHOE-WIBTS-Q4 since 1997. These data are useful as additional indicators of trends in recruitment, mean size and sex ratio for this *Nephrops* stock. Figure B.4.1. displays IGFS and EVHOE stations with *Nephrops* catches in FU19.

Commercial cpue

Disaggregated effort and lpue data are available for the Irish *Nephrops* directed fleet in FU19 from 1995–2012 for all vessels >18 metres total length. The lpue and effort-series is based on the same criteria for FU15, 16, 17, 22 and 20-21 (30% landings threshold) and will be contingent on the accuracy of landings data reported in log-books. Effort and lpue data are not standardized, and hence do not take into account vessel capabilities, efficiency, seasonality or other factors that may bias perception of lpue abundance trend over the longer term. These data are not used in the assessment.

Assessment: data and method

Model used: UWTV Based Approach to generate catch options.

Software used: separable SCA model Bell analysis in r.

In 2009 WKNEPH debated the use of the surveys as either an absolute measure of abundance or a relative index (ICES, 2009a). Ultimately this led to a consensus that bias corrected survey abundance estimates could be used directly in the formulation of catch advice. Two modelling approaches were used to estimate sustainable stock specific Harvest Ratio reference points; SCA (a separable cohort analysis model Bell) and Age Structured Simulation model (Dobby) (ICES, 2009a). WKCELT 2014 carried out MSY explorations using the most recent data available for FU19 and the SCA Bell model. The model requires landing and discard numbers by length and sex, typically a 3year average to remove strong year-class effects. Additional parameters required are the von Bertalanffy growth parameters, natural mortality and weight-length parameters by sex. Parameters for ogives governing female maturity and the selectivity of the TV survey are also required. Table C.1 below gives the von Bertalanffy growth parameters, natural mortality and weight-length parameters by sex for various Nephrops stocks.

FU	Ground	VBK. Female	L.INF. Female	M. Female	VBK. Male	L.INF. Male	M. Male	a.Female	b.Female	a.Male	b.Male	L50Female maturity
6	Farn Deeps	0.06	58	0.2	0.16	66	0.3	0.00091	2.895	0.00038	3.17	25
7	Fladen	0.1	56	0.2	0.16	66	0.3	0.00074	2.91	0.00028	3.24	25
8	Firth of Forth	0.065	58	0.2	0.163	66	0.3	0.00085	2.91	0.00028	3.24	26
9	Moray Firth	0.06	56	0.2	0.165	62	0.3	0.00074	2.91	0.00028	3.24	25
11	North Minch	0.06	60	0.2	0.16	70	0.3	0.00074	2.91	0.00028	3.24	25
12	South Minch	0.06	59	0.2	0.16	66	0.3	0.00074	2.91	0.00028	3.24	25
13	Clyde	0.06	60	0.2	0.16	73	0.3	0.00074	2.91	0.00028	3.24	25
15	western Irish Sea	0.1	56	0.2	0.16	60	0.3	0.00068	2.96	0.00032	3.21	24
14	eastern Irish Sea	0.1	56	0.2	0.16	60	0.3	0.00068	2.95	0.00032	3.21	24
17	Aran	0.1	56	0.2	0.16	60	0.3	0.000684	2.963	0.000322	3.207	22
16	Porcupine	0.16	50	0.2	0.14	75	0.2	0.00009	3.55	0.00009	3.55	26.2
19	S and SW coast Ireland	0.8	56	0.2	0.16	60	0.3	0.000684	2.963	0.000322	3.207	24
22	Smalls	0.1	49	0.2	0.17	68	0.3	0.000684	2.963	0.000322	3.207	22

Catch option table based on UWTV surveys

1. Survey indices are worked up annually resulting in the TV index.

   Comment if some patches not surveyed (take previous years estimate or average if time series available).
2. Adjust the annual survey index by the bias correction factor to calculate the adjusted survey index.
3. Generate mean weight in landings and discards. Check the time-series of mean catch weights for evidence of changes in the most recent period. If there is no firm evidence of a recent change in mean weight then use a 3 year average. It may be necessary to deviate from this procedure in cases where there are changes to mean weight related to recruitment or sampling issues. This should be reviewed annually by WGCSE.
4. The catch option table will include the harvest ratios associated with fishing at combined sex F0.1, F35% SpR and FMAX. These values were estimated by WKCELT but may be revised if there are indications of changes to fisheries or biological factors.
5. Multiply the adjusted survey index by the harvest ratios to give the number of total removals.
6. Create a landings number by applying the discard ratio (dead discard rate).
7. Produce landings biomass by applying mean weight.

Medium-term projections

None presented.

Long-term projections

None presented.

Biological reference points

The reference points derived by WKCELT are given in text table below:

These should remain under review by WGCSE and may be revised should improve data become available. The combined sex $F_{0.1}$ should be used as an F_{msy} proxy for *Nephrops* in FU19.

		Harvest Rate (%)
	Male	8.1
	Female	9.0
F0.1	Comb	8.1
	Male	12.3
	Female	13.0
Fmax	Comb	12.3
	Male	13.0
	Female	15.2
F35% SpR	Comb	14.5

Other issues

Historical overview of previous assessment methods

WGCSE 2012 carried out the first MSY explorations for FU19. In response to the recommendations of WKFRAME (2010), the Bell/Dobby combined sex–length cohort analysis (SCA) model (WK*NEPH*, 2009) was used to determine Harvest Rates associated with fishing at various potential F_{MSY} proxies i.e. $F_{35\%}$ SPR, $F_{0.1}$ and F_{max}. This approach was previously applied to all other *Nephrops* stocks with UWTV and catch sampling data. Length distributions for male and female landings and discards were available for Irish sampling from FU19 from 2002 to 2011.

Model used: Age Structured Simulation model (Dobby) per recruit analysis in r.

Model Options chosen: The length–frequency distributions reference period 2009–2011 were used. The length distributions in the reference period were relatively stable. The L_{50} for female maturity was estimated at 26 mm and was based on Irish sampling in FU19.

Other SCA inputs such as growth parameters and discard survival were all taken from the stock annex.

Parameter	Males	Immature Females	Mature females
L □	68	68	49
K	0.17	0.17	0.1
Natural Mortality	0.3	0.3	0.2
Discard Survival	10%	10%	10%
A	0.000322	0.000684	0.000684
B	3.207	2.963	2.963

The results of the final SCA model carried out are given in the text table below. The F multipliers required to achieve the potential F_{msy} proxies, the harvest rates that correspond to those multipliers and the resulting level of spawner per recruit as a percentage of the virgin level.

The L_{50} for female maturity was estimated at 26 mm and was based on Irish sampling in FU19. Figure G.1 shows the estimated YPR and SPR curves. The SCA model fit to both landings and discards of both sexes is fairly good. The YPR plot indicates a more domed YPR for females than males. The results of the model in the table below show the F multipliers required to achieve the potential F_{MSY} proxies; the harvest rates that correspond to those multipliers and the resulting level of spawner-per-recruit as a percentage of the virgin level. The estimated harvest rates are very close to those estimated for several other stocks in VI and VII.

		Fmult	Fbar 20–40mm		Harvest Rate %	% Virgin Spawner per Recruit		
			Male	Female		Male	Female	Comb
F0.1	Male	0.2	0.13	0.04	6.5	42.57	72.19	53.38
F0.1	Female	0.55	0.36	0.11	14.2	18.97	49.02	29.94
F0.1	Comb	0.24	0.16	0.05	7.5	37.60	68.41	48.85
Fmax	Male	0.36	0.24	0.07	10.4	27.48	59.20	39.06
Fmax	Female	1.04	0.68	0.21	21.9	10.54	34.63	19.33

		Fmult	Fbar 20–40mm		Harvest Rate %	% Virgin Spawner per Recruit		
			Male	Female		Male	Female	Comb
Fmax	Comb	0.47	0.31	0.10	12.7	21.85	52.80	33.15
F35%SpR	Male	0.27	0.18	0.06	8.3	34.51	65.83	45.94
F35%SpR	Female	1.03	0.68	0.21	21.8	10.63	34.83	19.46
F35%SpR	Comb	0.44	0.29	0.09	12.1	23.16	54.40	34.56

A trial LCA assessment for this stock was carried out by the *Nephrops* WG in 2003 (ICES, 2003) and the assessment was not accepted as the quality of the assessment inputs was poor, with only one year's LFD data available for the LCA. More importantly the WG concluded that the steady state criteria necessary to accept an LCA were not met.

Model used: LCA

Software used: n/r

Model Options chosen: No Final model was accepted

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Table A.1.1. *Nephrops* in FU19 (S and SW Ireland). Data available to define discrete *Nephrops* grounds.

	WKCELT 2014						
	Commercial Data		Seabed Mapping Data			Survey Data	
Ground	VMS 2006-2011	Observer Trip Data	Backscatter	Bathymetry	Sediment Samples	UW TV	Ground Fish
Bantry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cork Channels	Yes	Yes	Partial	Partial	Yes	Yes	Yes
Galley Grounds1	Yes	Yes	Partial	Partial	No	Yes	Yes
Galley Grounds2	Yes	Yes	Partial	Partial	No	Yes	Yes
Galley Grounds3	Yes	Yes	No	No	No	Yes	Yes
Galley Grounds4	Yes	Yes	No	No	No	Yes	Yes
Helvick 1	Yes	No	Yes	Yes	Yes	Yes	Yes
Helvick 2	Yes	Yes	Partial	Partial	No	Yes	No
Helvick 3	Yes	No	No	No	No	Yes	No
Kenmare Bay	No	Yes	Yes	Yes	Yes	No	Yes

Table A.1.2. *Nephrops* in FU19 (S and SW Ireland). Area Calculations of *Nephrops* grounds and final average areas.

	Integrated VMS 2006-2011			
	Irish National Grid (km^2)	Eckert VI (world) (km^2)	Cylindrical Equal Area (km^2)	Average (km^2)
Bantry	121.75	121.54	121.27	121.52
Cork Channels	562.93	562.17	560.91	562.01
Galley Grounds1	60.97	60.88	60.74	60.86
Galley Grounds2	76.87	76.76	76.59	76.74
Galley Grounds3	134.16	133.98	133.68	133.94
Galley Grounds4	926.56	925.40	923.33	925.10
Helvick 1	33.15	33.10	33.03	33.09
Helvick 2	59.62	59.53	59.40	59.52
Total	1976.02	1973.36	1968.95	1972.78

Table A.1.3. *Nephrops* in FU19 (S and SW Ireland). Positions of WKCELT Bantry Bay and Helvick 1-2 polygons.

	Bantry Bay			Helvick 1			Helvick 2	
Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude
1	-9.64	51.66	1	-7.43	52.01	1	-7.40	51.76
2	-9.67	51.64	2	-7.43	52.00	2	-7.43	51.75
3	-9.70	51.62	3	-7.43	51.99	3	-7.47	51.74
4	-9.73	51.61	4	-7.44	51.99	4	-7.50	51.75
5	-9.77	51.60	5	-7.45	51.98	5	-7.54	51.75
6	-9.80	51.59	6	-7.46	51.99	6	-7.58	51.75
7	-9.83	51.57	7	-7.47	52.00	7	-7.62	51.75
8	-9.86	51.55	8	-7.47	52.00	8	-7.60	51.76
9	-9.88	51.54	9	-7.48	52.01	9	-7.56	51.76
10	-9.91	51.53	10	-7.49	52.01	10	-7.55	51.79
11	-9.95	51.53	11	-7.50	52.00	11	-7.51	51.81
12	-9.98	51.53	12	-7.51	52.00	12	-7.47	51.81
13	-10.02	51.52	13	-7.52	52.01	13	-7.43	51.80
14	-10.04	51.53	14	-7.51	52.02	14	-7.40	51.82
15	-10.02	51.56	15	-7.50	52.03	15	-7.39	51.80
16	-9.99	51.57	16	-7.49	52.03	16	-7.43	51.79
17	-9.96	51.59	17	-7.48	52.03	17	-7.47	51.79
18	-9.92	51.58	18	-7.47	52.04	18	-7.51	51.79
19	-9.90	51.59	19	-7.47	52.05	19	-7.54	51.77
20	-9.87	51.60	20	-7.46	52.06	20	-7.50	51.76
21	-9.83	51.61	21	-7.45	52.06	21	-7.47	51.76
22	-9.80	51.62	22	-7.44	52.06	22	-7.43	51.76
23	-9.77	51.63	23	-7.43	52.06	23	-7.39	51.77
24	-9.73	51.64	24	-7.42	52.06	24	-7.37	51.80
25	-9.70	51.66	25	-7.42	52.05	25	-7.33	51.81
26	-9.67	51.66	26	-7.42	52.04	26	-7.29	51.83
27	-9.64	51.67	27	-7.43	52.03	27	-7.30	51.80
28	-9.60	51.68	28	-7.43	52.03	28	-7.33	51.79
29	-9.61	51.67	29	-7.43	52.02	29	-7.36	51.77
30	-9.64	51.66	30	-7.43	52.01	30	-7.40	51.76

Table A.1.3. ***Nephrops*** **in FU19 (S and SW Ireland). Positions of WKCELT Cork Channels polygon.**

	Cork Channels			Cork Channels			Cork Channels	
Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude
1	-7.76	51.74	36	-8.02	51.55	71	-8.08	51.71
2	-7.74	51.71	37	-7.99	51.57	72	-8.12	51.68
3	-7.73	51.69	38	-8.02	51.56	73	-8.15	51.66
4	-7.70	51.67	39	-8.05	51.57	74	-8.19	51.65
5	-7.68	51.63	40	-8.09	51.56	75	-8.23	51.64
6	-7.66	51.60	41	-8.13	51.55	76	-8.26	51.62
7	-7.69	51.60	42	-8.11	51.54	77	-8.28	51.65
8	-7.71	51.64	43	-8.07	51.54	78	-8.24	51.65
9	-7.73	51.67	44	-8.03	51.54	79	-8.20	51.66
10	-7.76	51.69	45	-8.05	51.53	80	-8.17	51.68
11	-7.77	51.73	46	-8.09	51.53	81	-8.14	51.70
12	-7.80	51.74	47	-8.13	51.52	82	-8.10	51.71
13	-7.84	51.72	48	-8.17	51.52	83	-8.08	51.75
14	-7.85	51.69	49	-8.21	51.51	84	-8.05	51.76
15	-7.83	51.65	50	-8.25	51.51	85	-8.01	51.75
16	-7.80	51.62	51	-8.29	51.50	86	-7.97	51.75
17	-7.81	51.59	52	-8.33	51.47	87	-7.95	51.72
18	-7.82	51.62	53	-8.36	51.48	88	-7.91	51.73
19	-7.84	51.64	54	-8.33	51.50	89	-7.88	51.74
20	-7.88	51.65	55	-8.29	51.51	90	-7.84	51.75
21	-7.92	51.65	56	-8.26	51.53	91	-7.80	51.76
22	-7.96	51.64	57	-8.24	51.55	92	-7.77	51.78
23	-7.97	51.61	58	-8.27	51.56	93	-7.77	51.82
24	-7.95	51.58	59	-8.30	51.54	94	-7.80	51.85
25	-7.91	51.58	60	-8.34	51.53	95	-7.76	51.84
26	-7.87	51.60	61	-8.33	51.55	96	-7.74	51.81
27	-7.84	51.60	62	-8.30	51.56	97	-7.70	51.81
28	-7.85	51.58	63	-8.26	51.58	98	-7.72	51.78
29	-7.86	51.57	64	-8.23	51.61	99	-7.75	51.77
30	-7.82	51.57	65	-8.19	51.63	100	-7.76	51.74
31	-7.84	51.57	66	-8.16	51.65			
32	-7.88	51.57	67	-8.13	51.67			
33	-7.92	51.57	68	-8.09	51.68			
34	-7.96	51.55	69	-8.05	51.69			
35	-8.00	51.55	70	-8.04	51.71			

Table A.1.3. ***Nephrops*** **in FU19 (S and SW Ireland). Positions of WKCELT Galley grounds 1-3 polygons.**

	Galley Ground 1			Galley Ground 2			Galley Ground 3	
Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude
1	-9.28	51.46	1	-9.09	51.35	1	-8.59	51.57
2	-9.29	51.44	2	-9.09	51.33	2	-8.59	51.56
3	-9.30	51.42	3	-9.10	51.32	3	-8.62	51.54
4	-9.33	51.42	4	-9.12	51.31	4	-8.66	51.54
5	-9.35	51.42	5	-9.14	51.31	5	-8.70	51.53
6	-9.38	51.41	6	-9.16	51.31	6	-8.73	51.52
7	-9.39	51.40	7	-9.17	51.30	7	-8.74	51.49
8	-9.38	51.38	8	-9.19	51.30	8	-8.75	51.46
9	-9.40	51.37	9	-9.20	51.29	9	-8.79	51.45
10	-9.43	51.37	10	-9.19	51.27	10	-8.83	51.44
11	-9.41	51.38	11	-9.20	51.26	11	-8.87	51.44
12	-9.40	51.40	12	-9.22	51.25	12	-8.90	51.43
13	-9.42	51.40	13	-9.24	51.25	13	-8.94	51.42
14	-9.44	51.41	14	-9.26	51.25	14	-8.98	51.42
15	-9.47	51.41	15	-9.27	51.25	15	-8.98	51.44
16	-9.47	51.42	16	-9.29	51.26	16	-8.95	51.45
17	-9.46	51.44	17	-9.30	51.27	17	-8.91	51.46
18	-9.44	51.44	18	-9.29	51.29	18	-8.88	51.48
19	-9.42	51.44	19	-9.27	51.30	19	-8.91	51.49
20	-9.41	51.46	20	-9.26	51.31	20	-8.92	51.51
21	-9.39	51.46	21	-9.24	51.32	21	-8.88	51.52
22	-9.38	51.46	22	-9.22	51.32	22	-8.85	51.52
23	-9.38	51.44	23	-9.21	51.33	23	-8.81	51.53
24	-9.35	51.44	24	-9.19	51.34	24	-8.77	51.53
25	-9.33	51.45	25	-9.17	51.34	25	-8.73	51.53
26	-9.31	51.45	26	-9.16	51.34	26	-8.69	51.54
27	-9.33	51.46	27	-9.14	51.35	27	-8.66	51.54
28	-9.31	51.48	28	-9.12	51.35	28	-8.62	51.56
29	-9.29	51.48	29	-9.10	51.36	29	-8.62	51.58
30	-9.28	51.46	30	-9.09	51.35	30	-8.59	51.57

Table A.1.3. ***Nephrops*** **in FU19 (S and SW Ireland). Positions of WKCELT Galley ground 4polygon.**

	Galley Ground 4			Galley Ground 4	
Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude
1	-8.51	51.16	31	-8.49	50.95
2	-8.45	51.16	32	-8.44	50.98
3	-8.38	51.15	33	-8.49	51.00
4	-8.32	51.15	34	-8.55	51.00
5	-8.25	51.15	35	-8.53	51.04
6	-8.19	51.15	36	-8.46	51.06
7	-8.13	51.15	37	-8.40	51.07
8	-8.06	51.15	38	-8.34	51.07
9	-8.02	51.13	39	-8.29	51.10
10	-8.01	51.09	40	-8.36	51.10
11	-7.99	51.08	41	-8.42	51.10
12	-8.06	51.08	42	-8.49	51.09
13	-8.11	51.05	43	-8.55	51.08
14	-8.16	51.01	44	-8.61	51.08
15	-8.17	50.95	45	-8.67	51.10
16	-8.22	50.92	46	-8.74	51.10
17	-8.29	50.93	47	-8.80	51.11
18	-8.34	50.93	48	-8.86	51.13
19	-8.40	50.92	49	-8.93	51.13
20	-8.46	50.90	50	-8.99	51.12
21	-8.52	50.87	51	-9.04	51.11
22	-8.57	50.84	52	-9.00	51.15
23	-8.54	50.88	53	-8.94	51.16
24	-8.48	50.91	54	-8.88	51.18
25	-8.42	50.93	55	-8.82	51.19
26	-8.36	50.95	56	-8.75	51.20
27	-8.31	50.99	57	-8.69	51.21
28	-8.34	51.00	58	-8.64	51.18
29	-8.40	50.98	59	-8.58	51.16
30	-8.45	50.95	60	-8.51	51.16

Table B.2.1. ***Nephrops*** **in FU19 (S and SW Ireland). Sampling levels.**

Number of Samples				Total numbers of Nephrops measured			
Year	Graded Landings	Catch	Discards	Year	Graded Landings	Catch	Discards
2002		3	2	2002		2235	1081
2003	2	12	15	2003	763	3173	7234
2004	1	5	4	2004	152	1278	1169
2005		6	2	2005		3221	1670
2006		8		2006		4716	
2007	2	13		2007	561	22170	
2008		18		2008		12311	
2009		16		2009		7601	
2010	1	18		2010	331	7662	
2011		15		2011		7684	
2012		21		2012		9958	
2013		17	11	2013		8623	4586

Table B.2.2. ***Nephrops*** **in FU19 (S and SW Ireland). Sampling levels by grounds.**

	Number of Catch Samples												Number of Discard Samples				
Fishing Grounds	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	**2002**	**2003**	**2004**	**2005**	**2013**
Ballycotton Ground							1										
Baltimore		2	3	1				1						2	2		
Bantry Bay			1		1	4	7	7	14	15	13	12			1		8
Canyons		1												1			
Castletownbere						3	4	2			1						
Daunt								1									
Dingle Bay Outer					1		2										
Dunmanus bay					1	2											
Galley head	2	4	1		1		1				1		2	5	1		
Helvic	1			1													
Kenmare Bay					3	4	2	2	5	1	2	4					2
Mine Head												1					1
Not Known		1		4	1			1		2	4			1		2	
Power Head														1			
South Kinsale		1												1			
South of Cape Clear		1												1			
South of Cork								2						1			
Union hall		2					1							2			
	3	12	5	6	8	13	18	16	19	18	21	17	2	15	4	2	11

Table B.1. Biological Input Parameters for FU19 Nephrops Stock.

Parameter	Value	Source
Discard Survival	25%	WKCELT 2014 assumed in line with other stocks
MALES		
Growth - K	0.16	WKCELT 2014
Growth - L(inf)	60	WKCELT 2014
Natural mortality - M	0.3	assumed, in line with other stocks
Length/weight - a	0.000322	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	3.207	"
FEMALES		
Immature Growth		
Growth - K	0.16	WKCELT 2014
Growth - L(inf)	60	WKCELT 2014
Natural mortality - M	0.3	assumed, in line with other stocks
Size at maturity (L50)	24	WKCELT 2014
Mature Growth		
Growth - K	0.08	WKCELT 2014
Growth - L(inf)	56	WKCELT 2014
Natural mortality - M	0.2	assumed, in line with other stocks
Length/weight - a	0.000684	based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	2.963	"

Table B.3.1.*Nephrops* in FU19 (SW and SE Ireland). Female Maturity.

Parameter	Value	Source
Female L25	23	Bantry Bay 2009-2013
Female L50	24	"

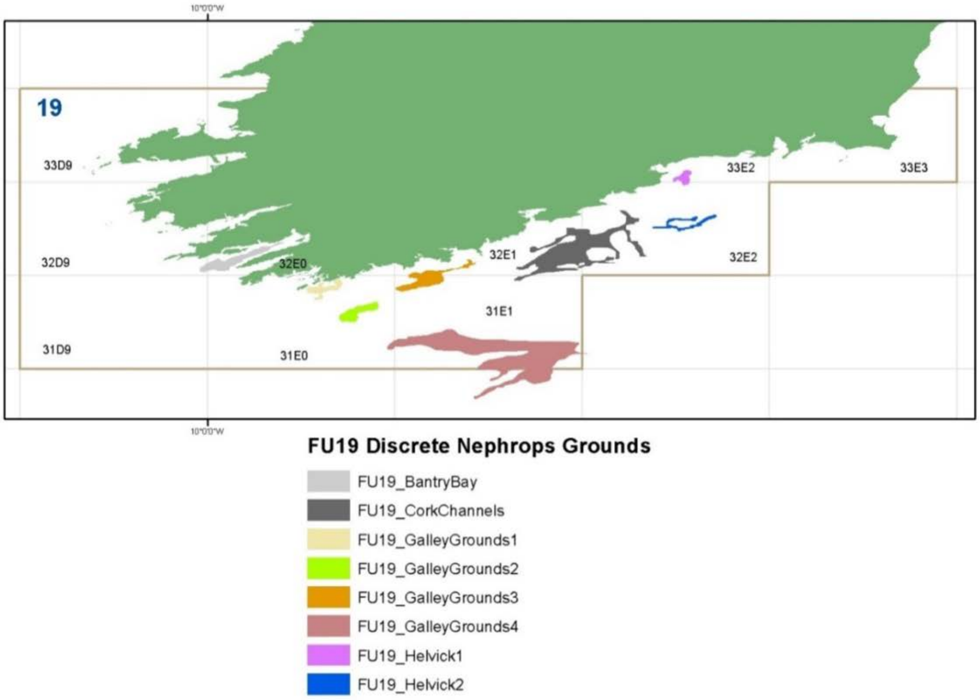


Figure A.1.1. ***Nephrops*** **in FU19 (S and SW Ireland). Discrete** ***Nephrops*** **grounds.**

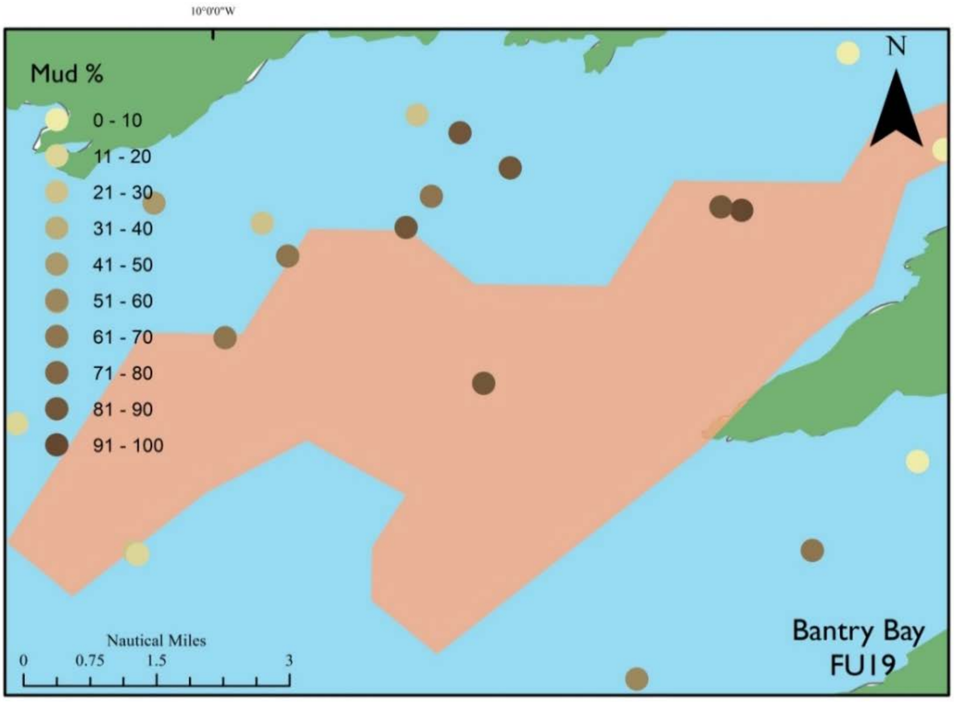


Figure A.3.1. ***Nephrops*** **in FU19 (S and SW Ireland). Sediment samples in Bantry Bay.**

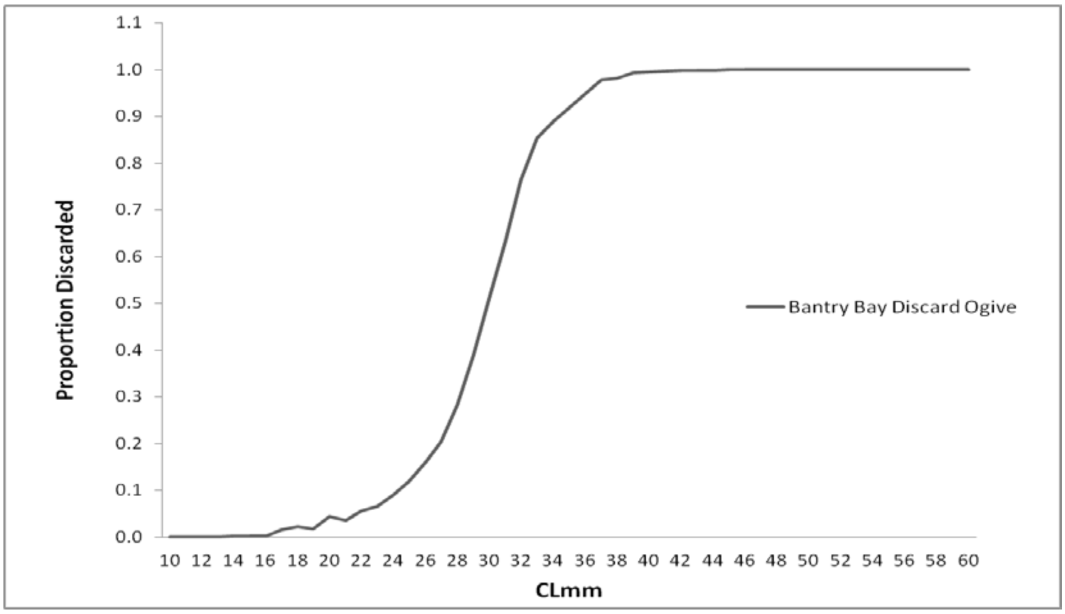


Figure B.2.1. ***Nephrops*** **in FU19 (S and SW Ireland). Discard ogive selected for Bantry Bay based on sample data from 2008 Q1 and 2013 Q3-Q4 averaged.**

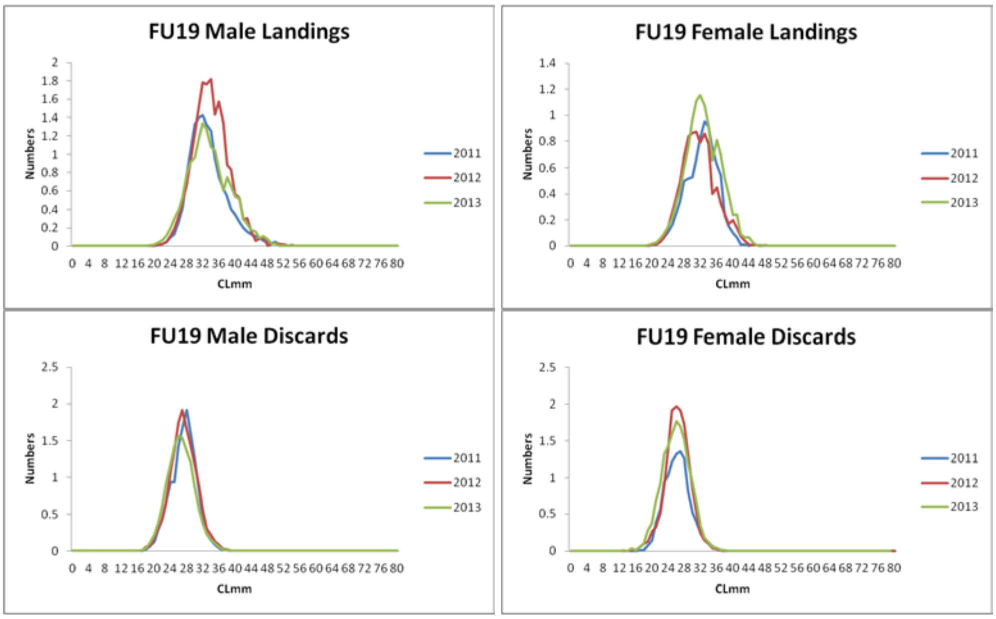


Figure B.2.2. ***Nephrops*** **in FU19 (S and SW Ireland). Length frequency data by sex for reference period 2011-2013 partitioned using the WKCELT discard selection ogive.**

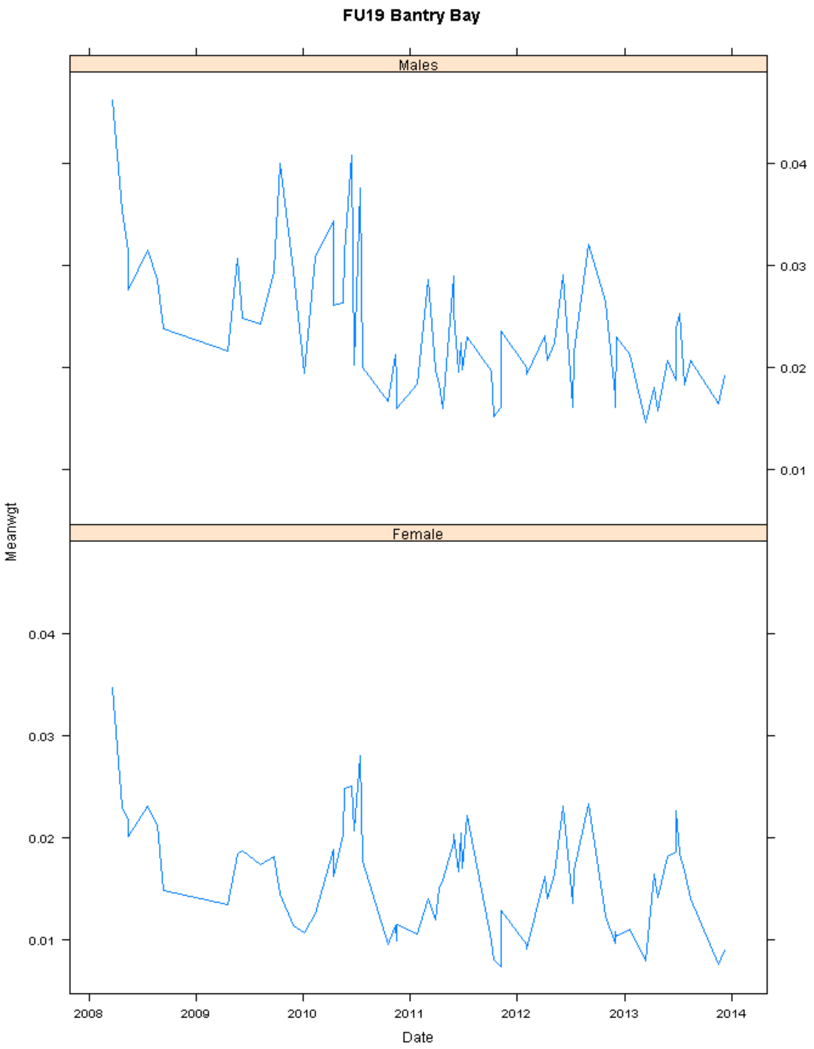


Figure B.3.1. *Nephrops* in FU19 (SW and SE Ireland). Mean weight (Kg) by sex from Bantry Bay 2008 -2013.

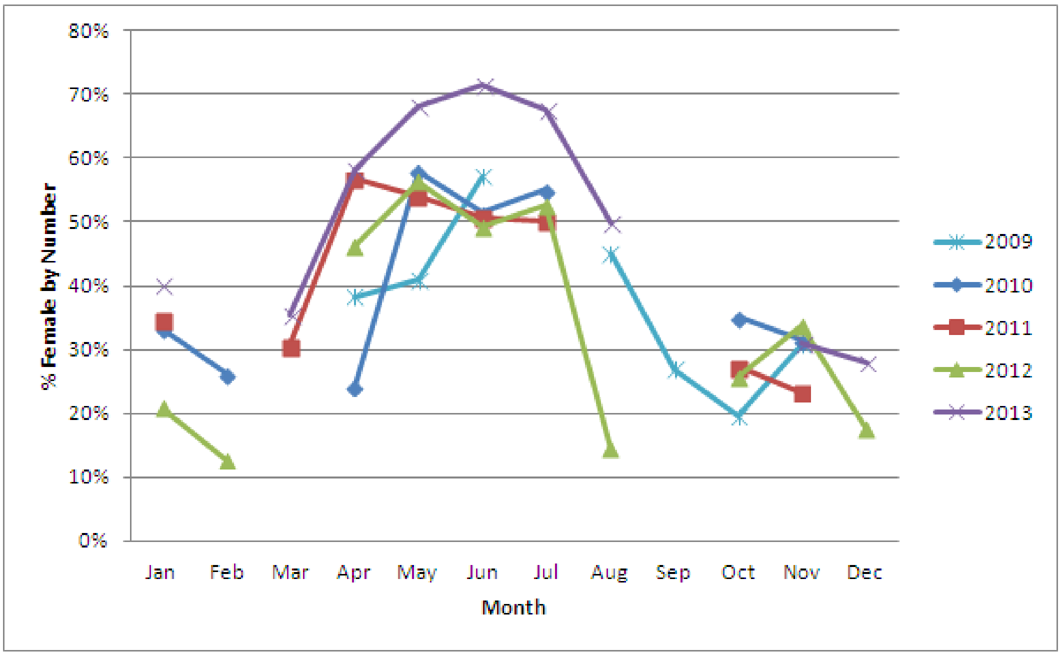


Figure B.3.2. ***Nephrops*** **in FU19 (SW and SE Ireland). Sex ratio by month for Bantry Bay unsorted catch sampling showing a seasonal trend.**

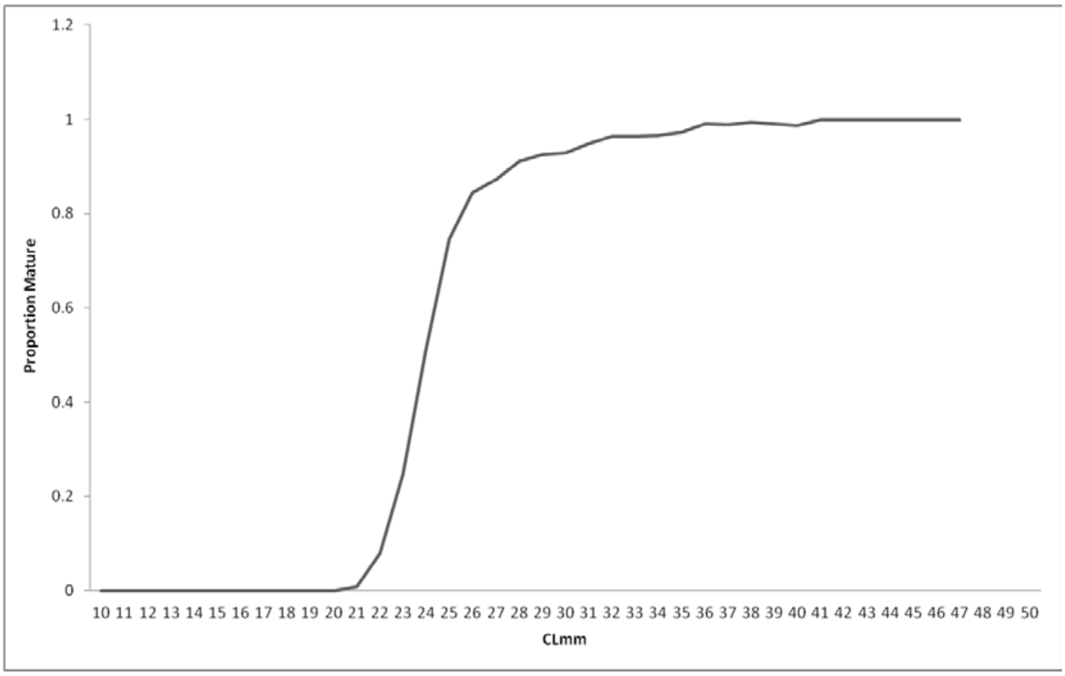


Figure B.3.3. ***Nephrops*** **in FU19 (S and SW Ireland). Female maturity ogive based on sampling data from Bantry Bay 2009-2013.**

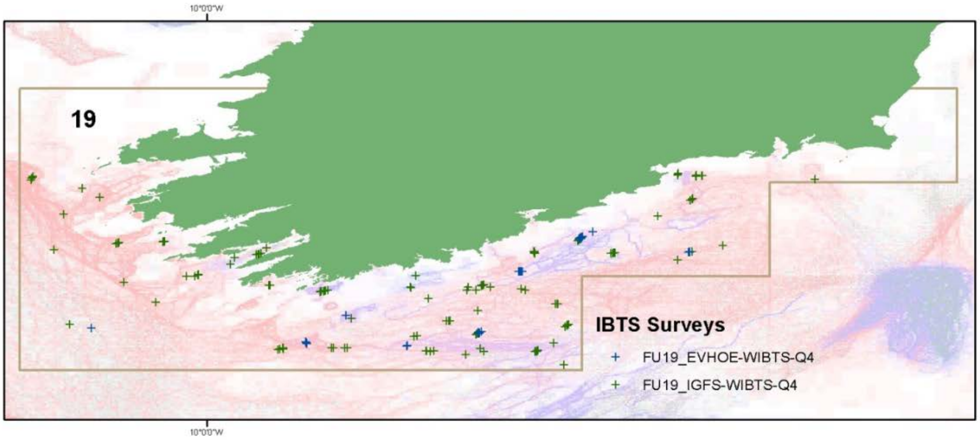


Figure B.4.1. ***Nephrops*** **in FU19 (S and SW Ireland). Station positions with** ***Nephrops*** **catches from Irish (green cross) and French (blue cross) groundfish survey.**

Annex 5 Stock Annex *Nephrops* FU2021

Stock specific documentation of standard assessment procedures used by ICES.

Stock	*Nephrops* (FU2021) FU 20 (Labadie, Baltimore and Galley), FU 21 (Jones and Cockburn)
Date	06 February 2014 (WKCELT 2014)
Revised by	Jennifer Doyle, Colm Lordan and Spyros Fifas.

General

Stock definition

Nephrops is limited to muddy habitat, and requires sediment with a silt and clay content of between 10–100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. The knowledge of the distribution of suitable *Nephrops* habitat in this area is developing. Information so far suggests that *Nephrops* are found in complex channels, which are probably the remnants of fluvial channels related to the deglaciation of the Irish ice sheet at the end of the last ice age.

The spatial extent of the *Nephrops* grounds in FU20-21 has been re-defined using Irish 2006-2011 integrated VMS-logbook data using the methods described in Gerritsen and Lordan (2011). Here, *Nephrops* directed activity was defined for VMS pings where >30% of daily operational landings was reported to be *Nephrops*. Integrated French VMS data 2008-2012 is also available. The knowledge of the distribution of suitable *Nephrops* habitat in this area is developing. Information so far suggests that *Nephrops* are found in complex channels, which are probably the remnants of fluvial channels related to the deglaciation of the Irish ice sheet at the end of the last ice age. The initial ground perimeter used during this survey was established using a combination of integrated logbook VMS data (using the methods described in Gerritsen and Lordan, 2011), BGS sediment maps and data collected on observer trips. The total area of this polygon is 9840 km^2.

The Functional Unit for assessment includes some parts of the following ICES Divisions VIIg,h. The fishery data for this includes the following ICES Statistical rectangles: 28-30E1; 28-31E2; 30E3 (Figure A.1.1).

Adult *Nephrops* probably only undertake very small-scale movements (a few 100 m). Recent studies in larval tracking models show that larval transfer in this area is minimal where this ground retains most of the larvae whereas other *Nephrops* grounds in the Celtic sea may donate larvae to this ground such as the offshore Galley Grounds 4 in FU19 (O' Sullivan *et al*., in press).

Fishery

France and Ireland are the main countries involved in the FU20-21 *Nephrops* fishery. The fishery is almost exclusively an otter trawl fishery with most vessel using twin rigs. There are a large number of species taken as bycatch in the fishery. Economically whiting, monkfish, cod and megrim and to a lesser degree haddock, tend to be the most important species retained with *Nephrops*.

Ireland

The Irish fleet has been the main participant in this fishery in recent years. Vessels >18 m tend to fish the offshore *Nephrops* and target *Nephrops* on several in other FUs to optimize catch rates depending on tides and weather. These larger vessels freeze the catches at sea and have become increasingly prevalent since 2006. The Irish fishery is more mixed (~50% *Nephrops* by weight) in the northern part of the area whereas further south *Nephrops* dominate the landings (>75% by weight) (Gerritsen *et al*., 2012).

France

French trawlers operating in this area fish also in the Celtic Sea (FU22 and FU20-21) and switch between FUs depending on weather conditions. The French fishery is general more mixed (~10% *Nephrops* by weight) with where vessels often switch target species between *Nephrops* and gadoid species.

UK

Minimal participation by the UK in this fishery.

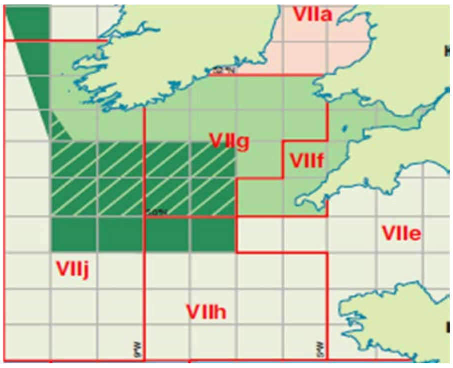
Technical Measures

The following TCMs are in place for *Nephrops* in VII (excluding VIIa) after EC 850/9 in operation since 2000: Minimum Landing Sizes (MLS); total length >85 mm, carapace length >25 mm, tail length >46 mm. This regulation is applied by the Irish and UK fleets whereas a more restrictive regulation adopted by the French Producers' Organizations (35 mm CL i.e. 11.5 cm total length) is applied by the French trawlers.

The French minimum mesh size of codend was set at 100 mm in January 2000.

The mesh size, catch composition and square mesh panel requirements in the Celtic Sea after EU 737/2012 are shown below in the table and maps below. The majority of Irish *Nephrops* vessels operating in the area use 70-89 mm mesh and are obliged to have a 120 mm square mesh panel (SMP) since 2012. Some Irish vessels and most French Nephrops vessels use >100 mm cod end mesh with a 100 mm SMP.

	VII (Celtic Sea & West of Ireland)								
	Area VII Outside restricted areas				Celtic Sea Protection Zone				HAKE BOX
Mesh size (mm)	70-79	80-89	90-99	100+	70-79	80-89	90-99	100+	100+
Twine thickness	4mm double or single 6mm								
Headline Panel (mm) (Beam Trawlers see footnote 1)	-	-	-	-	-	-	-	-	-
Square mesh panel (mm)	80	-	-	-	110	110	110	100	-
Maximum number of meshes in codend circumference	120	120	100	100	120	120	100	100	100
Catch Composition	-	Either - Or		-	Either - Or		-	-	-
Maximum % of cod allowed. (Council Reg 39/2013)	-	-	-	-	-	-	-	-	-
Maximum % cod, haddock, saithe allowed	-	-	30	-	-	-	30	-	-
Maximum % of hake allowed	20	20	20	-	20	20	20	-	-
Minimum % of saithe required	-	-	-	-	-	-	-	-	-
Minimum % of Nephrops required	35	30	-	-	35	30	-	-	-
Minimum % of Annex I List (see footnotes)	-	-	70[2]	-	-	-	70[2]	-	-
Minimum % of haddock, hake, whiting, megrim, monkfish, rays, saithe and Nephrops	-	-	-	-	-	-	-	-	-



Source:http://www.bim.ie/media/bim/content/newsandevents/BIM_Fisheries_Management_Map_2013.PDF

Ecosystem aspects

Physical oceanography

There is evidence of a cyclical gyre in the Labadie. Outputs from the larval tracking modelling study suggest that surface water flow above the Labadie is strongest during summer. Retention of larvae is quite high on this ground which indicates that some gyre formation may be in effect entraining the larvae within the area. This is most apparent in April and May with surface water adopting a southwesterly orientation about the domain during June (O' Sullivan *et al.,* in press).

Sediment distribution

Current available sediment information is based on British Geological survey data which is not of a fine spatial resolution. The Celtic Sea contains a fan-like system of shelf-crossing ridges which are thought to be palaeo-tidal sandbanks with a glacial origin (Praeg *et al.*, 2010). Mapping of VMS data linked to *Nephrops* landings can be viewed as a proxy for sediments (muddy).

Bathymetry

UWTV station depths ranged from 95 to 134 metres on the Labadie.

Data

Commercial catch

Commercial landings data are supplied by Ireland, France and the UK for FU20-21 since 1999. Previously landings were available for FU20-22.

Landings statistics for the Irish fleet are obtained from EU logbooks since 1999. Vessels record daily retained catches in operations and make a declaration of total landings on re-turn to port. Since 2012, most vessels in the fleet have been using electronic logbooks (EC Regulation 1224 of 2009 and 404 of 2011). Vessels are required to electronically report catches on board in each 24 hour period. Similarly landings from UK Scotland and England, Wales and Northern Ireland are available from the logbooks. Landings from France are obtained from EU logbooks.

Sampling Data

Sampling of this *Nephrops* stock has been very limited by both countries due to the remoteness of the fishery and consequent logistic problems.

Ireland

Sampling is very limited (5 samples in 2012, 7 in 2013). A catch self-sampling programme has been in operation where this involves unsorted catch and discard samples being provided by vessels or collected by observers at sea on discard trips.The catch sample is partitioned into landings and discards using an on board discard selection ogive derived for the discard samples.

France

Routine sampling of the landings with occasional on board sampling.

Biological

Biological parameters for this stock are outlined in Table B.1.

Length–weight

The annual mean weight for Irish landings is estimated from the length–frequency data and a length–weight relationship from studies on Scottish stocks by Pope and Thomas (1955). The annual mean weight for French landings is estimated using parameters derived from Scottish weight–length relationships (Pope and Thomas, 1955).

No changes in these parameters were made at WKCELT 2014.

Natural mortality

A natural mortality rate of 0.3 was assumed for all length classes and years for males and immature females, with a value of 0.2 for mature females. The lower value for mature females reflects the reduced burrow emergence while ovigerous and hence an assumed reduction in predation. The accuracy of these assumptions is unknown. No changes in these parameters were made at WKCELT 2014.

Maturity

Female

L_{50} is taken from FU22, to date there has been no maturity ogive estimated for this area.

Male

To date there has been no maturity ogive estimated for this area.

Discard survival

Trip durations (French trips ~15 days, Irish Trips ~7-15 days) and behaviour of the fleet means the majority of discards are returned to the sea over suitable sediment.

The proportion scavenged by birds is probably quite low. Tow durations, volume of catches, prolonged sorting on deck and moderate density of *Nephrops* on the seabed probably results in a moderate discard survival. This is estimated to be around 25% (Chareau *et al.*, 1982). No changes in these parameters were made at WKCELT 2014.

Surveys

UWTV Survey

In 2006 Ireland conducted the first underwater television survey (UWTV) in FU2021, however only 9 stations were completed. From 2012 to 2013 an average of 56 stations have been completed. The 2013 survey design was based on a randomized isometric grid of 95 stations with a 6.0 nautical mile spacing was planned.Stations depths varied from 95 m to 134 m and the completed stations ranged from 55 to 135 nautical miles (nmi) offshore. The methods used during the survey were similar to those employed for UWTV surveys of *Nephrops* stocks around Ireland and elsewhere and are documented by WKNEPHTV (ICES, 2007), SGNEPS (ICES, 2009, 2010, 2012) and WGNEPS (2013). So far only 60% of the grounds has been covered by the UWTV survey. UWTV survey methodology and results are available at http://hdl.handle.net/10793/915.

UWTV Survey relative to absolute conversion factors

In order to use the survey abundance estimate as an absolute it is necessary to correct for potential biases. For FU2021 the field of view of the camera was 0.75 m and expert judgment of the mean burrow diameter was in the range of 0.25–0.4 m. The edge effect is estimated at 1.25 which is similar to FUs of moderate density. In future it may become possible to quantitatively estimate burrow diameter from mosaics of the footage from this and other areas. Burrow detection rates were thought to be relatively high due to good water clarity. Burrow identification could be slightly overestimated since burrows with the classical *Nephrops* signatures are common but they are interspersed with burrows of various crab and other burrowing megafauna species. The proposed cumulative correction factor for the area was 1.3 (Table below). When compared to with the correction factors applied in other areas it is quite close to the average used on other grounds.

The biases associated with the estimates of *Nephrops* abundance in FU19 are:

	Established	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU2021:	2012	1.25	0.9	1.15	1	1.3

IBTS Groundfish Survey

There are two IBTS-GSF GFS catching *Nephrops* in FU20–21: French groundfish survey EVHOE-WIBTS-Q4 since 1997 and Irish groundfish survey-Q4: IGFS-WIBTS-Q4 commenced in 2003. These data are useful as additional indicators of trends in recruitment, mean size and sex ratio for this *Nephrops* stock. Figure B.4.1. shows IGFS and EVHOE stations with *Nephrops* catches in FU2021.

Commercial cpue

Disaggregated effort and lpue data are available for the Irish *Nephrops* directed fleet in FU2021 from 1999 for all vessels >18 metres total length. The lpue and effort-series is based on the same criteria for FU15, 16, 17, 19, 22 and 20-21 (30% landings threshold) and will be contingent on the accuracy of landings data reported in logbooks.

Effort and LPUE data are not standardized, and hence do not take into account vessel capabilities, efficiency, seasonality or other factors that may bias perception of LPUE abundance trend over the longer term.

French time series is based on a 10% threshold for *Nephrops* targeting and is for all of the Celtic Sea (FU20-22). Effort data are available from 1983 to 2008 for the French *Nephrops* fleet for the overall Celtic Sea. Since 2009, the new registration system of official French statistics has changed the way fishing effort is computed. As a consequence, there is no reference to the number of hours for use of a fishing gear and that hampers unbiased estimates while vessels alternate fishing gears and targeted species during the same trip. To circumvent this problem, new allocation method was tested to characterize a *Nephrops* trawler based on thresholds of *Nephrops* landings weight with no reference to the other species composing the landings by trip. Estimators based on a simple threshold of 500 kg landed *Nephrops*/trip gave satisfactory results compared to the previous estimators (see Stock Annex). Thus, estimates of French fishing effort (h) and LPUE (kg/h) since 2009 have been calculated by this way.

Since FU20-21 and FU22 have been split the WGCSE investigated the disaggregated LPUE series for FU20-21 and FU22 separately for Irish trawlers but inseparably for French trawlers which are essentially operating in FU20-21 and the bias induced is considered to be minor. The highest LPUEs simultaneously for both countries were observed in 2008-2009 with a reduction evident in 2010. In 2011 Irish LPUE indices remain relatively stable whereas French series declined. In the two recent years no change occurred for the French LPUEs although Irish indices grew up and reached the historical highest level of the time series.

Assessment: data and method

Data limited approach

WKLIFE II (ICES 2012) establishes procedures for generating advice for stocks with various shortcomings in the data. The *Nephrops* data-limited approach which was first used by WGCSE 2012 to provide advice for FU2021 and has now been formally incorporated into the ICES DL framework as Method 4.1.4 ‘Data borrowing for sedentary species’. This method requires the following inputs to derive Harvest Ratios for given levels of density and landings:

- Absolute bias corrected density from TV survey
- Spatial extent of the grounds
- mean weight in the landings
- percentage of dead discards in numbers

Steps in formulating the data-limited table:

1. Use absolute bias corrected density and survey area to derive *Nephrops* abundance for a range of densities

2. Convert potential landings weight into numbers using landings mean weight for a range of total landings (ten year average, half of ten year average, maximum of time-series);
3. Convert landings numbers into total removals by dividing by (1-discard rate in number);
4. Divide total removals (from 3) by *Nephrops* abundance (from 1) to obtain a matrix of harvest rates which can be compared to F_{MSY}.

Text table below is an example of the data limited approach for FU 2021.

	FU 20-21: Labadie			3,710	Area (km2)	34.4	mean weight (g)		28%	percentage discards
				Density						
	landings	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55
	1000	6.7%	5.0%	4.0%	3.4%	2.9%	2.5%	2.2%	2.0%	1.8%
	1250	8.4%	6.3%	5.0%	4.2%	3.6%	3.1%	2.8%	2.5%	2.3%
	1500	10.1%	7.5%	6.0%	5.0%	4.3%	3.8%	3.4%	3.0%	2.7%
	1750	11.7%	8.8%	7.0%	5.9%	5.0%	4.4%	3.9%	3.5%	3.2%
	2000	13.4%	10.1%	8.0%	6.7%	5.7%	5.0%	4.5%	4.0%	3.7%
	2250	15.1%	11.3%	9.0%	7.5%	6.5%	5.7%	5.0%	4.5%	4.1%
	2500	16.8%	12.6%	10.1%	8.4%	7.2%	6.3%	5.6%	5.0%	4.6%
	2750	18.4%	13.8%	11.1%	9.2%	7.9%	6.9%	6.1%	5.5%	5.0%
	3000	20.1%	15.1%	12.1%	10.1%	8.6%	7.5%	6.7%	6.0%	5.5%
average	2163	14.5%	10.9%	8.7%	7.2%	6.2%	5.4%	4.8%	4.3%	4.0%
maximum	3144	21.1%	15.8%	12.6%	10.5%	9.0%	7.9%	7.0%	6.3%	5.7%
Minimum	972	6.5%	4.9%	3.9%	3.3%	2.8%	2.4%	2.2%	2.0%	1.8%

UWTV survey approach

The UWTV survey approach should be applied to this FU when improved survey coverage is achieved in future. In the interim *Nephrops* data limited approach should be used. Any improvements in mean weights and discard rates are to be included in this approach.

Medium-term projections

None presented.

Long-term projections

None presented.

Biological reference points

None presented.

Other issues

Historical overview of previous assessment methods

Age structured XSA assessment for this stock was carried *Nephrops* WG in 2003 (ICES, 2003) for FU20-22 and only for male component. The results were considered unreliable for several reasons most importantly; inadequate historical sampling of catch, growth and natural mortality assumptions and concern about accuracy of tuning data. Since then the focus has been on developing a time-series of UWTV survey data as the basis of assessment and advice for this stock.

Model used: XSA, LCA

Software used: n/r

Model Options chosen: No Final model was accepted

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Table A.1.1. *Nephrops* in FU2021. Area calculations of Labadie grounds and final average area.

	Labadie FU2021			
	Irish National Grid (km²)	Eckert VI (world) (km²)	Cylindrical Equal Area (km²)	Average
Integrated VMS 2008-2012	10 028.27	10 018.02	9995.86	10 014

Table A.1.2. *Nephrops* in FU2021. Positions of 2014 Labadie polygon.

Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude	Position	Decimal Latitude	Decimal Longitude
1	-7.71	50.94	36	-7.97	49.70	71	-9.07	50.02
2	-7.57	50.91	37	-7.79	49.85	72	-9.16	50.00
3	-7.74	50.83	38	-7.96	49.75	73	-9.27	49.98
4	-7.92	50.81	39	-7.99	49.80	74	-9.08	50.11
5	-7.92	50.73	40	-7.94	49.88	75	-8.88	50.22
6	-7.72	50.81	41	-8.11	49.73	76	-8.72	50.32
7	-7.54	50.76	42	-8.30	49.76	77	-8.93	50.25
8	-7.31	50.74	43	-8.52	49.77	78	-9.14	50.20
9	-7.19	50.72	44	-8.38	49.90	79	-9.16	50.22
10	-7.01	50.61	45	-8.44	49.93	80	-9.25	50.21
11	-6.99	50.40	46	-8.67	49.91	81	-9.23	50.31
12	-7.08	50.45	47	-8.80	49.89	82	-9.02	50.38
13	-7.19	50.53	48	-8.61	50.02	83	-8.80	50.43
14	-7.18	50.36	49	-8.42	50.14	84	-8.59	50.52
15	-7.32	50.49	50	-8.42	50.20	85	-8.39	50.62
16	-7.54	50.51	51	-8.62	50.09	86	-8.20	50.73
17	-7.77	50.51	52	-8.71	50.10	87	-8.37	50.68
18	-7.96	50.39	53	-8.85	49.92	88	-8.58	50.68
19	-8.11	50.23	54	-8.98	49.86	89	-8.66	50.70
20	-7.98	50.23	55	-8.92	49.94	90	-8.70	50.73
21	-8.01	50.11	56	-9.00	49.93	91	-8.48	50.79
22	-7.78	50.13	57	-8.80	50.02	92	-8.27	50.87
23	-7.66	50.04	58	-8.63	50.17	93	-8.14	50.92
24	-7.53	50.12	59	-8.44	50.30	94	-8.16	50.90
25	-7.46	50.08	60	-8.47	50.35	95	-8.37	50.80
26	-7.63	49.95	61	-8.56	50.33	96	-8.43	50.75
27	-7.47	49.84	62	-8.36	50.44	97	-8.25	50.79
28	-7.55	49.93	63	-8.14	50.51	98	-8.05	50.90
29	-7.40	50.05	64	-7.96	50.64	99	-7.87	50.91
30	-7.25	50.13	65	-8.11	50.63	100	-7.71	50.94
31	-7.24	49.94	66	-8.32	50.53			
32	-7.38	49.79	67	-8.51	50.42			
33	-7.58	49.71	68	-8.65	50.24			
34	-7.74	49.79	69	-8.83	50.10			
35	-7.93	49.65	70	-9.02	49.98			

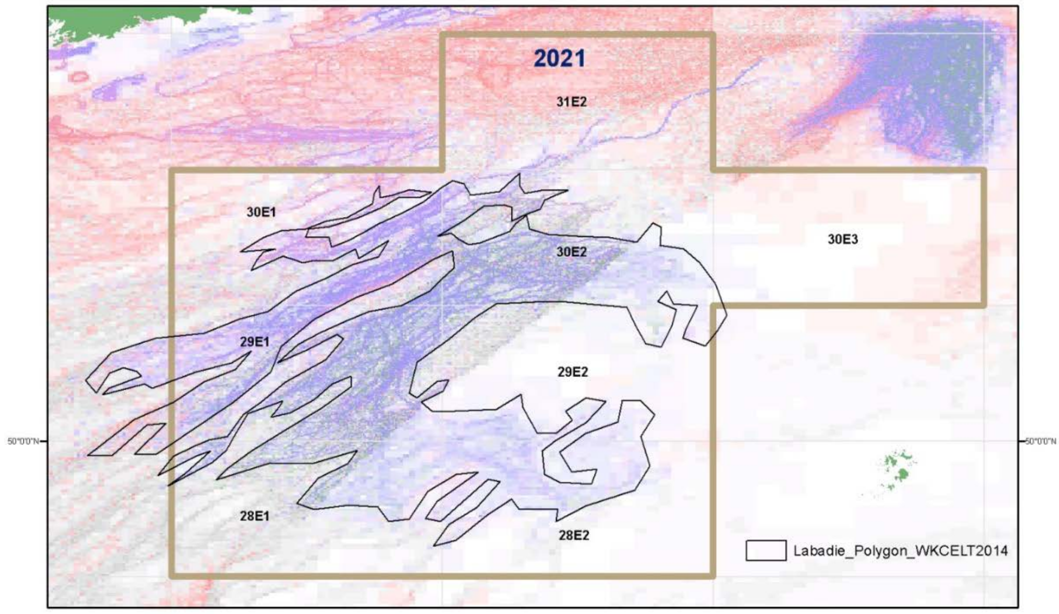

Figure A.1.1. ***Nephrops*** **in FU2021. WKCELT Labadie polygon overlaid on proportion of** ***Nephrop*****s in the Irish landings (red=0% Nephrops; blue=50-60% Nephrops; grey=unknown (no Irish landings).**

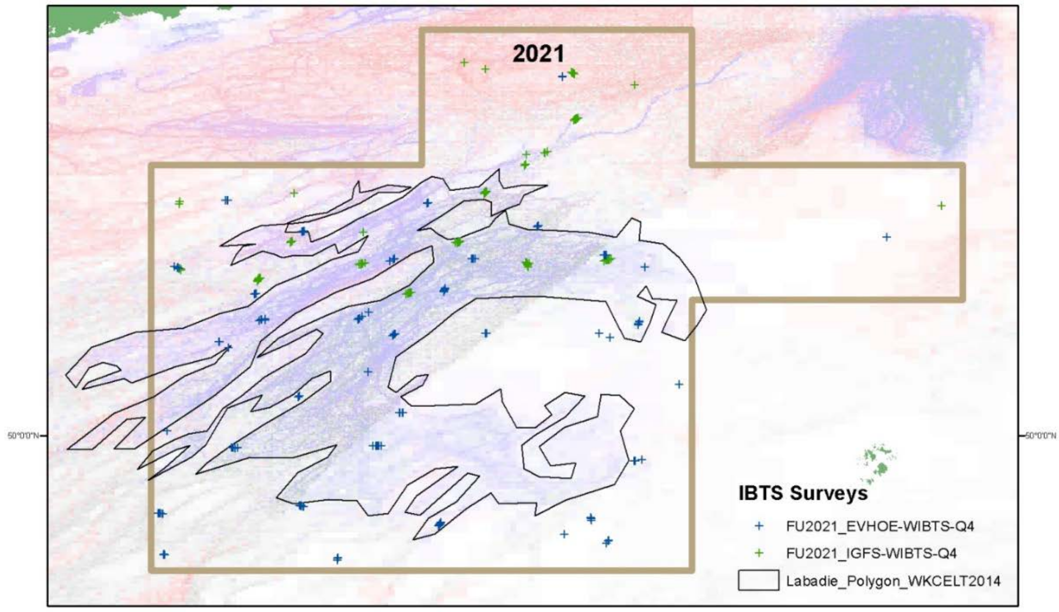

Figure B.4.1 ***Nephrops*** **in FU2021. The spatial distributions of stations with** ***Nephrops*** **catches Station positions with** ***Nephrops*** **catches from Irish (green cross) and French (blue cross) groundfish survey.**

Table B.1. Biological Input Parameters for FU2021 *Nephrops* Stock.

Parameter	Value	Source
Discard Survival	25%	Assumed in line with other stocks
MALES		
Growth - K	0.17	based on FU22
Growth - L(inf)	68	based on FU22
Natural mortality -M	0.3	assumed, in line with other stocks
Length/weight - a	0.000322	Used to raise Irish data.
		Based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	3.207	"
FEMALES		
Immature Growth		
Growth - K	0.17	based on FU22
Growth - L(inf)	68	based on FU22
Natural mortality - M	0.3	assumed, in line with other stocks
Size at maturity (L50)	22	ICES 2006 (Lordan and Gerritsen).Based on FU22
Mature Growth		
Growth - K	0.1	based on FU22
Growth - L(inf)	49	based on FU22
Natural mortality - M	0.2	assumed, in line with other stocks
Length/weight - a	0.000684	Used to raise Irish data.
		Based on Scottish data (Pope and Thomas, 1955)
Length/weight - b	2.963	"

Annex 6 Working Documents

Working Document to WKCELT 2014

Irish whiting discards in VIIbgj – Evaluation of raising methods

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This document reviews the most appropriate raising variables for estimating the Irish whiting discards in VIIbgj.

Landings of whiting by Irish vessels in VIIbc,e-k originate mostly from VIIg (79%); VIIj (16%) and VIIb (4%); the remaining divisions account for 1% (logbook data 2003-12). Whiting landings are mainly taken using otter trawls (64%) followed by seines (34%), the remaining gears account for less than 2% of the landings.

Figure 1 shows maps of the aggregated discard data from 1995-2012. Although there is some OTB effort in VIIc and VIIk, there are virtually no landings or discards of whiting in these divisions which are therefore excluded from the discard raising procedure. The proportion of the catches discarded varies by region but there is no obvious effect of mesh size. The discard weight per unit effort is particularly high in the areas directly to the south and north of the Smalls grounds.

Figure 2 illustrates the variability in discard rate between trips. SSC trips are most variable; most trips discarded less than 6 kg per hour but some trips discarded around 600 kg/h. OTB trips are also very variable with most trips discarding less than 2 kg/h, but some had around 300 kg/h.

Whiting discard volume was plotted against a range of possible auxiliary variables but none shows a consistent correlation. Therefore the precision of a range of raising procedures was investigated. The number of discard trips in each year is too low to follow the sampling design and stratify by Year, Division and Quarter (Table 1). In order to find the best raising variable and stratification (for OTB gears), a number of different options were applied and the precision of these was estimated by bootstrapping. Only OTB data from 2003 onwards were used as earlier years and other gears did not have sufficient trips (Table 1). Trips were used as bootstrapping units and 500 bootstrap replications were performed to estimate the mean weight of whiting discards per trip. The relative standard error was estimated by dividing the standard deviation of the bootstrap estimates by the mean. All raising procedures were done on an annual basis (as opposed to quarterly). The raising variables that were tested were effort (hours), effort (kW hours), Gadoid landings (cod, haddock and whiting), whiting landings and total landings (all species). The fleets were stratified by target species, mesh size or ices divisions. Two different groupings of target species were used: (1) Gad/Other where gadoid trips had at least 15% gadoid landings and all other trips were grouped together; (2) Nep/HMM/Other where nephrops trips had at least 50% nephrops landings, HMM trips had at least 50% hake+monk+megrim landings and all other trips were grouped together

Precision was estimated for the following raising variables and stratification levels:

	Raising variable	Stratification
1.	Effort (hours)	Target Species: Gad / Other
2.	Effort (hours)	Target Species: Nep / HMM / Other
3.	Effort (hours)	Mesh: 70-89 / 100-119 / Other
4.	Effort (hours)	ICES Div: VIIb / VIIg / VIIj
5.	Effort (kW hours)	Target Species: Gad / Other
6.	Effort (hours)	No stratification
7.	Gadoid landings	ICES Div: VIIb / VIIg / VIIj
8.	Whiting landings	ICES Div: VIIb / VIIg / VIIj
9.	Total landings	ICES Div: VIIb / VIIg / VIIj

Figure 3 shows that using whiting or gadoid landings as raising variable generally resulted in poor precision. Not using any stratification also resulted in poor precision before 2007. Using effort (h) resulted in similar precision to effort (kWh) in most years. Stratifying by Gad/Oth target species, mesh size or ICES Division resulted in similar precision levels. Figure 4 shows the annual discard weight estimates for each of the procedures (stratification by mesh size was omitted because the data were not readily available). Using Gad/Oth or Nep/HMM/Oth stratifications resulted in very variable results; stratifying by Ices divisions resulted in somewhat less variation between years. Using total landings as auxiliary variable resulted in the least interannual variation. Figure 5 shows the landings weight estimated from the observer trips. Raising method 8 results in the correct landings estimates (because it uses whiting landings as auxiliary variable). Using total landings and gadoid landings also results in fairly accurate landings estimates. Stratification by target species (Gad/Oth or Nep/HMM/Oth) results in the most variable landings estimates.

None of these results can objectively establish the best auxiliary variable and stratification, however because the discard sampling design is based on ICES Divisions and because this stratification did not perform worse than any other, it was chosen as the preferred method. None of the auxiliary variables correlated well with the volume of discards (data not shown). The choice of auxiliary variable is between effort and total landings (landings of gadoids or whiting did not perform well). Total landings did not appear to perform better than effort, the latter is most commonly used for Irish stocks and there is no reason to deviate from that for whiting.

Figure 6 shows OTB fishing effort by year and Division. Effort in VIIg has increased considerably in recent years. SSC effort is relatively small. Figure 7 shows whiting discard weights, raised to the Irish fleet level using effort. The discard estimate is almost completely dominated by the OTB fleet in VIIg.

Figure 8 shows the annual discard length frequency distributions by ICES division and gear. Discards in VIIb tend to have a mode around 15cm while VIIg and VIIj discards (OTB and SSC) tend to consist mainly of fish larger than the MLS of 27 cm.

The number of observer trips was too low to allow stratification by quarter, however young whiting grow quite fast and it would be inappropriate to apply an annual Age Length Key (ALK). Based on the quarterly ALKs (all years and divisions combined) and the shape of the quarterly length distributions (all years combined) it was possible to apply a quarterly (knife-edge) age split (Figure 9 and Table 2). This is less sophisticated than an ALK but it is expected to cope better with varying cohort strength than a quarterly ALK for all years combined (sampling is insufficient for ALKs by year *and* quarter). The proposed approach is to assign age classes to the raw data (before raising) on a quarterly basis and next to raise the data on annual basis.

The following steps summarize the full process, note that the raising procedure is stratified by division and year, while the ages are stratified by area and quarter:

1. Assign age classes to the raw discard data using age splits (Table 2).
2. Estimate the annual effort of the discard trips in VIIb, VIIg and VIIj for OTB and VIIgj for SSC.
3. Estimate the annual effort of all OTB and SSC logbook trips in VIIb, VIIg and VIIj. Any effort in VIIefh is included in VIIg. Effort in VIIck is not included.
4. Estimate the raising factor as (effort all logbook trips) / (effort discard trips) for each year, gear and Division (all quarters combined).
5. Estimate the total age distribution of the discards for the sampled trips multiply by the appropriate raising factor.

Figure 10 and Table 3 show the final discard numbers-at-age estimates.

Figure 11 shows a comparison of the estimated Irish discard numbers-at-age for Divisions VIIg and VIIj to the WGCSE 2013 estimated number of recruits (age 0). The two estimates do not show similar trends, which may be a consequence of the lack of discard data in the assessment; alternatively the discard data may be too noisy for clear patterns to emerge. Also note that the number discards at age 2 of the 2005 cohort is nearly as high as the number of recruits of that cohort as estimated by the XSA.

Table 1. Number of OTB and SSC discard trips by gear, division and year.

Mesh	OTB			SSC
Division	VIIb	VIIg	VIIj	VIIgj
1995	1	0	2	0
1996	13	3	9	1
1997	11	8	9	4
1998	6	4	6	4
1999	4	2	3	1
2000	3	1	2	0
2001	7	2	4	0
2002	2	3	3	1
2003	9	5	14	4
2004	22	15	16	6
2005	13	12	14	3
2006	3	1	4	0
2007	5	15	12	4
2008	14	12	11	3
2009	15	16	14	6
2010	19	17	23	7
2011	13	10	9	6
2012	8	14	11	4

Table 2. Age–length split by quarter (for all years).

	Age				
Quarter	0	1	2	3	4
1		0-22	23-32	33-38	39+
2	0-12	13-23	24-32	33-38	39+
3	0-18	19-27	28-32	33-38	39+
4	0-21	22-30	31-34	35-38	39+

Table 3. Estimated discard numbers and weight at age (DNAA, thousands; DWAA, grammes).

DNAA	Age					DWAA	Age				
Year	0	1	2	3	4	Year	0	1	2	3	4
1995	0	12584	11603	74	0	1995		37	129	265	
1996	388	2424	2379	906	36	1996	33	56	171	283	467
1997	220	3805	10319	1813	152	1997	37	72	170	287	
1998	161	5040	9224	1273	15	1998	32	58	171	280	462
1999	22	1181	4309	357	0	1999	36	87	172	274	
2000	2214	2030	3235	209	0	2000	33	72	164	277	
2001	49	10428	15340	441	0	2001	26	116	168	281	
2002	0	6405	19862	1260	6	2002		99	178	277	
2003	409	6687	6352	583	15	2003	25	59	160	287	
2004	216	2360	2254	482	22	2004	26	92	179	290	506
2005	78	8984	17847	3758	83	2005	40	94	175	290	457
2006	0	102	4307	2243	183	2006		70	177	297	
2007	53	2121	36241	3193	34	2007	29	69	172	283	
2008	59	3175	8240	875	14	2008	21	63	172	282	
2009	72	3874	15984	1367	6	2009	36	98	164	277	
2010	75	1223	7241	2210	403	2010	27	64	170	300	

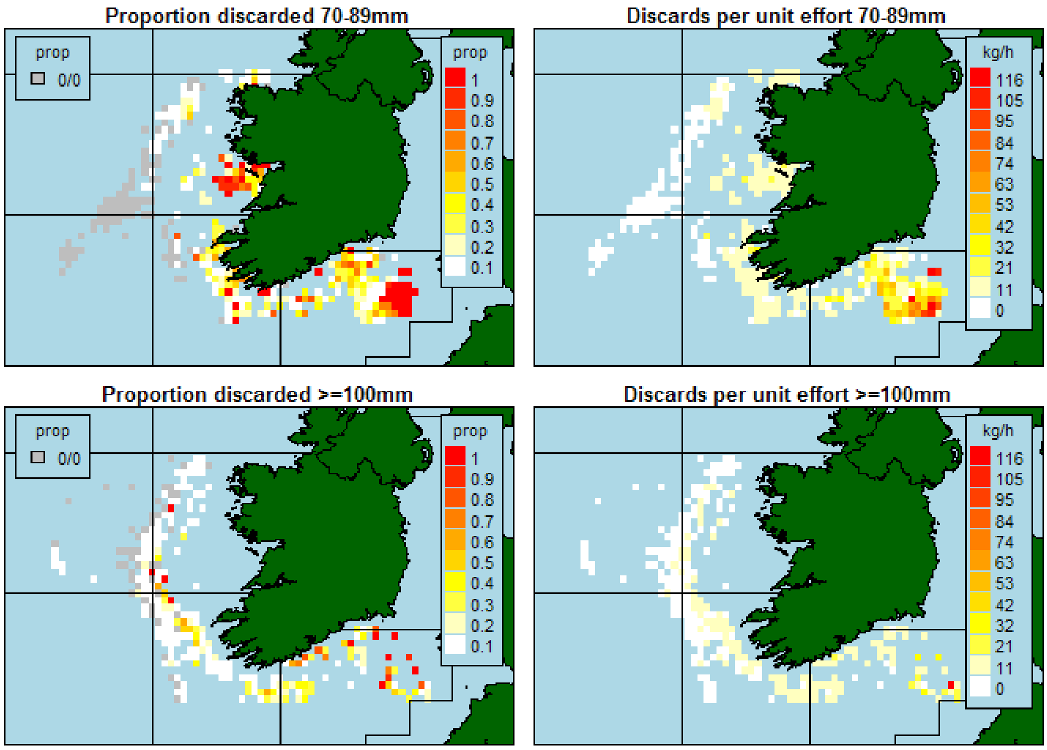

Figure 1. OTB discard data 1995-2012. The panels on the left show the proportion of whiting that were discarded, the right-hand panels show the whiting discard weight per unit effort (hours trawled). The top panels show the data for mesh sizes from 70 to 89mm and the bottom panels show the data for meshes of 100m and more.

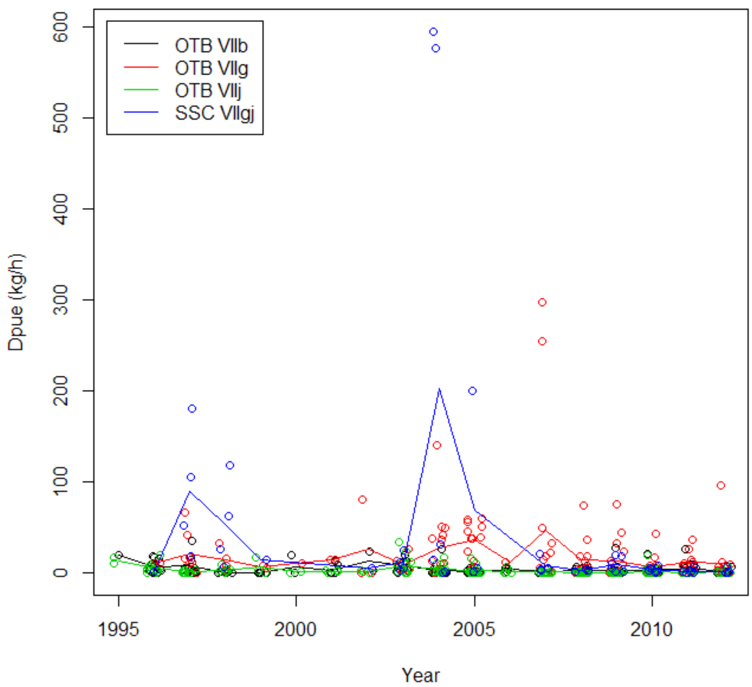

Figure 2. Mean dpue by year and Division. Each point represents a trip. Some random noise was added to the x-axis for visualisation.

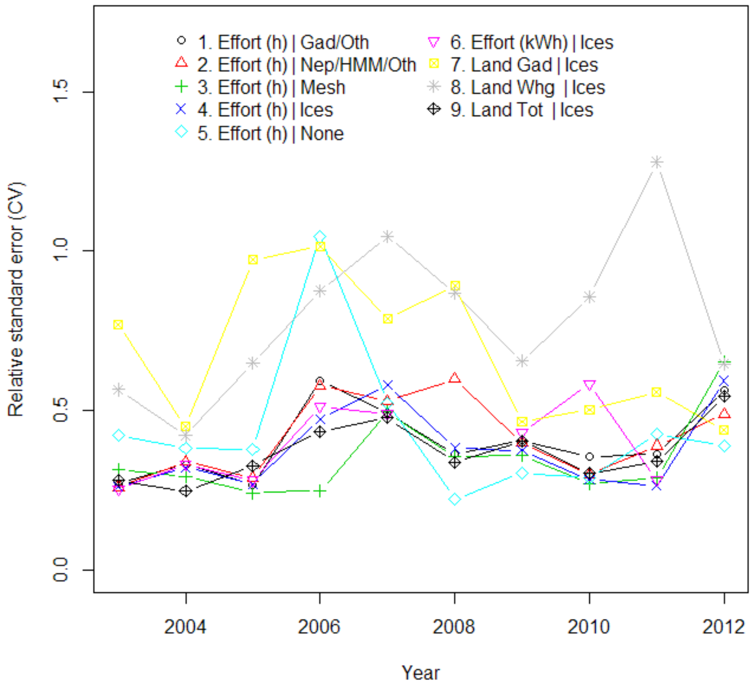

Figure 3. Bootstrapped precision levels of various raising variables and levels of stratification. See main text for a description of the raising methods.

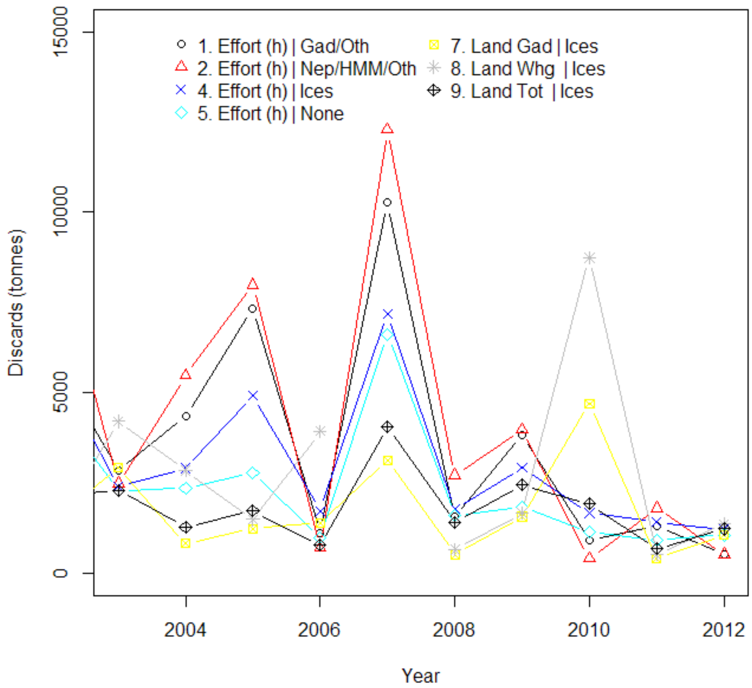

Figure 4. Raised discard weight estimates using various raising variables and levels of stratification. See main text for a description of the raising methods.

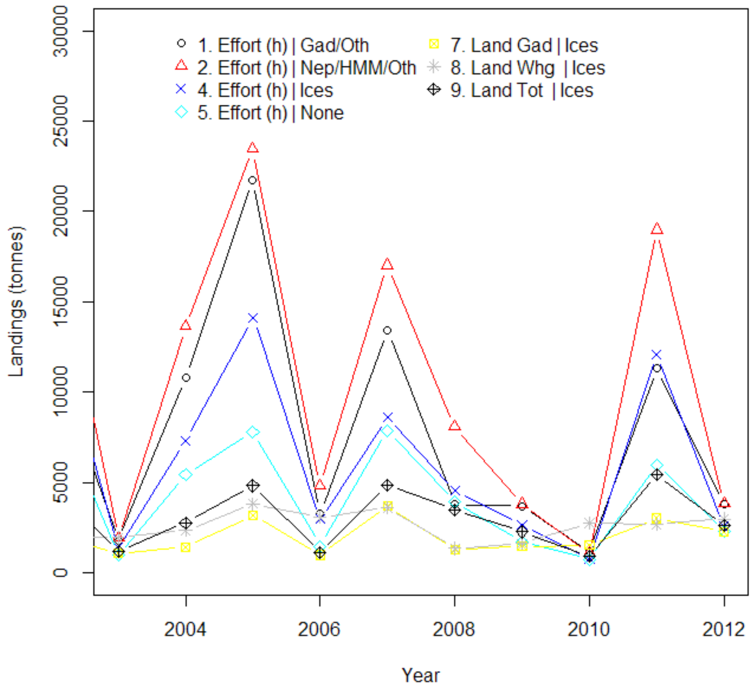

Figure 5. Raised landings weight estimates (from the discard trips) using various raising variables and levels of stratification. Method 8 (Land Whg | Ices) gives the true landings. See main text for a description of the raising methods

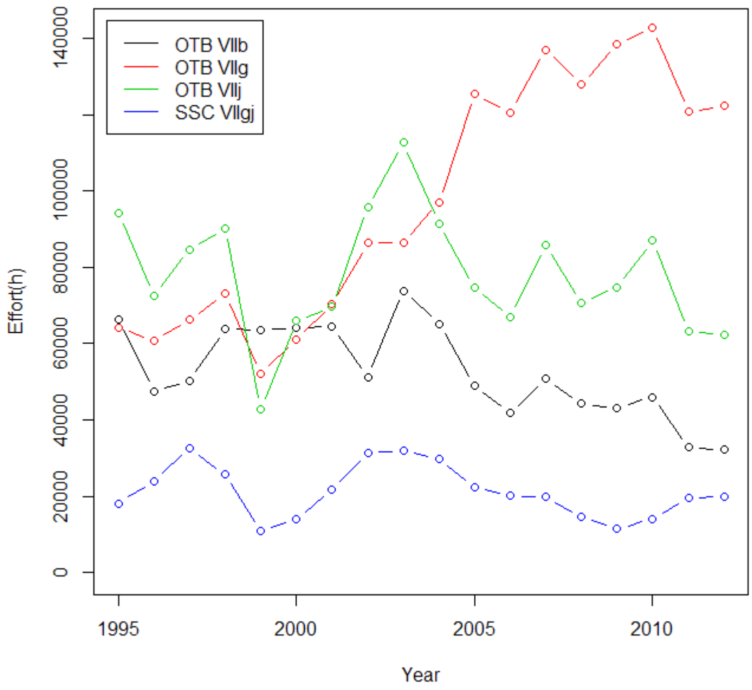

Figure 6. Total otter trawl effort by year and Division (from logbooks database). The small amount of effort in VIIe, f, h is included in VIIg. Effort in VIIc, k was excluded because catches (landings + discards) of whiting in these divisions are close to zero.

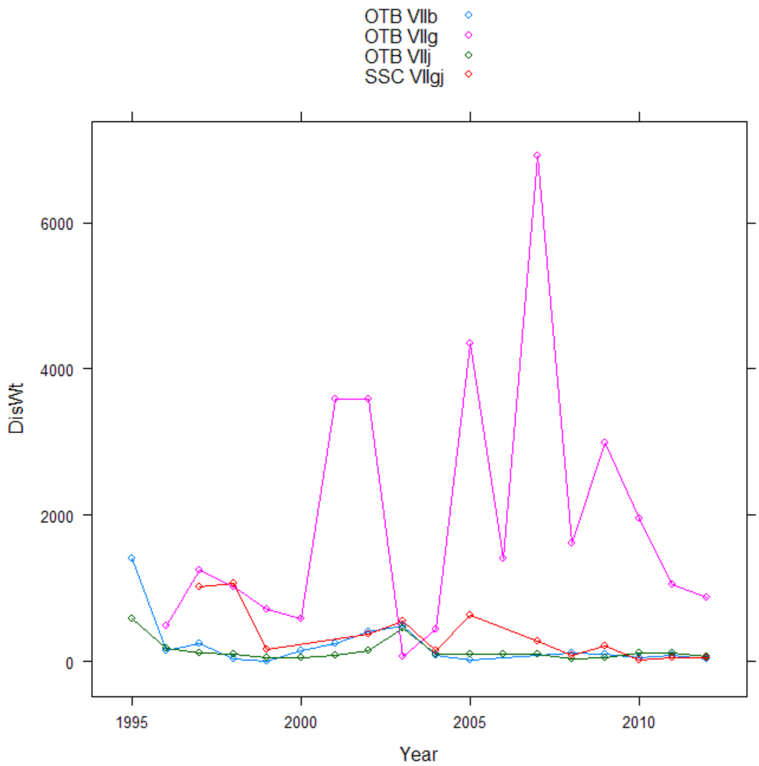

Figure 7. Whiting discards raised to the fleet level (using effort). Discards are dominated by OTB in VIIg

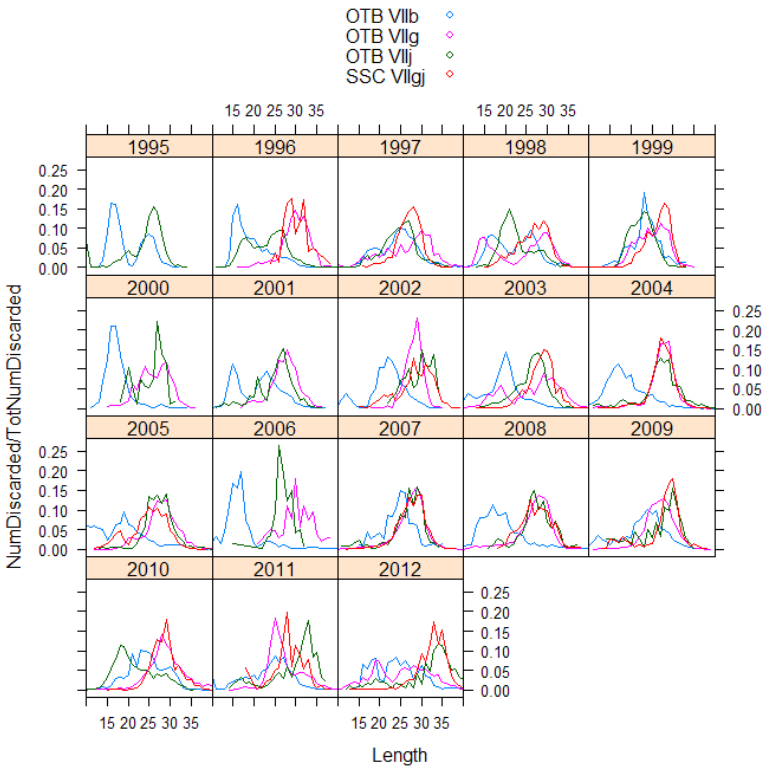

Figure 8. Whiting discards in VIIb tend to include more small fish than in the other areas.

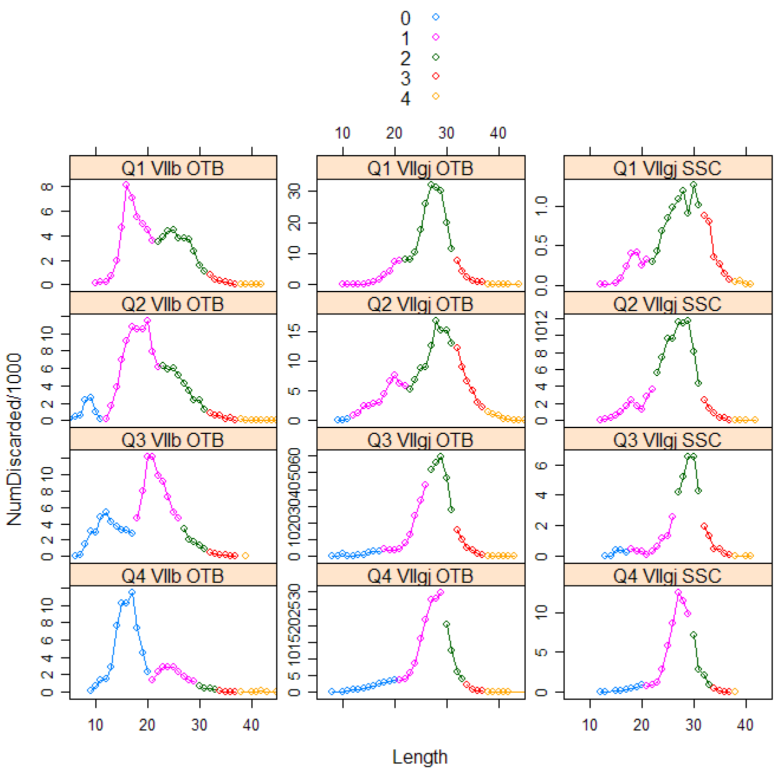

Figure 9. Age–length split that was applied to the two areas and four quarters.

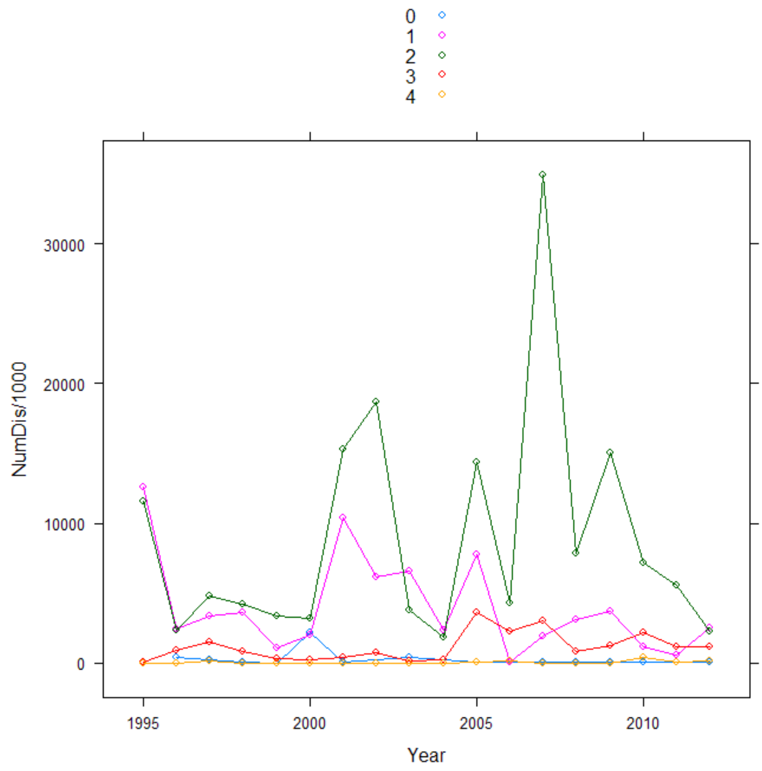

Figure 10. Discard numbers-at-age.

Figure 11. Comparison of the WGCSE 2013 XSA recruitment numbers (age 0; black circles), to the Irish VIIgj discard numbers-at-age 1 (red triangles) and age 2 (green crosses). Note the log scale.