

Stock Annex: Cod in VIIe–k Celtic Sea cod

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Cod in VIIe–k (Celtic Sea cod)
Expert Group	Celtic Sea Working Group
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Revised by	Colm Lordan, Lionel Pawlowski

A. General

A.1. Stock definition

Since 1997, this assessment has related to the cod in Divisions VIIe–k, covering the Western Channel and the Celtic Sea. Tagging information presented at WKROUND 2012 (WDs 9 and 11) confirms minimal movement of cod from VIIe–k to other areas. In fact even within VIIe–k there seems to be limited mixing between fish tagged in VIIg or VIIa South and those tagged in VIIf and VIIe.

Up to 2008, the management area was set in Divisions VIIb–k, VIII, IX, X, and CECAF 34.1.1 which does not correspond to the area assessed. The management area was revised in 2009 to exclude VIId. The new TAC covers ICES Areas VIIb–c, VIIe–k, VIII, IX, X, and CECAF 34.1.1(1). This is more representative of the stock area in recent years and landings from VIIbc, VIII, IX and X have been minimal.

The area assessed has gradually increased from VIIfg before 1994 to VIIfgh, to VIIefgh in 1996 and finally to VIIe–k. In 1994, at the request of ACFM, the ICES Working Group on Southern Shelf Demersal Stocks (WGSSDS) studied the possible extension of the area assessed from VIIfg to VIIfgh. Examination of data from surveys and logbooks indicated a continuity of the distribution of VIIg cod into VIIh. Depending on the year, catches in Division VIIh represented 9–15% of the catches in VIIfg, with a coincidence of years of peak or low catches in both areas. Therefore, catches from VIIh were included in the assessment. In 1996, at the request of ACFM, WGSSDS studied the possible extension of the area assessed from VIIfgh to VIIefgh. The population dynamics parameters for VIIfgh and VIIe cod were examined and compared for the period 1988–1994, when independent tuning fleets, international catch-at-age, mean weights-at-age in the landings and in the stocks were available for both areas. Patterns of F were consistent between VIIe and VIIfgh in earlier years (1988–1990), and SSBs trends were similar in the period 1988–1992. The patterns of recruitments (age 1) were found to be fairly consistent through this period 1988–1994, though it cannot be assumed that this consistency was also valid in earlier years when catch-at-age were only available in Divisions VIIf, g, h. It was therefore decided to combine Western Channel Cod with the Celtic Sea Cod assessment for the years 1988–1995, but an independent assessment of Celtic sea Cod in VIIfgh was maintained for the longer period available 1971–1995. This was to allow scaling of the historic (1971–1987) SSBs and recruitment values from VIIfgh to VIIe–h.

At WGSSDS 1997, due to the lack of a long independent series of catch-at-age in Divisions VIIj,k, the estimate of landings from Divisions VIIjk was discussed and it was decided to combine the data of Divisions VIIe,f,g,h and Divisions VIIjk for the period 1993–1996 and to raise the data in Divisions VIIe–h to landings in Divisions VIIe–k for the period 1988–1992. The results of an XSA assessment of this series in

Divisions VIIe–k for 1988–1996 had been compared with the results of the assessment in Divisions VIIe–h in terms of trends of F, SSB and recruitment. Patterns of these parameters were found very similar and the merging of Divisions VIIjk with Divisions VIIe–h mainly resulted in a scaling upwards of SSB and recruitment. The new assessment areas comprised cod in Divisions VIIe–k.

At the 1999 WGSSDS meeting, an alternative procedure to the tedious re-scaling of SSB and recruitment of the earlier series 1971–1987 in VII fgh to VIIe–k every year was proposed (Bellail, 1999, WD3). A long series of landings data from 1971–1987 was reconstructed. An average raising factor (1.24) from VII fgh to VIIe–k in the period 1988–1997 was applied to VII fgh landings of the series 1971–1987. Results of assessment in terms of SSB and R were very close to those obtained when these parameters were scaled. ACFM accepted this procedure.

In the past few biological criteria have been used to justify the widening the stock area. However, recent tagging work by Ireland and the UK supports the idea that there is a resident stock in the Celtic Sea and Western Channel (VIIe–k) and mixing with other areas appears to be minimal. The Irish Sea front, running from SE Ireland (Carnsore point) to the Welsh Coast, appears to act as boundary between the Irish Sea and Celtic Sea stock. Juveniles found close to the SE Irish Coast (south of VIIa) are considered part of the Celtic Sea stock.

Some migrations and mixing are known to occur in this cod stock. Both conventional and DST tagging information for VIIg (where the majority of landings are made) shows that distribution remained fairly constrained within VIIg. There was some preference to central areas within VIIg during January–March. Between April and June the cod appeared to be more widely dispersed within VIIg during Q1 & Q2. Fish tagged in VII f tended to mix with those off shore in VIIg and h. Whereas some fish tagged in the western English Channel VIIe migrated into VII d for at least part of the year.

A.2. Fishery

The majority of the landings are made by demersal trawls targeting roundfish (i.e. cod, haddock and whiting), although, in recent years an increasing component have been from gillnets and otter trawls targeting *Nephrops* and benthic species.. Landings are made throughout the year but are generally more abundant during the first semester. Constraining TAC's set since 2003 and the impact of the Trevose Head Closure applied since 2005 have reduced landings in Q1 somewhat and spread landings more throughout the year.

WGCSE should routinely monitor spatial and temporal changes in landings, effort and lpue for the main fleets catching cod in VIIe–k. This has previously been done using maps of landings and lpue by ICES rectangle.

A.3. Ecosystem aspects

Cod recruitment success has generally shown an increase over the period 1970–2006 during which time sea-surface temperature in the Celtic Sea has increased (Lynam *et al.*, 2009). Notably the highest recruitment success was for cod spawned in 1986, a year with an exceptionally cold spring. Lynam *et al.* (2009) also found that SST in spring (MAM) and *Calanus helgolandicus*, abundance in the Celtic Sea, did prove to be significant predictors of recruitment in Celtic Sea cod in a GAM model. The time lag between availability of this SST and zooplankton information means that their model cannot be readily used in forecasting recruitment in advance of what groundfish

surveys might detect. Nevertheless this research should be pursued further, particularly in the context ecosystem determinants of the strong 2009 and 2010 year classes.

B. Data

B.1. Commercial catch

Landings

On a quarterly basis, France, Ireland and UK (E+W) have provided catch numbers-at-age and catch weights-at-age for their landings. The Irish landings in VIIg are augmented with some landings made or reported off the southeast coast of Ireland in ICES rectangles 33E2 and 33E3. These rectangles are in the very south of VIIa. Landings only are available for Belgium.

France, UK and Ireland data are added quarterly and raised to international landings taking into account Belgian data. Then the quarterly datasets are summed up to the annual values.

As a consequence of an update to the French database of landings statistics, some minor revisions (downward) have been applied since 2002 and the updated datasets for international landings.

There is no information on the absolute level of misreporting for this stock but there is evidence that misreporting has increased from 2002 when quotas became restrictive with a maximum in 2008. Misreporting has decreased since then.

Discards

Discards data sampled under EU/DCR since 2003 have been generally presented in previous WGCSE but not used in the assessments as they do not cover all the main fleets and quarters yet.

Due to the annual management system adopted by the French POs since 2003 in response to the quota restrictions, high grading has occurred in the French fishery, mainly in VIIg. A procedure using both the UK and French landings length data enabled estimation of the French high grading for the years 2003–2005 (WD 1, WGSSDS 2006). The adjustments were reapplied to improved estimates of French landings from 2006 at the ICES WKROUND 2009.

French landings have been corrected with high grading estimates from 2003 to 2005. The method used to estimate the high-graded component is described in WD#1 of the WGSSDS 2006. For smaller length classes, a scaling of French numbers-at-length based on UK length frequencies or UK number-at-length has been used to estimate length compositions of the French component of high grading. The accuracy of this method is unknown but it probably underestimates the high-grading levels for those years. Unfortunately, the sampling level of total catch at sea in that period was too poor to get an estimate of the level of bias. This method was not applied from 2006 onward because highgrading was also observed in the UK landings. Instead, self-sampling data obtained in 2008–2009 have been used to estimate the French high-grading level, assuming that the discarding practices in 2006–2007 were the same as those observed in 2008 for the main self-sampled fleet. Applying this method back to 2003 was considered inappropriate. The representatives of fishermen's organisations at WKROUND 2009 indicated that the discarding level was probably not the same in earlier years as high-grading practices are linked to the level of the TAC. The whole

method has been described in the WD#17 of WKROUND 2009. In 2009 and 2010, the low estimate of highgrading is likely to be related to the French vessels not being restricted by quota because of the decommissioning plan and the reports of effort directed towards more profitable species. Highgrading has also occurred in the UK catches in 2007–2008 but given the low level of landings, it was not estimated prior to this year, as well as for Belgian landings. The MLS of the Belgian landings is currently set at 50 cm since 2008. The estimates of highgrading by year are slightly revised when annual landings statistics are updated.

In 2008 the French self-sampling programme on Celtic Sea cod has produced datasets enabling estimation of discarding and high-grading rates. Assuming the same pattern of discarding in recent years, estimates of French discarding and highgrading back to 2003 were also computed. Estimates of highgrading were also calculated for the French tuning fleets used in the analysis (ICES WKROUND, 2009, WD 17). In 2009 and 2010, the low estimate of highgrading is likely to be related to the French vessels not being restricted by quota because of the decommissioning plan and the reports of effort directed towards more profitable species.

Discard estimates are available from Ireland since 1995 (see Marine Institute & Bord Iascaigh Mhara, 2011). For now the assumption is that the discards is mainly at-age 1 and the estimates are very uncertain. There are indications that Irish discard rates have increased since 2005; this is something that WGCSE should monitor, and discards should be included in the assessment if there are major changes, or it is found to have a large impact on the assessment.

Discards were also available from Belgium. For these fleets, the modal distribution of discards was around 30 cm. Due to the MLS being set at 50 cm for Belgium, discards occur well above 35 cm while relatively low in numbers. Belgian MLS switched back to 35 cm on the 1st of October 2011.

Lpue

Landings and effort data are available for all the main fleets operating in the area and catching cod. The table below summarizes the available data. WGCSE should monitor changes in these fleets over time.

Name	Area	Series
FR gadoid fleet ¹	Vllfgh	1983-onwards
FR <i>Nephrops</i> fleet ¹	Vllfgh	1983- onwards
FR otter trawlers ²	Vlle	1983- onwards
FR otter trawlers ²	Vllfgh	1983- onwards
FR otter trawlers ²	Vlle-k	1983- onwards
UK otter trawlers	Vlle	1972- onwards
UK otter trawlers	Vlle-k	1972- onwards
UK beam trawlers	Vlle-k	1978- onwards
IR otter trawlers	Vllg	1995- onwards
IR beam trawlers	Vllg	1995- onwards
IR Scottish seiners	Vllg	1995- onwards
IR otter trawlers	Vllj	1995- onwards
IR beam trawlers	Vllj	1995- onwards
IR Scottish seiners	Vllj	1995- onwards

¹ For Q2+3+4 for consistency with the Trevoise Head Closure since 2005 during the first quarter.

² Annual values, including the Fr gadoid and *Nephrops* fleets.

B.2. Biological

Weights-at-age

At the 1999 WGSSDS, data for the years 1971–1980 were set to the average 1981–1997. A revision was carried out at 2001 WGSSDS where the values for the period 1971–1980 were set to the average values 1981–2000. Depending on the annual datasets available by country for the period 1988–2001, catch weights-at-age data were calculated as the weighted means from French, Irish and UK datasets. Since 2002, VIIe–k catch weights-at-age have been calculated as the annual weighted means of French, Irish and UK datasets.

WKROUND 2012 reviewed the data and concluded that there is a downward trend in mean weights-at-age during the 1980s but they have been relatively stable since then at about 10% lower mean weights than observed in the 1980s. There is some evidence of year effects (e.g. 2001 and 2005) and cohort effects (e.g. 1999).

Stock weights-at-age are the catch weight-at-age data from the 1st quarter.

Maturity

The maturity ogive applied since 1999, was estimated from the datasets of the UK-WCGFS survey (1st quarter) has been used for the overall series. It replaced an assumed ogive used for the year prior to 1999, derived from Irish Sea cod data, when both stocks (VIIa and VIIfg) were assessed in the Irish Sea & Bristol Channel WG up to 1992. The table below summarizes the maturity ogives used.

Age	1	2	3	4	5+
Before 1999	0.00	0.05	1.00	1.00	1.00
Current	0.00	0.39	0.87	0.93	1.00

Natural mortality

In the assessments, natural mortality is assumed to be constant for the whole range of years and is age dependant. The table below summarizes the values of M accordingly to age.

Age	0	1	2	3	4	5	6	7	8	9	10
M	1.12	0.51	0.37	0.30	0.269	0.247	0.233	0.223	0.216	0.210	0.207

B.3. Surveys

Three surveys series are available.

The discontinued UK-WCGFS-Q1 (1986–2004), conducted during the first quarter, is generally truncated into a shorter series (1992–2004) as it showed a strong trend (dome-shaped) when using the full series. This pattern is related to the progressive extension of the studied area of this survey from VIIe to VIIefgh over the years. This time-series only contributes to the estimates at older ages (4 and older). Due to the lack of new data, the series is no longer used in the assessment.

The FR-EVHOE (EVHOE-WIBTS-Q4) survey (1997–), during the 4th quarter, covers the Divisions VIIefghj. The IrGFS (IGFS-WIBTS-Q4) survey (2003–), during the 4th quarter, in VIIg and VIIj is also used in the assessment.

The absolute numbers of cods caught in all of these surveys are extremely low. Attempts to combine survey data have been done at WKROUND 2009 and 2012 to overcome that problem. WKROUND 2012 tested two combinations: mixing data for the whole area and just those in the overlapping area.

WKROUND concluded that the overlap area combined index was an improvement on using the two surveys independently or using the full area index. This conclusion was based on the good cohort tracking and fairly consistent catch curves in the combined index Ages 1–4.

Time-series of survey indices scrutinized at WGCSE. IR - GFS: Irish Groundfish Survey (IBTS 4th Qtr) - VIIg Cod number-at-age (Effort Standardised to 1hr).

2003	2012								
1	1	0.79	0.92						
0	7								
1	0.0	0.4	0.7	0.7	0.3	0.0	0.0	0.0	2003
1	0.4	1.0	0.4	0.1	0.1	0.1	0.0	0.0	2004
1	0.1	2.0	0.6	0.1	0.0	0.0	0.0	0.0	2005
1	0.1	2.2	0.6	0.1	0.0	0.0	0.1	0.0	2006
1	0.0	2.6	0.8	0.4	0.1	0.0	0.0	0.0	2007
1	0.0	0.5	1.3	0.3	0.1	0.0	0.0	0.0	2008
1	0.2	1.9	0.2	0.3	0.1	0.0	0.0	0.0	2009
1	0.0	12.4	1.2	0.0	0.0	0.0	0.0	0.0	2010
1	0.0	6.5	5.9	0.3	0.0	0.0	0.0	0.0	2011
1	0.0	0.8	2.5	1.3	0.4	0.0	0.0	0.0	2012

IR - GFS : Irish Groundfish Survey (IBTS 4th Qtr) - VIIg Cod number at age (Effort Standardised to 1hr)

2003	2011								
1	1	0.79	0.92						
0	7								
1	0.0	0.2	0.2	0.2	0.0	0.0	0.0	0.0	2003
1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2004
1	0.0	1.8	0.0	0.1	0.0	0.0	0.0	0.0	2005
1	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	2006
1	0.0	0.5	0.2	0.0	0.0	0.0	0.0	0.0	2007
1	0.0	0.1	0.3	0.1	0.0	0.0	0.0	0.0	2008
1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2009
1	0.2	3.5	0.2	0.0	0.1	0.0	0.0	0.0	2010
1	0.0	0.9	1.8	0.1	0.1	0.0	0.0	0.0	2011
1	0.0	0.0	0.2	0.4	0.0	0.0	0.0	0.0	2012

FR-EVHOE Groundfish Oct-Nov survey in VII f,g,h,j, numbers per 30 mn							
1997	2012						
1	1	0.75	1				
1	6						
1	0.213	0.095	0.246	0.117	0.048	0	1997
1	0.212	0.52	0.207	0.045	0.045	0	1998
1	0.155	0.184	0.283	0.015	0.03	0.015	1999
1	1.046	0.041	0.118	0.064	0.013	0	2000
1	0.716	0.18	0.029	0.038	0.018	0.007	2001
1	0.033	0.313	0.148	0	0.015	0	2002
1	0.052	0.041	0.142	0.061	0.008	0	2003
1	0.066	0.144	0.072	0.122	0.046	0	2004
1	0.255	0.12	0.055	0	0.026	0	2005
1	0.125	0.139	0	0.048	0.045	0	2006
1	0.321	0.206	0.117	0.033	0	0	2007
1	0.217	0.141	0.117	0.096	0	0	2008
1	0.237	0.092	0.132	0.078	0	0.023	2009
1	1.805	0.21	0.028	0.094	0	0	2010
1	0.792	1.119	0.095	0.031	0.011	0	2011
1	0.063	0.416	0.529	0.025	0	0	2012

As part of constructing a combined index for whiting during the 2014 WKCELT benchmark process a review of methods was made to speed up and simplify the spatial aggregation process. Updated indices were then recalculated for both Celtic Sea whiting and cod and offered as an alternative tuning series for consideration by the stock coordinators along with the existing time-series.

No changes were made to the input data, but the historic method of aggregation was to use a 0.5 deg Latitude x 0.5 deg Longitude grid in ArcGis. Numbers per hour at-age per survey haul were plotted and averaged within each grid cell to produce a mean number per age per grid cell (see WDx: WKROUND 2012 for details). As effort was already standardised the mean number-at-age per cell was summed across the grid to produce the annual index. While good for exploratory work, using GIS separately generated a lot of files and was cumbersome. Therefore the R code used to apply the ALKs per station was extended to carry out the gridding and aggregations also. In addition, it was evaluated whether having more symmetrical grid cells would impact on the index and therefore the grid was reduced in latitude from 0.5 degree to 0.25 degree (Figure B). This gave an approximate distance of 30 nmi E-W per grid cell and 23 nmi N-S in contrast to 47 nmi N-S in the earlier grid. Finally a mean across grid cells was used to generate the annual index instead of the sum.

Figure 3 show that the correlation between the indices is very high, which further validates the use of the new index in the assessment. Details presentations of both estimates are presented in Table A.

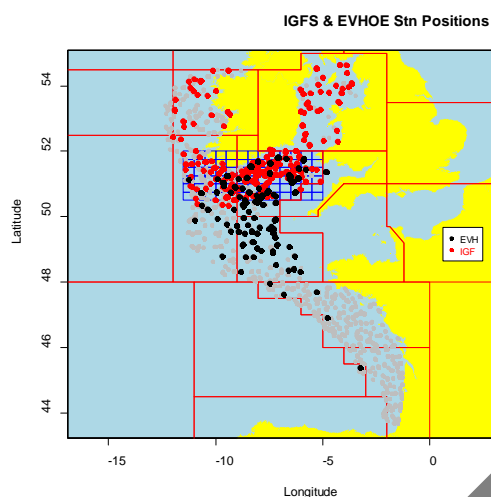


Figure A. Map of all survey hauls collated for the index calculations. Positive Irish survey catches (IGF) in red, positive French survey catches (EVH) in black. Data is aggregated using a cell size of 0.25 degree Latitude by 0.5 degree Longitude.

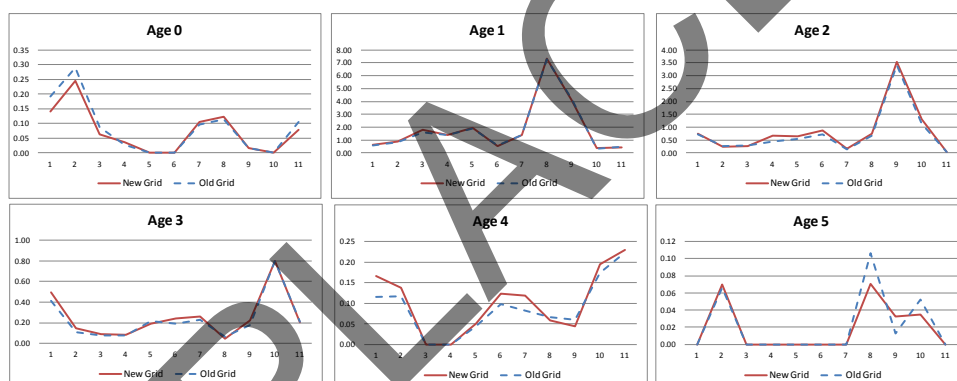


Figure B. Plots of mean catch numbers-at-age for the combined survey series using the historic grid (0.5 deg lat x 0.5 deg long-dashed line) compared with the new grid (0.25 deg lat x 0.5 deg long-solid line).

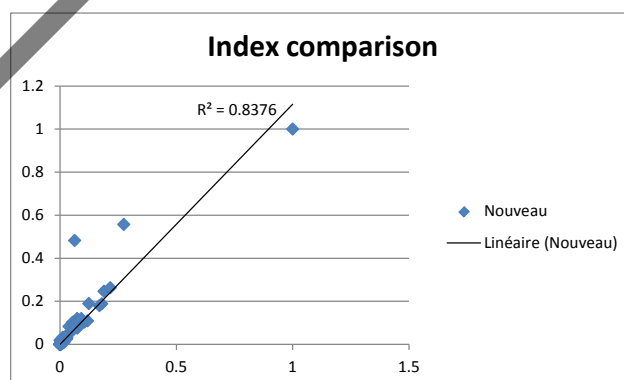


Figure C. Comparison of the two indices.

Table A. Estimate indices using the two methods.

###Old Index

Cod VIIg-j, Combined IGFS:EVHOE Survey Index

101

Combined IGFS:EVHOE Survey effort standardised to Sum mean No/Hr per grid cell

2003	2013						
1	1	0.79	0.92				
0	7						
1	0	9.9	13.8	14.4	3.6	0	
1	3	18.7	7.7	3.5	4.8	2.3	
1	1.3	48.3	5.8	2.9	0	0	
1	1	31.6	15.2	2.5	0	0	0.
1	0	55	16.8	7.4	1.5	0	
1	0	19	23.4	6.4	3.2	0	
1	1.1	45.8	5.5	6.9	2.7	0	0.
1	2.1	254.8	26.9	2.6	2.7	4.4	
1	1.58	69.85	16.06	7.06	2.8	1.13	0.1
1	0	10.74	43.15	30.21	6.45	2	
1	3.29	11.23	1.32	6.42	5.89	0	

###New Index

Cod VIIg-j, Combined IGFS:EVHOE Survey Index

101

Combined IGFS:EVHOE Survey effort standardised to Average mean No/Hr per grid cell

2003	2013						
1	1	0.79	0.92				
0	6						
1	0.14	0.61	0.75	0.5	0.17	0	

1	0.24	0.88	0.24	0.15	0.14	0.07	
1	0.06	1.81	0.26	0.09	0	0	
1	0.04	1.39	0.67	0.08	0	0	0.0
1	0	1.93	0.64	0.19	0.05	0	
1	0	0.55	0.88	0.24	0.12	0	
1	0.1	1.38	0.17	0.26	0.12	0	0.0
1	0.12	7.34	0.76	0.04	0.06	0.07	
1	0.02	4.09	3.54	0.22	0.04	0.03	
1	0	0.39	1.32	0.8	0.19	0.04	
1	0.08	0.42	0.05	0.21	0.23	0	

B.4. Commercial cpue

FR-OTDEF: a new time-series of tuning indices has been introduced at WKROUND 2012 upon French datasets considering landings and fishing efforts from otter trawlers (OTDEF métier) which catch per trip are at least 40% made of gadoids in Divisions VIIb-k during quarters 2 to 4. FR-OTDEF is a substitute for the discontinued FR-Gadoid and FR-*Nephrops* fleet.

Because of the strong recruitment of cod for 2009 and 2010, this limit of 40% has proven not reliable this year as more vessels were included which led to a suspicious increase of effort of 170%. During the WG, four indicators were used to evaluate the true relative difference in effort between 2011 and 2010, i.e. number of trips and number of days at sea in the Area VIIe-k by French trawlers and then in a restricted area including only those ICES rectangles where at least 1 ton of cod was fished during the two years (to exclude flatfish trawling areas in VIIe that could bias the estimates). The four indicators were extremely consistent giving values between -3% to +1%. The highest value (+1%) was retained for correcting the 2011 effort figure of the tuning series.

In 2012 and 2013, the calculation of French OTDEF demersal fleet tuning series was carried out by aggregating the effort of the vessel ids which reached the 40% threshold in 2009 and 2010 as these years were considered to be "normal" years for gadoids.

B.5. Other relevant data

Input from industry

No new datasets. There are several industry-science partnership regarding cod:

- French industry self-sampling programme.
- Ireland-UK tagging programme in the Irish and Celtic Seas.
- Irish industry-science partnership quarter 1 cod survey 2010.

At the moment only the data from the French self-sampling programme are integrated into the observation-at-sea dataset used at the assessment working group. Information on tagging are however reviewed each year at the WG and by WKROUND. An Irish industry–science partnership survey was carried out in Q1 2010. This survey has not been repeated due to resource constraints. Any new information provided by the industry are also reviewed each year.

French self-sampling programme

The French self-sampling programme was initiated in 2009 as a Fishery-Science partnership, under the auspices of the main fishermen's organisation P.D.B (Pêcheurs de Bretagne). Depending of the year, up to six otter trawlers has been participating, providing data for métiers targeting either gadoids (OTB or OTTPD), *Nephrops* (OTTLN) or benthic species such as monkfish, megrim, rays, john dory (OTB or OTTPB). Since 2010, these sampling data are provided by the Professional Organization (P.D.B) and stored in a database currently located at Ifremer/Lorient. Motivation of the crew or the vessel owners could become a problem in future. The reasons are that 1) the effort required of the industry to provide more biological data is not linked with incentives in setting TAC and quotas, 2) since 2009 there has been a pragmatic link between the quota set and change in fleet effort by métier, or even decommissioning, which led to an under-consumption of the agreed quota. In addition, the reduction of scientific staff to manage or deal with the data flows from the industry adds additional problems to have the information made available in time for the working group.

Ireland–UK tagging programme in the Irish and Celtic Seas and Irish industry–science partnership quarter 1 cod survey

A tagging programme on both nursery areas and spawning aggregations of cod in the Irish and Celtic Seas, involving conventional (plastic) tags and sophisticated electronic data storage tags, was initiated in 2007. The main objectives were to examine the movements of cod in relation to closed areas and in respect to stock mixing; to determine fine-scale movements and behaviour of cod during spawning; to examine vertical distribution (in relation to catchability) and thermal experiences (in relation to gonad development). Detailed results were presented to the ICES ASC in 2009 (Bendall *et al.*, 2009) and are summarized in the WGCSE 2012 report. No additional information was presented to the group this year.

In recognition of ICES advice (ICES, 2009), the Marine Institute and the Federation of Irish Fishermen, in 2010 initiated an annual Q1 fishery-independent survey for Celtic Sea Cod (See WGCSE 2012 for complementary information and Figure 7.2.1). No updated information was presented to the group this year and no further survey is planned.

C. Historical stock development

Model to be used: XSA

Software: R 2.8.1 with FLR packages FLCore 2.2, FLAssess 2.0.1, FLXSA 2.0, FLEDA 2.0.

Outputs of the XSA run using R are compared with outputs from VPA.95 software.

Model Options agreed at WKROUND 2012:

- Taper : no

- Age s catch dep. Stock size : none
- q plateau : 3
- F shrinkage se : 1
- F shrinkage year range : 5
- F shrinkage age range : 3
- F shrinkage age range of mean F: 2–5
- Fleet SE threshold : 0.3
- Prior weights : No

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Landings in tonnes	1971–	1–7+	Yes
Canum	Landings at age in numbers	1971–	1–7+	Yes
Weca	Weight at age in the commercial catch	1971–	1–7+	Yes
West	Weight at age of the spawning stock at spawning time.	1971–	1–7+	Yes
Mprop	Proportion of natural mortality before spawning	1971–	1–7+	No
Fprop	Proportion of fishing mortality before spawning	1971–	1–7+	No
Matprop	Proportion mature at age	1971–	1–7+	No
Natmor	Natural mortality	1971–	1–7+	No

Tuning data:

Type	Name	Year range	Age range
French Otter Trawler in Villek Q2-Q4	FR-OTDEF	2000–	1–7+
Combined EVHOE-WIBTS, IGFS-WIBTS	FR-IR-WIBTS	2003–	0–4+

Xsa.control:

```
xsa.control <- FLXSA.control(tol = 1e-09, maxit = 30, min.nse = 0.3, fse = 1.0,
                             rage = -1, qage = 3, shk.n = TRUE, shk.f = TRUE,
                             shk.yrs = 5, shk.ages = 3, window = 100, tsrange = 99,
                             tspower = 0)
```

D. Short-term projection

Model used: Age structured

Software used: STF R script

Initial stock size:

- 1) the survivors at-age 2 and greater from the XSA assessment;
- 2) N at-age 1 = long-term geometric mean omitting the last two years.

Maturity: same ogive as in the assessment

F and M before spawning: 0 (for all ages and years)

Weight-at-age in the stock: average stock and catch weights over the preceding three years.

Exploitation pattern: The F vector used is the average F -at-age in the last three years, scaled by F_{BAR} (2–5) to the level of last year unless there is strong indication of a significant trend in F . In the latter case the average selectivity pattern will be rescaled to the final F in the series.

E. Medium-term projections

Medium-term forecasts are not provided for this stock.

F. Yield and biomass per recruit

No stock–recruit relationship exists for this stock.

Software used: YPR 3.0 (NOAA fisheries toolbox)

- Stock/catch-at-age/spawning stock weights-at-age: Average last five years
- Selectivity on Fishing mortality: Rescaled F Average last five years
- Selectivity on Natural mortality: Rescaled M -at-age (Lorenzen), M at-age 1 = 1
- Fraction mature: same as maturity ogive
- Proportion of fishing/natural mortality before spawning: 0.0

G. Biological reference points

Cod in Divisions VIIe–k. Reference points, values and their technical basis.

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	10 300 t.	Default to value of B_{pa}	WD 2015-WGCSE
	F_{MSY}	0.32	(WD, 2015). Median point estimates of multiple stock–recruitment model using Eqsim. F_{MSY} ranges (0.20–0.45).	WD 2015-WGCSE
Precautionary approach	B_{lim}	7300 t.	Biomass at F50%	WD 2015-WGCSE
	B_{pa}	10 300 t.	$B_{pa} = B_{lim} \times 1.4$. Biomass above this value affords a high probability of maintaining SSB above B_{lim} , taking into account the variability in the stock dynamics and the uncertainty in assessments.	WD 2015-WGCSE
	F_{lim}	0.78	F50%	WD 2015-WGCSE
	F_{pa}	0.56	$F_{pa} = F_{lim} \exp(-1.645\sigma)$, with σ of 0.2 (ICES, 2013).	WD 2015-WGCSE
Management plan	SSB _{MGT}	Undefined.		WD 2015-WGCSE
	F_{MGT}	Undefined.		WD 2015-WGCSE

H. Other issues

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