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 (*Pleuronectes platessa*) in Irish Sea (7.a)
Working group	Celtic Seas Ecoregion
Stock last updated	February 2017
Revised by	Tim Earl (WKIRISH3)
Timeline of revisions	February 2017
Main modifications	Change to assessment method including reconstruction of historical discards
Last Benchmarked	WKIRISH3, 2017

A.1 General

A.1.1 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).

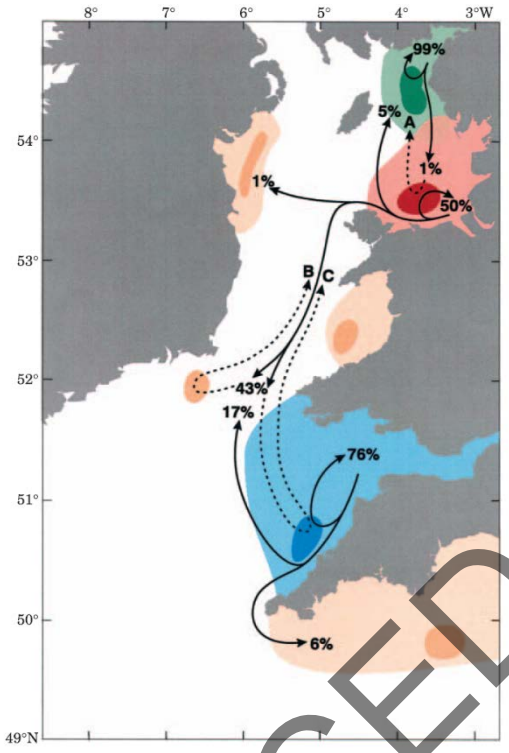

Figure A1 (right) Principal substock areas and movements of plaice on the west coast of England and Wales. Percentages are the recaptures rates of tagged plaice <25 cm total length when released, and >26 cm when recaptured in English and Welsh commercial fisheries. Tagging exercises in 1979–1980 and 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).

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 subpopulations that share a common spawning.

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 requirements of recent EU technical conservation regulations and national legisla-

tion. 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 and North Sea) and sea surface temperature 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

NA.

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 in 2011. At that working group, estimates were made of discarded numbers-at-age since 2004. At WKIRISH 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.

WKIRISH 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

WKIRISH 2017 considered the information available on maturity-at-age, and considered that there were 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 WKIRISH 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 B1.

Table B.1 Plaice in 7.a, natural mortality rates at age adopted by WKIRISH 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 landings and discards from UK(England and Wales), Ireland and Belgium by year. In each case, the minimum landing size (270 mm) seems to be explain almost all of the observed behaviour; almost all fish below this size are discarded, and almost all above it are retained.

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 the 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. 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.*, 2002 and WD 9, WGCSE 2011). 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 below (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	13303	19	5654	36	7649	19
2006	14417	16	3885	29	10532	19
2008	14352	19	4639	43	9713	18
2010	15071	14	3435	20	11636	18

Splitting the SSB estimate by substrata (Figure A4 below) 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.

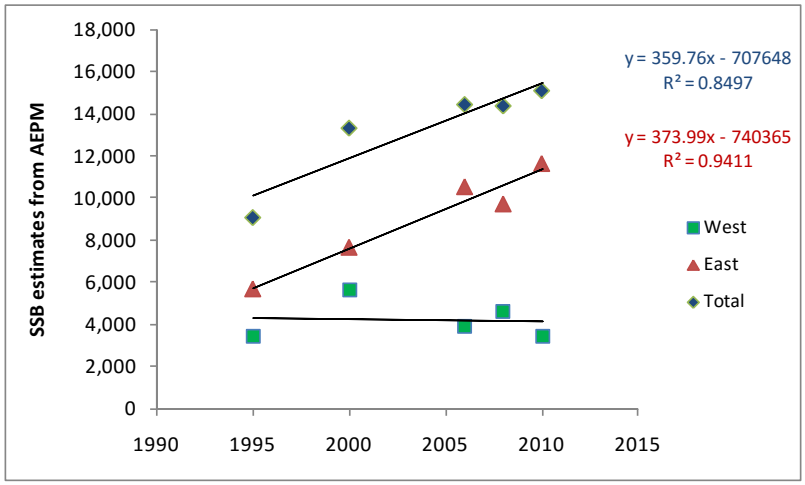

Figure A4. AEPM estimates by year and substrata.

B.3.1 Survey design and analysis

B.3.2 Survey data used

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 recalculated 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 underestimation 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.

WKIRISH 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 (ICES, WKIRISH3).

C.2 Model used of basis for advice

WKIRISH3 (2017) selected the SAM model (ICES, WKIRISH3 2017) as the basis for assessment of this stock. The settings used are shown in Table C. 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.

C.3. Assessment model configuration

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

Model used: FLR projection

Software used: FLR projection

Initial stock size: Taken from last year of assessment

Maturity: The constant maturity ogive used in the assessment

F and M before spawning: 0

Weight-at-age in the stock: Average of the last three years' catch weights-at-age

Weight-at-age in the catch: Average of the last 3 years' catch weights-at-age

Exploitation pattern: Average of the last three years' selectivity

Intermediate year assumptions: average F from last three years

Stock–recruitment model used: Geometric mean recruitment

Procedures used for splitting projected catches: Catches are split according to average landings fractions at age from last three years.

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

Reference points were calculated as part of WKIRISH (2017) using the EQSim package, and following ACOM guidance.

	Type	Value	Technical basis
MSY	MSY Btrigger	10 400 t	Lower 5%ile of current biomass
Approach	FMSY	0.154	Stochastic simulations with segmented regression from entire time-series (1981–2015).
	Blim	4200 t	Median breakpoint of stochastic fitting of segmented regression stock-recruit function
Precautionary	Bpa	7900 t	SSB cv taken from model outputs (0.38)
Approach	Flim	0.48	F that gives average SSB of Blim with no assessment error.
	Fpa	0.25	F cv taken from model outputs (0.40)

H Other issues

H.1 Biology of species

H.2 Stock dynamics, regulations in 20th century, historic overview

H.3 Current fisheries

H.4 Management and advise

H.5 Others (e.g. age terminology)

I References

ICES. 2017. Report of the Benchmark Workshop on the Irish Sea Ecosystem (WKIrish3), 30 January–3 February 2017, Galway, Ireland. ICES CM 2017/BSG:01. 165 pp.

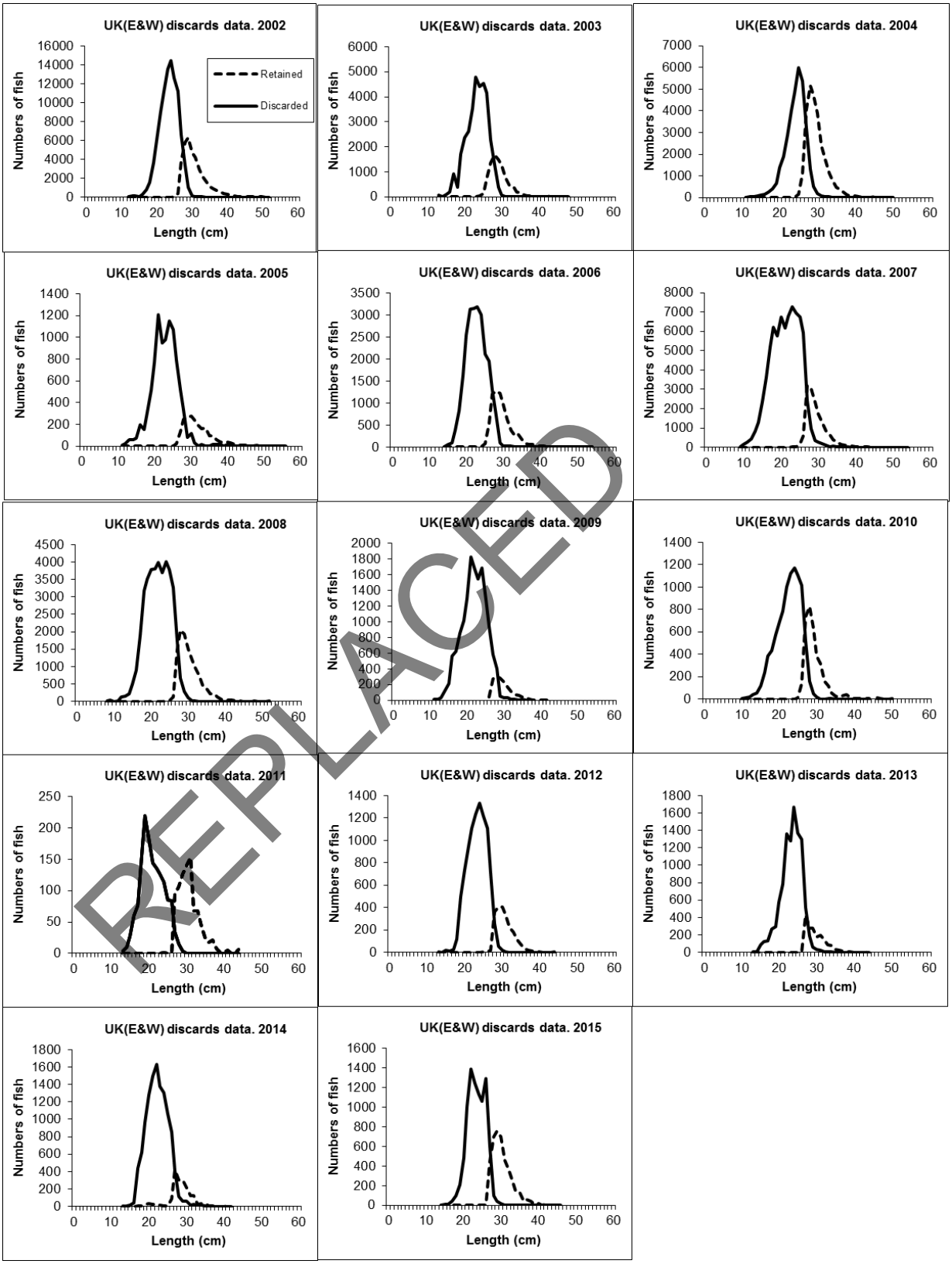

Figure X. Length distributions of discarded and retained catches from UK(E&W).

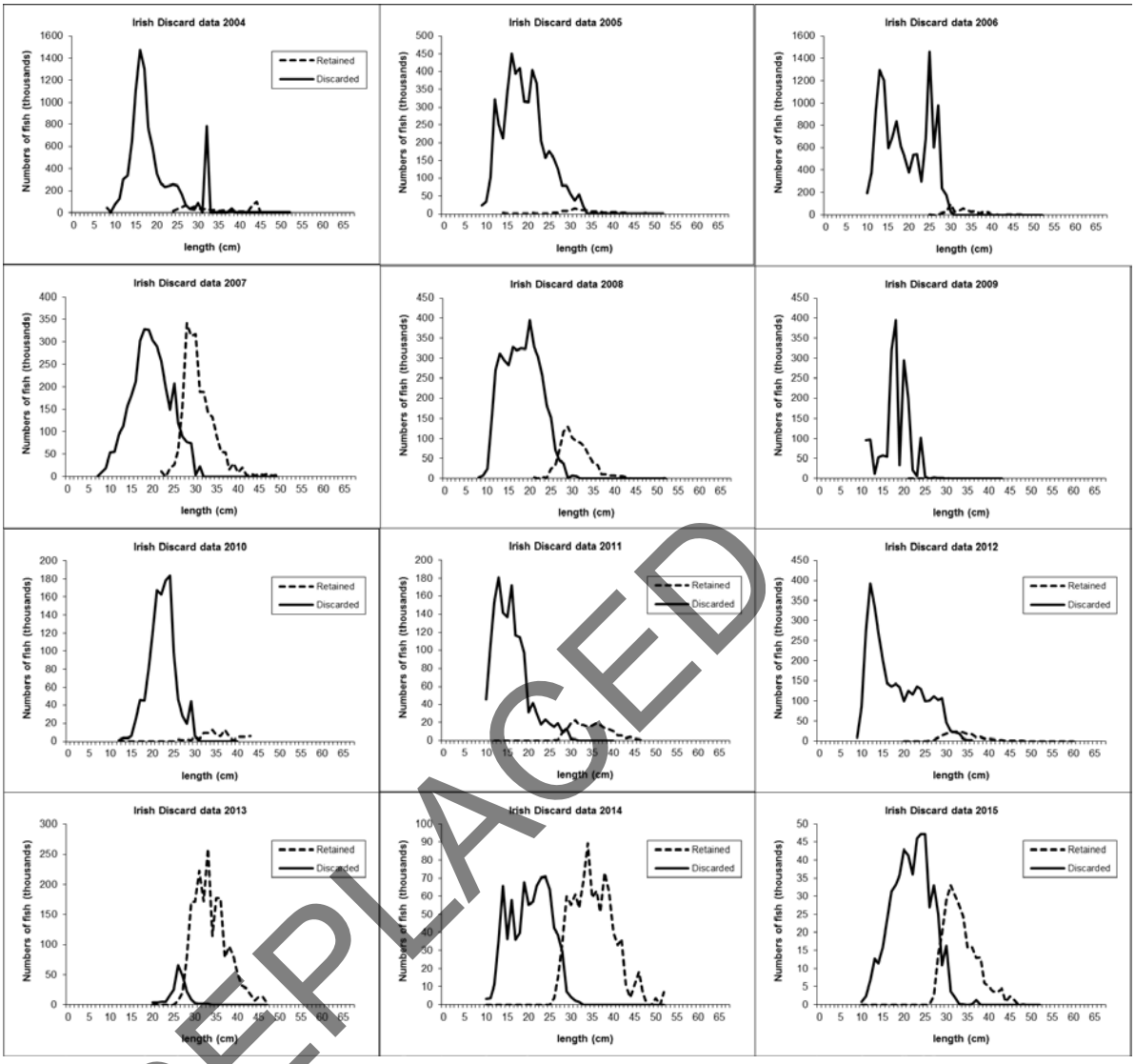

Figure x. Length distributions of discarded and retained catches from Ireland.

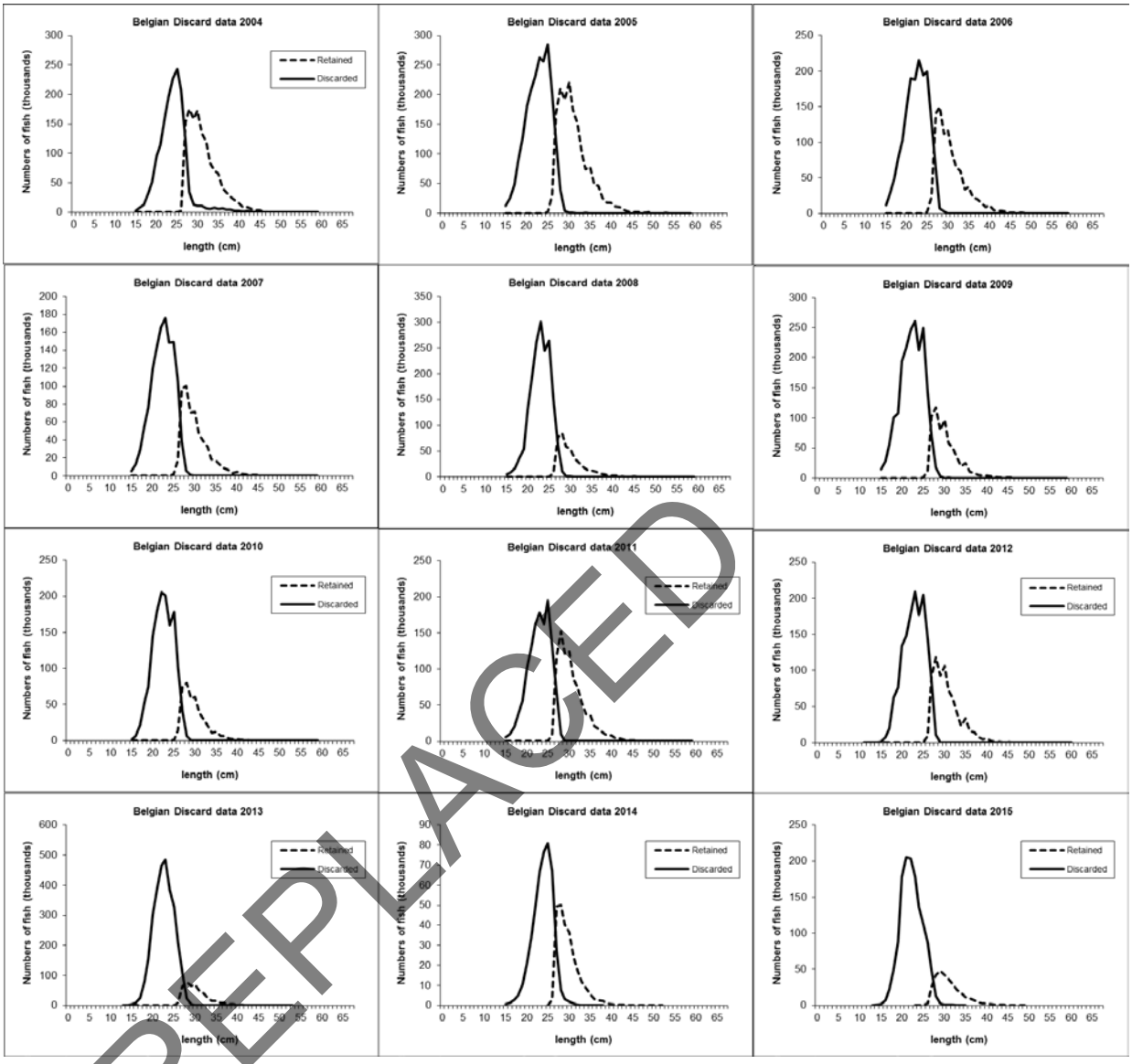

Figure x. Length distributions of discarded and retained catches from Belgium.