

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

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

<b>Stock</b>	Cod
<b>Working group</b>	WGCSE
<b>Last date when the stock was updated</b>	October 2023
<b>Revised by</b>	WGCSE
<b>Main modifications</b>	Removed recreational fishery, updated the effective sample size for the commercial fleet
<b>Last Benchmarked</b>	February 2022

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## A. General

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### 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, Cod tagging report 2019). Studies based on meristic characteristics, allele frequencies and microsatellite 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 divisions 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.

New tagging studies of cod in the Irish Sea, Celtic Sea and to the north of Ireland have taken place in 2008–2009. A new tagging study from 2016–2018 revealed movement of adult fish outside the area, while no evidence was seen of cod migrating into the 7a area.

Further tagging and genetics studies are required to investigate stock structure, seasonal movements and mixing in 7.a and neighbouring areas, a directed study started in 2022 using otolith trace element analysis and DST tagging.

## **A.2 Fishery**

### **A.2.1 General description**

Countries involved: UK, Ireland

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 bycatches 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.

## **A.2.2 Fishery management regulations**

### **A.2.2.1 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 80–89 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 80–99 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.

### **A.2.2.2 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.

#### **A.2.2.3 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**

#### **A.3.1 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**

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### **B.1 Commercial catch**

#### **B.1.1 Landings data**

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.

### B.1.2 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.
- 5 ) Data from 2020 have not been sufficiently sampled to provide numbers-at-age and raised discards due to limited sampling efforts during the Covid-19 lockdown.

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.

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.1.3 Discards estimates**

#### **B.1.3.1 Data coverage and quality**

Discards have been included in the 2017 assessment for the first time. Suitable discards estimates are not available prior to the mid-1990s and are not complete for many subsequent years; however, efforts have been made to estimate discards. Available data indicate that discarding was historically mainly a function of MLS (35 cm) and therefore mainly restricted to catches of  $\leq 1$ -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 supplied were raised to the appropriate fleet/métier level by the Member States.

Prior to 2000 discards from the NI *Nephrops* self-sampling scheme in the 1990s were raised to the international *Nephrops* fleet, discards from other NI fleets were added to the total discards without raising internationally.

As historically discards were largely from the *Nephrops* fleet consisting mainly of age 0 and 1 fish reported discards from the *Nephrops* fleet self-sampling scheme in the 1990s were averaged and then proportionally, depending on tonnage of *Nephrops* catches, historically back-calculated to the NI *Nephrops* fleet since 1968. Those values were then raised to the international *Nephrops* fleet.

For year 2003–2006, in which no discard data were available, discards were estimated as mean discards from the years 2007–2015.

#### **B.1.3.1.1 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.

### **B1.3.1.2 UK Northern Ireland**

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.

### **B.1.3.1.3 UK-England and Wales**

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).

### **B.1.3.1.4 Belgium**

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.

#### **B.1.3.2 International discard raising**

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.

#### **B.1.4 Recreational Data**

*The Recreational data is no longer included since the 2023 assessment due to high uncertainties.*

This section summarises marine recreational fishery (MRF) catch estimates for cod (*Gadus morhua*) provided by European countries for use by the Irish Sea cod benchmark meeting 2022 following a data call. The overall aim was to generate a time-series of recreational removals (retained plus dead releases) for use in the assessment. This involved collating all recreational catch and length data for the Irish Sea and summarising all studies of post-release mortality of cod. These were combined to generate a time-series of recreational removals (retained plus dead releases) and length–frequency distribution for removals that could be used in the assessment.

##### **B 1.4.1 Survey data and catch estimates**

Recreational catch estimates were provided by the whole of the UK for 2016–2020. Whilst Ireland also have access to the stock, their first national survey was conducted in 2020, but was hampered by COVID and so no catch estimates are available at present.

An off-site survey approach was adopted involving a UK-wide randomised face-to-face omnibus survey of water sports activities to estimate the number, demography and other characteristics of UK residents going sea angling during each year, and a panel of sea anglers volunteering each year to keep catch diaries to record number and sizes of fish retained and released in each fishing trip. Annual numbers and tonnages of fish retained and released are estimated for each species using a Bayesian multilevel regression model with post-stratification (termed MRP; Hyder *et al.*, 2022). It should be noted that the onsite UK estimates used in this analysis are likely to represent an over-estimate of the actual levels of catch, so represent a worst-case scenario. Numbers and tonnages Catch estimates were provided for all fishing platforms combined (shore and boat). The number and tonnage of fish retained and released, and the associated error are provided (Table 1). ICES area was not included as a factor in the MRP model, so estimates for 27.7.a had to be generated by partitioning national estimates. The proportion of fish caught within each ICES area estimated using a post-stratification approach (see Hyder *et al.*, 2021 for a description) was applied to the total catches estimated by MRP. For example, if the reweighting approach estimated that 10% of cod was caught in 27.7.a, and MRP estimated that 10 tonnes was caught in total, then the total catches in 27.7.a would be 1 tonne. Furthermore, the RSE provided here is based on the RSE from the reweighing procedure, which are typically larger than the errors from MRP due to the model's ability to use multiple years of data. The impact of this was reduced via calculating the re-weighting RSE for the whole time-series within each ICES area rather than in within individual years.

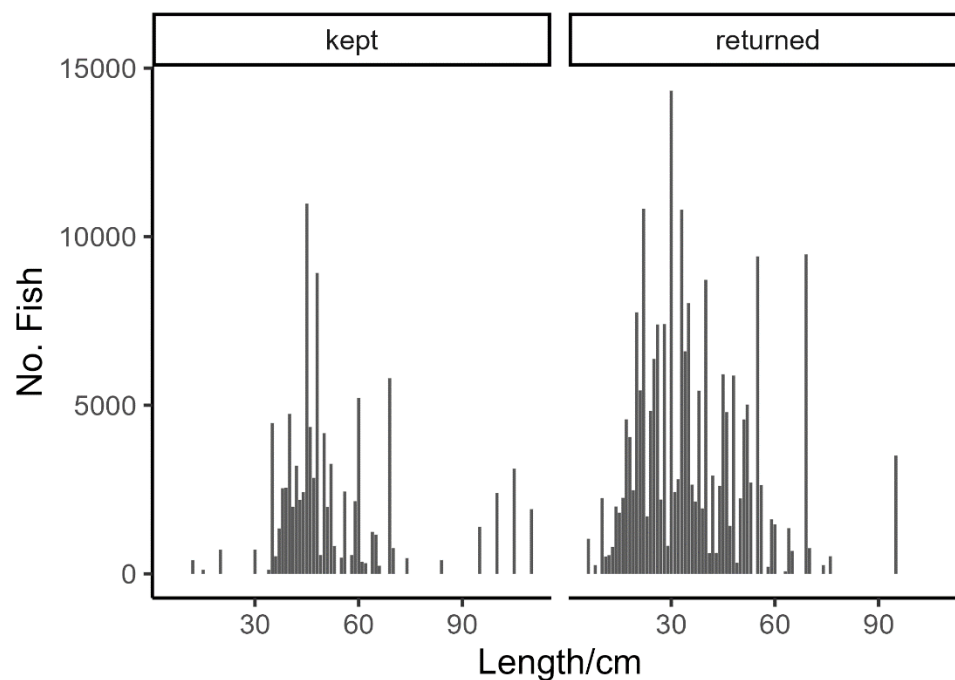


**Table 1: The total catches of Irish Sea Atlantic Cod by recreational fishers in the UK. RSE are given as %.**

Year	Component	Number	Number RSE/%	Tonnage	Tonnage RSE
2016	kept	21787	55.4	33.71	67.4
2016	returned	53339	38.9	31.27	70.8
2017	kept	21262	55.4	32.87	67.4
2017	returned	50882	38.9	29.86	70.8
2018	kept	18939	55.4	29.31	67.4
2018	returned	42937	38.9	25.22	70.8
2019	kept	16400	55.4	25.36	67.4
2019	returned	39833	38.9	23.39	70.8
2020	kept	17993	55.4	27.84	67.4
2020	returned	27852	38.9	16.32	70.8

#### B 1.4.2 Lengths of fish caught

Extrapolating the length-distribution of fish caught in the UK sea angling diary study to the total population was not done using the MRP model. Instead, the proportion of fish caught at each length was used to generate a length distribution of recreational kept and returned fish for the whole time-series are presented (Figure 1).



**Figure 1: The number of fish kept and returned at length in the UK's sea angling diary programme.**

#### B 1.4.3 Post-release mortality

As a precautionary approach the upper 95% confidence limit of 35.1% from the Capiz-zano *et al.* (2016) study is used as post-release mortality rate in the present document to derive recreational fishery removals of cod.

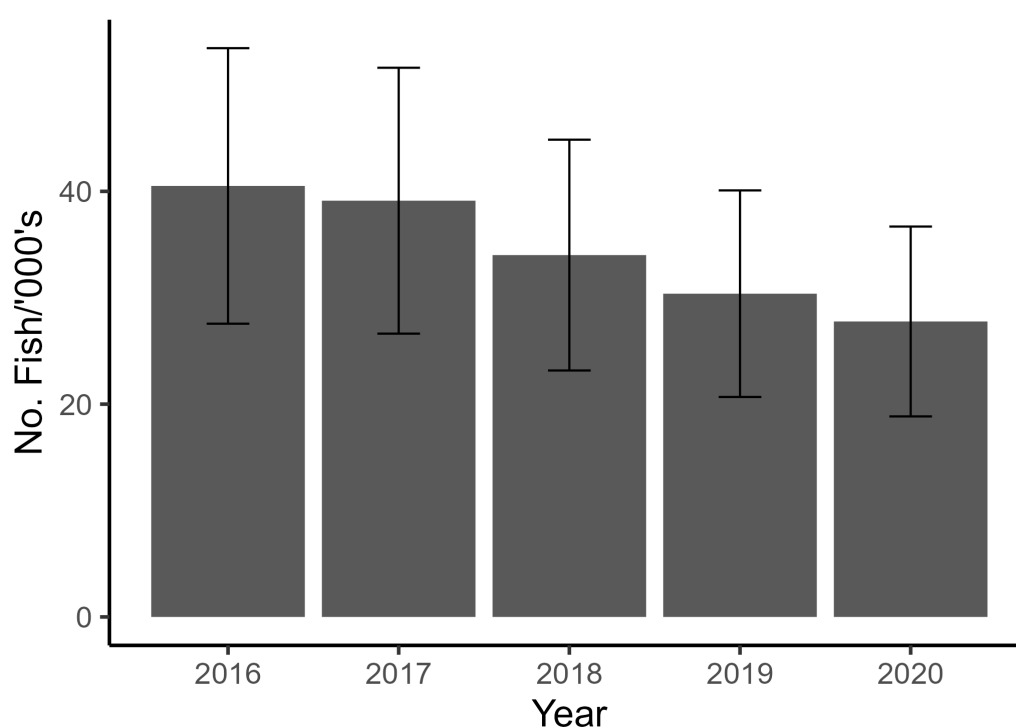
#### B 1.4.4 Recreational removals

##### B 1.4.4.1 Number and tonnage removed

The weight and number of fish removed for all three post-release mortality values were calculated (Table 2; Figures 2 and 3). This was done by adding the weight and number of fish kept to the number/weight of fish returned, multiplied by the relevant post-release mortality value. This assumes an average weight for fish returned that die after release.

**Table 2: The total removals of Irish Sea Atlantic Cod by recreational fishers in the UK assuming a 35.1% post-release mortality. RSE are given as %.**

Year	Number fish	Number RSE/%	Weight fish/t	Weight RSE/%
2016	40509	32.0	44.68	48.8
2017	39122	31.9	43.35	48.8
2018	34010	31.9	38.17	48.8
2019	30381	32.0	33.57	48.8
2020	27769	32.1	33.57	49.9



**Figure 2: The total number (thousands) of Atlantic Cod removed from the Irish Sea by UK recreational fishers.**

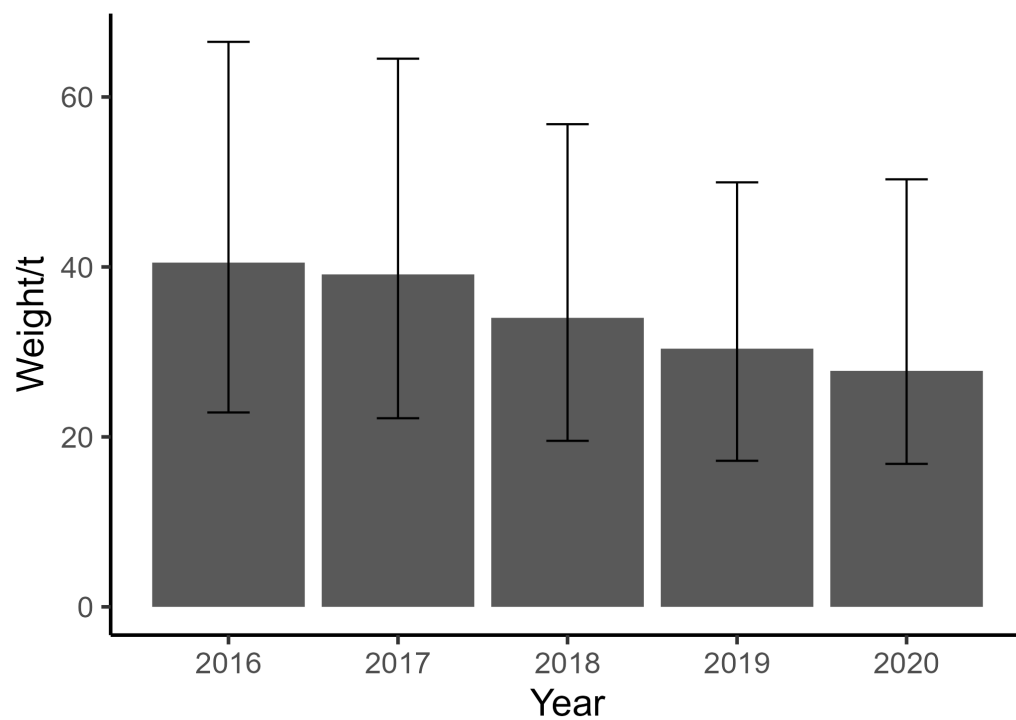


Figure 3: The total weight (tonnes) of Atlantic Cod removed from the Irish Sea by UK recreational fishers.

#### B 1.4.4.2 Length–frequency distribution of removals

The number of fish removed from the stock at each length category were calculated for all three post-release mortality values were calculated (Figure 4). However, as the sea angling diary programme does not aim to extrapolate length-distribution data to the total population, the proportion caught in each length group in the raw data were used to partition the total number caught at length.

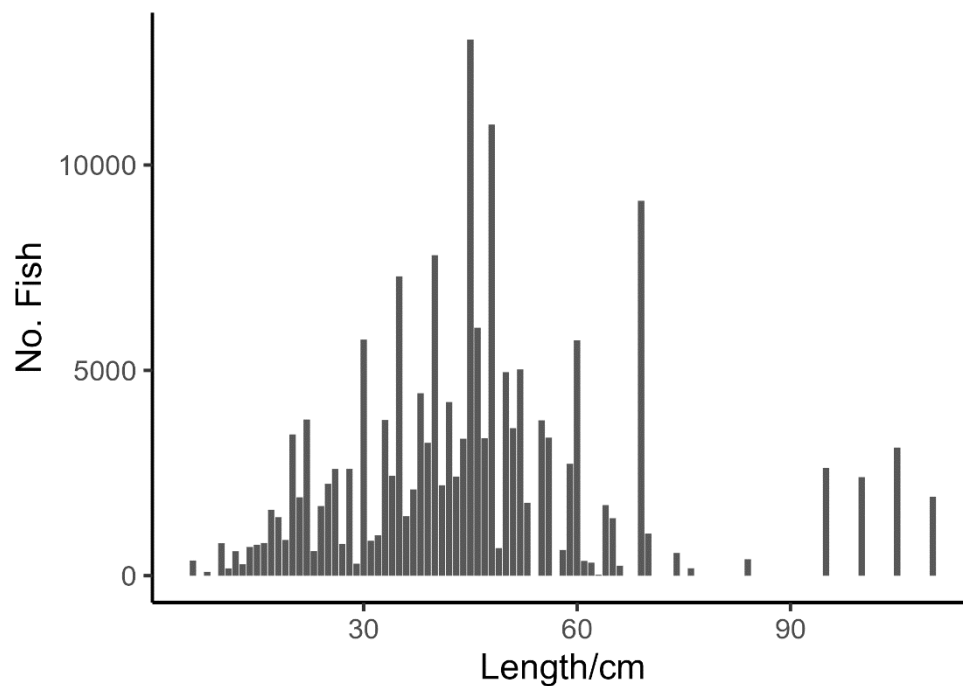


Figure 4: The number of Atlantic cod removed at length from the Irish Sea by UK recreational fishers assuming a 35.1% post-release mortality.

## B.2 Biological sampling

### B.2.1 Maturity

Maturity-at-age is summarized in the text table below. Maturity since 1997 varies annually, a smoother is applied which results in all values being adjusted annually.

AGE	<2	2	3+
Proportion mature 1968–1996	0	0.27	1
Proportion mature 1997	0	0.34	1
Proportion mature 1998	0	0.40	1
Proportion mature 1999	0	0.45	1
Proportion mature 2000	0	0.51	1
Proportion mature 2001	0	0.56	1
Proportion mature 2002	0	0.61	1
Proportion mature 2003	0	0.65	1
Proportion mature 2004	0	0.67	1
Proportion mature 2005	0	0.68	1
Proportion mature 2006–2008	0	0.69	1
Proportion mature 2009	0	0.70	1
Proportion mature 2010	0	0.70	1
Proportion mature 2011–2012	0	0.71	1
Proportion mature 2013	0	0.71	1
Proportion mature 2014	0	0.70	1
Proportion mature 2015	0	0.70	1
Proportion mature 2016	0	0.71	1
Proportion mature 2017	0	0.72	1

AGE	<2	2	3+
Proportion mature 2018	0	0.72	1
Proportion mature 2019	0	0.73	1
Proportion mature 2020	0	0.74	1

### B.2.2 Natural mortality

The current assessment uses the Lorenzen mortality estimates as used for a range of other gadoid species for ages 0 and 1, the older ages are estimated from the tagging data from the 1970s and 2017–2019.

Age	0	1	2	3+
M	1.7	0.714	0.68	0.65

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

## B.3 Surveys

Three of the nine available research vessel survey series for cod in 7.a were used for the assessment by WKNCS in 2022.

### B.3.1 UK (Northern Ireland) October Groundfish Survey (NIGFS-WIBTS-Q4): age 0 recruits, years 1995–2022

The survey series commenced in its present form in 1992, however the first three years data seemed unreliable data, and were excluded for the assessment. It initially 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 rockhopper otter trawl deployed from the RV Lough Foyle. The survey designs are stratified by depth and seabed type. Mean numbers 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.

### B.3.2 UK (Northern Ireland) March Groundfish Survey (NIGFS-WIBTS-Q1): ages 1–5, years 1995–2022

General description as for October surveys above, except that some 3-mile stations have been retained in all strata other than in the St Georges Channel. Virtually all cod are aged. An ALK for the whole survey is used for filling in for any length groups with no ages at a station. 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.

### B.3.3 UK Fishery Partnership Surveys (UK-FSP), Western Irish Sea, in March: ages 2–6, years 2005–2013, 2015–2022

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.

#### 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 methods and settings

#### C.1 Choice of stock assess model

Stock Synthesis (SS3) was used in the most recent stock assessment for cod in the Area 7.a.

#### C.2 Model used of basis for advice

#### C.3 Assessment model configuration

Table C-1. Assessment data updated in October 2023.

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR?
Caton	Catch in tonnes	1968–current, since 2016 inclusive of Recreational removals		Yes (except years 2003–2005)
Canum	Catch-at-age in numbers	1968–current	0–6+	Yes (except years 2003–2005)
Weca	Weight-at-age in the commercial catch	1968–current	0–6+	Yes (except years 2003–2005)
West	Weight-at-age of the spawning stock at spawning time	1968–current	0–6+	Yes (except years 2003–2005)
Mprop	Proportion of natural mortality before spawning	1968–current	0–6+	No
Fprop	Proportion of fishing mortality before spawning	Not relevant		
Matprop	Proportion mature at-age	1968–current	0–6+	Yes, values from 1997 onwards.
Natmor	Natural mortality	1968–current	0–6+	No

Table C-2. Model configuration values.

Input	Values
Fleets	Single Fleet, including the recreational removals since 2016
CatchSelectivity	1968–1999: empirical as random walk, model estimated for ages 2–3, afterwards staying at age 3 selectivity 2000–present: empirical as random walk, model estimated for ages 2–3, afterwards staying at age 3 selectivity
Fbar	2–4
Catch	All available age classes (age 0–6) were included. Catch weights and numbers include discards. Catch weights also include recreational removals since 2016.
Index specification	NIGFS-Q1 (ages 1–4) NIGFS-Q4 (age 0) UK FSPW (ages 2–5)
Index selectivity	Q1 Groundfish: empirical as random walk, model estimated for ages 2, dome shaped Q4 Groundfish: Age 0 recruitment index UK FSPW: empirical as random walk, 0 at ages 0 and 1, model estimated for ages 2–5, dome shaped
Index CV and ESS	NIGFS-Q1: real values UK FSPW: 0.2 all years The effective sample size: 60 for Q1. N/A for Q4, number of tows FSP (between 18 and 20)
Fleet CV and ESS	CVs 0.065, (1968–1992) 0.05 (1993–present, excluding 2003–2005, 2020) 0.075 (2003–2005, 2000) ESS 100 until 1986, 50 since 1990 no catch-at-age 2003–2005, 2020
Recruitment deviations	1968 # first year of main recr_devs; early devs can precede this era 2021 # last year of main recr_devs; forecast devs start in following year 0 #_forecast_recruitment phase (incl. late recr) (0 value resets to maxphase+1) 1 #_lambda for Fcast_recr_like occurring before endyr+1 1939.4 #_last_yr_nobias_adj_in_MPD; begin of ramp 1968 #_first_yr_fullbias_adj_in_MPD; begin of plateau 2020 #_last_yr_fullbias_adj_in_MPD 2022 #_end_yr_for_ramp_in_MPD (can be in forecast to shape ramp, but SS sets bias_adj to 0.0 for fcast yrs)
Recruitment blocks	1968–2001, 2002@current +1, estimate different $R_0$ values Beverton–Holt recruitment

## D Short-term prediction

Model used:

Software used: *FLR*

Initial stock size: SSB

Maturity: average three years

F and M before spawning: N/A

Weight-at-age in the stock: average three years

Weight-at-age in the catch: average three years

Exploitation pattern: average three years

Intermediate year assumptions: GM 2002 to years-2

Stock–recruitment model used: GM

Procedures used for splitting projected catches:

## **E Medium-term prediction**

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Model used:

Software used:

Initial stock size:

Natural mortality:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Intermediate year assumptions:

Stock–recruitment model used:

Uncertainty models used:

- 1 ) Initial stock size:
- 2 ) Natural mortality:
- 3 ) Maturity:
- 4 ) F and M before spawning:
- 5 ) Weight-at-age in the stock:
- 6 ) Weight-at-age in the catch:
- 7 ) Exploitation pattern:
- 8 ) Intermediate year assumptions:
- 9 ) Stock–recruitment model used:

## **F Long-term prediction**

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Model used:

Software used:

Maturity:

F and M before spawning:

Weight-at-age in the stock:

Weight-at-age in the catch:

Exploitation pattern:

Procedures used for splitting projected catches:



## G Biological reference points

Following the new effective sample sizes, the reference points were updated accordingly in 2023

TYPE	VALUE	TECHNICAL BASIS
MSY $B_{trigger}$	13012	$B_{pa}$
$F_{MSY}$	0.174	Median point estimates of ( $F_{MSY}$ ) EqSim with combined S-R
$F_{MSYlower}$	0.141	
$F_{MSYupper}$	0.224	
$F_{ECO}$	0.191	
$B_{lim}$	9364 t	Lowest SSB with above average recruitment
$B_{pa}$	13012 t	$B_{lim}$ combined with the assessment error
$F_{lim}$	0.33	F with 50% probability of SSB less than $B_{lim}$
$F_{pa}$	0.170	$F_{05}$

## H Other issues

### H.1 Biology of species

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

YEAR (Y)	2007	2008	2012	2016	2022
Assessment model	ICA model	ICA model	SAM Nielsen <i>et al.</i> , 2012	ASAP	SS3
Software					
Catch data range	19-?		1947-Y	1968-Y	1968-Y
Cpue Series 1 (years)	PT-TRF9a (1977-?)				
Cpue Series 2 (years)					
Index of Biomass (years)	PT-TRC9a (1989-2006)				
Error type	Condition on yield				
Number of bootstrap	500				
Maximum F	8.0 (y-1)				
Statistical weight B1/K	1				

YEAR (Y)	2007	2008	2012	2016	2022
Assessment model	ICA model	ICA model	SAM Nielsen <i>et al.</i> , 2012	ASAP	SS3
Statistical weight for fisheries	1,1				
B1-ratio (starting guess)	0.5				
MSY (starting guess)	3000 t				
K (starting guess)	20 000 t				
q1 (starting guess)	1d-5				
q2 (starting guess)	1d-4				
q3 (starting guess)					
Estimated parameter	All				
Min and Max allowable MSY	2000 (t) -10 000 (t)				
Min and Max K	5000 (t) -500 000 (t)				
Random Number Seed	1 964 185				

DATA	2006	2023
Catch data	Years: 1978–(AY-1) Ages: 1–8+	Years 1968–Y
Survey: A_Q1	Years: 1985–AY Ages: 1–7	Years 1995–Y Ages 1–4
Survey: B_Q4	Years: 1996–(AY-1) Ages: 1–5	Years 1996–Y Age 0
Survey: C	Not used	Fsp, 2004–Y, ages 2–6

### H.3 Current fisheries

### H.4 Management and advice

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