
Stock Annex: Cod (*Gadus morhua*) in Division 7.a (Irish Sea)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Cod

Working Group: Working Group for the Celtic Seas Ecoregion (WGCSE)

Date:

Authors:

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Last updated by: Alessandro Ligas

A. General

A.1. Stock definition

All catches and survey data from within ICES Division 7.a are assumed to come from a unit stock. Stock structure of cod in European waters has been the subject of increasing study in recent years. Current information is summarized in Crozier *et al.*, 2007.

Recent egg surveys in 2006 and 2008, using DNA probes to distinguish early stage eggs of cod from other gadoids, confirm the location of distinct cod spawning grounds in the western and eastern Irish Sea (Goodsir *et al.*, 2008). Historical tagging studies indicated spawning site fidelity but varying degrees of mixing of cod between the Irish Sea, Celtic Sea and west of Scotland/north of Ireland (see Lordan *et al.*, 2011). Studies based on meristic characteristics, allele frequencies and micro-satellite markers genetics and population structure have not provided unequivocal evidence of genetically isolated stocks in the Irish Sea and surrounding waters.

A recent tagging programme run from 1997–2000, in which over 2200 cod were tagged using external and data storage tags revealed that although there was some movement of cod between the Irish and Celtic Seas, the component of Irish Sea cod in the Celtic Sea was low. Furthermore, no cod tagged in the Celtic Sea were recovered from the Irish Sea (Connolly and Officer, 2001). One problem with interpreting this evidence is that the overall stock sizes in both areas have declined significantly in recent years. There may therefore have been changes in geographic range and movement patterns making comparison of recent results with earlier studies problematic.

More recent tagging of cod off Greencastle on the north coast of Ireland (Ó Cuaig and Officer, 2007), and limited tagging on UK Fisheries Science Partnership surveys, have demonstrated movements of cod between Division 6.a and 7.a. Most recaptures in 7.a from cod tagged in 6.a have come from the North Channel and in or near the deep basin in the western Irish Sea that is a southward extension of the North Channel. The research surveys used for tuning the 7.a cod assessment cover only the western and eastern Irish Sea, and do not extend into the deeper water of the North Channel, where large catches of cod were made by mid-water trawlers in the 1980s and 1990s.

Immature cod may disperse over a wide area as demonstrated by fish tagged and released from various parts of the Irish Sea (including Belfast Lough). These demonstrated a substantial migration into the Celtic Sea and round the north and west of

Ireland. Once these fish mature however they appear to return to the Irish Sea spawning grounds. Extensive tagging off the West of Scotland produced no recaptures from the Irish Sea.

Further tagging and genetics studies are required to investigate stock structure, seasonal movements and mixing in 7.a and neighbouring areas. New tagging studies of cod in the Irish Sea, Celtic Sea and to the north of Ireland have taken place in 2008–2009.

A.2. Fishery

Irish Sea fisheries for cod have changed considerably over the last four decades: A brief description is given below.

1960s and 1970s. UK and Irish single otter trawlers targeted spawning cod in spring in both the western and eastern Irish Sea. Fisheries for young cod (codling) took place in autumn and winter. The growing single-rig *Nephrops* fleet took by-catches of cod. Several strong year classes of cod were formed resulting in good catches. Fleets were catching around 40–50% of the stock of adult fish each year.

1980s. Development of mid-water trawls and bottom-trawls capable of fishing on rough grounds opened up opportunities to fish in difficult areas such as the North Channel. “Dual purpose” trawls were developed to optimize catches of *Nephrops* and whitefish. The English beam trawl fleet grew rapidly in the 1980s, taking a bycatch of cod. The percentage of the stock of adult cod caught each year increased from 50% to 60%. Throughout the 1980s, TACs remained well above scientific advice to avoid triggering of The Hague Preference agreement which would have given Irish fleets a relatively bigger fraction of the TAC.

1990s. Mid-water trawlers developed a summer and autumn fishery for cod. The English otter trawl fleet declined and was reduced to inshore vessels taking mixed demersal fish, including codling. Fishing effort of the English beam trawl fleet peaked in 1990 then declined. Twin-rig trawling for *Nephrops* and whitefish grew rapidly in the 1990s. This fleet also took a bycatch of cod. The Irish whitefish fleet moved increasingly to grounds off the south and west coasts, leaving mainly a *Nephrops* fleet and a number of vessels fishing rays, cod and haddock in the Irish Sea. A major change in the 1990s was the growth of the haddock stock. Vessels that would have fished for cod also targeted haddock in the western Irish Sea, although still taking a bycatch of cod in certain areas and time periods.

2000 onwards. Emergency measures were introduced in 2000 to allow the maximum number of cod to spawn. These measures included a closure of the western and eastern Irish Sea spawning grounds from mid-February to the end of April, and modifications to trawl gear to improve selectivity. The closure was retained in 2001–2005, but only in the western Irish Sea. Derogations were allowed for *Nephrops* fishing in the closure, and experimental fisheries for haddock, flatfish and rays were permitted in some years with observers. Irish scientists successfully tested inclined separator panels in *Nephrops* trawlers, demonstrating large reductions in bycatch of cod. Vessels using such panels have been allowed to fish over a wider area of the closure since 2002. Vessels displaced from the closed area either switched to twin-rigging for *Nephrops*, fished for cod in the North Channel and Clyde, or tied up. From 2001, the Clyde fishing grounds were also closed in spring as part of emergency measures to protect west-of-Scotland cod. TACs for Irish Sea cod from 2000 onwards were reduced substantially.

Technical measures

The fishery is managed by a combination of TAC, area closures, technical measures, and effort restrictions.

In 2000, the cod spawning grounds were closed for ten weeks from mid-February to maximize the reproductive output of the stock (EU Regulations 304/2000 and 2549/2000). Revisions in 2001, 2002, and 2003 reduced the closure to the western Irish Sea only, coupled with changes in net design to improve selectivity. There are various derogations for gears not targeting cod, notably *Nephrops* trawls. During the closure, whitefish trawlers have been displaced to other fishing grounds or have switched to *Nephrops* trawling using 70–89 mm mesh nets.

The cod recovery plan introduced a system for limiting fishing effort by adjusting the number of fishing days allowed for various vessel categories deploying gears with various mesh sizes. STECF 2008 reported that the fishing effort of trawlers using 100–119 mm mesh declined by 83% between 2003 and 2007, and by 86% for vessels with a track record of <5% cod in their landings. This was as a consequence of a combination of factors restricting the activities of these vessels. A number of whitefish vessels switched to *Nephrops* gears to take advantage of the additional days at sea and the high value of *Nephrops* and some were removed from the fleet. Despite vessels switching to *Nephrops* fishing, the fishing effort of trawlers with 70–99 mm mesh declined by 2% between 2003 and 2007 and by 16% for vessels with a track record of <5% cod. This partly reflects vessels being decommissioned or increasingly fishing in the North Sea. Effort of beam trawlers declined by 48% and effort of fixed nets declined by 31% between 2003 and 2007.

New technical regulations for EU waters came into force on 1 January 2000 (Council Regulation (EC) 850/98 and its amendments). The regulation prescribes the minimum target species' composition for different mesh size ranges. Since 2001, cod in Division 7.a have been a legitimate target species for towed gears with a minimum codend mesh size of 100 mm. The minimum landing size for cod in the Irish Sea is 35 cm.

Management plans

Regulation (EC) No 423/2004 introduced cod recovery measures aimed at progressive rebuilding of spawning-stock biomass. However in 2008 the EU adopted a long-term plan for cod stocks and the fisheries exploiting those stocks (Council Regulation (EC) 1342/2008) that repeals Regulation (EC) No 423/2004, and has the objective of ensuring the sustainable exploitation of the cod stocks on the basis of maximum sustainable yield while maintaining a target fishing mortality of 0.4 on specified age groups.

The scientific evaluation of the revised cod Management Plan (Council Regulation (EC) 1342/2008) indicates that it may not be sufficiently precautionary to allow rebuilding of the Irish Sea cod stock to a level where it can regain historical productivity by 2015 (see WGCSE 2009 Report, Section 9.2). The probability of recovery of the cod stock will be increased by measures to eliminate discards of cod which historically have mainly comprised undersized fish.

Effort control

Direct control of fishing effort has been a key aspect of cod recovery plans. Monthly effort limitation was extended to the Irish Sea (and other “cod recovery” areas) under Annex V to Council Regulation (EC) No 2287/2003. This Regulation and subsequent

amendments (e.g. Council Regulation (EC) No 27/2005) restrict the number of allowable days fishing per month according to gear type, mesh size band and various derogations.

The effort regulations have provided an incentive for some vessels previously using >100 mm mesh in otter trawls to switch to smaller mesh gears, thus claiming a larger number of days-at-sea.

A.3. Ecosystem aspects

Recruitment and the environment

There is evidence that the reduction in cod recruitment observed in the Irish Sea since the 1990s may be as a consequence of a combination of small spawning-stock biomass and poor environmental conditions, coinciding with a shift towards above-average sea temperatures (ICES, 2006).

B. Data

B.1. Commercial catch

B.1.1. Landings

Quarterly and annual landings data have been supplied by the UK (N. Ireland), UK (E&W), UK (Scotland), Ireland, Belgium, and the IOM from databases maintained by national Government Departments and research agencies. The landings figures may be adjusted by national administrations or scientists to correct for known or estimated misreporting by area or species. To avoid double counting of landings data, each UK region supplies data for UK landings into its regional ports, and landings by its fleet into non-UK ports.

Member States that have collected length and age composition data for 7.a cod as required by the EU data Collection Framework entered quarterly and annual landings-at-age data on InterCatch. Quarterly and annual estimates of landings-at-age are provided by the UK (E&W), UK (NI), Belgium and Ireland. These have been raised to include landings by the other countries, then summed over quarters to produce the annual figures for input to stock assessment.

In addition, the stock coordinator compiles the international landings and catch-at-age data and maintains a time-series of such data with any amendments (Cod 7a CNAA 1991–2012.XLS). The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the stock co-ordinator.

Adjustments to official landings data

The input data on fishery landings and age compositions are split into four periods (Figure 6.2.21):

- 1) 1968–1990. Landings in this period, provided to ICES by stock coordinators from all countries, are assumed to be un-biased and are used directly as the input data to stock assessments.
- 2) 1991–1999. TAC reductions in this period caused substantial misreporting of cod landings into several major ports in one country, mainly species misreporting. Landings into these ports were estimated based on observations of cod landings by different fleet sectors during regular port visits. For other

national landings, the WG figures provided to ICES stock coordinators were used.

- 3) 2000–2005. Cod recovery measures were considered to have caused significant problems with estimation of landings. The ICES WG landings data provided by stock coordinators for all countries are considered uncertain and estimated within an assessment model. Observations of misreported landings were available for 2000, 2001, 2002 and 2005. However, they have generally not been used to correct the reported landings but have been used to evaluate model estimates in those years.
- 4) 2006–2012. The introduction of the UK buyers and sellers legislation is considered to have reduced the bias in the landings data but the level to which this has occurred is unknown. Consequently comparisons were made between the fit of the model to recorded landings under an assumption of bias and unbiased information.

In addition to the above, Irish landings of cod reported from ICES rectangles immediately north of the Irish Sea/Celtic Sea boundary (ICES rectangles 33E2 and 33E3) have been reallocated into the Celtic Sea as they represent a combination of inaccurate area reporting and catches of cod considered by ICES to be part of the Celtic Sea stock (ICES, 2009). The amount of Irish landings transferred from 7.a to 7.e–k by year is shown below:

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Tonnes	108	54	103	527	558	193	143	147	130	75

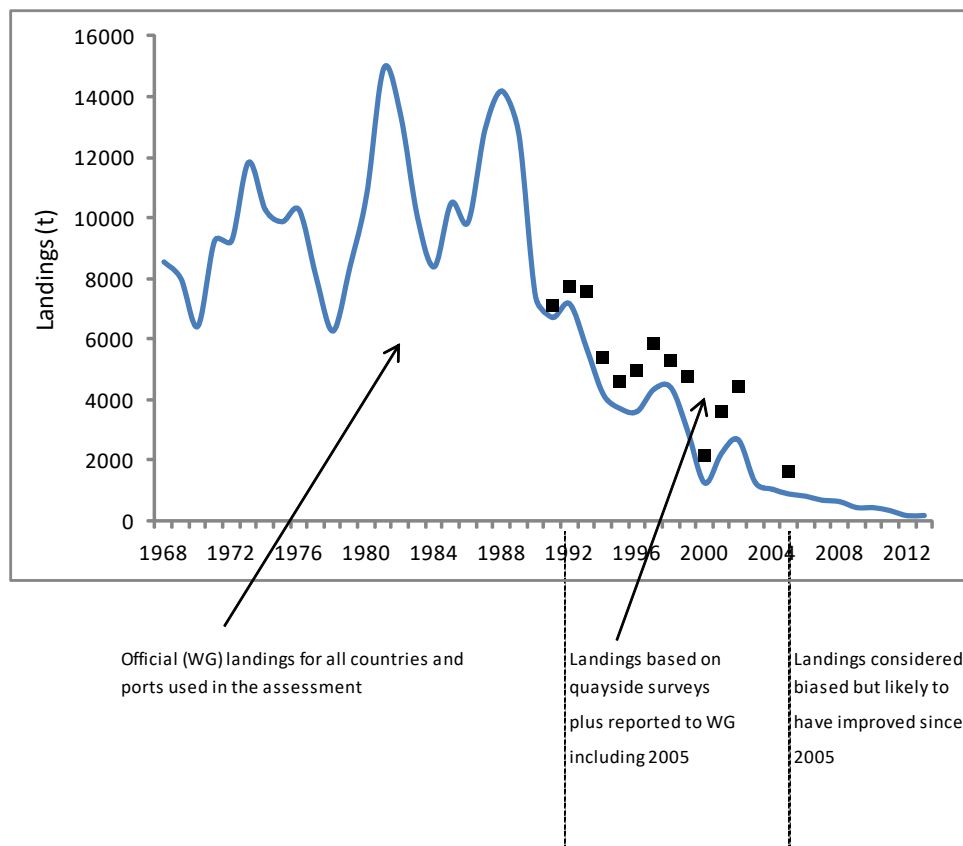
The higher level in 2007 and 2008 was a consequence of limited quota in 7.e–k and available quota in 7.a. Since 2009 more restrictive monthly quotas have been set for 7.a during periods of high cod abundance close to the 7.a–g boundary.

There are no long-term trends in catch weights-at-age from 1982 onwards. Weights-at-age prior to 1982 are fixed at constant values lower than estimated for subsequent years, leading to sum-of-products errors, and weights-at-ages 6+ are becoming noisy for the last few years. Given these problems, and the likelihood of further deterioration in the quality of the data on older aged fish, WGCSE and WKROUND2 considered that future revision of historical catch-at-age data and associated weights is considered appropriate.

However, WKROUND2 established that revising the weight-at-age would only represent only minor refinements to the model estimates of mortality and SSB trends and the reference point which are dependent on them compared to the sensitivities associated with the estimation of unallocated mortality. Consequently the revision of the weights-at-age should be conducted following the determination of the reasons for the current high mortality rates on the stock.

Total mortality rates for the stock have been high throughout the time period for which information is available. Even when the stock was considered abundant and recruitment levels supported high levels of catch the gradient of the catch curve was in the range 0.8–1.0. Year classes rapidly disappeared from the commercial landings data. The increase in the negative slope indicates that total "mortality" rates have increased over time and now are double that recorded in the historic data during the period when the stock was abundant. There is currently no evidence from the age compositions from

surveys or commercial fishery operations of any improvement in age structure that would result from a reduction in total mortality.



B.1.2. Discards

No discards data are currently included in the assessment. Suitable discards estimates are not available prior to the mid-1990s and are not complete for many subsequent years. Available data indicate that discarding was historically mainly a function of MLS (35 cm) and therefore mainly restricted to catches of ≤ 1 -gp cod.

EU countries are now required under the EU Data Collection Framework to collect data on discards of cod and other species. Consequently at WKROUND 2012 collation of recent discard information provided by Member States for the stock was carried out as a scoping exercise ready for future modelling and the provision of advice.

Up to 2003, estimates of discards are available only from limited observer schemes and a self-sampling scheme. Observer data are collected using standard at-sea sampling schemes. Results have been reported to ICES. Discards data (numbers-at-age and/or length frequencies) are have been supplied for 7.a cod by Ireland, UK (Northern Ireland) and UK (E&W) and Belgium. The data were supplied raised to the appropriate fleet/métier level by the member states.

Discards raising

Ireland: Length frequencies from Irish (Marine Institute) observer trips in specified fleet métiers are raised to the trip level, averaged across trips during each year (not by quarter) then multiplied by the annual number of trips per year in the Irish fleet in 7.a

to give raised annual LFDs for discards. An age–length key from discards trips is then applied to give annual discards by age class and métier.

Northern Ireland self-sampling scheme: The quantity of cod discarded from the UK (NI) *Nephrops* fishery from 1996 to 2002 was estimated on a quarterly basis from samples of discards and total catch provided by skippers. The discards samples contain the heads of *Nephrops* tailed at sea. Using a length–weight relationship, the live weight of *Nephrops* that would have been landed as tails only is calculated from the carapace lengths of the discarded heads. The number of cod in the discard samples is summed over all samples in a quarter and expressed as a ratio of the summed live weight of *Nephrops* in the discard samples (i.e. those represented as heads only in the samples). The reported live weight of *Nephrops* landed as tails only is then used to estimate the quantity of cod discarded using the cod:*Nephrops* ratio in the discard samples. The length frequency of cod in the discard samples is then raised to the fleet estimate.

Northern Ireland observer trips: Length frequencies from NI (AFBI) observer trips in specified fleet métiers are raised to the trip level, summed across trips during each year or by quarter then raised to the annual number of trips per year in the NI fleet in 7.a to give raised annual LFDs for discards. An age–length key from discards trips is then applied to give annual discards by age class and métier.

UK (E&W) observer trips: Trips are arranged on vessels selected using a vessel randomisation scheme. Discard numbers are raised to sampled hauls then to the trip. The trip-raised length frequencies from Cefas observer trips in specified fleet métiers are then raised to the trip level, summed across trips during each quarter. Sampled quarters are then raised to total discards by quarter from the landings to discards ratios at age. As recorded in the data sent annually to ICES catches and discards of cod within the Irish Sea by UK (E&W) vessels have been extremely low for a number of years. For instance in 2010, 63 hours fishing were observed distributed across quarters 1–4 with three cod caught and one discarded in quarter 1 (six hours trawling), 21 caught and 20 discarded in quarter 2 (32 hours) and 0 (zero) cod caught and discarded in quarters 3 (twelve hours) and 4 (13 hours).

Belgium observer trips: Several Belgian métiers are operating in the Irish Sea. The beam trawl fleet targeting sole and plaice (TBB_DEF_70-99_0_0) is the most important fleet, but, it should be noted that the OTB_DEF_70-99_0_0 métier (otter trawls) is becoming more important each year. Part of the landings and effort that could not be allocated to the main métiers, are referred to as: ‘no allocated métier’. Since the observers only collect information from the commercial beam trawlers, the data can only be raised to the TBB_DEF_70-99_0_0 fleet and not to all Belgian métiers operating in the Irish Sea. In order to find the most suitable raising procedure for the Belgian discard (and landing) data, the tools developed by the COST project were used. Having considered the different raising procedures, raising by hauls was found to be the most appropriate method for the Belgian cod 7.a data. The results of the raising procedure were scaled relative to the official landings. The time stratification for the Belgian data is by year, as sampling was insufficient to provide quarterly figures. It should be noted that due to the lack of Belgian individual length–weight information, the length–weight keys used in the analyses, are based on Irish sampling data. Note also that the Belgian minimum landing size has changed a couple of times over the last years, which is reflected in the differences in length–frequency distributions between years of the retained and discarded part of the catch.

- From the beginning of 2004 until the 30th of June 2008: 40 cm;
- From the 1st of July 2008 until 30th of September 2011: 50 cm;

- From the 1st of October 2011 up to today: 35 cm.

Raising to total international discards

National, raised to fleet discard numbers-at-age from Ireland, Belgium, UK(E&W) and NI were added to give the international numbers (with no additional weighting). The data represent the main fleets discarding cod, i.e. *Nephrops* and beam trawlers.

The current discard information is considered representative of the information for the main fleets highlighting strong differences between national, quarterly and potentially regional discard rates as the national fleets tend to fish differing areas with differing gears.

The time-series are still too short to include the data within an assessment and at the youngest ages discard raising still needs some development, however that also applies to landings numbers-at-age, which have deteriorated significantly in quality in recent years in terms of sampling levels due to low levels of landings.

B.2. Biological

Natural mortality

The current assessment uses constant values of $M=0.2$ (all ages).

Maturity

Maturity-at-age is summarized in the text table below.

Age	0	1	2	3+
Proportion Mature (1968-1995)	0	0	0.38	1
Proportion Mature (2001-to present)	0	0	0.65	1

A transition from the historic value of 0.38, developed at WKROUND2, is adopted for the period between 1996 and 2000.

B.3. Surveys

Nine research vessel survey series for cod in 7.a were used by WGCSE in 2013 and 2014. In all surveys listed the highest age represents a true age not a plus group.

- UK (England and Wales) Beam Trawl Survey (E/W-BTS-Q3): ages 0 (brought forward to obtain indices of age 1), years 1993 (1994)–2013 (2014).

The survey covers the entire Irish Sea excluding the North Channel and is conducted in September on the R.V. *Corystes*. The survey uses a 4 m beam trawl targeted at flat-fish. The survey is stratified by area and depth band, although the survey indices are calculated from the total survey catch in the eastern Irish Sea, and without accounting for stratification except for ALKs. Numbers of 0-gp and 1-gp cod at-age per 100 km towed are provided for prime stations only (i.e. those fished in most surveys). An automated data extraction and analysis routine in *r* is now used, and the series was revised in 2008 using this routine. The 2009 assessment used data for years 1993 onwards.

- UK (Northern Ireland) October Groundfish Survey (NIGFS-WIBTS-Q4): ages 1–3, years 1992–2013.

The survey-series commenced in its present form in 1992. It comprises 45 three mile tows at fixed station positions in the northern Irish Sea, with an additional twelve one mile tows at fixed station positions in the St George's channel from October 2001 (the latter are not included in the tuning data). The surveys are carried out using a rock-hopper otter trawl deployed from the R.V. Lough Foyle. The survey designs are stratified by depth and seabed type. Virtually all cod are aged apart from 0-gp and 1-gp fish when particularly abundant. An ALK for the whole survey is used for filling in for any length groups with no ages at a station. Mean numbers-at-age per 3-mile tow are calculated separately by stratum, and weighted by surface area of the strata to give a weighted mean for the survey or group of strata. From 2002 onwards, all stations in the survey have been reduced to 1 nautical mile. A number of comparative 1-mile and 3-mile tows are done during each survey to build up calibration data. Since 2005, the RV Lough Foyle used for all surveys since 1992 has been replaced by the larger RV Corystes. The trawl gear and towing practices have remained the same.

- UK (Northern Ireland) March Groundfish Survey (NIGFS-WIBTS-Q1): ages 1–5, years 1993–2014.

General description as for October Surveys above, except that 3-mile stations have been retained in all strata other than in the St Georges Channel. Since 2005, the RV Lough Foyle used for all surveys since 1993 has been replaced by the larger RV Corystes. The trawl gear and towing practices have remained the same. The 1992 survey had only partial coverage of the western Irish Sea and is no longer used in the assessment.

- UK (Northern Ireland) Methot–Isaacs–Kidd Survey (NIMIK): age 0 (brought forward to obtain indices of age1), years 1994 (1995)–2013 (2014).

The survey uses a Methot–Isaacs–Kidd frame trawl to target pelagic juvenile gadoids in the western Irish Sea at 40–45 stations. The survey is stratified and takes place in June during the period prior to settlement of gadoid juveniles. Indices are calculated as the arithmetic mean of the numbers-per-unit sea area.

- UK (Scotland) groundfish survey in spring (ScoGFS-WIBTS-Q1): ages 1–5, years 1996–2006.

This survey represented an extension of the Scottish West Coast groundfish survey (Area 6), using the research vessel Scotia. The survey gear is a GOV trawl, and the design is two fixed-position stations per ICES rectangle from 1997 onwards (17 stations) and one station per rectangle in 1996 (nine stations). The survey extends from the Northern limit of the Irish Sea to around 53°30'.

- UK (Scotland) groundfish survey in autumn (ScoGFS-WIBTS-Q4): ages 1–2, years 1997–2007.

This survey represented an extension of the Scottish West Coast groundfish survey (Area 6), using the research vessel Scotia. The survey gear is a GOV trawl, and the design is two fixed-position stations per ICES rectangle from 1997 onwards (17 stations) and one station per rectangle in 1996 (nine stations). The survey extends from the Northern limit of the Irish Sea to around 53°30'.

- UK Fishery Partnership Surveys (UK-FSP), Western Irish Sea, in March: ages 1–5, years 2005–2013.

The Irish Sea roundfish survey was initiated in 2003 as a fully collaborative project between the fishing industry and Cefas scientists. It forms part of the UK Fisheries Science Partnership funded by the UK's Department for Environment, Food and Rural Affairs (Defra). The main objective of the Irish Sea roundfish survey is to develop a

time-series of data to track year-on-year changes in abundance, population structure and distribution of the target species (cod, haddock and whiting). The results of the surveys provide information supporting the scientific assessment of the stocks and the management of the fisheries in the Irish Sea. The surveys were designed to achieve full coverage of potential cod, haddock and whiting habitats within the area of the main roundfish fisheries of the Irish Sea, using a stratified design to allow additional trawling effort in areas expected to have the greatest densities of cod, haddock or whiting.

- UK Fishery Partnership Surveys (UK-FSP), Eastern Irish Sea, in March: ages 1–5, years 2005–2013.

The Irish Sea roundfish survey was initiated in 2003 as a fully collaborative project between the fishing industry and Cefas scientists. It forms part of the UK Fisheries Science Partnership funded by the UK's Department for Environment, Food and Rural Affairs (Defra). The main objective of the Irish Sea roundfish survey is to develop a time-series of data to track year-on-year changes in abundance, population structure and distribution of the target species (cod, haddock and whiting). The results of the surveys provide information supporting the scientific assessment of the stocks and the management of the fisheries in the Irish Sea. The surveys were designed to achieve full coverage of potential cod, haddock and whiting habitats within the area of the main roundfish fisheries of the Irish Sea, using a stratified design to allow additional trawling effort in areas expected to have the greatest densities of cod, haddock or whiting.

- UK IS-AEMP, Irish Sea, in March: SSB index, years 1995, 2000, 2006, 2008, 2010.

The Annual Egg Production Survey has been used to obtain estimates of cod spawning-stock biomass in the Irish Sea.

B.4. Commercial cpue

Commercial cpue for several national fleets are available to ICES, but these are no longer used in the assessment.

B.5. Other relevant data

No other relevant data.

C. Assessment: data and method

Model used: SAM (State-space assessment model)

Software used: FLSAM 0.99–99.

The SAM model allows for the inclusion of a spawning biomass index which the B-ADAPT would need recoding for. Consequently and in view of the current trend within ICES to move assessments towards statistical models, and the consistency with B-ADAPT in the previous WGCSE evaluation of the stock, the SAM model was chosen for the assessment of the Irish Sea cod.

Model configuration

```
# FLSAM.version          0.99-99
# FLCore.version         2.4
# R.version              R version 2.13.1 (2011-07-08)
# platform                i386-pc-mingw32
```

```

# run.date                2014-05-15 11:15:52# Auto generated
file
# Min, max age represented internally in model
  1 6
# Max age considered a plus group? (0 = No, 1= Yes)
  1
# Coupling of fishing mortality STATES (ctrl@states)
# 1 2 3 4 5 6 #
  1 2 3 4 5 5 # catch
  0 0 0 0 0 0 # NIGfsMar
  0 0 0 0 0 0 # ScoGfsQ1
  0 0 0 0 0 0 # ScoGfsQ4
  0 0 0 0 0 0 # NIGfsOct
  0 0 0 0 0 0 # UKFspW
  0 0 0 0 0 0 # UKFspE
  0 0 0 0 0 0 # EngBtsSep
  0 0 0 0 0 0 # NIMikNet
  0 0 0 0 0 0 # EggSurvey

# Coupling of catchability PARAMETERS (ctrl@catchabilities)
# 1 2 3 4 5 6 #
  0 0 0 0 0 0 # catch
  1 2 3 4 4 0 # NIGfsMar
  5 6 7 8 9 0 # ScoGfsQ1
 10 11 0 0 0 0 # ScoGfsQ4
 12 13 13 0 0 0 # NIGfsOct
 14 15 16 17 17 0 # UKFspW
 18 19 20 20 20 0 # UKFspE
 21 0 0 0 0 0 # EngBtsSep
 22 0 0 0 0 0 # NIMikNet
  0 0 0 0 0 0 # EggSurvey

# Coupling of power law model EXPONENTS (ctrl@power.law.exps)
# 1 2 3 4 5 6 #
  0 0 0 0 0 0 # catch
  0 0 0 0 0 0 # NIGfsMar
  0 0 0 0 0 0 # ScoGfsQ1
  0 0 0 0 0 0 # ScoGfsQ4
  0 0 0 0 0 0 # NIGfsOct
  0 0 0 0 0 0 # UKFspW
  0 0 0 0 0 0 # UKFspE
  0 0 0 0 0 0 # EngBtsSep
  0 0 0 0 0 0 # NIMikNet
  0 0 0 0 0 0 # EggSurvey

# Coupling of fishing mortality RW VARIANCES (ctrl@f.vars)
# 1 2 3 4 5 6 #
  1 1 1 1 1 1 # catch
  0 0 0 0 0 0 # NIGfsMar
  0 0 0 0 0 0 # ScoGfsQ1
  0 0 0 0 0 0 # ScoGfsQ4
  0 0 0 0 0 0 # NIGfsOct
  0 0 0 0 0 0 # UKFspW
  0 0 0 0 0 0 # UKFspE
  0 0 0 0 0 0 # EngBtsSep
  0 0 0 0 0 0 # NIMikNet
  0 0 0 0 0 0 # EggSurvey

# Coupling of log N RW VARIANCES (ctrl@logN.vars)
  1 1 1 1 1 1

# Coupling of OBSERVATION VARIANCES (ctrl@obs.vars)
# 1 2 3 4 5 6 #
  1 1 1 1 1 1 # catch
  2 3 3 4 4 0 # NIGfsMar

```

```

    5  6  6  7  7 0 # ScoGfsQ1
    8  9  0  0  0 0 # ScoGfsQ4
   10 11 11  0  0 0 # NIGfsOct
   12 13 13 14 14 0 # UKFspW
   15 16 16 17 17 0 # UKFspE
   18  0  0  0  0 0 # EngBtsSep
   19  0  0  0  0 0 # NIMikNet
    0  0  0  0  0 0 # EggSurvey
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more
in time
0
# Years in which catch data are to be scaled by an estimated
parameter (mainly cod related)
9

# Years
2003 2004 2006 2007 2008 2009 2010 2011 2012 2013
#Ages
  1  1  1  1  1  1
  2  2  2  2  2  2
  3  3  3  3  3  3
  4  4  4  4  4  4
  5  5  5  5  5  5
  6  6  6  6  6  6
  7  7  7  7  7  7
  8  8  8  8  8  8
  9  9  9  9  9  9
 10 10 10 10 10 10
# Fbar range
2 4
# Checksums to ensure correct reading of input data
123456 123456

```

D. Short-term projection

E. Medium-term projections

F. Long-term projections

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY B _{trigger}	10 000 t	B _{pa}
Approach	F _{MSY}	0.4	Provisional proxy. Fishing mortalities in the range of 0.25–0.54 are consistent with F _{MSY} .
	B _{lim}	6000 t	B _{lim} = B _{loss} , lowest observed level.
Precautionary	B _{pa}	10 000 t	B _{pa} = MBAL; this level affords a high probability of maintaining the SSB above B _{lim} . Below this value the probability of below-average recruitment increases.
Approach	F _{lim}	1.00	F _{lim} = F _{med}
	F _{pa}	0.72	F _{pa} : F _{med} * 0.72. This F is considered to have a high probability of avoiding F _{lim} . Fishing mortalities above F _{pa} have been associated with the observed stock decline.

(unchanged since: 2010)

H. Other issues

H.1. Historical overview of previous assessment methods

Until 2011.

Model used: B-Adapt.

Software used: B-Adapt-F.exe (13/5/06)

Model Options chosen:

SETTING	VALUES
Plus group	5-plus
F_{BAR} range	2–4 (arithmetic mean)
Year range for tuning VPA	1992 onwards
Surveys after final year of catch data used.	$F_{mult} = 0.75$
VPA model or cohort analysis used	v (exact)
First age with constant catchability	0 for all tuning fleets
q-plateau	Entered as 3 for all tuning fleets
Tapered time weighting applied	No
Number of missing catch multipliers	9 (from 2000 onwards)
No. ages for terminal F mean, and scaling factor for mean	ages = 1; scaling factor = 1.0; arithmetic mean (i.e. $F(4) = F(3)$)
Constraint on F or catch? Stiffness weight (λ)	Constrain F; $\lambda = 1.0$
Prior weighting of fleets	None
Output tables	VPA output

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