Stock Annex: Sole (*Solea solea*) in Division 7.e (Western English Channel)

STOCK	SOLE (*SOLEA SOLEA*) IN DIVISION 7.E (WESTERN ENGLISH CHANNEL); SOL.27.7E
Working Group	WGCSE
Date	May 2016
Last revision	WGCSE 2017 – Provide more digits for reference points WGCSE May 2021 – Updated basis of F_{pa} to $F_{p.05}$
Main modifications	
Last benchmarked	WKFLAT 2012; Inter-benchmark: IBPWCFlat2 2015

A. General

A.1. Stock definition

The management area for this stock is strictly that for Division 7.e. Biologically speaking, however, the picture is much less clear. Sole in general are relatively sedentary, once settled they perform seasonal inshore-offshore movements during their spawning migration with a random longshore component. Therefore, the management unit of the stock is well defined for mature fish. There is strong evidence to suggest that the stock is split into two biological stocks geographically separated on either side of the Hurd Deep. If the Hurd Deep prevents complete mixing of the stock, an assessment methodology capable of taking into account the geographical separation should be applied. Differences in the trends representative of stock dynamics between the fisheries could be explained by this geographical separation. The two main fisheries on the UK coast operate around Lyme Bay and Start point as well as the coastal fishery in the eastern part of the management area. All of which are clearly separated by the deeper waters of the channel, and therefore the fishery covers only about half of the management area so incomplete mixing may be a problem in this stock.

With respect to the stock as observed by the fishery, there seem to be relatively few issues regarding stock identity and once individuals are fully recruited the stock appears to represent a closed population. Spawning migrations by sole tend to be in a seasonal onshore-offshore pattern with a small random movement alongshore described for the species in other areas. Given the layout of the stock and the apparent breaks in the distribution of sole at the edges of the management area, there appears to be little concern for significant leakage across stocks. However, the biological stock unit for Division 7.e is much less certain at the larval and pre-recruit stage. The proportion of the area that represents nursery grounds is much smaller than those for other sole stocks of equal size, with only two small regions (the inner part of Lyme Bay and the Bay de Mount St Michelle) known to regularly produce 1-groups of sole.

Tagging information of juvenile sole, mostly 1–3 year olds, show that there is significant ingress of recruits from the adjacent stock in ICES Division 7.d from both the French and the UK coastlines that appear in the region out of Lyme Bay. Unfortunately, very little tagging data are available to examine if there is an equal or greater reciprocal movement in the opposite direction but given the limited nursery habitat and the abundance of sole recruits in Division 7.e, it seems reasonable to assume that there is a net inwards migration of pre-recruits that remain in the area following maturation.

Spawning is known to occur in the division from survey evidence in a relatively small concentration on the 'Bank de Langoustine' and intermittently in very low concentrations in the western part of the UK coastal region and around the edges of the Hurd Deep. Little is known about the fate of the spawning products, but given the relatively long egg and larval stages as well as the significant net eastward movement of waters in the channel, it is plausible that the stock utilises nursery habitat in the eastern half of the channel. The degree of stock isolation for these recruits has not been investigated, but it is possible that the recruits contribute to a common pool of recruits with the eastern stock.

Isolation from the Celtic Sea (both the Bristol Channel and the Bay of Biscay) appears to be more rigorous according to tagging information, with few individuals traversing the strong environmental and habitat gradients found in the rocky areas around Land's End. However, the 1998 year class is indicated to be above average from all tuning information. The fact that this cohort is readily observed in information from the westerly and offshore parts of the stock area may indicate that there are other, as yet poorly understood recruit sources within the region.

From a stock assessment perspective and in the absence of a modelled stock–recruitment relationship, there appears relatively little concern over a lack of a closed population given the low movement rates post maturation. The low movement rates and its seasonality in conjunction with the high concentration of fishing effort around Start Point may produce effects of local depletion implying higher rates of fishing mortality for the UK-CBT fleet compared to mortality rates from other indices covering a wider area. Such conjecture is potentially supported by the fact that when the Q1SWBeam survey is viewed as an absolute index of abundance, it produces higher estimates of stock size than the assessment. While stock size and the behaviour of the fishery remains stable, differences in abundance estimates are unlikely to affect the assessment given that the inconsistency is absorbed in the catchability estimates. If the fishery expands spatially with a commensurate reduction in the per-unit-area effort or migration rates change in response to stock size, differences in abundance estimates may become more apparent in the assessment so that it is important to consider/examine such changes in future.

The assessment method agreed by WKFLAT 2012 (ICES, 2012) and described in this "Stock Annex" does not specifically deal with the uncertainty regarding stock boundaries, nor the issue of incomplete mixing and spatial dynamics in the stock as well as fishers. However, for advisory purposes the assessment methodology agreed at WKFLAT 2012 (ICES, 2012) is able to provide robust advice despite these slight omissions. Part of the problem is that such process error is apparent in this stock only because of the high degree of precision and certainty in the data. Spatial issues are known to occur in other stocks, but the results of this process error are not apparent from the assessments because overall variability is much greater.

A.2. Fishery

A.2.1. General description

The principal gears used to target sole in the Western Channel are beam and otter trawls for the UK fleet, and entangling nets and otter trawls for the French fleet. In recent years, UK vessels have accounted for around three quarters of the total international landings, with France taking approximately a quarter and Belgian vessels the remainder. UK landings were low and stable between 1950 and the mid-1970s, but increased rapidly after 1978 due to the replacement of otter trawlers by beam trawlers.

International landings follow a similar temporal trend given that the UK fleet is the primary contributor. Sole is the target species of an offshore beam trawl fleet concentrated around south Devon and the Cornish coast off the United Kingdom. The offshore beam trawl fleet also catches plaice and anglerfish. In recent years, a winter fishery targeting cuttlefish has developed for the English beam trawl fleet in the Western Channel, lasting from November till the end of March. Consequently, the dependence of the fleet on sole has decreased but sole still represents a substantial portion of the catch during this time so it is not clear to what degree the switch to targeting cuttlefish has reduced fishing mortality on sole.

Discarding of sole in this fishery is thought to be negligible, as illustrated by the time-series (2002–2008) of discard information for the UK fleet shown in Figure A.2.1. Landings of sole reached a high level above 1400 t in the 1980s, boosted initially by high recruitment in the late 1970s followed by an increase in exploitation. A decrease in landings was observed between 1988 and 1991, following the recruitment of three below average year classes (1986–1988). Since 1991, landings have fluctuated between 800 t and 1100 t. Substantial quantities of sole caught in Division 7.e have been reported to two rectangles in Division 7.d in order to avoid quota restrictions. Corrections for this misreporting were first made during the 2002 Working Group, but misreporting to other areas has been more difficult to identify. In addition, black landings are likely to have occurred to various degrees since quotas became restrictive in the late 1980s. No estimates of the scale of the problem exist, and therefore this uncertainty has not been incorporated into the assessment process.

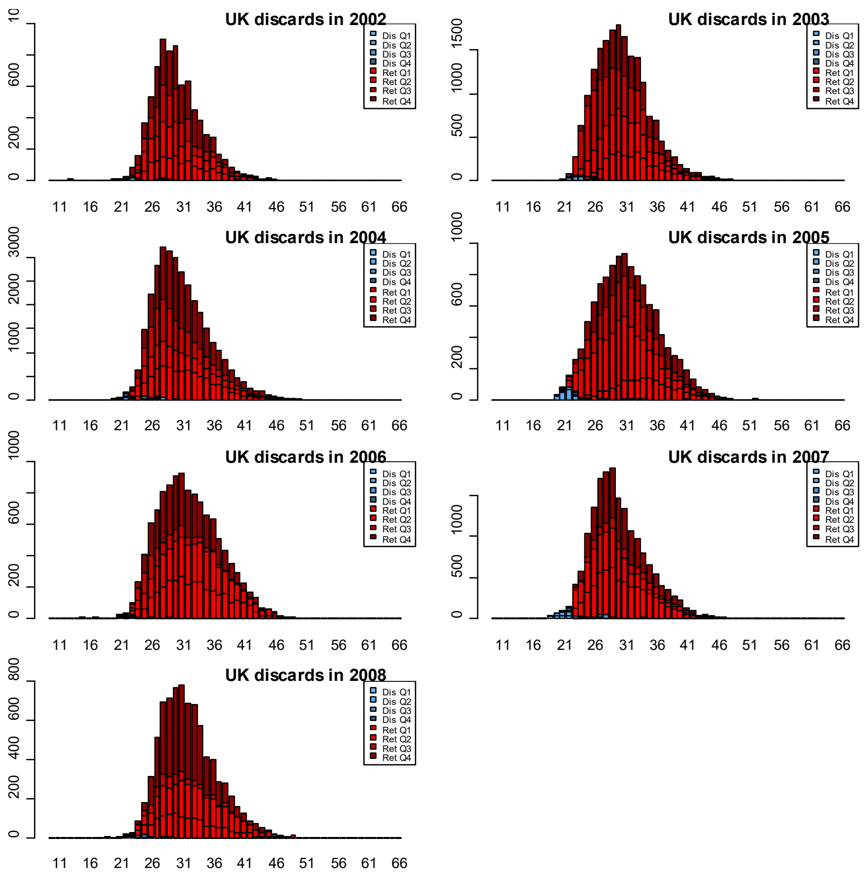

Figure A2.1. Time-series of UK discard data raised to trip information from 2002 to 2008.

Since the development of the beam trawl fleet in the Western Channel in the early 1980s, there has been a consolidation to larger more powerful vessels particularly in the late 1990s and early 2000s. However, the severe quota restrictions at that time have led to a reversal of this trend and a lesser emphasis on sole as the major income for the fleet. Undoubtedly, sole still form the back bone of this fishery due to the steady availability over the ground. However, in recent years, the fishery has adapted by opting for smaller, more flexible vessels with a fleet-wide reduction in kWH and a small decrease in the number of boats due to a decommissioning scheme. These smaller, more flexible vessels allow fishers to exploit other resources in the Division such as scallops, cuttlefish and gurnards foregoing possible higher catch rates of sole. This is reflected in the offshore movement of the fishery around Start Point.

At the lower catch rates described above, the fleet is at an appropriate capacity to take the available quota and appears to have sufficient financial stability and certainty to allow for continued investment in the fishery. If the industry returned to previous patterns of exploitation targeting the younger and more abundant sole in Lyme Bay, it would almost certainly be able to increase the fishing mortality to levels greater than that assumed to be sustainable. The current enforcement regulations with a change in the attitude of the industry have meant that the TAC is an appropriate management tool in at least the UK fishery. Limiting days at sea further will have a perverse tendency to reverse this trend and focus effort grounds in Lyme Bay because of their proximity and the higher catch rates.

A.2.2. Fishery management regulations

Sole in Division 7.e management plan

A management plan was agreed for 7.e sole in 2007:

Council Regulation (EC) No 509/2007 establishes a multi-annual plan for the sustainable exploitation of sole in Division 7.e. Years 2007–2009 were deemed a recovery plan, with subsequent years being deemed management plan. For 2007–2009, the TAC was required to be at a value whose application will result in a 20% reduction in F compared with F_{BAR} (03–05). If this value exceeded a 15% change in TAC, a 15% change in TAC was to be implemented. Fishing mortality <0.27 was reached in 2009, although the average fishing mortality over three years as prescribed by the management plan was only reached in 2010. After reaching F_{MSY}=0.27 the stock is to be maintained at this level of fishing mortality.

A.3. Ecosystem aspects

Little is known about the effects of environmental variability on the stock dynamics of sole in Division 7.e. Certainly the division is on the convergence between the Celtic Sea and the Channel/North Sea ecosystem. If predicted increases in temperature were to materialise, changes to the stock dynamics of sole and other species in the Division would be expected. For example, there is strong evidence of a sizeable increase in the abundance of bass in the area, a species with a similar pan European distribution as sole. In addition, there is some anecdotal evidence of changes in the range of some species such as langoustine, triggerfish and black sea bream from warmer parts of the Atlantic. In the North Sea, it has also been suggested that cold periods immediately prior to spawning have a tendency to increase year-class strength and there is some indication of this for this stock, but no statistical analysis has been carried out to date.

Beam trawling is known to have a significant impact on the seabed. Areas of seabed affected by beam trawling can, nevertheless, continue to be productive for the target species. After the initial degradation of the habitat usually associated with the loss of sessile macrofauna, continued use of beam trawls seems to have few further impacts on the seabed.

B. Data

B.1. Commercial catch

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

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

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

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

Table A. 7.e Sole. Catch derivation table for assessment years 1981–2015.

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

		source			
Year of WG	Data	UK	France	Derivation of international landings	% sampled
1997		As for 1995	-	As for 1995	73
1998		As for 1995	-	As for 1995	64
1999		As for 1995	-	As for 1995	57
2000		As for 1995	-	As for 1995	56
2001		As for 1995	-	As for 1995	59
2002		As for 1995	-	As for 1995	60
2003	length composition	As for 1995	quarterly	UK and French raised to total international	~95%
	ALK	As for 1995	biannually		~95%
2004		As for 1995	As for 2003	As for 2003	~95%
2005		As for 1995	As for 2003	As for 2003	~95%
2006		As for 1995	As for 2003	As for 2003	~95%
2007		As for 1995	As for 2003	As for 2003	~95%
2008		As for 1995	As for 2003	As for 2003	~95%
2009		As for 1995	As for 2003	As for 2003	~95%
2010		As for 1995	As for 2003	As for 2003	~95%
2011		As for 1995	As for 2003	As for 2003	~95%
2012		As for 1995	As for 2003	As for 2003	~95%
2013		As for 1995	As for 2003	As for 2003	~95%
2014		As for 1995	As for 2003	As for 2003	~95%
2015		As for 1995	As for 2003	As for 2003	~89%
2016		As for 1995	As for 2003	As for 2003	~79%
2017		As for 1995	As for 2003	As for 2003	80%

B.1.1. Discards estimates

Discards are not included in the assessment but available for monitoring (UK métiers TBB_DEF, OTB_CRU, OTB_DEF, GNS_DEF and since 2012 on InterCatch).

B.1.2. Recreational catches

Not included in the assessment.

B.2. Biological sampling

B.2.1. Weights-at-age

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

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

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

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

B.2.2. Maturity

Assessments prior to 1997, used knife edge maturity-at-age 3. This was changed in 1997 to a maturity ogive from area 7.f and g according to Pawson and Harley (WD presented to WGSSDS in 1997), which is applied in all years, 1969 to present, since the 1997 WG.

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

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

B.2.3. Natural mortality

Natural mortality is assumed constant over ages and years at 0.1. This is consistent with the natural mortality estimates used for sole by other ICES Working Groups (WGNSSK: 4, 7.d, WGCSE: 7.a, 7.fg, 7.a.b) and consistent with estimates of M reported in Horwood (1993) for 7.fg sole as well as other stocks and papers cited therein.

B.3. Surveys

UK-FSP

A spatially extensive survey-series has been developed and managed by Cefas since 2003 in the UK in conjunction with the fishing industry. Age sampling issues preclude the use of the data in the first year and the time-series is used here since 2004. The survey vessels (two separate trips are carried out annually see Annex 1 of this Stock Annex) are subject to a three yearly tendering procedure. Consequently, the characteristics of the vessels and the gears used have changed over the period which is why the index has been standardized by meter beam and hour fished. The survey covers the extent of the UK fishery for the species including the less frequently exploited western part of the stock. Age information from this survey shows evidence of some internal consistency in the medium age range but the series is too short to evaluate this at the older or younger ages at present. However, the survey appears to show consistency with other survey indices and is therefore included in the present assessment for the entire age range available (ages 2–11). Data from this survey has been used in the plaice 7.e assessment since 2008.

Q1SW Beam

This survey was included in the assessment for the first time at WKFLAT 2012 (ICES, 2012). The survey-series starts in 2006. Important considerations for WKFLAT 2012 (ICES, 2012) were that the survey is based on a stratified random survey approach and covers the entire region of the management area and some adjacent waters which may not fully conform to the delineation. The survey shows strong gradients in species composition within the western channel (justifying the stratification approach), although there is some indication that more appropriate post stratification could provide an increase in precision of single species abundance estimates.

Given sampling effort, fundamentally this survey is more variable than fixed stations survey designs of equal effort, but also inherently is less biased when there are potential changes in the distribution of the species within the area. Although estimates of survey variance of the limited data-series are available, these are unlikely to reflect the full range of the variance that would be encountered in a longer time-series as variance estimates are unlikely to have reached their asymptote, particularly since the range of SSBs observed by the survey is very restricted.

The survey-series started in 2006. To include as much information as is available at the time of the assessment Working Group, the survey that is conducted in the first quarter was traditionally shifted to back by one year and one age. This was practical given that it added further available information on recruitment-at-age 1 into the assessment. The benefits of shifting the series were thought to out-weight the potential error that may be introduced by this procedure if the seasonal pattern of true F were to change in future. Nevertheless, the "offsetting" traditionally applied to this survey-series was stopped after 2014 given that the recruitment age was increased from 1 to 2 at IBPWCFlat 2015 (ICES, 2015a).

Age information provides estimates of abundance for all ages in the assessment, despite the fact that the survey only catches between 250 and 300 sole in a given year. Theoretically, this removes the necessity of retaining the commercial lpue (at age) series required. Internal consistency estimation is very difficult given the short time-series, and relatively small contrast in cohort strength observed (based on other series). Despite this, some cohort tracking is apparent and the signal matches the cohort signal from other survey series, particularly the UK-FSP survey.

Given these uncertainties regarding true survey variance and concerns regarding future funding for the survey, it seemed unreasonable to put the entire weight on this survey so at this stage it is not sensible to remove the commercial fleets from the assessment as they provide a high degree of precision at the cost of introducing some bias into the assessment.

B.4. Commercial lpue

The commercial tuning-series available for the current assessment are the same as in previous assessments. Two historic surveys were included in previous versions of the assessment given that historically reference points for the stock were based on historic development of the fishery and variance in the early time-series indicated considerable uncertainty in historic reference point estimates due to the choice of plus group in the assessment. The new assessment is less susceptible to these variable estimates of catch-at-age and the group decided to not base reference points on the historic development of the stock so that the historic indices are no longer required in the assessment and are not discussed further here.

UK-COT

The UK otter trawl index is the same as presented in previous assessments, except that lpue estimates were converted into kg per 1000 days for the entire time-series in 2015 to account for changes in UK e-logbook effort recording (ICES, 2015b). As previously observed, the index suffers from two distinct negative year effects in 1991–1992 and 2004. These inconsistencies were observed in previous assessments and the Working Group concluded that given the length of the period the effects of these in the historic period were minor on the current estimates of F and SSB as they are modelled mainly as residuals in the XSA model. For the most recent assessments, however, time-series weighting was applied to exclude lpue estimates for the UK-COT fleet prior to 2002 from the fit of the XSA model due to the presence of noisy residuals that reduced the accuracy of assessment outputs.

Currently this fleet contributes only a small proportion of the overall landings, but it is sampled much more heavily than its representation in the landings so continues to provide a good independent time-series from the main commercial catches. It is uncertain whether the new DCF sampling will continue to provide such accurate data as the intent is to sample catches more proportional to landings.

Despite the year effects, the series is characterised by high internal consistency and is also consistent with other series in identifying strong cohorts.

UK-CBT

The time-series of commercial beam trawl information has always formed the backbone of this assessment, but investigations at WKFLAT 2009 (ICES, 2009) indicated that this series showed declining lpue, particularly at the younger ages, in contrast to other information in the surveys and to a lesser degree to the catch-at-age despite the fact that the fleet accounts for around 60% of the landings in the stock. It was assumed that it was largely this fleet that was responsible for the persistent bias in the assessment. Historic area misreporting by the fleet prior to 2010 had been an issue, but after discussions with the industry in 2002 landings information and lpue data have been corrected for this, and the incidence of this practice had been decreasing (see Figure B4.1 for an overview of the areas used for the calculation of lpue time-series). Increased scrutiny by enforcement and lpue limits imposed by the producer organization contributed to the reduction in misreporting.

The operation of the fleet was examined at WKFLAT 2012 (ICES, 2012) using VMS data from 2006–2011. The conclusions from this analysis were that since 2006 the fleet has been increasingly shifting its effort southwards more into the central regions of the channel. Effort in Lyme Bay, the region where catch data and survey information indicate the majority of younger fish are found, are now much lower than previously and have ceased almost entirely in 2010 and 2011. This shift in the selectivity towards older ages is very apparent also from the catch-at-age information for the fleet from market sampling records suggesting that it would be appropriate to split the fleet on the basis of inconsistent operation.

Independent information could not discern when the majority of the contrast in effort information occurred, and hence to decide on appropriate time to split the series, because VMS data are not available prior to 2006. Information from the industry also confirmed that there had been changes in the operation of the fleet, but again suggested that these changes had been gradual rather than abrupt making the choice of the year for a split of this fleet difficult. WKFLAT 2012 (ICES, 2012) determined that 2002, the period when the area misreporting was officially acknowledged, would be an appropriate point for splitting the time-series and would be suitable for the assessment as this would retain a sufficiently long time-series over which to estimate the new catchabilities for the fleet. This methodology was adapted and the UK-CBT fleet was included in previous assessment as two fleets, UK-CBT-early (1989–2002) and UK-CBT-late (2003–2013). In 2015, lpue estimates were converted into kg per 1000 hours to account for changes in UK e-logbook effort recording and the UK-CBT-early fleet was excluded from the assessment given that the fleet contributed little to historic assessment outputs except for noise (ICES, 2015b).

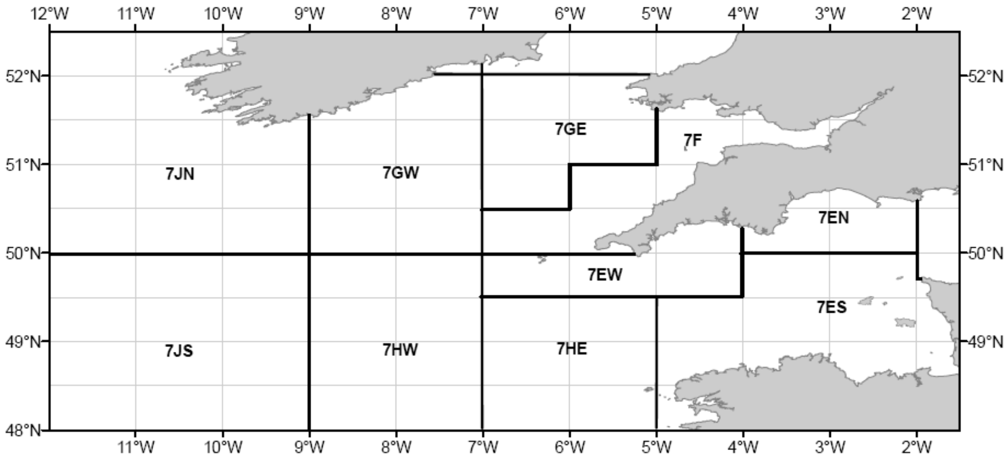

Figure B4.1. Areas used for the calculation of lpue time-series exploring temporal changes in the distribution of stock and effort.

B.5. Other relevant data

None.

C. Assessment methods and settings

C.1. Choice of stock assessment model

Model used: Extended Survivor Analysis (XSA)

Software used: FLXSA (version 2.5)

	2013	2014	2015*	2016	2017
Assmnt Age Range	1–12+	1–12+	2–12+	2–12+	2–12+
Fbar Age Range	F(3–9)	F(3–9)	F(3–9)	F(3–9)	F(3–9)
Assmnt Method	XSA	XSA	XSA	XSA	XSA
Tuning Fleets					
Q1SWBeam	2006–12 2–12 (offset by 1y 1a)	2006–13 2–11 (non-offset)	2006–14 2–12 (offset by 1y 1a)	2006–15 2–11 (non-offset)	2006–16 2–11 (non-offset)
UK-FSP	2004–12 2–11	2004–13 2–11	2004–14 2–11	2004–14 2–11	2004–16 2–11
UK combined beam Ages (early)	1988–02 3–11	–	1988–02 3–11	–	–
UK combined beam Ages (late)	2003–12 3–11	2003–13 3–11	2003–14 3–11	2003–15 3–11	2003–16 3–11
UK otter trawl Ages	1988–12 3–11	1988–13 3–11	1988–13 3–11	1988–15 3–11	1988–16 3–11
UK BTS Ages	1988–12 1–9	–	1988–13 1–9	–	–
Time taper	No	No	Yes	Yes	Yes
Power model	No	No	Tricubic	Tricubic	Tricubic
Taper range	No	No	15 years	15 years	15 years
P shrinkage	No	No	No	No	No
Q plateau age	6	6	7	7	7
F shrinkage S.E	0.5	0.5	0.5	0.5	0.5
Num yrs	3	3	3	3	3
Num ages	5	5	5	5	5
Fleet S.E.	0.6	0.6	0.4	0.4	0.4

*** Note that the XSA assessment settings were updated to incorporate revised tuning data at the Inter-Benchmark Protocol of West of Channel Flatfish (IBPCWCFlat2) meeting in 2015 (ICES, 2015b).**

FLXSA control object settings used since 2015

control <– FLXSA.control(fse = 0.5, rage = 0, qage = 7, shk.n = FALSE, shk.f = TRUE, shk.ages = 5, shk.yrs = 3, min.nse = 0.4, tspower = 3, tsrange = 15, maxit= 200)

Inter-benchmark 2015

Reductions in UK science funding resulted in the termination of the UK Western Channel beam trawl (UK-WEC-BTS) survey in 2013. Concern had been expressed about the impact of terminating the UK-WEC-BTS survey on the perception of stock status and the ICES management forecast for 7.e sole (ICES, 2013). Consequently, the Inter-Benchmark Protocol of West of Channel Flatfish (IBPWCFlat) meeting convened in 2015 to:

(1) examine the impacts of truncating and excluding the UK-WEC-BTS time-series on recruitment, spawning-stock biomass and fishing mortality estimates; and (2) revise the XSA settings to increase the robustness of the assessment to changes in tuning information resulting from the termination of the UK-WEC-BTS survey (ICES, 2015a).

IBPWCFlat recommended revising the parameterisation and tuning index configuration of the XSA assessment. The revised XSA assessment had frequently smaller fleet log-catchability residuals with lower standard errors, a more balanced weighting of survivor estimates and less pronounced retrospective patterns in stock status estimates compared to the assessment conducted at ICES WGCSE 2013. Accordingly, the revised XSA assessment settings increased the robustness of the assessment to changes in tuning information resulting from the termination of the UK-WEC-BTS survey and improved the fit of the XSA model to 7.e sole data.

At ICES WGCSE 2015, the assessment was rejected due to retrospective bias in stock status and fishing mortality estimates. Concern was expressed over the magnitude and direction of the retrospective patterns arising from the most recent assessment input data. Another Inter-Benchmark Protocol of West of Channel Flatfish (IBPWCFlat2) meeting was subsequently opened later in 2015 to review the assessment input data and evaluate the parameterisation of XSA model (ICES, 2015b).

IBPWCFlat2 updated the XSA assessment settings to incorporate revised tuning data due to changes in lpue estimates for the UK-CBT-late fleet resulting from modifications in the UK e-logbook effort recording system in 2012. The updated assessment settings outlined in the table above optimised the fit of the XSA model to the revised input data by generating the smallest log catchability residuals with lowest standard errors, the most evenly weighted survivor estimates and the greatest stability in the retrospective patterns in stock status and fishing mortality estimates.

C.3. Assessment model configuration

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1969–2016	–	Yes
Canum	Catch-at-age in numbers	1969–2016	2–12	Yes
Weca	Weight-at-age in the commercial catch	1969–2016	2–12	Yes
West	Weight-at-age of the spawning stock at spawning time.	1969–2016	2–12	Yes
Mprop	Proportion of natural mortality before spawning	1969–2016	2–12	No
Fprop	Proportion of fishing mortality before spawning	1969–2016	2–12	No

Type	Name	Year range	Age range	Variable from year to year Yes/No
Matprop	Proportion mature-at-age	1969–2016	Age2–14% Age3–45%; Age4–88% Age 5–98%; Age6+–100%	No
Natmor	Natural mortality	1969–2016	2–12 (0.10)	No

D. Short-term prediction

Model used: XSA

Software used: MFDP / FLR

ICES has provided advice for this stock on the basis of a short-term forecast, with the exception of 2009 when the advice was based on a trends only assessment. The assessment methodology developed at this benchmark meeting is determined to be appropriate to such projections and advice. This conclusion is largely based on the diagnostics of the assessment. The forecast methodology described below has not been specifically evaluated at the benchmark but given the biology of the species, the understanding of fleet dynamics and the similarity to the previous assessment the procedure described below is considered suitable.

Input data

Short-term forecasts require the input of a selection pattern, which is taken from the average of the last three years. In cases where a F_{sq} forecast is appropriate (i.e. where there is no documented trend in the level of F in the final three years), the selection pattern is scaled to the average F over the final three years. When there are significant changes in F over the last three years, the selectivity pattern is rescaled to the final year to estimate catches in the 'interim year'. When catches have been constrained at the level of the TAC, a TAC constraint is implemented and the selectivity pattern is rescaled by the value of F that produces landings equal to the TAC for the 'interim year'.

Survivor estimates for fish greater than age three in the interim year are used in the projections. Recruits, including the last cohort in the assessment (age two, given as survivors at-age 3), are not thought to be particularly reliably estimated as they are poorly selected even in the inshore survey so their values are replaced by geometric mean recruitment determined as in the paragraph below depreciated for natural mortality.

Recruitment in subsequent years is determined as geometric mean recruitment over the appropriate time-series. For this stock, the entire time-series excluding the last two years (i.e. 1969–2008 for the 2011 assessment) has been traditionally used to determine geometric mean recruitment. Historically, there have been periods where recruitment was thought to be lower or higher, in which case the geometric mean is calculated over a shorter recruitment-series, minus one year. In 2014, the Working Group decided to forecast recruitment using a three-year geometric mean (2011–2013) due to successive low recruitment in recent years and strong autocorrelation in the time-series. In 2015, IBPWCFlat2 decided to forecast recruitment using a long-term geometric mean of the entire time-series (1969–2014) due to temporal variability in the time-series and the lack of distinct periods of successive high or low recruitment in recent years. This approach has been continued since then. IBPWCFlat2 also issued a caveat that recruitment should be forecast using a short-term geometric mean if distinct periods of successive low or high recruitment is evident over the final three years (ICES, 2015b).

E. Medium-term prediction

No longer applicable.

F. Long-term prediction

Long-term projections are no longer carried out as part of the stock assessment procedure at Working Groups. However, STECF (SGMOS 9-02, SGMOS 10-06a) carried out long-term simulations as part of the management plan evaluations. The methodology examined the effects of different types of biases and uncertainty on the management of the stock running stochastic simulations under similar assumptions to the short-term forecast. This method was also employed to derive the level of MSY $B_{trigger}$ by WKFLAT 2012 (ICES, 2012).

G. Biological reference points

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

	WG(1998)/ACFM(1998)	since WG(2001)/ACFM (2001)
		Age range extended from 1–10+ to 1–12+
F_{lim}	0.36 (Floss WG98)	0.28 (F_{loss} WG01)
F_{pa}	0.26 (Flim*0.72)	0.20 (F_{lim}*0.72)
B_{lim}	1800 t (Bloss= B73 WG98)	2000 t (B_{loss}= B_{00} WG01)
B_{pa}	2500 t (B_{lim}*1.4)	2800 t (Historical development)

The assessment methodology that formed the basis for these precautionary reference points was rejected by WKFLAT 2009 (ICES, 2009) and resulted in rejection of the reference points. ICES has adopted a provisional MSY $B_{trigger}$ based on the former B_{pa} as the technical basis. Having developed a new assessment methodology during WKFLAT 2012 (ICES, 2012), appropriate values for the assessment, given a sound technical basis, were determined as shown below.

	Type	Value	Technical basis
MSY	MSY $B_{trigger}$	2800 t	Based on the lower 95% confidence limits of exploitation at Fmax from LT simulations.
Approach	F_{MSY}	0.27	Based on a suitably defined Fmax and stochastic LT simulations
	B_{lim}	1300 t	WKFRAME 2 meta-analysis (ICES, 2011)
Precautionary	B_{pa}	1800 t	WKFRAME 2 meta-analysis (ICES, 2011)
Approach	F_{lim}	Undefined	
	F_{pa}	Undefined	

WKMSYREF4 convened in 2015 to provide plausible values around F_{MSY} ranges in response to the EC long-term management plans for western EU waters (ICES, 2016). Specifically, the workshop was held to address Article 10 of Regulation (EU) No 1380/2013 on the Common Fisheries Policy, which re-quires a multiannual plan including quantifiable target. Estimates of reference points B_{lim}, B_{pa}, F_{lim} and F_{pa} were provided, and the F_{MSY} ranges [F_{lower}, F_{upper}] were estimated by ICES to be precautionary, delivering no more than 5% reduction in long-term yield compared with MSY. The updated reference points from WKMSYREF4 are presented in the table below.

Framework	Reference point	Value*	Unrounded value**	Technical basis
MSY Approach	MSY $B_{trigger}$	2900 t	2826 t	Based on the 5th percentile of the distribution of SSB when fishing at F_{MSY} (0.29) with no error (ICES, 2016)
	F_{MSY}	0.29	0.291	Based on the peak of the median landings yield curve (ICES, 2016)
Precautionary Approach	B_{lim}	2000 t	2039 t	Based on B_{pa}/1.4 (ICES, 2016)
	B_{pa}	2900 t	2855 t	Based on B_{loss} (1999 yc). Lowest SSB with high recruitment (ICES, 2016)
	F_{lim}	0.44		Based on a segmented regression simulation of recruitment with B_{lim} as the breakpoint and no error (ICES, 2016)
	F_{pa}^	0.39		$F_{p.05}$; the F that leads to SSB ≥ B_{lim} with 95% probability (ICES, 2016)
Management plan	SSB_{MGT}	–	–	
	F_{MGT}	0.27		EC (2007)

*** The accepted values used for providing advice.**

**** Unrounded values from ICES (2016), if available.**

^ The basis for Fpa was changed in 2021 to Fp.05. Previously, the Fpa value provided in ICES (2016) was used (0.32, based on F_{lim}*exp(-1.645*σ); σ=0.2).

H. Other issues

Historical overview of previous assessment methods

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

Table B demonstrates the history of Division 7.e sole assessments and details the assessment model used (XSA) and the parameters and settings used in each year's assessment until 2008.

Table B. History of 7.e sole assessments.

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

Time taper	20yr tri	20yr tri	20yr tri	20yr tri	No	No	No	No	No	No	No	No	No	No	No	No	No
Power model ages	1	1–2	1–4	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–6	1–6	No	No	No	No
P shrinkage	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
Q plateau age	8	5	6	7	7	7	7	7	7	9	9	9	9	9	8	8	8
F shrinkage S.E	0.3	0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	1.0	1.0	1.0
Num yrs	5	5	5	5	5	5	5	5	5	5	5	5	5	3	4	5	5
Num ages	5	3	5	3	3	3	3	3	3	5	5	5	5	5	5	5	5
Fleet S.E.	0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.5	0.5	0.5

	2009	2010	2011	2012	2013	2014	2015*	2016	2017
Assmnt Age Range		**1–12+**	**1–12+**	**1–12+**	**1–12+**	**1–12+**	**2–12+**	**2–12+**	**2–12+**
Fbar Age Range		**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**
Assmnt Method	**Trends**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**
Tuning Fleets									
UK Inshore beam		1973–87 2–11	1973–87 2–11						
UK Offshore beam		1973–87 3–11	1973–87 3–11						
Q1SWBeam				2006–12 2–12 (offset by 1y 1a)	2006–13 2–12 (offset by 1y 1a)	2006–14 2–12 (offset by 1y 1a)	2006–14 2–11 (non–offset)	2006–15 2–11 (non–offset)	2006–16 2–11 (non–offset)
UK-FSP				2004–11 2–11	2004–12 2–11	2004–13 2–11	2004–14 2–11	2004–15 2–11	2004–16 2–11
UK combined beam (early)		1988–09 3–11	1988–10 3–11	1988–02 3–11	1988–02 3–11	1988–02 3–11	–	–	–
UK combined beam (late)				2003–11 3–11	2003–12 3–11	2003–13 3–11	2003–14 3–11	2003–15 3–11	2003–16 3–11
UK otter trawl		1988–09 3–11	1988–10 3–11	1988–11 3–11	1988–12 3–11	1988–13 3–11	1988–14 3–11	1988–15 3–11	1988–16 3–11
UK BTS		1988–09 1–9	1988–10 1–9	1988–11 1–9	1988–12 1–9	1988–13 1–9	–	–	–
Time taper		No	No	No	No	No	Yes	Yes	Yes
Power model		No	No	No	No	No	Tricubic	Tricubic	Tricubic
Time taper		No	No	No	No	No	15 years	15 years	15 years
P shrinkage		No	No	No	No	No	No	No	No
Q plateau age		8	8	6	6	6	7	7	7

	2009	2010	2011	2012	2013	2014	2015*	2016	2017
Assmnt Age Range		**1–12+**	**1–12+**	**1–12+**	**1–12+**	**1–12+**	**2–12+**	**2–12+**	**2–12+**
Fbar Age Range		**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**	**F(3–9)**
Assmnt Method	**Trends**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**	**XSA**
Tuning Fleets									
F shrinkage S.E		1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5
Num yrs		10	10	3	3	3	3	3	3
Num ages		5	5	5	5	5	5	5	5
Fleet S.E.		0.5	0.5	0.6	0.6	0.6	0.4	0.4	0.4

***Note that the assessment settings were updated to incorporate revised tuning data at the Inter-Benchmark Protocol of West of Channel Flatfish (IBPCWCFlat2) meeting in 2015 (ICES, 2015b).**

References

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

ICES. 2009. Report of the Benchmark and Data Compilation Workshop for Flatfish (WKFLAT 2009), 6–13 February 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:31. 192 pp.

ICES. 2011. Report of the Workshop on Implementing the ICES F_{MSY} Framework (WKFRAME-2), 10–14 January 2011, ICES, Denmark. ICES CM 2011/ACOM:33. 110 pp.

ICES. 2012. Report of the Benchmark Workshop on Flatfish Species and Anglerfish (WKFLAT 2012), 1–8 March 2012, Bilbao, Spain. ICES CM 2012/ACOM:47.

ICES. 2013. Report of the Working Group for Celtic Seas Ecoregion (WGCSE), 8–17 May 2013, Copenhagen, Denmark. ICES CM 2013/ACOM:12.

ICES. 2015a. Report of the Inter-Benchmark Protocol of West of Channel Flatfish (IBPWCFlat), From January to March 2015, By correspondence. ICES CM 2015\ACOM:36. 157 pp.

ICES. 2015b. Report of the Second Inter-Benchmark Protocol on West of Channel Flatfish (IBPWCFlat2), June–September 2015, By correspondence. ICES CM 2015/ACOM:55. 142 pp.

ICES. 2016. Report of the Workshop to consider F_{MSY} ranges for stocks in ICES categories 1 and 2 in Western Waters (WKMSYREF4), 13–16 October 2015, Brest, France. ICES CM 2015/ACOM:58. 187 pp. https://doi.org/10.17895/ices.pub.5348.

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