Stock Annex: Plaice (*Pleuronectes platessa*) in Division 7.a (Irish Sea)

Stock-specific documentation of standard assessment procedures used by the International Council for Exploration of the Sea (ICES).

STOCK	PLAICE PLE.27.7A
Working group	Celtic Seas Ecoregion
Last date when the stock was updated	May 2019
Revised by	Marta Quinzan (WGCSE 2019)
Main modifications	Updated Biological Reference Points according to ICES Special Request Advice Celtic Seas Ecoregion (2018); modification of section D. Short-term prediction
Last Benchmarked	WKIrish3, 2017

A. General

A.1. Stock definition

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

The level of mixing between the east and west components of the Irish Sea stock appears small (Dunn and Pawson, 2002). Length-at-age measurements from research surveys as well as anecdotal information from the fishing industry suggests that plaice in the western Irish Sea grow at a much slower rate than those in the eastern Irish Sea. Earlier studies have suggested that the east and west components of the stock are distinct (Brander, 1975; Sideek, 1981). Morphometric differences have been observed between the east and west components of the stock; the 2004 WG indicated that the UK(E&W) beam trawl survey in September (from 1989) catches plaice off the Irish coast that are smaller-at-age than those caught in the eastern Irish Sea.

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

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

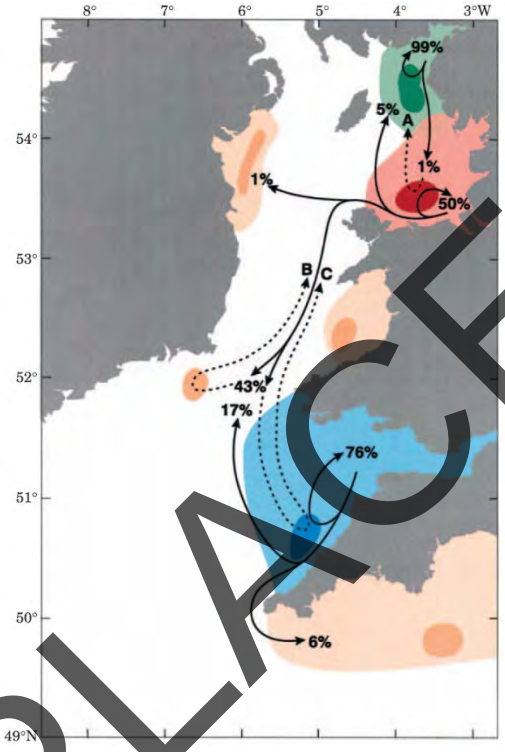

Figure A1. Principal substock areas and movements of plaice on the west coast of England and Wales. Percentages are the recaptures rates of tagged plaice <25 cm total length when released, and >26 cm when recaptured in English and Welsh commercial fisheries. Tagging exercises in 1979–1980 and 1993–1996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

A.2. Fishery

A.2.1. General description

The status and activities of the fishing fleets operating in ICES Subdivision 7.a are described by Pawson *et al.* (2002). Following the massive decline in effort (hours fished) by otter trawlers targeting demersal fish in the early 1990s, the majority of fisheries effort in the Irish Sea is now exerted by otter trawlers fishing for *Nephrops* in the western Irish Sea followed by beam trawlers targeting sole in the eastern Irish Sea. Only a small proportion of otter trawlers still target cod, haddock, whiting and plaice with bycatch of angler-fish, hake and sole. From 2001, trawlers for demersal fish adopted mesh sizes of 100–120 mm and other gear modifications depending on the require-

ments of recent EU technical conservation regulations and national legislation. However, in 2004 the effort exerted by UK trawlers with mesh 100–120 mm declined to low levels. In 2006, the effort by UK trawlers targeting demersal fish with mesh 80–99 mm also declined to low levels. Concomitantly, the effort by UK trawlers targeting *Nephrops* with mesh 80–99 mm increased to record highs. Square mesh panels have been mandatory for UK otter trawlers since 1993 and for Irish trawlers since 1994, but this will have little effect on plaice catches. Four Irish trawlers for *Nephrops* have made use of grids since 2009 and reported 75% drop in fish bycatch. Fishing effort in 2009 by the Irish and UK(E&W) otter fleets targeting demersal fish reached historic lows.

Beam trawling increased in the Irish Sea during the late 1980s, with vessels from England and Belgium exploiting sole. This fishery has important bycatch of plaice, rays, brill, turbot and anglerfish. The fishing effort of the Belgium beam trawl fleet varies according to the catch rates of sole in the Irish Sea relative to the other areas in which the fleet operates.

A.2.2. Fishery management regulations

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

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

A.3. Ecosystem aspects

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

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

B. Data

B.1. Commercial catch

B.1.1. Landings data

Catch data from 2012 onwards are collated and raised within the ICES InterCatch platform. In InterCatch, the catch data are reported disaggregated by country, catch category (landings, discards), fleet and quarter. Some of the reported catches have samples (numbers-at-age and weight-at-age) associated with them.

For fleets for which no discards were reported, discards (in weight) were raised within InterCatch, based on available discard ratios from other fleets. For internal consistency in the raising procedure, fleets were combined into groups depending on country and fleet in accordance with the historical raising procedure. If discard data from a certain fleet were available for some quarters, these ratios were used for the remaining quarters of the same fleets. In general, discards from Belgium, Ireland and Netherlands were treated separately, and available discard ratios for each of these countries were applied to the fleets without reported discard. Within UK fleets, missing discard were raised based on the same or similar UK gear types, if available. For the remaining UK fleets, all UK discard ratios (excluding Northern Ireland) were combined. Northern Ireland provided in general discard information for some quarters of all their fleets and these discard ratios were then used for the remaining quarters of the same fleets. In case of landings of unspecified gear types, all available discard ratios from all countries were combined. If more than one discard ratio was used to raise discards for a certain fleet or fleet groups, the average of the discard ratios weighted by the landings tonnage ("Landing CATON") was applied. The contributions of the raised discards towards the total catches vary by year and were 13.8%, 4.9%, 13.8%, 9.5%, 19.7% and 48.6% for the years 2012–2017 respectively.

Sampling coverage of landings and discards varies by year and country. For 2012–2017, samples covered on average 82.7% of the landings and 43% of the reported discards, which corresponds to 35% of the total raised discards. Catches for which no samples were provided were allocated with available sample data, separately for landings and discards. If more than one sample was used for a certain allocation, the mean weight from all used samples, weighted by the numbers-at-age, was used. Groups of fleets were created, based on the procedure historically applied to this stock. If sample data from a certain fleet were available for some quarters, these samples were used for the remaining quarters of the same fleets (highest priority). Catches from unspecified gears were allocated with all available sample data combined. Catches of Belgium, Ireland, France and the Netherlands were treated as individual groups as they usually provided only annual samples or reported very little catches. All available samples from each of these countries were used for unsampled catches of the same country. Unsampled catches from the UK (including England, Wales, Isle of Man, Northern Ireland and Scotland) were grouped according to the quarter and all available UK sample data for this quarter were used.

The total international, aggregated and raised catch data from InterCatch are then exported and used in the stock assessment. Exported catch numbers-at-age are the sum of the numbers-at-age from all fleets in InterCatch. Exported catch weights-at-age are the weighted mean of the weights-at-age from all fleets. As the assessment for this plaice stock assumes a certain survival rate of the discards, landings and discards are exported separately to allow for the survival correction outside of InterCatch. During

the export of the InterCatch catch data, age 8 is defined as a plus group as the catch time-series prior to 2012 also uses age 8 as plus group.

B.1.2. Discards estimates

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

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

Discard information was not routinely incorporated into the assessment prior to benchmarking by WKFLAT (ICES, 2011). At that working group, estimates were made of discarded numbers-at-age since 2004. At WKIrish3 (ICES, 2017), a model was used to estimate discards numbers prior to 2004 taking into account the change in minimum landing size, and long-term declining trend in size-at-age.

WKIrish3 2017 considered the available information about discard survival in plaice, and concluded that it was appropriate to multiply the estimated discards by 0.6 before applying the assessment, to reflect that around 40% of plaice are estimated to survive after discarding.

B.2. Biological sampling

B.2.1. Maturity

WKIrish3 2017 considered the information available on maturity-at-age, and considered that there was insufficient new data to revise the existing estimates of maturity-at-age. The maturity ogive used in the assessment of this stock is shown in Table A1.

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

Age	WG 1978–1982		WG 1983–1992	WG 1992–2016
	M	F		
1	0	0	0	0
2	0.3	0.04	0.15	0.24
3	0.8	0.4	0.53	0.57
4	1.0	0.94	0.96	0.74
5	1.0	1.0	1.0	0.93
6	1.0	1.0	1.0	1.0

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

B.2.2. Natural mortality

Natural mortality and maturity was initially determined on a separate sex basis. Natural mortality was taken as 0.15 for males and 0.1 for females. In 1983 when a combined sex assessment was undertaken a sex weighted average value of 0.12 was used as an estimate of natural mortality. This estimate of natural mortality has remained unchanged since 1983. At WKIrish3 2017, the natural mortality was revised to take account of the Lorenzen age relationship, but scaled so that the average natural mortality over the ages 3–6 remained at 0.12. The values derived by this method are shown in Table A2.

Table A2. Plaice in 7a, natural mortality rates at age adopted by WKIrish3 2017.

Age	Natural mortality
1	0.1389918
2	0.1283001
3	0.1243611
4	0.1215475
5	0.1187339
6	0.1153576
7	0.1097304
8+	0.1069168

B.2.3. Length and age composition of landed and discarded fish in commercial fisheries

Length distributions of landed and discarded fish estimates are presented for all UK(E&W) gears, for Irish otter trawls and Belgium beam trawl fleets in Figures A2, A3 and A4. In each case, the Minimum Landing Size (270 mm) seems to be the explanation for almost all of the observed behaviour; almost all fish below this size are discarded, and almost all above it are retained.

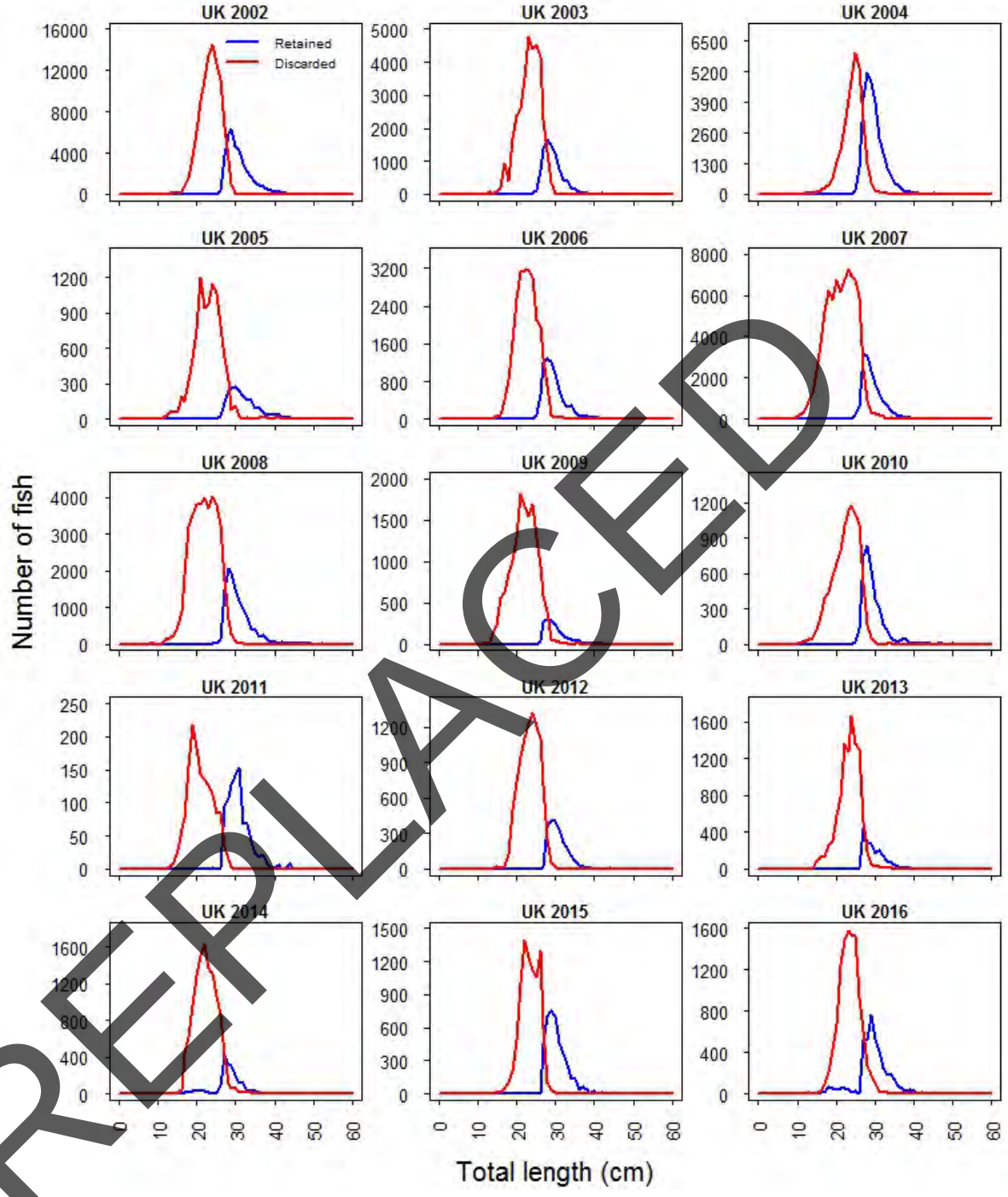

Figure A2. Length distributions of discarded and retained catches from UK(E&W) (2004–2016).

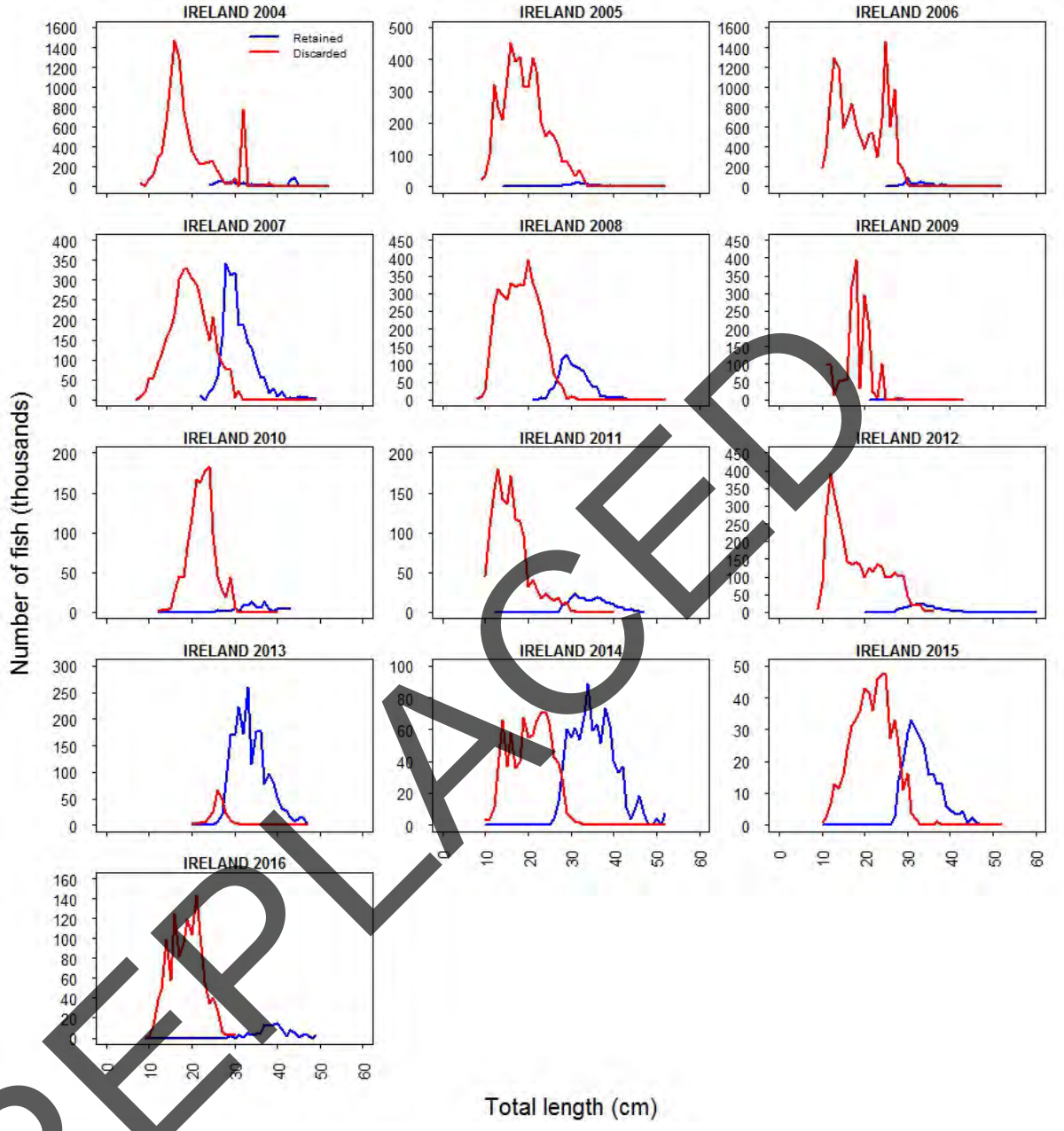

Figure A3. Length distributions of discarded and retained catches from Ireland (2004–2016).

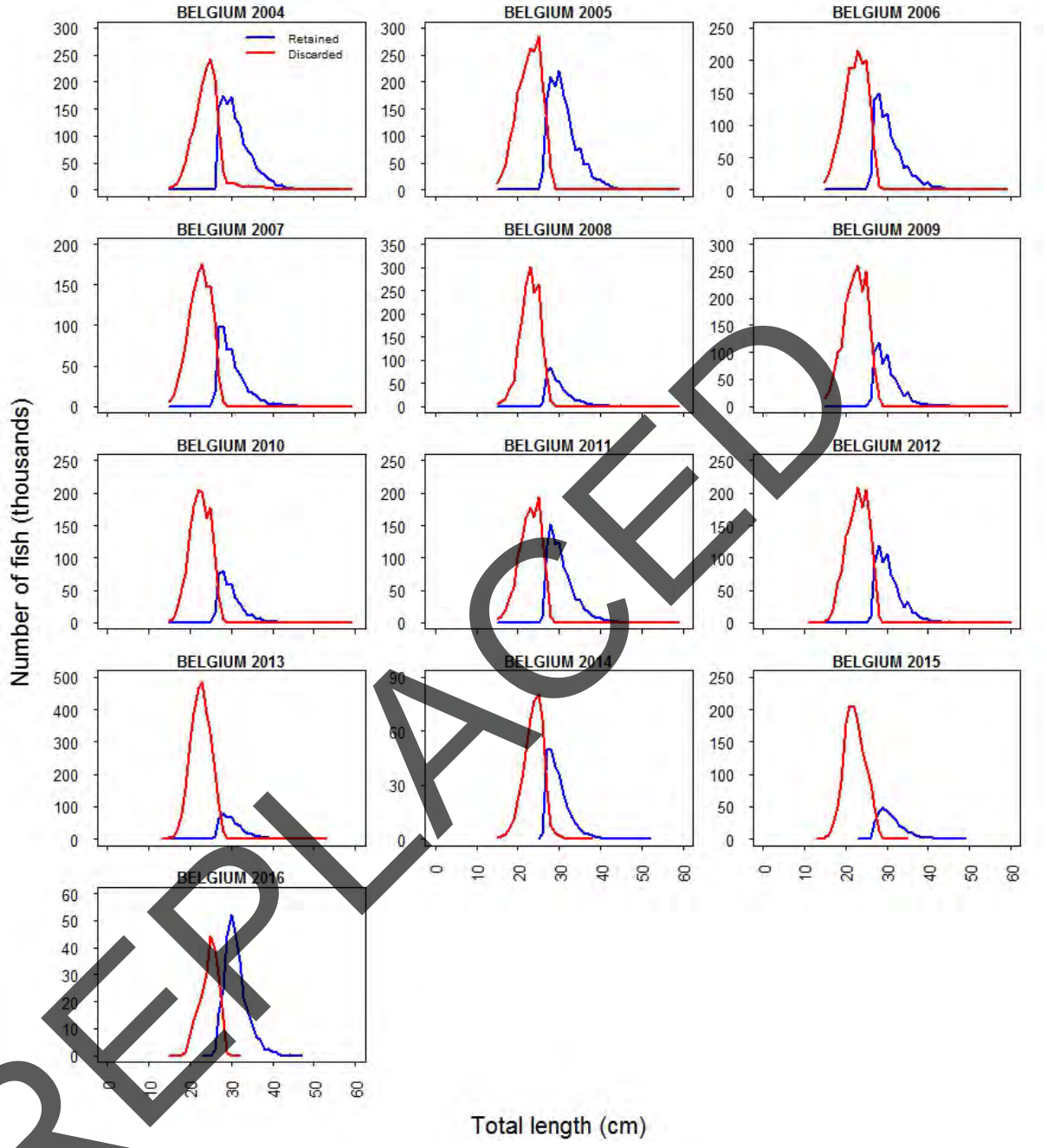

Figure A4. Length distributions of discarded and retained catches from Belgium (2004–2016).

B.3. Surveys

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

In 2011, the UK(E&W) beam trawl survey was re-examined and additional stations sampled in the western Irish Sea and St Georges Channel (Cardigan and Caernarfon

Bays) since 1993 were included in the index. The extended index replaced the earlier 'prime stations' index since it was considered more representative of the entire stock (WKFLAT 2011).

An Irish juvenile plaice survey index was presented to the WG in 2002 (1976–2001, ages 2–8). Between 1976 and 1990 this survey had used an average ALK for that period. Serious concerns were expressed regarding the quality of these data for this period, and the series was truncated to 1991. The stations for this survey are located along the coast of southeast Ireland between Dundalk Bay and Carnsore Point, and there was some concern that this localised survey series would not be representative of the plaice population over the whole of the Irish Sea. Numerous tests were conducted at the 2002 WG to determine the validity of this and other tuning indices and it was concluded that this survey could be used as an index of the plaice population over the whole of the Irish Sea. This survey is no longer used in the assessment.

The SSB of plaice can be estimated using the Annual Egg Production Method (AEPM) (Armstrong *et al.*, 2001 and WD 9 from WGCSE (ICES, 2011b). This method uses a series of ichthyoplankton surveys to quantify the spatial extent and seasonal pattern of egg production, from which the total annual egg production can be derived. The average fecundity (number of eggs spawned per unit body weight) of mature fish is estimated by sampling adult females immediately prior to the spawning season. Dividing the annual egg production by average fecundity gives an estimate of the biomass of mature females. Total SSB can be estimated if the sex ratio is known. Although substantial discrepancies between absolute estimates of SSB from the Annual Egg Production method (AEPM) and the ICES catch-based assessments were observed, they do confirm that SSB of plaice in the Irish Sea is currently at high levels.

AEPM estimates of SSB for plaice (RSE = relative standard error, as %), based on production of Stage 1 eggs) are shown in Table A3 (note 1995 and 2000 estimates were revised in 2010 and 2006 and 2008 estimates revised in 2011 see WD 9, WGCSE 2011).

Table A3. AEPM estimates of SSB for Irish Sea plaice. All estimates from stratified mean (design-based) estimates.

	total		west		east	
Year	**SSB(t)**	**RSE**	**SSB(t)**	**RSE**	**SSB(t)**	**RSE**
1995	9081	21	3411	42	5670	22
2000	13 303	19	5654	36	7649	19
2006	14 417	16	3885	29	10 532	19
2008	14 352	19	4639	43	9713	18
2010	15 071	14	3435	20	11 636	18

Splitting the SSB estimate by substrata (Figure A5) suggests that the perceived increase in plaice SSB is limited to the eastern Irish Sea. This finding agrees with an analysis of NIGFS-WIBTS data and UK(E&W)-BTS-Q3 by substrata, which also indicate increases in biomass limited to the eastern Irish Sea.

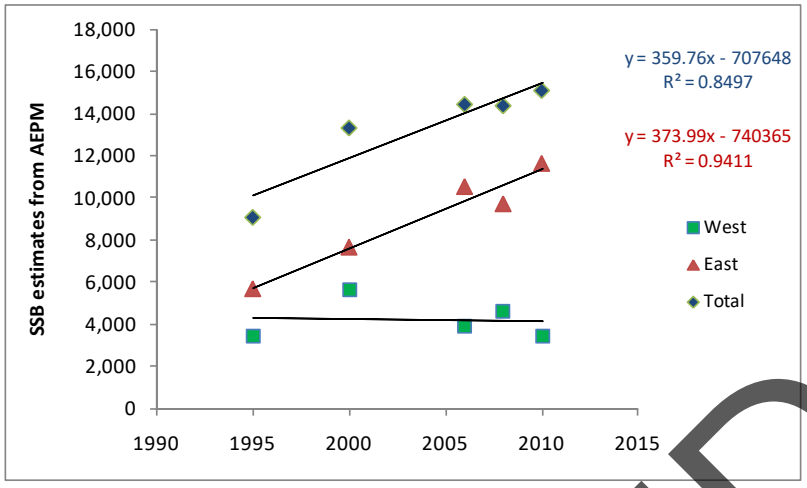

Figure A5. AEPM estimates by year and substrata.

Since 2004, Irish Sea plaice assessment have only included the UK(E&W) beam trawl survey (UK-BTS-Q3 and the two Northern Irish Groundfish Surveys (NIGFS-Q1 and Q4) spawning biomass indices as tunning fleets.

B.3.1. Surveys design and analysis

UK–BTS–Q3

Area covered: Irish Sea, 52°N–55°N, 3°W–6°30'W.

Target species: flatfish species, particularly juvenile plaice and sole. Length data are recorded for all finfish species caught: samples for age analysis are taken from selected species.

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.

Vessel used: RV *Endeavour* (Cefas).

Survey design is stratified by depth band and sector (depth bands are 0–20, 20–40, 40+). Station positions are fixed. Number of stations= 35 in the eastern Irish Sea, 15 in the western Irish Sea, and 16 in St George's Channel (primary stations). Sampling intensity highest in eastern Irish Sea, in the main flatfish nursery and fishery areas.

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

NI–GFS–Q1

Area covered: Irish Sea

Target species: commercial fish, primary species are cod, haddock, whiting, herring and plaice.

Gear used: rock-hopper otter trawl with a 17 m footrope fitted with 250 mm non-rotating rubber discs.

Vessel used: RV *Corystes* (UK-Northern Ireland).

Survey design is stratified by length and substratum. A target of 62 stations of fixed positions are towed. The survey is at March with a duration of 23 days (weather dependent).

Method of analysis: The species composition of each catch is to be recorded by total weight of species caught and length frequencies recorded for all species. Dependent of the number of individual fish caught all samples of cod, haddock, herring and whiting have length, weight, sex and maturity recorded and otoliths are to be obtained for ageing. If the number of individual fish is large, an appropriate subsample should be taken. The biological samples of code and herring may be further analysed for parasite burden. In addition temperature and salinity are recorded at each station.

NI-GFS-Q4

Area covered: Irish Sea

Target species: commercial fish, primary species are cod, haddock, whiting, herring and plaice.

Gear used: rock-hopper otter trawl with a 17 m footrope fitted with 250 mm non-rotating rubber discs. Scanmar sensors are fitted to gear and trawl parameters recorded.

Vessel used: RV *Corystes* (UK-Northern Ireland).

Survey design is stratified by length and substratum. A target of 62 stations of fixed positions are towed. The survey is at October with a duration of 19 days (weather dependent).

Method of analysis: The species composition of each catch is to be recorded by total weight of species caught and length frequencies recorded for all species. Dependent of the number of individual fish caught all samples of cod, haddock, herring and whiting have length, weight, sex and maturity recorded and otoliths are to be obtained for ageing. If the number of individual fish is large, an appropriate subsample should be taken. The biological samples of code and herring may be further analysed for parasite burden.

B.4. Commercial cpue

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

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

The UK(E&W) trawl tuning series was revised in 1999 and separate otter trawl and beam trawl tuning series were produced using length samples from each gear type and an all gears ALK. Since the data could only be separated for 1988 onwards the two new

tuning series were slightly reduced in length. In 1996 UK(E&W) commercial effort data were re-scaled to thousands of hours so as to avoid numerical problems associated with low cpue values and in 2000 the UK(E&W) otter trawl series was re-calculated using otter trawl age compositions only rather than combined fleet age compositions as previously.

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

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

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

Commercial lpue data are no longer used in the assessment.

B.5. Other relevant data

None.

C. Assessment methods and settings

C.1. Choice of stock assess model

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

Assessment methods and settings

In 1987 the stock was assessed using a Laurec-Shepherd (hybrid) tuned VPA. Concerns about deteriorating data quality prompted the use in 1994 of XSA. A subsequent divergence in commercial cpue and survey data, and the wish to include biomass indices, prompted the use of ICA. The settings for each of the assessments between 1991 and 2009 are detailed in Table B.2. Since 2006, the assessment has been an update ICA assessment with the separable period increased by one year at each assessment working

group. In 2009 and 2010, FLICA was used to run the assessment: the R and FLR packages have been documented within the WG report. In 2011, WKFLAT estimated discards at age and proposed that the AP model is used to model the stock.

- Over the years, trial runs have explored many of the options with regards XSA settings, including:
- The applicability of the power model on the younger ages was explored in: 1994; 1996; 1998; 1999; 2000 and 2001.
- Different levels of F shrinkage were explored in 1994; 1995; 1997.
- The effect of different time tapers was investigated in 1996.
- The S.E. threshold on fleets was examined in 1996.
- The level of the catchability plateau was investigated in 1994.

ICA settings explored since 2005 have included:

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

AP model settings were trialled in 2011:

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

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

WKIrish3 2017 adopted the approach of externally estimating a plausible time-series of discards numbers-at-age for the period 1981–2003 and applying a SAM statistical catch-at-age model (Nielsen and Berg, 2014).

C.2. Model used of basis for advice

WKIrish3 2017 selected the SAM model (Nielsen and Berg, 2014) as the basis for assessment of this stock. The settings used are shown in Table A4. Prior to running the model, discards are multiplied by 0.6 to reflect that around 40% of plaice are estimated to survive after discarding. The model treats catch as potentially uncertain and provides estimates of the catch as output – these only reflect the portion of the catch that is assumed to die, and need to be raised to reflect the whole catch.

Table A4. SAM settings as established in WKIrish3 2017.

Tunning fleets	Extended UK-BTS-Q3	1993–2017, ages 1–7
	NIGFS-WIBTS-Q1	1992–2017
	NIGFS-WIBTS-Q4	1992–2017
Selectivity model		Correlated random walk
Discard fraction		Estimated by WKIrish3 (ICES, 2017)
Landings numbers-at-age		1981–2017, ages 1–8+
Discards numbers-at-age		1981–2017, ages 1–8+

C.3. Assessment model configuration

Input data to SAM are shown in Table A5. The assessment make use of commercial catch-at-age data. Discards values available from 2004, whilst estimates of discards were reconstructed for 1981–2003 (WKIrish3). Only the dead fraction of discards (0.6) is accounted for in the model. The maturity is fixed and natural mortality constant over years and different across ages.

Table A5. Input data to SAM.

Type	Name	Year range	Age range	Variable from year to year?
Caton	Catch in tonnes	1981–present	All	Yes
Canum	Catch-at-age in numbers	1981–present	1–8+	Yes
Weca	Weight-at-age in the commercial catch	1981–present	1–8+	Yes
West	Weight-at-age of the spawning stock at spawning time.	1981–present	1–8+	Yes
Mprop	Proportion of natural mortality before spawning	All	All	No
Fprop	Proportion of fishing mortality before spawning	1981–present	1–8+	No
Matprop	Proportion mature-at-age	1981–present	1–8+	No
Natmor	Natural mortality	1981–present	1–8+	No

D. Short-term prediction

Forecasting takes the form of short-term stochastic projections. A total of 1000 samples are generated from the estimated distribution of survivors. These replicates are then simulated forward according to model and forecast assumptions (Table A6), using the usual exponential decay equations, but also incorporating the stochastic sur-vival process (using the estimated survival standard deviation) and subject to different catch-

options scenarios. Recruitment in the intermediate year is taken as the median from a distribution about the assessment estimate. Estimates of recruitment for intermediate year and subsequent years were resampled from the 2015–2018 year classes, reflecting recent low levels of recruitment. These re-sampled recruitments are only used for SAM forecasts in order to evaluate future stock dynamics.

Previous sotware: FLR

Table A6. Forecast assumptions.

Initial stock size	Starting populations are simulated from the estimated distribution at the start of the intermediate year (including covariances)
Maturity	Average of final three years of assessment data
Natural mortality	Average of final three years of assessment data
F and M before spawning	Both taken as zero
Weight at age in the catch	Average of final three years of assessment data
Weight at age in the stock	Assumed to be the same as weight at age in the catch
Exploitation pattern	Fishing mortalities taken as a three year average
Stock recruitment model used	Recruitment for the intermediate year onwards is sampled, from 2015 to the final year of catch data.
Procedures used for splitting projected catches	Average of final three years of landing fractions. Discard values are raised to include the live portion. Discard numbers multiplied by 5/3 to account for discard survival. Total catch is sum of three components: landings, discards assumed to die, and discards assumed to survive.

E. Medium-term prediction

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

Previous Software: *MLA miscellany*

F. Long-term prediction

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

G. Biological reference points

The reference points for this stock were estimated in 2018 (ICES, 2018) as ICES request for EU western waters stocks and are presented in the table below.

Table A7. Reference points as derived in ICES, 2018.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	8757 tonnes	Lower 5th percentile of B F_{MSY}	ICES (2018)
	F_{MSY}	0.196	Stochastic simulations with segmented regression from the entire time-series (1981–2017)	ICES (2018)
Precautionary approach	B_{lim}	3958 tonnes	Bloss = minimum SSB observed	ICES (2018))
	B_{pa}	5294 tonnes	$B_{lim} \times \exp(1.645 \times \sigma)$; $\sigma = 0.177$	ICES (2018)
	F_{lim}	0. 49	F with 50% probability of SSB < B_{lim}	ICES (2018)
	F_{pa}	0.35	$F_{lim} \times \exp(-1.645 \times \sigma)$; $\sigma = 0.201$	ICES (2018)
Management plan	SSB_{mgt}	Not applicable		
	F_{mgt}	Not applicable		

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