4 Cod (*Gadus morhua*) in Subarea 4, Division 7.d and Subdivision 20 (North Sea, Eastern English Channel, Skagerrak)

4.1 General

This assessment relates to the cod stock in the North Sea (Subarea 4), the Skagerrak (Subdivision 20), and the eastern Channel (Division 7.d). This assessment is presented as an update assessment based on the revised assessment protocol specified by the 2021 meeting of WKNSEA (ICES WKNSEA, 2021).

A stock annex records more detail and references information on the stock definition, ecosystem aspects and the fisheries. This report section records only recent developments and new information presented to WGNSSK.

4.1.1 Stock definition

The North Sea stock consists of reproductively isolated populations of Viking and Dogger cod, with the Dogger population exhibiting spatial heterogeneity and extending to the northern part of Division 6.a. A comprehensive summary of available information on stock definition can be found in ICES WKNSCodID (2020).

4.1.2 Ecosystem aspects

The North Sea is characterised by episodic changes in productivity of key components of the ecosystem. Phytoplankton, zooplankton, demersal and pelagic fish have all exhibited such cycles in variability. Managers should expect long-term change and ensure that management plans have the potential to respond to new circumstances. For example, a regime shift occurred in the North Sea in the mid-1980s and evidence suggests another from around 1998, a time from which North Sea cod recruitment has been low. A summary of available information on ecosystem aspects is presented in the Stock Annex.

4.1.3 Fisheries

Cod are caught by virtually all the demersal gears in Subarea 4, Subdivision 20 (Skagerrak) and 7.d, including beam trawls, otter trawls, seine nets, gill nets, trammel nets and lines. Most of these gears take a mixture of species. In some of them, cod is considered a bycatch (for example in beam trawls targeting flatfish), and in others, the fisheries are directed mainly towards cod (for example, in large-meshed otter trawls and some fixed gear fisheries). The main gears landing North Sea cod are primarily TR1 (mainly operated by Scotland and Denmark), but also GN1 (mainly Denmark and Norway), TR2 and BT1. Cod are also an important target for marine recreational fisheries. A summary of information on cod fisheries and past and current technical measures used for the management of cod is presented in the Stock Annex.

Technical Conservation Measures

The recovery plan for cod (EC 1342/2008) triggered considerable improvements in selectivity and cod avoidance through incentives that were linked to the fishing effort regime and through

national measures, such as the Scottish Conservation Credits Scheme. The Conservation Credits scheme was suspended on 20 November 2016 and the fishing effort regime discontinued in 2017 (EC 2094/2016). Further details of these measures are presented in the Stock Annex.

The expansion of the closed-circuit TV (CCTV) and FDF programmes in 2010–2016 in Scotland, Denmark, Germany, England and the Netherlands is expected to have contributed to a reduction of cod mortality. The cod specific FDF scheme terminated at the end of 2016. Further details are presented in the Stock Annex.

4.1.4 Management

Management of cod is by TAC and technical measures. The agreed TACs for Cod in Subarea 4, Division 7.d and Subdivision 20 (Skagerrak) over the last ten years were as follows:

TAC(000t)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
20(Skagerrak)	3.8	3.8	4.0	4.2	4.8	5.7	8.0	4.2	2.1	1.9
2.a + 4	26.5	26.5	27.8	29.2	33.7	39.2	43.2	29.4	14.7	13.2
7.d	1.5	1.5	1.6	1.7	2.0	2.1	1.7	1.7	0.9	0.8

For 2012–2016, Council Regulations (EC) N°44/2012, N°297/2013, N°432/2014, N°2015/104 and N°2016/72 allocated different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size as stipulated by Council Regulation (EC) N°43/2009. The effort regime has now been discontinued, and the TACs for 2017–2020 are given in Council Regulations (EC) N°2017/127, N°2018/120, N°2019/124 and N°2020/123 respectively.

The EU landing obligation was implemented from 1 January 2017 for several gears, including otter trawlers with >100 mm mesh (TR1), beam trawlers with >120 mm mesh (BT1) and fixed gears. The EU landing obligation was fully implemented in the North Sea and Skagerrak from 1 January 2018 and in the eastern Channel from 1 January 2019, although a few exemptions exist. Council Regulation (EC) N°2019/2238 lists *de minimis* exemptions for cod caught in some bottom trawls targeting *Nephrops* or Northern prawn in Subdivision 20, mixed demersal fisheries using TR2 gears in Subarea 4 and beam trawls targeting brown shrimp in Divisions 4b-c. Council Regulations (EC) N°2019/2238 and N°2019/2239 respectively detail survivability exemptions for by-catch in pots and fyke nets in Subarea 4 and Subdivision 20 and for species caught using pots, traps and creels in Division 7.d.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as bycatch.

Cod recovery and management plans

A Cod Recovery Plan which detailed the process of setting TACs for the North Sea cod was in place until 2008. Details of it are given in EC 423/2004 and previous working group reports.

In December 2008, the European Commission and Norway agreed on a new cod management plan that aimed to be consistent with the precautionary approach and was intended to achieve sustainable fisheries and high yield, leading to a target fishing mortality of 0.4. In addition to the EU–Norway agreement, the EU implemented effort restrictions, reducing KW-days available to

EU vessels in the main métiers catching cod in direct proportion to reductions in fishing mortality until the long-term phase of the plan was reached, for which the target F was 0.4 if SSB is above B_{pa}. Details of the European Commission plan are given in EC 1342/2008.

A joint ICES STECF group met during 2011 to conduct a historical evaluation of the effectiveness of these plans (ICES WKROUNDMP, 2011; Kraak *et al.*, 2013) and concluded that for North Sea cod, although there had been a gradual reduction in F and discards, the plans had not controlled F as envisaged.

In November 2016, the cod management plan was amended to discontinue the effort regime set out in EC 1342/2008 as it became an obstacle to the implementation of the landing obligation. Details of the amended cod management plan are given in EC 2016/2094.

In July 2018, the European Union agreed to a multiannual management plan for demersal fisheries in the North Sea (MAP). However, the plan was not adopted by Norway and is therefore not used as the basis of advice for this shared stock. Details of the plan are given in EC 2018/973.

In June 2018, EU-Norway requested an evaluation of multiple management strategies (ICES WKNSMSE, 2019); however, these are no longer consistent with the assessment and reference points following the benchmark in 2021.

Since 2015, advice has been given according to the ICES MSY approach.

4.2 Data available

4.2.1 Catch

Landings data from human consumption fisheries for recent years as officially reported to ICES together with those estimated by the WG are given for each area separately and combined in Table 4.1.

The catch estimate for 2020 (uploads in weight) is 24 224 tonnes, split as follows for the separate areas (tonnes):

	TAC	Landings	Discards	BMS*
20–Skagerrak	2103	2299	2113	0
4	14718	17192	2566	21
7.d	858	32	0	<1
Total	17679	19523	4701	

*** BMS landings uploaded to InterCatch.**

Prior to the use of InterCatch for discard estimation, discard numbers-at-age were estimated for areas 4 and 7.d by applying the Scottish discard ogives to the international landings-at-age, and were based on observer sampling estimates for Subdivision 20–Skagerrak. Discard raising for 2002–2020 was performed in InterCatch, with the different nations providing information by area, quarter and métier. Sampling for discards and age compositions was poor in area 7.d in 2002–2003, and this necessitated combining areas 4 and 7.d in those years. The provision of discard information has vastly improved since the reform of the EU's data collection framework in 2008 (see http://datacollection.jrc.ec.europa.eu/) but was lower in 2020 (57% of the landings) than recent years, likely due to the COVID-19 pandemic. All nations apart from Norway now provide discard information. Figure 4.1a plots reported landings and estimated discards (including BMS landings) used in the assessment. Discard ratio sampling coverage by area and season for 2020

is provided in Table 4.2e, along with the contributions to total landings, discards and BMS from each area prior to raising.

Norwegian discarding is illegal, so although this nation has accounted for 7–15% of cod landings over the period 2002–2020 (InterCatch data), it does not provide discard estimates. Nevertheless, the agreed procedure applied in InterCatch is that discards raising should include Norway (i.e., Norway will be allocated discards associated with landings in reported métiers). Furthermore, tagging and genetic studies have indicated that Norwegian coastal cod are different to North Sea cod and do not generally move into areas occupied by North Sea cod. Therefore, Norwegian coastal cod data have been removed from North Sea cod data by uploading only North Sea cod data into InterCatch for 2002 onwards, and by adjusting catches prior to 2002 to reflect the removal of Norwegian coastal cod data (an annual multiplicative adjustment of no more than 2.5% was made using Norwegian coastal cod data (see ICES WKNSEA, 2015, for more details).

For cod in 4, 20–Skagerrak and 7.d, ICES first raised concerns about the misreporting and non-reporting of landings in the early 1990s, particularly when TACs became intentionally restrictive for management purposes. Some WG members have since provided estimates of under-reporting of landings to the WG, but by their very nature these are difficult to quantify. In terms of events since the mid–1990s, the WG believes that under-reporting of landings may have been significant in 1998 because of the abundance in the population of the relatively strong 1996 year-class as 2-year-olds. The landed weight and input numbers at age data for 1998 were adjusted to include an estimated 3000 tonnes of under-reported catch. The 1998 catch estimates remain unchanged in the present assessment (apart from the adjustment for Norwegian coastal cod). The UK Buyers and Sellers legislation, introduced towards the end of 2005, is expected to have improved the accuracy of reported cod landings.

Since the WG has no basis to judge the overall extent of under-reported catch over time, it has no alternative but to use its best estimates of landings, which in general are in line with the officially reported landings. The figures shown in Table 4.2c and Figure 4.1a comprise the input values to the assessment.

Age compositions

Age compositions were provided by all nations apart from France and Northern Ireland for 2020 data. The sampling coverage for landings and discards age compositions for 2020 are reported in Table 4.2e, showing lower coverage in Subarea 4 in Q2, likely due to the COVID-19 pandemic.

Landings in numbers at age for age groups 1–11+ and 1963–2020 are given in Table 4.2a. These data form the basis for the catch at age analysis but do not include industrial fishery bycatches landed for reduction purposes prior to 2002 (values from 2002 onwards were entered into InterCatch for all relevant nations except Norway, and were included in the raising, although the numbers were very small). Bycatch estimates are available for the total Danish industrial fishery in Subdivision 20 and Subarea 4 (Table 4.1). During the last five years, an average of 64% of the international landings in number were accounted for by juvenile cod aged 1–3; this average rises to 82% when considering landings and discards combined. In 2020, age 1 cod comprised 51% of the total catch by number, age 2, 31% and age 3, 8%.

Discard numbers-at-age (including BMS landings from 2016) are shown in Table 4.2b. The proportions of the estimated numbers discarded for ages 1–4 and the proportion of the estimated total discards by weight and number are shown in Figure 4.1b. Estimated proportion of total numbers caught that were discarded (Figure 4.1b) had decreased from a peak of 84% in 2006 to 36% in 2019 but increased to 67% in 2020. Historically, the proportion of numbers discarded at age 1 has fluctuated around 80% but was estimated at 93% in 2020 due to the stronger 2019-year class. At ages 2 to 4 discard proportions increased to a maximum around 2006–10 but have

subsequently declined to give 60% for age 2, 15% for age 3 and 1% for age 4 cod in 2020. Note that these observations refer to numbers discarded, not weight.

Total catch numbers-at-age are shown in Table 4.2c. Landings, discards (including BMS landings) and total catch numbers at age are given by season in Table 4.2d for 2020. Reported landings, estimated discards (including BMS landings from 2016) and total catch (sum of landings and discards), given in tonnage, are shown in Table 4.4.

InterCatch

InterCatch was used for estimation of landings, discards (including BMS landings) and total catch at age and mean weight at age in 2020. Data co-ordinators from each nation were tasked to input data into InterCatch, disaggregated to quarter and métier. The data from Norway excluded Norwegian coastal cod. Allocations of discard ratios and age compositions for unsampled strata were then performed to obtain the data required for the assessment. The approach used for discard ratio allocations was to do it by area (20, 4 and 7.d), giving three broad categories. Annual discards were first matched to quarterly landings. Then, within each of these three categories, ignoring country and season, where métiers had some samples these were pooled and allocated to unsampled records within that métier. At the end of this process, any remaining métiers were allocated an all samples pooled discard ratio for the given category.

The landings and discards imported in weight or raised for 2020 are as follows (tonnes):

Catch Category	Raised or Imported	CATON	Percentage
BMS landing	Imported	21	100
Discards	Imported	2687	57
Discards	Raised	1992	43
Landings	Imported	19523	100
Logbook Registered Discard	Imported	0	NA

A similar approach was used for allocating age compositions, except that there were six broad categories because discards (including BMS landings) were treated separately to landings. However, age compositions for Division 7.d had to be allocated from métiers in Subarea 4 as there was no age sampling in 7.d in 2020.

The landings and discards imported in weight or raised, with age distribution sampled or estimated for 2020 are as follows (tonnes):

Catch Category	Raised or Imported	Sampled or Estimated	CATON	Percentage
Logbook Registered Discard	Imported	Estimated	0	NA
Landings	Imported	Sampled	14665	75
Landings	Imported	Estimated	4859	25
Discards	Imported	Sampled	2645	57
Discards	Raised	Estimated	1992	43
Discards	Imported	Estimated	41	1
BMS landing	Imported	Sampled	21	99
BMS landing	Imported	Estimated	<1	1

InterCatch is discussed in Section 1.2, and all results are available on the WGNSSK SharePoint. Further work is ongoing, analysing the InterCatch data (cf. ICES WGMIXFISH meeting during 2021).

Recreational catches

Recreational catches were estimated for 2010–2019 from data provided by Belgium, Denmark, Germany, Sweden, Norway, the Netherlands, and UK, but are considered provisional and not included in the assessment due to length of time series and unknown age structure and uncertainty. Further details are provided in the stock annex and ICES WKNSEA (2021). Estimates of commercial and recreational removals along with the percentage of recreational removals and percentage of recreational removals derived from imputation are as follows:

	commercial removals (t)			Recreational removals (t)				
Year	Landings	Discards	Total	Retained	Released	Total	% recr.	%imputed
2010	36762	12341	49103	1636	320	1955	3.8	56
2011	31979	8711	40689	1432	390	1822	4.3	87
2012	32124	8638	40762	1638	361	2000	4.7	90
2013	30474	10289	40763	2342	226	2569	5.9	80
2014	34651	10538	45190	3959	476	4434	8.9	60
2015	37373	12537	49910	2681	370	3051	5.8	82
2016	38104	12203	50307	2000	328	2327	4.4	15
2017	37668	8702	46371	1536	352	1888	3.9	37
2018	40153	7744	47898	2079	339	2418	4.8	3
2019	32361	3555	35917	1110	219	1330	3.6	36
Mean	35165	9526	44691	2041	338	2379	5.0	55

4.2.2 Weight-at-age

Mean weight at age data for landings, discards (including BMS landings from 2016) and catch, are given in Tables 4.3a–c. Landings, discards and catch mean weights at age are given by season in Table 4.3d for 2020. Long-term trends in mean catch weights-at-age by catch component for ages 1–7 are plotted in Figure 4.2a, which indicates an overall decline from around 2010 for ages 3 and above. Ages 1 and 2 show little absolute variation over the long term.

Stock mean weights are derived from the NS–IBTS–Q1 survey data for ages 1–2 and from the Q1 catch data for ages 3+. Stock mean weights are given in Table 4.5a and plotted in Figure 4.2b.

4.2.3 Maturity and natural mortality

Values for proportion mature at age are derived from an area-weighted maturity age key constructed from NS–IBTS–Q1 data from 1978. The calculation is described in the Stock Annex. In 2021, biological sampling in the Viking 20 (Skagerrak) and Southern subareas was low (<5 fish at each age) and necessitated pooling with samples from the Viking 4a and Northwestern subareas respectively (see Figure 4.16c for subarea definitions). The time-varying maturity ogive used as input to the assessment is given in Table 4.5b and illustrated in Figure 4.2c.

Table 4.5c and Figure 4.2d show estimates of M based on multi-species considerations adopted for the assessment. Estimates of natural mortality are derived from multispecies analyses updated by the Working Group on Multi-Species Stock Assessment Methods (WGSAM) every three years in so-called "key runs" to account for improved knowledge of predation on cod by other species (mainly seals, harbour porpoises and gurnards) and cannibalism; the last update occurred in 2020 with the new key run (ICES WGSAM, 2020).

An ad-hoc adjustment is made to the M values of ages 3+ to mimic a 15% emigration out of the assessment area from 2011 (Table 4.5c and Figure 4.2d). Full details of this adjustment are given in the Stock Annex.

4.2.4 Catch, effort and research vessel data

Reliable, individual, disaggregated trip data were not available for the analysis of CPUE. Therefore, only survey and combined commercial landings and discard information are analysed within the assessment presented.

Two survey series are available for use within this assessment:

Quarter 1 international bottom-trawl survey (IBTS–Q1): ages 1–6+, covering the period 1976–2021. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.

Quarter 3 international bottom-trawl survey (IBTS–Q3): ages 0–6+, covering the period 1991–2020. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.

Maps showing the IBTS distribution of cod are presented in Figures 4.3a–b (ages 1–3+). The recent dominant effect of the size and distribution of 2005, 2009, 2013 and 2016 year-classes are apparent from these charts. Fish of older ages continued to decline until 2006 due to the very weak 2002- and 2004-year classes, but subsequently increased, especially in the north and west. The abundance of 3+ fish is still at a low level compared to historic levels and has declined over the past four years due to the weak 2017- and 2018-year classes. The 2019 year-class appears stronger (Figure 4.3a).

Standardised age-based survey indices for North Sea cod are calculated based on GAMs and Delta-distributions. The general methodology is described in Berg and Kristensen (2012) and Berg *et al*. (2014) and is implemented in R based on the DATRAS (http://rforge.net/DATRAS/) and surveyIndex packages. The Delta-GAM is fit to each survey separately. For the IBTS–Q1, the Delta-GAM is fit to ages 1–6+, with ages 1–5 retained and used in the assessment model. For the IBTS–Q3, the Delta-GAM is fit to ages 0–5+, with ages 1–4 retained and used as an index in the assessment. Because the first age in the assessment model is age 1, estimates of age 0 from the IBTS–Q3 indices are retained as a separate recruitment index forward shifted to 1st January the following year.

More details of the method used to produce the NS–IBTS Delta–GAM indices are provided in the stock annex and can be found in ICES WKNSEA (2021), as well as the above-mentioned publications. In summary, the final Delta–GAM models selected for NS–IBTS–Q1 and Q3 comprised a high resolution stationary spatial model with low resolution yearly independent deviations and included ship, year, depth, time of day and haul-duration effects. The NS–IBTS Delta–GAM indices and associated standard deviations used in the assessment are given in Table 4.6. Figures 4.3d-e compare the Q1 and Q3 NS–IBTS Delta–GAM indices to the corresponding NS–IBTS extended indices (calculated using the standard stratified mean methodology applied to an extended area; Figure 4.3c) and the Delta-GAM indices from the recent benchmark (which have one year fewer data; ICES WKNSEA 2021). Retrospective analyses with three peels give average Mohn's rho values of -0.01 and 0 across all ages for the IBTS–Q1 and IBTS–Q3 indices, respectively.

4.3 Data analyses

4.3.1 Assessment audit

The assessment audit for North Sea cod was completed and no significant issues found for the assessment itself. Additional checks on the forecast are carried out during the ICES WGMIXFISH meeting in 2021.

4.3.2 Exploratory survey-based analyses

Survey abundance indices are plotted in log-mean standardised form by year and cohort in Figure 4.4a for the IBTS–Q1 survey, together with log-abundance curves and associated negative gradients for the age range 2–4. Similar plots are shown for the IBTS–Q3 survey in Figure 4.4b. The log-mean standardised curves track cohort signals well (top right), although there is some loss of signal between the 2012 and 2013 cohorts associated with an apparent positive year effect in 2017 and disappearance of the strong 2013-year class from survey catches at older ages. The log abundance curves for each survey series had shown an increase in steepness in the most recent years (bottom left) with a substantial increase in the negative gradient for ages 2–4 following the 2015 year-class in the IBTS-Q1 (age 2 in 2017) and the strong 2013 year-class in the IBTS-Q3 (bottom right). However, a large drop in negative gradient is now observed in the IBTS–Q1, corresponding to the 2017 year-class that reached age 4 in 2021.

Figures 4.5a and b show within-survey consistency (in cohort strength) for the NS-IBTS Q1 and Q3 Delta–GAM survey indices, while Figures 4.5c and 4.5d show between survey consistencies (for each age) for the two surveys. These show generally good consistency, justifying their use for survey tuning.

The SURBAR survey analysis model was fitted to both the Q1 and Q3 NS–IBTS Delta-GAM survey indices (ages 1–5). The summary plots are presented in Figure 4.6a.

Biomass: Spawning stock biomass reached the lowest level in the time series in 2005 and subsequently increased because of the stronger 2005- and 2009-year classes and reductions in mortality, reaching a peak in 2013. SSB has since declined rapidly with a slight, but more uncertain, increase estimated for 2020–2021. A similar trend can also be seen in the time series for total stock biomass.

Total mortality: the SURBAR analysis indicates an overall gradual decline in total mortality until 2014, followed by a rapid increase peaking in 2018 and reaching the lowest value in the time-series by 2020.

Recruitment: the SURBAR analysis indicates that the recruiting year classes since 1996 have been relatively weak, but with stronger 1999-, 2005-, 2009-, 2013-, 2016- and 2019-year classes.

Residuals from the SURBAR analysis are positive for all ages in the NS-IBTS-Q1 in 2017 and negative for ages 2+ in the NS-IBTS-Q3 in 2017–2018 (Figure 4.6b).

4.3.3 Exploratory catch-at-age-based analyses

Catch-at-age matrix

The total catch-at-age matrix (Table 4.2c) is expressed as numbers at age, and proportions-at-age, standardised over time in Figure 4.7. It clearly shows the contribution of the 2005-, 2009- and 2013-year classes to catches in recent years and indicates a relative increase in the number of older fish in the catches. The relatively strong 2016-year class does not appear strongly in the catches in 2020.

Catch curve cohort trends

The top panel of Figure 4.8 presents the log catch curve plot for the catch at age data. In recent years there has been a gradual decrease in the slope at the youngest ages–a sign of decreased mortality rates. The bottom panel plots the negative slope of a regression fitted to the ages 2–4, the age range used as the reference for mortality trends. Although there are peaks in the negative gradients for the 2013- and 2015-year classes in the most recent period, these gradients still represent some of the lowest values in the time series, which is in contrast to equivalent plots for the survey indices. The sharp increase for the 2016-year class corresponds to lower-than-expected catches at age 4 in 2020.

4.3.4 Final assessment

The final assessment used SAM (State-space Assessment Model; Nielsen and Berg, 2014) run with R *stockassessment* package version 0.9.0/bioparprocess in R version 3.5.1. The data used in the assessment are given in Tables 4.2–3 and 4.5–6, and the model configuration in Table 4.7a. Random walk processes are used to model recruitment and fishing mortality-at-age, where the random walks for fishing mortality are correlated among ages according to an AR(1) process. Correlations between ages in the IBTS surveys are modelled according to an AR(1) process that estimates a single parameter for the correlation between ages 1 and 2 and common correlation parameters between the older ages (Berg and Nielsen, 2016). Maturity is modelled as a Gaussian Markov Random Field (GMRF) process with cohort- and within year correlations. Model fitting diagnostics, parameter estimates, and associated correlation matrix are given in Table 4.7b.

Figure 4.9 shows summary plots of the final assessment in terms of population trends. Estimates of fishing mortality at age, stock numbers at age, catches at age and maturity at age are given in Tables 4.8–11 respectively, while a summary table for estimates of recruitment (age 1), TSB, SSB, catches and F_{bar} (2–4) are given in Table 4.12a (along with 95% confidence bounds), and estimates of landings, discards and catches are given in Table 4.12b (and can be compared to the corresponding data in Table 4.4). Mean fishing mortality split into landings and discards, using landings fraction, and split into ages is shown in Figure 4.10a and selectivity in F is shown in Figure 4.10b, while estimated maturity at age is shown in Figure 4.11. Estimated correlations between ages in the catch and survey indices are shown in Figure 4.12. These correlations reflect the couplings specified in the model configuration (Table 4.7a) assuming independence in the catch and correlation between ages in each of the IBTS surveys.

Residual plots are shown in Figures 4.13a-b, indicating no serious model misspecification, although residuals for the IBTS–Q1 are all positive in 2017 (bar a small negative residual for age 2) and all negative in 2018 while residuals for the IBTS–Q3 are all negative in 2017–2018. Retrospective plots for SSB, average fishing mortality, recruitment at age 1 and TSB are shown in Figure 4.14. Mohn's rho statistics based on a five-year peel are calculated as 0.150, -0.061, 0.109 and 0.131 for SSB, $F_{2–4}$, recruitment, and TSB respectively.

A comparison with the benchmark assessment (ICES WKNSEA, 2021) is provided in Figure 4.15a. Differences between the assessments are due to the addition of one year of catch and NS–IBTS Q1 and Q3 survey data, as well as slight revisions to the delta-GAM indices. The addition of the new data results in a slight downscaling of SSB and an increase in Mohn's rho (from 0.077 to 0.150). It was demonstrated that better model diagnostics (likelihood, AIC and Mohn's rho for SSB) could be obtained by increasing the ad hoc adjustment on M from 15% to 20%, to mimic increased emigration. However, as the retrospective bias is within acceptable limits (ICES WKFORBIAS, 2020), and to avoid ad hoc tuning of the adjustment without appropriate ecological justification, the adjustment was maintained at 15%. A comparison with the SURBAR survey-based assessment is provided in Figure 4.15b and shows similar trends between models.

4.4 Historic stock trends

The historic stock and fishery trends are presented in Figures 4.9–10 and Tables 4.12a–b.

Recruitment fluctuated at a relatively low level from 1998. The 1996-year class was the last large year class that contributed to the fishery, and subsequent year classes have been the lowest in the time series, but with stronger 1999-, 2005-, 2009-, 2013-, 2016 and 2019-year classes.

Fishing mortality increased until the early 1980s, remained high until 2000 and declined to its lowest level in 2013. This decline in F subsequently reversed with F increasing rapidly to a peak in 2018. F is now below both precautionary reference points, F_{lim} and F_{pa}, but above F_{MSY}.

SSB declined steadily during the 1970s and 1980s. There was a small increase in SSB following improved recruitment coupled with a slight dip in fishing mortality in the mid-1990s, but with low recruitment since 1998 and continued high mortality rates, SSB continued to decline to its lowest level in 2006. SSB subsequently increased with a decline in fishing mortality, reaching a peak in 2016, but has since declined rapidly and is now below B_{lim}.

The North Sea cod stock consists of reproductively isolated populations of Viking cod and Dogger cod, with the Dogger cod population exhibiting spatial heterogeneity and extending to the northern part of Division 6.a (ICES WKNSCodID, 2020). These genetically different groups have different rates of maturity and growth. Trends in biomass and recruitment have been strongly correlated among subareas of the North Sea but have diverged in the last decade, with no apparent rebuilding in the South (Figures 4.16a-c). The low landings in 7.d (32 tonnes in 2020) and low biological sampling in the southern subregion in the NS-IBTS Q1 survey may indicate a collapse of the stock in this area. Official nominal landings from 2020 are low in both divisions 4.c (72 tonnes) and 7.d (40 tonnes).

Figure 4.17 indicates that the age structure in the population gradually improved (number of fish aged 5 and older in the population increased) with the decrease in fishing mortality, but this trend appears to have reversed, with poorer survival to the older ages now evident.

4.5 Recruitment estimates

Recruitment in the intermediate year (2021) was sampled from a normal distribution about the assessment estimate and is reported as the median of those samples. Estimates of recruitment for subsequent years were resampled from the 1997–2020-year classes, reflecting recent low levels of recruitment, but including the relatively stronger 1999-, 2005-, 2009-, 2013-, 2016- and 2019-year classes.

4.6 MSY estimation

MSY estimation is performed with the EQSIM software (ICES WGMG, 2013), in accordance with the ICES guidelines. MSY estimation for North Sea cod was last performed during ICES WKNSEA (2021) based on a truncated recruitment time-series (1998–2020) and without the ad hoc adjustment on M. Details of the analysis are available in the expert group report (ICES WKNSEA, 2021).

A summary of the biological reference points (not including the advisory HCR in all but $F_{P.05}$) is provided in the following table.

Stock	
F_{MSY}	0.28
F_{MSY} lower	0.186
F_{MSY} upper	0.45
$F_{P.05}$ (5% risk to B_{lim}, with HCR included)	0.49
F_{MSY} upper precautionary	0.45*
MSY	51 541 t
Median SSB at F_{MSY}	163 738 t
Median SSB at F_{MSY} upper precautionary	92 668 t
Median SSB at F_{MSY} lower	247 255 t

*** Note that the FP0.5 value is 0.49 for an EQSIM run (with HCR included), so the F_{MSY} upper value is not constrained.**

4.7 Short-term forecasts

The May forecast

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

The assessment and forecasts were conducted with R version 3.5.1; however, slightly different results are obtained when running the forecasts with newer versions of R because the routine to generate random seeds changed in R version 3.6.0.

At WGNSSK, the intermediate year assumption was taken as a 37% overshoot of the TAC, following a 37% overshoot of the TAC in 2020. This would result in an intermediate year F of 0.29. A status quo F assumption was considered but, given the 10% reduction in TAC for 2021, would have resulted in an assumed catch that exceeds the TAC by 16 208 tonnes (i.e., an extra 102% is taken in addition to the TAC). A proportion of F_{2020} (taken as F_{2020} / F_{2019} = 0.83) was also considered although the WG felt it was too early to judge a trend in F. This assumption would result in a catch that exceeds the TAC by 11 526 tonnes (i.e. an extra 72% is taken in addition to the TAC).

At the Advice Drafting Group, a reduction in F below historically observed levels was considered unrealistic. Therefore, as an intermediate year assumption, fishing mortality was assumed to be at the lowest level of the time series. It is recognized that this will give a 71% overshoot of the TAC. This will imply a reduction in fishing mortality (from 0.45 to 0.37) which was considered to be realistic given the technical measures in place in 2021.

Forecasts options are presented in tables 4.13 and 4.14. Forecast assumptions are as follows (note that the values that appear in the catch scenarios in tables 4.13 and 4.14 are medians from the distributions that result from the stochastic forecast):

Initial stock size	Starting populations are simulated from the estimated distribution at the start of the intermediate year (including co-variances).
Maturity	Forecasted according to the SAM GMRF process for maturity (Figure 4.11).
Natural mortality	Average of final three years of assessment data with M-adjustment.
F and M before spawning	Both taken as zero.
Weight at age in the catch	Average of final three years of assessment data.
Weight at age in the stock	Average of final three years of assessment data.
Exploitation pattern	Forecasted according to the SAM F processes.
Intermediate year assumptions	Median total catch in the intermediate year assuming either (1) a 37% overshoot of TAC or (2) an F of 0.37 in the intermediate year.
Stock recruitment model used	Recruitment for the intermediate (the year the WG meets) is sampled from a normal distribution of the SAM estimate and reported as the median. Recruitment for the TAC year onwards is sampled, with replacement, from 1998 to the intermediate year.
Procedures used for splitting projected catches	The final year landing fractions are used in the forecast period.

The October forecast

Since the final SAM model includes two indices from the IBTS Q3, the assessment is subject to the AGCREFA protocol for reopening of advice in the autumn (ICES AGCREFA, 2008; ICES WKNSROP, 2020). The reopening protocol for North Sea cod is:

1. Re-run the delta-GAM index for Q3 including the new data from the autumn survey.
2. Conduct an RCT3 check on age 1 for year classes y-1 and y including information from the IBTS Q3 only.
3. If a reopening is triggered:
    a) Rerun SAM with the updated Q3 indices;
    b) Populate and re-run the forecast procedure with the resulting assessment estimates, using the SAM estimate of recruitment in the TAC year (y+1) rather than a resampled recruitment, as done in May.

The current May forecast

Several scenarios were considered as follows (note, $B_{trigger} = B_{pa}$ = 97 777 tonnes, and $F_{MSY} = 0.28$; see Section 4.9):

1. MSY framework: F_{bar} (2022) = $F_{MSY} \times \min\{1; SSB_{2022}/B_{trigger}\}$
2. EU-MAP: F_{bar} (2022) = $F_{MSY\ lower} \times \min\{1; SSB_{2022}/B_{trigger}\}$
3. Zero catch: F_{bar} (2022) = 0
4. F_{pa}: F_{bar} (2022) = $F_{pa} = F_{P.05} = 0.49$
5. $F_{p.05}$ without AR: F_{bar} (2022) = 0.41
6. F_{lim}: F_{bar} (2022) = $F_{lim} = 0.58$
7. SSB (2023) = B_{lim}: F corresponding to SSB (2023) = B_{lim}
8. SSB (2023) = $B_{trigger} = B_{pa}$: F corresponding to SSB (2023) = $B_{trigger} = B_{pa}$
9. Lower TAC constraint: F_{bar} (2022) such that TAC (2022) = 0.8×TAC (2021)
10. Rollover TAC 15%: F_{bar} (2022) such that TAC (2022) = 0.85×TAC (2021)
11. Rollover TAC 10%: F_{bar} (2022) such that TAC (2022) = 0.9×TAC (2021)
12. Rollover TAC 5%: F_{bar} (2022) such that TAC (2022) = 0.95×TAC (2021)
13. Rollover TAC: F_{bar} (2022) such that TAC (2022) = TAC (2021)
14. Rollover TAC + 5%: F_{bar} (2022) such that TAC (2022) = 1.05×TAC (2021)
15. Rollover TAC + 10%: F_{bar} (2022) such that TAC (2022) = 1.1×TAC (2021)
16. Rollover TAC + 15%: F_{bar} (2022) such that TAC (2022) = 1.15×TAC (2021)
17. Upper TAC constraint: F_{bar} (2022) such that TAC (2022) = 1.2×TAC (2021)
18. Status quo – constant F: F_{bar} (2022) = F_{bar} (2021)
19. $F_{MSY\ lower}$: F_{bar} (2022) = $F_{FMY\ lower} = 0.186$
20. F_{MSY}: F_{bar} (2022) = $F_{FMY} = 0.28$
21. $F_{MSY\ upper}$: F_{bar} (2022) = $F_{FMY\ upper} = 0.45$

Forecasts for the SAM final run are given in Tables 4.13 and 4.14. The working group raised concerns regarding the intermediate year assumption on F given the restrictiveness of the 2021 TAC and because cod are a choke species in mixed fisheries. Figure 4.18 presents catch forecasts for the MSY approach (i.e. $F = F_{MSY} \times SSB_{2022}/B_{trigger}$) assuming different multipliers on F(2020) in the intermediate year, and show a wide range of potential advised total catches for 2022 (12 672–23 882 tonnes).

4.8 Medium-term forecasts

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

4.9 Biological reference points

The reference points for cod in Subarea 4, Division 7.d and Subdivision 20 were estimated at ICES WKNSEA (2021). Biological reference points and their technical basis are as follows:

Framework	Reference point	Value	Technical basis	Source
MSY approach	MSY $B_{trigger}$	97 777 t	B_{pa}; in tonnes	ICES WKNSEA (2021)
	F_{MSY}	0.28	Stochastic simulations (EqSim) based on recruitment period 1998–2020	ICES WKNSEA (2021)
Precautionary approach	B_{lim}	69 841 t	B_{pa} / 1.4; in tonnes	ICES WKNSEA (2021)
	B_{pa}	97 777 t	Highest observed SSB (1998) based on the recruitment period 1998–2020 with 2019 as the last year of catch data; in tonnes.	ICES WKNSEA (2021)
	F_{lim}	0.58	The F that on average leads to B_{lim}	ICES WKNSEA (2021)
	F_{pa}	0.49	The F that provides a 95% probability for SSB to be above B_{lim} ($F_{P.05}$ with AR)	ICES WKNSEA (2021)

4.10 Quality of the assessment

The quality of the commercial landings and catch-at-age data for this stock deteriorated in the 1990s following reductions in the TAC without associated control of fishing effort. The WG considers the international landings figures from 1993–2005 to have inaccuracies but no longer estimates a catch multiplier in the SAM assessment to account for this (ICES WKNSEA, 2021).

The proportion of landings sampled for ages was lower in 2020 (75%) than in 2019 (89%), primarily due to lower sampling in Subarea 4 in Q2 (Table 4.2e) and therefore likely due to the COVID-19 situation. Weights at age in the catch and selectivity patterns however did not exhibit unreasonable deviations from the previous years.

Stock identity remains an issue with this assessment, with multiple populations inhabiting the North Sea and extending to neighbouring areas (ICES WKNSCodID, 2020). The 2021 benchmark introduced an ad hoc adjustment to account for emigration of North Sea cod to the West of Scotland area (ICES WKNSEA, 2021), which is currently not included in the assessment area.

The estimated CVs for observed catch at age 1, for the NS–IBTS–Q1, Q3 and Q3 recruitment indices at age 1 and the stock-recruitment relationship are all large: 59%, 235%, 233%, 243% and 80%, respectively. These large CVs suggest that these sources of information are somewhat ignored in the SAM recruitment estimation, which might therefore be more influenced by age 2 abundance estimates and model assumptions about F-at-age 1. The CV of the survival process is assumed to be the same for all non-recruiting ages (estimated at 12%) and this might have an impact on recruitment estimates (and, hence, age 1 catch and survey residuals) because it constrains the changes permitted between abundance at ages 1 and 2 of a cohort.

Conflicts between the information from catches and surveys, as indicated by the negative gradients, are becoming more apparent. The high correlation (0.95) estimated for the increments of log[F(y,a)] across ages suggests that the model might react slowly to changes in selectivity that may be associated with e.g. increased targeting of older cod.

A reduction of the plus group from 7+ to 6+ following the 2015 benchmark (ICES WKNSEA, 2015) introduced increasingly domed selection in the latter half of the time series that was not present in previous assessments; although there are reasons why such increasingly domed selection might occur, such as some evidence that larger cod inhabit less accessible rocky areas or simply move away from areas fishing vessels operate in, these reasons remain largely speculative.

There is general agreement across both models presented (SAM and SURBAR) of a recent sharp decline in SSB and a corresponding peak in total mortality, and stronger 2005-, 2009-, 2013-, 2016- and 2019-year classes (Figure 4.15b). The slight increase in SSB predicted by SURBAR in 2020–2021 is not observed in SAM, which shows a further decline.

4.11 Status of the stock

There has been a sharp decline in the status of the stock in the last few years. SSB has decreased and is now below B_{lim}.

Fishing mortality has declined from a peak in 2018 and is now below both the precautionary reference points, F_{lim} and F_{pa}, but above the level that achieves the long-term objective of maximum yield, F_{MSY}.

Recruitment of 1-year old cod has varied considerably since the 1960s, but since 1998, average recruitment has been lower than any other time. The last larger recruitment observed during this period was the 2019-year class.

4.12 Management considerations

Cod has been fully under the EU landing obligation since 2018 in Subarea 4 and Subdivision 20, and since 2019 in Division 7d although there are some *de minimis* exemptions in Subarea 4 and Subdivision 20 (see Section 4.1.4). BMS landings of cod reported to ICES are currently negligible and much lower than the estimates of catches below MCRS (Minimum Conservation Reference Size) estimated by observer programmes.

It is uncertain whether if and to what extent, the discontinuation of the days-at-sea regulation in 2017, which was part of the cod recovery plan, has had an impact on the recent decline of the cod stock.

There is a need to reduce fishing induced mortality on North Sea cod, particularly for younger ages, to allow more fish to reach maturity and increase the probability of good recruitment. Discards currently contribute 20% of the total catch by weight and 67% of the catch by number with 93% of 1 year old, 60% of 2-year-old and 15% of 3-year-old cod being discarded.

Because the fishery is at present so dependent on incoming year classes, fishing mortalities on these year classes remain high. At the same time, the unbalanced age structure of the stock reduces its reproductive capacity even if a sufficient SSB were reached, as first-time spawners reproduce less successfully than older fish. Both factors are believed to have contributed to the reduction in recruitment of cod.

The North Sea cod stock consists of reproductively isolated populations of Viking cod and Dogger cod, with the Dogger cod population exhibiting spatial heterogeneity and extending to the northern part of Division 6.a (ICES WKNSCodID, 2020). Because these genetically different groups have different rates of maturity and growth, management measures that ensure sustainable exploitation of substocks may be needed in addition to management for the stock as a whole. In particular, the low landings in 7.d in 2020 (32 tonnes in 2020) and low biological sampling in the southern subregion in the NS-IBTS Q1 survey may indicate a collapse of the stock in this area. Official nominal landings from 2020 are low in both divisions 4.c (72 tonnes) and 7.d (40 tonnes).

Cod are taken by towed gears in mixed demersal fisheries, which include haddock, whiting, *Nephrops*, plaice, and sole. They are also taken in directed fisheries using fixed gears. It is important to consider both the species-specific assessments of these species for effective

management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species TACs that do not incorporate such mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another, and the implications of any change need to be considered carefully. The ICES WGMIXFISH Group monitors the consistency of the various single-species management plans under current effort schemes, to estimate the potential risks of quota over- and undershooting for the different stocks.

The catch scenarios presented assume either a 37% overshoot of the TAC in 2021, following a 37% overshoot of the TAC in 2020, or an F of 0.37, the lowest in the time series. The former implies a reduction of catches in 2021 because the TAC in 2021 is 10% lower than the TAC in 2020. Both assumptions give a lower fishing mortality than assuming *status quo* for the intermediate year and may be too optimistic considering entrance of the larger 2019-year class to the fishery and potential for non-compliance to the landing obligation caused by cod becoming a choke species in mixed fisheries.

Both the WG estimates, and official landings reported to ICES show a substantial overshoot of the TAC in 2020, particularly in Subarea 4. The reasons for this are unknown but banking and borrowing or inter-area flexibility could be possibilities.

The forecasting procedure uses the assessment estimate of recruitment in 2021. This remains to be confirmed by the IBTS-Q3 survey and a reopening of the advice may be triggered in October.

4.13 Issues for future benchmarks

The stock was last benchmarked in 2021 and there are initial plans for another benchmark in 2023. Below is a list of issues that were either left unresolved from the last benchmark or have arisen during the subsequent WGNSSK meeting. A scoring system has been developed to aid working groups in prioritising stocks to be put forward for benchmark (see Annex 6 for further details). The current scoring for this stock is:

1. Assessment quality	2. Opportunity to improve	3. Management importance	4. Perceived stock status	5. Time since last benchmark	Total Score
3	4	5	5	1	3.5

4.13.1 Data

Stock identity

Stock identity is an issue for this assessment, with multiple populations inhabiting the North Sea and extending to neighbouring areas (ICES WKNSCodID, 2020). The ICES Workshop on Stock Identification of North Sea Cod (ICES WKNSCodID, 2020) recommended that stock assessments recognise and account for Viking and Dogger cod populations and consider accounting for phenotypic stocks within the Dogger cod population. However, the ability of the last benchmark to reflect the new paradigm of cod stock structure was limited by (1) the challenges of disaggregating historic fisheries data spatially; (2) unexplained differences between the spatially aggregated and disaggregated fisheries data; and (3) the decision to consider connectivity of cod between 6.aN and 4.aW in a future benchmark workshop (ICES WKNSEA, 2021). Trends in sub-stock biomass will continue to be monitored in the meantime.

Maturity

ICES WKNSEA (2015) raised concerns that accounting for the increase in maturity may give the impression that the spawning stock is in better condition than it is given the possibility of lower fecundity of younger age groups and the potential for a maternal age effect on survival, and recommended exploration of the significance of spawner age on reproductive potential.

Survey

Catchability issues and year effects are becoming apparent in the IBTS surveys, with reduced cohort consistency and lower than expected catch rates of older fish in recent years. There are also discrepancies between catch and survey data, with cohorts disappearing faster than expected in the scientific surveys compared to the catches. While there is some evidence to support emigration of North Sea cod to the West of Scotland, age reading issues may also contribute and should be investigated.

Recreational catches

Recreational catches are estimated to account for 5% of the total removals of this stock but are not included in the assessment due to length of time series and unknown age structure and uncertainty (Section 4.2.1). Work on standardisation of recreational inputs should be given relevance for future consideration in the assessment.

4.13.2 Assessment

A range of spatial approaches to stock assessment methods should be considered, including a single-area assessment of the current advisory unit, fleets-as-areas, spatially structured assessments, fully separated subarea assessments and survey-based assessments; ideally with simulation testing to evaluate the relative performance of these alternatives (ICES WKNSCodID, 2020; ICES WKNSEA, 2021).

4.13.3 Forecast

Walker (2020) explored the perception that short-term forecasts in a given year tend to be more optimistic than realised values in subsequent years; however, results of this analysis were largely driven by the retrospective pattern in the former assessment. Similar analyses should be conducted to gain a better idea of potential biases in the forecast procedure.

4.14 References

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Table 4.1 Nominal landings (in tonnes) of COD in Subarea 4, Division 7.d and Subdivision 20, as officially reported to ICES, and as used by the Working Group.

Sub-area IV										
Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	2,470	2,616	1,482	1,627	1,722	1,309	1,008	894	946	666
Denmark	8,358	9,022	4,676	5,889	6,291	5,105	3,430	3,831	4,402	5,686
Faroe Islands	9	34	36	37	34	3	-	16	45	32
France	717	1,777	620	294	664	354	659	573	950	782
Germany	1,810	2,018	2,048	2,213	2,648	2,537	1,899	1,736	2,374	2,844
Greenland	.	.	.	.	35	23	17	17	11	-
Netherlands	3,574	4,707	2,305	1,726	1,660	1,585	1,523	1,896	2,649	2,657
Norway	4,369	5,217	4,417	3,223	2,900	2,749	3,057	4,128	4,234	4,495
Poland	18	39	35	-	-	-	1	2	3	-
Sweden	661	463	252	240	319	309	386	439	378	362
UK (E/W/NI)	4,087	3,112	2,213	1,890	1,270	1,491	1,587	1,546	2,383	2,553
UK (Scotland)	15,640	15,416	7,852	6,650	4,936	6,857	6,511	7,185	9,052	11,567
Others	0	0	0	0	0	786	-	-	-	-
Danish industrial by-catch *	.	105	22	17	21	11	23	1	72	12
Norwegian industrial by-catch *	.	.	.	.	.	48	101	22	4	201
Total Nominal Catch	41,713	44,526	25,958	23,806	22,500	23,119	20,102	22,262	27,497	31,657
Unallocated landings	-740	-2,333	-1,875	-1,277	356	-2,041	-1,046	-605	136	-677
WG estimate of total landings	**40,973**	**42,193**	**24,083**	**22,529**	**22,855**	**21,078**	**19,056**	**21,657**	**27,634**	**30,980**
Agreed TAC	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**	**28,798**	**33,552**

Division VIId										
Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	93	51	54	47	51	80	84	154	73	57
Denmark	-	-	-	-	-	-	-	-	-	-
France	1,677	1,361	1,730	810	986	1,124	1,743	1,326	1,779	1,606
Netherlands	17	6	36	14	9	9	59	30	35	45
UK (E/W/NI)	249	145	121	103	184	267	174	144	133	127
UK (Scotland)	-	-	-	-	-	1	12	7	3	1
Total Nominal Catch	2,036	1,563	1,941	974	1,230	1,480	2,073	1,662	2,023	1,836
Unallocated landings	-463	1,576	190	40	29	-2	74	-33	-135	-128
WG estimate of total landings	**1,573**	**3,139**	**2,131**	**1,014**	**1,259**	**1,479**	**2,147**	**1,629**	**1,887**	**1,708**
Agreed TAC									**1,678**	**1,955**

Division IIIa (Skagerrak)**										
Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	5,900	5,525	3,067	3,038	3,019	2,513	2,246	2,553	3,024	3,286
Germany	32	83	49	99	86	84	67	52	55	56
Norway	762	645	825	856	759	628	681	779	440	375
Sweden	1,035	897	510	495	488	372	370	365	459	458
Others	-	-	27	24	21	373	385	13	2	26
Danish industrial by-catch *	687	20	5	4	2	3	2	7	2	10
Total Nominal Catch	7,729	7,170	4,483	4,516	4,375	3,972	3,751	3,769	3,982	4,211
Unallocated landings	-643	-316	-504	-602	-376	-715	-731	-376	-188	-154
WG estimate of total landings	**7,086**	**6,854**	**3,979**	**3,914**	**3,998**	**3,258**	**3,020**	**3,393**	**3,794**	**4,057**
Agreed TAC	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**	**4,114**	**4,793**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Nominal Catch	51,478	53,260	32,382	29,296	28,104	28,572	25,926	27,693	33,502	37,704
Unallocated landings	-1,846	-1,074	-2,189	-1,839	9	-2,757	-1,703	-1,014	-187	-958
WG estimate of total landings	**49,632**	**52,186**	**30,193**	**27,457**	**28,113**	**25,815**	**24,223**	**26,679**	**33,315**	**36,746**

** Skaggerak/Kattegat split derived from national statistics

* The Danish (up to 2001) and Norwegian industrial bycatch are not included in the (WG estimate of) total landings

. Magnitude not available - Magnitude known to be nil <0.5 Magnitude less than half the unit used in the table n/a Not applicable

Division IV and IIIa (Skagerrak) landings not included in the assessment										
Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Danish industrial by-catch *	687	-	-	-	-	-	-	-	-	-
Norwegian industrial by-catch	.	.	.	.	.	48	101	22	4	201
Total	**687**	**.**	**.**	**.**	**.**	**48**	**101**	**22**	**4**	**201**

Table 4.1 cont. Nominal landings (in tonnes) of COD in Subarea 4, Division 7.d and Subdivision 20, as officially reported to ICES, and as used by the Working Group.

Sub-area IV										
Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium	653	862	1,075	1,258	1,223	1,103	695	817	727	666
Denmark	4,863	4,803	4,536	5,457	6,026	6,713	6,119	5,493	4,964	3,064
Faroe Islands	-	-	-	-	-	-	-	-	0	.
France	619	369	287	637	517	391	401	583	450	265
Germany	2,211	2,385	1,921	2,257	2,133	2,083	2,300	1,510	822	755
Greenland	-	-	-	-	-	2	1	-	.	.
Netherlands	1,928	1,955	1,344	1,242	1,403	1,365	653	515	716	590
Norway	4,898	4,601	4,080	4,600	5,404	5,627	5,521	5,539	4,518	2,330
Poland	2	-	-	-	-	-	-	-	.	.
Sweden	316	471	332	401	415	373	387	274	344	354
UK (E/W/NI)	2,169	1,629	2,129	2,962	.	.	.	.	.	.
UK (Scotland)	10,141	10,565	10,619	10,517	.	.	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	14,889	16,603	18,523	21,265	15,589	9,061
Others	-	-	-	-	-	-	-	-	-	-
Danish industrial by-catch	0	0	2	24	0	5	147	0	2	11
Norwegian indust by-catch *	1	.	.	.	.	.	.	.	.	.
Total Nominal Catch	27,800	27,640	26,324	29,355	32,012	34,265	34,746	35,997	28,130	17,095
Unallocated landings	-1,125	-1,013	-1,009	-805	-768	-1,230	-1,637	-1,553	428	98
BMS landings	-	-	-	-	-	-	1	8	41	32
WG estimate of total landings	**26,675**	**26,627**	**25,315**	**28,550**	**31,244**	**33,035**	**33,109**	**34,444**	**28,558**	**17,192**
Agreed TAC	**26,842**	**26,475**	**26,475**	**27,799**	**29,189**	**33,651**	**39,220**	**43,156**	**29,437**	**14,718**

Division VIId										
Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium	56	40	53	72	78	39	18	8	3	8
Denmark	-	-	-	-	-	-	-	-	.	.
France	1,078	885	768	1,270	1,142	279	92	35	15	10
Netherlands	51	40	38	50	52	40	22	10	3	2
UK (E/W/NI)	125	99	100	156	.	.	.	.	.	.
UK (Scotland)	1	-	-	-	.	.	.	.	.	.
UK (combined)	n/a	n/a	n/a	n/a	162	102	48	39	17	20
Others	-	-	-	-	-	-	<0.5	-	<0.5	-
Total Nominal Catch	1,311	1,064	959	1,548	1,434	459	180	92	37	40
Unallocated landings	8	56	-43	-112	-36	-38	-10	-8	-2	-8
BMS landings	-	-	-	-	-	-	-	-	-	<0.5
WG estimate of total landings	**1,319**	**1,120**	**916**	**1,436**	**1,398**	**421**	**170**	**84**	**36**	**32**
Agreed TAC	**1,564**	**1,543**	**1,543**	**1,620**	**1,701**	**1,961**	**2,059**	**1,733**	**1,715**	**858**

Division IIIa (Skagerrak)**										
Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Denmark	3,118	3,178	3,033	3,430	3,344	3,696	3,665	4,222	2,740	1,857
Germany	60	78	69	84	87	94	67	87	53	35
Norway	421	615	575	533	500	551	486	288	152	94
Sweden	518	520	529	570	571	641	557	670	354	223
Others	-	-	33	28	26	25	37	58	40	18
Danish industrial by-catch	0	1	1	5	5	0	40	7	1	13
Total Nominal Catch	4,117	4,391	4,240	4,650	4,533	5,006	4,852	5,333	3,338	2,239
Unallocated landings	-161	-64	-86	37	31	-232	-137	151	140	61
BMS landings	-	-	-	-	-	-	1	4	3	4
WG estimate of total landings	**3,956**	**4,327**	**4,154**	**4,687**	**4,563**	**4,774**	**4,715**	**5,484**	**3,478**	**2,299**
Agreed TAC	**3,835**	**3,783**	**3,783**	**3,972**	**4,171**	**4,807**	**5,744**	**7,995**	**4,205**	**2,103**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Nominal Catch	33,228	33,095	31,523	35,554	37,978	39,730	39,778	41,422	31,506	19,373
Unallocated landings	-1,277	-1,022	-1,138	-880	-773	-1,500	-1,784	-1,410	566	150
BMS landings	.	.	.	.	.	.	2	12	44	36
WG estimate of total landings	**31,950**	**32,074**	**30,386**	**34,673**	**37,205**	**38,230**	**37,994**	**40,012**	**32,072**	**19,523**

*** WG estimates of total landings do not include BMS landings

** Skaggerak/Kattegat split derived from national statistics prior to 2016

* The Norwegian industrial by-catch are not included in the (WG estimate of) total landings

. Magnitude not available - Magnitude known to be nil <0.5 Magnitude less than half the unit used in the table n/a Not applicable

Division IV and IIIa (Skagerrak) landings not included in the assessment										
Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Norwegian indust by-catch *	1	.	.	.	.	.	.	.	.	.
Total	**1**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**

Table 4.2a. Cod in Subarea 4, Division 7.d and Subdivision 20: Landings numbers at age (Thousands).

Landings numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	3198	5004	15734	18133	10749	5800	2932	54219	44599	3813	25836	15484
2	42377	22373	51628	62202	70539	83416	22561	33747	154565	186744	31596	58624
3	6995	20003	17557	29695	32529	42373	31419	18395	17132	47885	54655	11347
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002	15745
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195	4601
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103	956
7	81	596	655	475	884	866	585	956	888	1671	1055	436
8	489	117	297	368	353	307	420	208	455	609	487	393
9	13	93	51	125	137	150	147	185	227	388	79	330
10	6	11	75	56	40	111	46	97	77	112	57	80
+gp	0	4	8	83	17	24	77	40	93	17	161	188
TOTALNUM	60659	56203	98460	121923	131671	152829	79251	129139	234508	252789	131226	108183
TONSLAND	115873	125408	180127	220225	251707	286921	199753	224989	326451	352200	237851	213204
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	33210	5695	75130	29593	34627	62394	20131	66220	25488	64358	8795	99841
2	46907	99779	50926	174912	91143	104356	187626	64755	128396	66026	117383	32308
3	18849	18481	25525	17178	44384	34938	34567	59907	21456	31087	18888	33973
4	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238	7779	5791
5	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415	1369	2981
6	2057	3056	833	1103	708	1269	779	2048	1246	1013	1257	602
7	447	920	1140	408	396	494	599	425	589	434	371	554
8	195	130	370	403	139	197	133	234	179	243	172	170
9	228	67	262	152	157	73	64	77	89	59	78	69
10	95	63	26	36	42	55	36	27	28	44	16	44
+gp	63	43	96	44	17	25	21	16	23	19	31	23
TOTALNUM	114215	136672	161191	236214	178997	218034	256998	206643	192083	170937	156139	176355
TONSLAND	204215	232994	208370	295645	268342	292656	333047	300723	256815	226904	213422	203242
SOPCOF %	100	100	100	100	101	100	100	99	100	100	100	101

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	24816	21362	22072	11629	13288	27162	4688	15366	15486	4871	23443	1243
2	127774	55025	36084	53783	23145	31472	54171	24969	62650	36303	28793	80948
3	9761	43712	18056	11795	16554	8523	11134	20885	12753	23046	18390	16794
4	8689	3117	9791	4299	3267	4916	3126	3045	5223	3125	6409	5909
5	1528	2543	994	2445	1372	1041	1546	859	790	1834	1221	2379
6	1071	652	1028	307	1039	482	426	513	282	393	690	504
7	234	293	249	307	222	323	200	140	148	159	151	233
8	215	66	139	54	137	51	106	57	41	87	47	41
9	55	63	27	60	27	39	17	32	14	42	14	16
10	48	23	31	12	4	17	10	7	13	4	15	4
+gp	12	18	10	9	9	9	13	16	5	8	10	12
TOTALNUM	174203	126873	88481	84698	59065	74034	75437	65889	97405	69872	79183	108083
TONSLAND	215356	183223	138881	124144	101122	111932	119323	109279	134091	124598	122453	144603
SOPCOF %	100	100	100	99	100	99	99	99	98	100	100	100

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	5831	8087	2164	4425	438	1470	1009	1286	776	338	519	1120
2	9549	22457	20309	8029	8893	3511	8175	4401	6334	3268	4833	5037
3	31624	6310	6044	13831	3552	5453	3036	4410	2264	4130	2839	4578
4	3959	6529	1114	2787	3072	1527	1714	969	1562	1146	2888	1582
5	1419	996	1053	395	397	939	479	520	398	706	596	1315
6	614	375	140	384	68	155	339	187	137	213	237	198
7	219	135	82	58	61	29	52	120	40	70	44	65
8	89	39	27	38	15	19	13	23	39	26	19	16
9	14	18	13	18	5	6	9	4	6	13	17	6
10	10	5	6	4	2	2	1	1	1	1	8	4
+gp	2	1	1	1	0	0	1	0	1	1	3	2
TOTALNUM	53329	44952	30953	29971	16505	13111	14830	11921	11558	9911	12003	13923
TONSLAND	94431	69586	48446	52187	30194	27457	28113	25815	24223	26679	33315	36746
SOPCOF %	100	100	100	98	99	99	100	101	100	99	100	100

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	1099	665	683	2240	686	167	351	170	886	790
2	4540	2230	2688	4207	6384	2035	2240	6004	1856	2861
3	4046	5367	3063	4376	4903	5644	3233	3599	6019	1675
4	1408	1963	2592	1605	1933	3150	3495	2039	1097	1482
5	610	633	865	1286	745	1012	1660	1776	928	440
6	451	248	190	332	584	277	385	780	496	279
7	48	139	84	64	144	188	94	282	338	115
8	27	15	38	38	22	44	78	67	82	47
9	5	4	5	6	6	9	24	45	62	11
10	2	4	1	2	1	5	9	15	4	11
+gp	2	1	1	0	2	2	2	9	6	0
TOTALNUM	12237	11269	10208	14156	15411	12534	11571	14789	11774	7712
TONSLAND	31950	32074	30386	34673	37205	38230	37994	40012	32072	19523
SOPCOF %	100	100	100	100	100	100	101	100	99	101

Table 4.2b. Cod in Subarea 4, Division 7.d and Subdivision 20: Discard numbers at age (including BMS landings from 2016; Thousands).

Discards numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	16150	8049	97921	108375	50214	31115	2502	52958	258920	38250	85915	124151
2	19902	6168	6599	22125	24736	22957	10279	8656	37224	59342	17387	15878
3	33	115	89	71	160	197	113	152	47	177	246	71
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	36085	14332	104609	130570	75110	54268	12894	61766	296192	97768	103548	140100
TONSDISC	12186	4707	29104	37918	23320	17487	4792	17838	83968	33678	30038	39607
SOPCOF %	100	101	100	100	100	100	101	101	100	100	100	100

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	136651	226781	472599	28908	581071	1185689	155732	181946	54949	537521	63301	563506
2	16214	83210	48009	78114	5270	17692	34307	8377	11130	12518	36573	5761
3	0	192	464	0	0	0	79	98	25	5	115	303
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	152866	310182	521072	107022	586341	1203381	190118	190421	66103	550043	99989	569571
TONSDISC	36874	72474	139296	32432	162293	294455	57474	54047	21890	151003	31326	138529
SOPCOF %	100	100	100	100	100	100	101	100	102	100	100	100

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	24634	15376	176920	33875	47473	102410	33433	320725	44756	14254	86109	15458
2	61948	17084	8685	48244	8383	9881	28538	16804	43434	23058	13701	90259
3	0	216	489	78	448	2	11	160	30	764	40	1500
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	86583	32676	186094	82197	56304	112293	61983	337689	88220	38075	99851	107216
TONSDISC	27729	10655	61650	26770	18306	36244	21425	98358	31714	14061	33155	40089
SOPCOF %	100	101	100	100	101	100	100	100	100	100	100	100

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	30962	37031	5460	26267	5696	20336	10213	26890	16171	10847	9608	9867
2	5630	5509	33094	13236	6082	8941	8303	35342	23047	9331	9055	9151
3	8280	0	753	3181	775	2007	1795	1965	2657	7591	2655	1254
4	0	0	0	17	55	122	149	51	481	223	650	65
5	0	0	0	0	0	6	66	4	52	14	50	30
6	0	0	0	0	0	0	12	1	24	11	17	0
7	0	0	0	0	0	0	0	1	0	0	9	0
8	0	0	0	0	0	0	0	0	2	0	0	0
9	0	0	0	0	0	0	2	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	2	0
+gp	0	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	44872	42540	39307	42702	12608	31413	20540	64253	42433	28017	22047	20366
TONSDISC	13916	13370	13523	11911	4081	8802	10087	12011	30450	25080	20965	12488
SOPCOF %	102	100	100	100	102	101	102	101	100	100	101	101

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	3936	11149	6188	7756	3980	3067	9767	2771	4101	11163
2	7851	5190	6055	6504	8935	4942	2814	9039	1614	4331
3	925	1422	856	1434	1965	3110	1271	737	915	287
4	81	115	397	163	180	257	493	147	16	9
5	6	5	83	58	55	31	96	8	4	0
6	4	1	40	5	64	1	9	0	0	0
7	1	1	16	0	15	0	1	0	0	0
8	1	0	0	0	5	0	1	0	0	0
9	0	0	0	0	3	0	0	2	0	0
10	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0
TOTALNUM	12804	17884	13635	15921	15201	11409	14453	12704	6650	15791
TONSDISC	8745	8689	10324	10666	12562	12315	8731	7824	3607	4701
SOPCOF %	100	101	100	101	100	101	100	101	101	100

Table 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch numbers at age (Thousands).

Catch numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	19347	13052	113655	126508	60962	36915	5434	107177	303519	42062	111751	139635
2	62280	28541	58227	84327	95275	106373	32840	42403	191789	246086	48983	74502
3	7028	20118	17646	29766	32689	42569	31532	18547	17179	48062	54901	11418
4	3519	4285	9135	6153	11205	12330	13641	13272	6720	5653	14002	15745
5	2774	1908	2375	3362	3255	6046	4542	6266	7065	2713	2195	4601
6	1207	1809	946	1272	1964	1407	2881	1754	2686	3184	1103	956
7	81	596	655	475	884	866	585	956	888	1671	1055	436
8	489	117	297	368	353	307	420	208	455	609	487	393
9	13	93	51	125	137	150	147	185	227	388	79	330
10	6	11	75	56	40	111	46	97	77	112	57	80
+gp	0	4	8	83	17	24	77	40	93	17	161	188
TOTALNUM	96744	70535	203069	252494	206780	207098	92145	190905	530700	350558	234774	248283
TONSLAND	128058	130116	209232	258143	275028	304408	204544	242827	410420	385878	267890	252811
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	169862	232476	547729	58501	615698	1248084	175863	248166	80437	601879	72096	663347
2	63121	182989	98935	253025	96413	122048	221933	73132	139526	78543	153957	38069
3	18849	18672	25989	17178	44384	34938	34646	60005	21480	31092	19003	34277
4	4640	6707	4597	9396	4011	12274	8953	9487	11787	4238	7779	5791
5	7525	1732	2286	2989	3375	1958	4088	3447	2803	3415	1369	2981
6	2057	3056	833	1103	708	1269	779	2048	1246	1013	1257	602
7	447	920	1140	408	396	494	599	425	589	434	371	554
8	195	130	370	403	139	197	133	234	179	243	172	170
9	228	67	262	152	157	73	64	77	89	59	78	69
10	95	63	26	36	42	55	36	27	28	44	16	44
+gp	63	43	96	44	17	25	21	16	23	19	31	23
TOTALNUM	267081	446854	682263	343235	765338	1421415	447116	397064	258186	720980	256129	745925
TONSLAND	241089	305468	347666	328077	430635	587111	390521	354770	278705	377907	244748	341771
SOPCOF %	100	100	100	100	101	100	100	100	100	100	100	101

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	49451	36738	198992	45504	60761	129572	38121	336092	60242	19124	109552	16701
2	189722	72109	44768	102027	31528	41353	82709	41773	106084	59360	42494	171206
3	9761	43929	18544	11873	17002	8525	11145	21045	12783	23809	18430	18293
4	8689	3117	9791	4299	3267	4916	3126	3045	5223	3125	6409	5909
5	1528	2543	994	2445	1372	1041	1546	859	790	1834	1221	2379
6	1071	652	1028	307	1039	482	426	513	282	393	690	504
7	234	293	249	307	222	323	200	140	148	159	151	233
8	215	66	139	54	137	51	106	57	41	87	47	41
9	55	63	27	60	27	39	17	32	14	42	14	16
10	48	23	31	12	4	17	10	7	13	4	15	4
+gp	12	18	10	9	9	9	13	16	5	8	10	12
TOTALNUM	260786	159550	274574	166895	115368	186327	137419	403578	185625	107947	179034	215299
TONSLAND	243085	193878	200531	150914	119428	148176	140748	207637	165805	138659	155608	184692
SOPCOF %	100	100	100	100	100	99	100	100	99	100	100	100

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	36793	45118	7624	30692	6135	21807	11222	28177	16947	11185	10127	10987
2	15180	27965	53403	21265	14975	12452	16478	39743	29381	12599	13887	14188
3	39904	6310	6797	17012	4328	7460	4831	6375	4921	11721	5494	5831
4	3959	6529	1114	2805	3127	1650	1863	1020	2043	1369	3539	1646
5	1419	996	1053	395	397	944	546	524	451	720	646	1344
6	614	375	140	384	68	155	351	187	161	224	254	199
7	219	135	82	58	61	29	52	121	40	70	53	65
8	89	39	27	38	15	19	13	23	41	26	19	16
9	14	18	13	18	5	6	11	4	6	13	17	6
10	10	5	6	4	2	2	1	1	1	1	10	4
+gp	2	1	1	1	0	0	1	0	1	1	3	2
TOTALNUM	98201	87491	70260	72673	29113	44524	35370	76174	53992	37928	34050	34288
TONSLAND	108347	82956	61969	64098	34274	36259	38200	37826	54673	51759	54280	49234
SOPCOF %	101	100	100	99	100	99	100	101	100	100	100	100

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	5035	11815	6871	9995	4666	3234	10118	2942	4986	11953
2	12391	7420	8743	10711	15319	6977	5054	15043	3470	7192
3	4970	6789	3919	5810	6869	8754	4504	4337	6935	1962
4	1489	2077	2989	1768	2113	3408	3987	2186	1113	1492
5	616	638	949	1345	800	1044	1756	1784	932	440
6	455	249	229	337	648	279	395	780	496	279
7	49	139	100	64	159	188	95	282	338	115
8	28	15	38	38	27	44	79	67	82	47
9	5	4	5	6	9	9	24	47	62	11
10	2	4	2	2	1	5	9	15	4	11
+gp	2	1	1	0	2	2	2	9	6	0
TOTALNUM	25041	29153	23844	30076	30612	23942	26024	27493	18425	23503
TONSLAND	40695	40763	40710	45339	49767	50544	46725	47836	35679	24224
SOPCOF %	100	100	100	100	100	100	101	100	99	101

Table 4.2d. Cod in Subarea 4, Division 7.d and Subdivision 20: Landings, discards (including BMS landings) and catch numbers at age (Thousands) by season (quarter or annual, depending on data stratification) from InterCatch for 2020.

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	23	54	146	539	28	790
2	228	472	953	1166	43	2862
3	284	643	474	255	19	1675
4	380	430	369	289	15	1483
5	102	157	117	60	5	441
6	96	75	69	36	3	279
7	46	33	19	15	1	114
8	7	11	16	12	1	47
9	5	2	2	1	0	10
10	3	2	4	1	0	10
+gp	0	0	0	0	0	0
TOTALNUM	1174	1879	2169	2374	115	7711

Discards numbers at age (including BMS landings; thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	1244	1835	1907	3447	2730	11163
2	1054	561	1146	1136	433	4330
3	26	34	112	69	46	287
4	1	1	2	0	4	8
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0
TOTALNUM	2325	2431	3167	4652	3213	15788

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	1267	1889	2053	3987	2758	11954
2	1283	1032	2099	2302	476	7192
3	310	677	586	324	65	1962
4	381	432	371	290	18	1492
5	102	157	117	60	5	441
6	96	75	69	36	3	279
7	46	33	19	15	1	114
8	7	11	16	12	1	47
9	5	2	2	1	0	10
10	3	2	4	1	0	10
+gp	0	0	0	0	0	0
TOTALNUM	3500	4310	5336	7028	3327	23501

Table 4.2e. Cod in Subarea 4, Division 7.d and Subdivision 20: Sampling coverage for discard ratio, landings age composition and discards age composition by area and season (quarter or annual, depending on data stratification) for 2020, calculated as the weight in each area–season–métier stratum covered by the relevant sampling, then summed over métiers and expressed as a proportion of the total for the area–season (note the country dimension is not used). Also provided is the contribution of landings, discards and BMS in each area (by weight) to the total for that catch category (before raising is conducted).

Discard ratio coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	76%	23%	61%	79%	27%
27.3.a.20	51%	50%	63%	39%	-
27.7.d	40%	-	16%	53%	-

Landings age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	91%	36%	81%	89%	27%
27.3.a.20	94%	94%	84%	94%	-
27.7.d	-	-	-	-	-

Discards age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
27.4	90%	71%	98%	98%	100%
27.3.a.20	100%	100%	100%	100%	-
27.7.d	-	-	-	-	-

Contribution to total (before raising)

Area/Type	Landings	Discards	BMS
27.4	88%	67%	100%
27.3.a.20	12%	33%	0%
27.7.d	0%	0%	0%

Table 4.3a. Cod in Subarea 4, Division 7.d and Subdivision 20: Landings weights at age (kg).

Landings weights at age (kg)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0.538	0.496	0.581	0.579	0.590	0.640	0.544	0.626	0.579	0.616	0.559	0.594
2	1.004	0.863	0.965	0.994	1.035	0.973	0.921	0.961	0.941	0.836	0.869	1.039
3	2.657	2.377	2.304	2.442	2.404	2.223	2.133	2.041	2.193	2.086	1.919	2.217
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776	4.156
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488	6.174
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453	8.333
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019	9.889
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810	10.791
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077	12.175
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359	12.425
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886	13.731

AGE/YEAR	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.619	0.568	0.541	0.573	0.550	0.550	0.723	0.589	0.632	0.594	0.590	0.583
2	0.899	1.029	0.948	0.937	0.936	1.003	0.837	0.962	0.919	1.007	0.932	0.856
3	2.348	2.470	2.160	2.001	2.411	1.948	2.190	1.858	1.835	2.156	2.141	1.834
4	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972	4.164	3.504
5	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190	6.324	6.230
6	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362	8.430	8.140
7	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317	10.362	9.896
8	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352	12.074	11.940
9	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505	13.072	12.951
10	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408	14.443	13.859
+gp	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472	16.588	14.707

AGE/YEAR	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.635	0.585	0.673	0.737	0.670	0.699	0.699	0.677	0.721	0.699	0.656	0.542
2	0.976	0.881	1.052	0.976	1.078	1.146	1.065	1.075	1.021	1.117	0.960	0.922
3	1.955	1.982	1.846	2.176	2.038	2.546	2.479	2.201	2.210	2.147	2.120	1.724
4	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293	4.034	3.821	3.495
5	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220	6.637	6.228	5.387
6	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980	8.494	8.394	7.563
7	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282	9.729	9.979	9.628
8	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743	11.080	11.424	10.643
9	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107	12.264	12.300	11.499
10	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052	12.756	12.761	13.085
+gp	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954	11.304	13.416	14.921

AGE/YEAR	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.640	0.611	0.725	0.626	0.573	0.726	0.747	0.793	0.830	1.067	0.788	0.715
2	0.935	1.021	1.004	0.996	1.079	1.072	1.160	1.200	1.182	1.389	1.412	1.292
3	1.663	1.747	2.303	1.844	1.895	2.089	1.952	2.239	2.365	2.456	2.674	2.671
4	3.305	3.216	3.663	3.735	3.347	3.252	3.647	3.894	4.050	4.063	4.145	4.223
5	5.726	4.903	5.871	5.537	5.757	5.184	5.244	5.676	6.053	6.224	6.119	6.049
6	7.403	7.488	7.333	8.006	6.694	7.438	7.225	7.234	8.250	7.393	7.490	8.299
7	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.243	9.262	9.651	8.968	9.472
8	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477	10.015	11.489	11.447	11.631
9	11.600	10.894	12.062	11.888	11.518	11.857	12.015	12.325	12.282	11.387	11.291	12.827
10	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862	14.559	12.725	11.716	12.083
+gp	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887	17.522	15.381	18.764	10.052

AGE/YEAR	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.862	0.938	0.883	0.699	0.596	0.800	0.753	0.607	0.764	0.759
2	1.328	1.369	1.240	1.213	1.206	1.315	1.119	1.065	1.119	1.358
3	2.525	2.354	2.461	2.390	2.291	2.342	2.379	1.943	2.136	1.925
4	4.596	4.175	4.164	4.180	4.112	3.862	3.906	3.838	3.707	3.809
5	6.481	6.391	6.187	5.678	5.935	5.744	5.393	5.633	5.505	5.424
6	7.843	8.115	8.347	7.435	6.920	7.342	6.897	6.829	7.188	6.729
7	9.681	9.092	9.817	9.191	8.775	7.928	8.906	7.683	7.764	8.964
8	9.629	11.799	9.486	9.180	9.622	8.717	8.664	8.867	9.684	8.671
9	10.845	12.548	11.364	11.469	10.654	10.367	9.586	8.481	6.788	11.459
10	14.436	11.436	10.935	16.456	13.838	11.926	17.579	8.972	11.466	16.458
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.381	21.796	14.596

Table 4.3b. Cod in Subarea 4, Division 7.d and Subdivision 20: Discard weights-at-age (includes BMS landings from 2016; kg).

Discards weights at age (kg)

AGE/YEAF	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0.270	0.270	0.269	0.269	0.269	0.269	0.268	0.268	0.268	0.268	0.268	0.268
2	0.393	0.393	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
3	0.505	0.508	0.506	0.509	0.506	0.505	0.504	0.505	0.508	0.507	0.507	0.508
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAF	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.227	0.189	0.255	0.287	0.276	0.242	0.279	0.274	0.297	0.270	0.276	0.242
2	0.359	0.354	0.382	0.309	0.361	0.411	0.396	0.489	0.458	0.469	0.376	0.365
3	0.000	0.412	0.376	0.000	0.000	0.000	0.517	0.593	0.534	0.509	0.652	0.437
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAF	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.237	0.300	0.326	0.260	0.315	0.314	0.274	0.287	0.316	0.342	0.313	0.358
2	0.353	0.339	0.431	0.371	0.366	0.408	0.429	0.362	0.404	0.380	0.453	0.375
3	0.000	0.463	0.484	0.526	0.395	2.309	0.705	0.483	0.553	0.515	0.616	0.481
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAF	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.257	0.298	0.232	0.243	0.262	0.236	0.302	0.224	0.288	0.404	0.385	0.292
2	0.389	0.422	0.361	0.314	0.345	0.270	0.565	0.116	0.814	0.735	0.984	0.785
3	0.422	0.000	0.406	0.413	0.498	0.686	0.814	0.827	1.690	1.699	2.013	1.533
4	0.000	0.000	0.000	2.205	0.528	0.864	2.223	2.557	3.949	3.002	3.485	3.137
5	0.000	0.000	0.000	0.000	0.000	3.852	4.255	4.208	6.609	5.311	6.565	5.323
6	0.000	0.000	0.000	0.000	0.000	11.300	6.509	5.437	10.198	9.341	8.521	8.369
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11.048	5.900	5.128	13.464	6.728
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.906	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	8.100	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.014	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAF	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.277	0.234	0.334	0.311	0.326	0.364	0.231	0.281	0.328	0.220
2	0.677	0.556	0.796	0.742	0.759	0.939	0.771	0.607	0.557	0.456
3	2.057	1.867	1.493	1.772	1.617	1.767	1.881	1.410	1.382	0.842
4	4.099	3.803	3.375	3.128	3.158	3.092	3.002	2.662	2.286	2.578
5	5.576	6.456	4.048	3.826	3.983	4.687	3.629	3.560	2.641	0.000
6	6.071	8.579	8.419	4.642	5.303	5.439	5.172	0.000	0.000	0.000
7	8.264	9.733	7.086	4.423	6.940	0.000	5.313	0.000	0.000	0.000
8	6.213	0.000	0.000	0.000	8.390	0.000	4.577	0.000	0.000	0.000
9	11.617	0.000	0.000	0.000	4.087	0.000	0.000	9.790	0.000	0.000
10	0.000	16.370	16.370	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch weights at age (kg).

Catch weights at age (kg)

AGE/YEAF	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0.314	0.357	0.312	0.313	0.326	0.327	0.417	0.449	0.314	0.300	0.335	0.304
2	0.809	0.761	0.900	0.836	0.868	0.848	0.755	0.845	0.834	0.729	0.700	0.901
3	2.647	2.366	2.295	2.437	2.395	2.215	2.127	2.028	2.188	2.080	1.913	2.206
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776	4.156
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488	6.174
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453	8.333
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019	9.889
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810	10.791
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077	12.175
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359	12.425
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886	13.731

AGE/YEAF	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.304	0.198	0.294	0.432	0.291	0.257	0.330	0.358	0.403	0.305	0.314	0.293
2	0.760	0.722	0.673	0.743	0.905	0.917	0.769	0.908	0.882	0.921	0.800	0.782
3	2.348	2.449	2.128	2.001	2.411	1.948	2.186	1.856	1.834	2.156	2.132	1.822
4	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972	4.164	3.504
5	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190	6.324	6.230
6	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362	8.430	8.140
7	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317	10.362	9.896
8	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352	12.074	11.940
9	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505	13.072	12.951
10	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408	14.443	13.859
+gp	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472	16.588	14.707

AGE/YEAF	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.437	0.466	0.364	0.382	0.393	0.395	0.326	0.305	0.420	0.433	0.386	0.372
2	0.773	0.753	0.932	0.690	0.889	0.970	0.846	0.788	0.768	0.831	0.797	0.634
3	1.955	1.975	1.810	2.165	1.995	2.546	2.477	2.188	2.206	2.095	2.117	1.622
4	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293	4.034	3.821	3.495
5	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220	6.637	6.228	5.387
6	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980	8.494	8.394	7.563
7	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282	9.729	9.979	9.628
8	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743	11.080	11.424	10.643
9	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107	12.264	12.300	11.499
10	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052	12.756	12.761	13.085
+gp	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954	11.304	13.416	14.921

AGE/YEAF	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.318	0.354	0.372	0.298	0.285	0.269	0.342	0.250	0.313	0.424	0.406	0.335
2	0.732	0.903	0.606	0.572	0.781	0.496	0.860	0.236	0.893	0.904	1.133	0.965
3	1.405	1.747	2.093	1.576	1.645	1.712	1.529	1.804	2.001	1.966	2.355	2.426
4	3.305	3.216	3.663	3.726	3.298	3.075	3.533	3.828	4.026	3.890	4.023	4.180
5	5.726	4.903	5.871	5.537	5.757	5.175	5.124	5.665	6.117	6.207	6.154	6.033
6	7.403	7.488	7.333	8.006	6.694	7.449	7.201	7.229	8.543	7.491	7.560	8.299
7	8.582	9.636	9.264	9.451	8.838	8.974	9.457	9.262	9.255	9.644	9.733	9.472
8	10.365	10.671	10.081	10.012	12.674	9.894	10.567	10.477	10.293	11.489	11.447	11.631
9	11.600	10.894	12.062	11.888	11.518	11.857	11.384	12.325	12.282	11.387	11.291	12.827
10	12.330	11.414	12.009	12.795	11.053	12.095	12.066	14.862	14.559	12.725	11.786	12.083
+gp	11.926	15.078	10.196	11.688	14.988	14.093	22.464	17.887	17.522	15.381	18.764	10.052

AGE/YEAF	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	0.405	0.274	0.388	0.398	0.366	0.387	0.249	0.300	0.405	0.256
2	0.915	0.800	0.932	0.927	0.945	1.049	0.925	0.790	0.857	0.815
3	2.438	2.252	2.249	2.237	2.098	2.138	2.238	1.853	2.036	1.766
4	4.569	4.154	4.060	4.083	4.031	3.803	3.794	3.759	3.687	3.802
5	6.472	6.392	5.999	5.598	5.802	5.712	5.296	5.624	5.493	5.424
6	7.829	8.117	8.360	7.392	6.761	7.332	6.857	6.829	7.188	6.729
7	9.656	9.095	9.385	9.190	8.602	7.928	8.850	7.683	7.764	8.964
8	9.461	11.799	9.486	9.180	9.410	8.717	8.618	8.867	9.684	8.671
9	10.853	12.548	11.364	11.469	8.663	10.367	9.586	8.546	6.788	11.459
10	14.436	11.754	11.680	16.456	13.838	11.926	17.579	8.972	11.466	16.458
+gp	12.421	20.644	29.764	34.656	30.079	19.623	20.519	23.381	21.796	14.596

Table 4.3d. Cod in Subarea 4, Division 7.d and Subdivision 20: Landings, discards (including BMS landings) and catch weights at age (kg) by season (quarter or annual, depending on data stratification) from InterCatch for 2020 (note, any differences in the +gp values between Tables 4.3a–c and Table 4.3d are due to rounding error alone).

Landings weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.702	0.753	0.713	0.774	0.77	0.759
2	0.946	1.293	1.314	1.495	1.517	1.358
3	1.793	1.437	2.14	2.886	2.157	1.925
4	3.355	3.44	3.912	4.823	3.854	3.809
5	5.03	4.765	6.026	6.65	5.547	5.424
6	6.297	6.577	7.226	7.249	6.708	6.729
7	8.679	8.794	9.875	9.044	9.269	8.964
8	7.942	9.788	8.652	8.083	8.619	8.671
9	10.996	11.433	12.196	12.532	11.496	11.459
10	16.863	17.762	14.569	21.285	16.99	16.458
+gp	15.53	15.947	15.643	15.398	11.734	14.597

Discards weights at age (including BMS landings; kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.16	0.163	0.265	0.249	0.218	0.22
2	0.319	0.516	0.564	0.357	0.688	0.456
3	0.839	1.007	0.84	0.666	0.991	0.842
4	2.229	2.86	3.444	2.683	2.028	2.578
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0

Catch weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.169	0.18	0.297	0.32	0.223	0.256
2	0.431	0.871	0.905	0.933	0.762	0.815
3	1.712	1.416	1.891	2.413	1.335	1.766
4	3.351	3.438	3.909	4.819	3.469	3.802
5	5.03	4.765	6.026	6.65	5.547	5.424
6	6.297	6.577	7.226	7.249	6.708	6.729
7	8.679	8.794	9.875	9.044	9.269	8.964
8	7.942	9.788	8.652	8.083	8.619	8.671
9	10.996	11.433	12.196	12.532	11.496	11.459
10	16.863	17.762	14.569	21.285	16.99	16.458
+gp	15.53	15.947	15.643	15.398	11.734	14.597

Table 4.4. Cod in Subarea 4, Division 7.d and Subdivision 20: Reported landings, estimated discards (including BMS landings from 2016) and total catch (landings + discards) in tonnes. Note any differences in values between Table 4.4 and those given in the report and advice are due to SOP correction.

year	landings	discards	catch
1963	115893	12199	128092
1964	125393	4656	130049
1965	180120	28973	209092
1966	220197	37862	258059
1967	251687	23285	274972
1968	286948	17468	304417
1969	199746	4757	204503
1970	224993	17663	242656
1971	326492	84007	410498
1972	352161	33603	385764
1973	237874	29966	267840
1974	213215	39533	252748
1975	204249	36841	241089
1976	233007	72397	305404
1977	208318	139027	347345
1978	294640	32434	327074
1979	266019	162278	428297
1980	293753	294208	587962
1981	333616	57076	390691
1982	302365	54008	356372
1983	257634	21430	279065
1984	227070	151004	378074
1985	214354	31298	245651
1986	201279	138604	339883
1987	216041	27706	243747
1988	183202	10504	193706
1989	139578	61656	201233
1990	124835	26747	151582
1991	101442	18199	119641
1992	112740	36193	148932
1993	119947	21412	141358
1994	109915	98208	208123
1995	136397	31707	168104
1996	124721	14030	138751
1997	122434	33184	155618
1998	144637	40102	184740
1999	94108	13642	107749
2000	69567	13360	82927
2001	48440	13519	61960
2002	53152	11901	65053
2003	30426	4007	34433
2004	27748	8721	36469
2005	28165	9932	38097
2006	25665	11923	37589
2007	24215	30422	54637
2008	26814	24984	51798
2009	33177	20846	54023
2010	36762	12341	49103
2011	31979	8711	40689
2012	32124	8638	40762
2013	30474	10289	40763
2014	34651	10538	45190
2015	37373	12537	49910
2016	38104	12203	50307
2017	37668	8702	46371
2018	40153	7744	47898
2019	32361	3555	35917
2020	19373	4700	24072

Table 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: Stock weights at age (kg). Values for 2021 are derived from NS–IBTS–Q1 survey data for ages 1–2 and taken as a three-year average for ages 3+.

	Age					
Year	1	2	3	4	5	6+
1963	0.060	0.533	2.278	3.996	6.117	9.590
1964	0.068	0.501	2.036	4.029	5.805	8.651
1965	0.060	0.593	1.975	4.014	6.549	10.379
1966	0.060	0.550	2.097	3.709	6.327	10.367
1967	0.062	0.572	2.061	2.805	6.125	10.159
1968	0.063	0.558	1.906	3.643	4.809	8.302
1969	0.080	0.497	1.830	3.427	5.146	7.184
1970	0.086	0.556	1.745	3.560	5.520	8.618
1971	0.060	0.549	1.883	3.788	5.877	9.120
1972	0.057	0.480	1.790	3.530	5.412	8.682
1973	0.064	0.461	1.646	3.360	4.941	8.476
1974	0.058	0.593	1.898	3.698	5.559	9.658
1975	0.058	0.500	2.020	3.760	5.766	8.975
1976	0.038	0.475	2.107	4.072	5.847	8.626
1977	0.056	0.443	1.831	4.098	6.045	9.694
1978	0.083	0.489	1.722	3.689	5.879	9.224
1979	0.056	0.596	2.075	3.935	5.923	9.562
1980	0.049	0.604	1.676	3.916	5.500	9.230
1981	0.063	0.506	1.881	4.106	6.343	9.389
1982	0.068	0.598	1.597	3.675	6.109	8.979
1983	0.077	0.581	1.578	3.452	5.844	8.837
1984	0.058	0.606	1.855	3.534	5.573	9.043
1985	0.060	0.527	1.835	3.705	5.694	8.906
1986	0.056	0.515	1.568	3.118	5.609	9.278
1987	0.084	0.509	1.682	3.248	5.449	8.957
1988	0.089	0.496	1.699	2.836	5.395	8.824
1989	0.070	0.614	1.558	3.190	4.748	8.273
1990	0.073	0.454	1.863	3.373	5.340	9.287
1991	0.075	0.585	1.717	3.533	5.476	8.125
1992	0.076	0.639	2.191	3.757	5.624	8.942
1993	0.062	0.557	2.131	4.049	5.888	8.603
1994	0.058	0.519	1.883	3.978	6.453	8.487
1995	0.080	0.506	1.898	3.820	6.501	9.268
1996	0.083	0.547	1.803	3.589	5.976	8.830
1997	0.074	0.525	1.822	3.400	5.607	8.388
1998	0.071	0.417	1.396	3.110	4.850	8.000
1999	0.061	0.482	1.209	2.941	5.155	7.567
2000	0.068	0.595	1.503	2.861	4.414	7.832
2001	0.071	0.399	1.801	3.259	5.286	8.067
2002	0.057	0.289	1.467	3.448	4.922	7.749
2003	0.058	0.431	1.565	3.037	5.256	7.706
2004	0.056	0.242	1.427	2.762	4.705	7.474
2005	0.060	0.445	1.324	2.946	4.528	7.084
2006	0.058	0.498	1.484	3.379	5.046	7.833
2007	0.072	0.436	1.689	3.465	5.527	8.276
2008	0.083	0.681	1.889	3.546	5.404	7.404
2009	0.056	0.734	1.908	3.663	5.525	8.076
2010	0.073	0.569	2.188	3.852	5.539	8.897
2011	0.062	0.479	2.094	4.238	5.841	7.547
2012	0.062	0.621	1.910	3.673	5.923	8.107
2013	0.068	0.466	1.889	3.774	5.707	8.283
2014	0.064	0.540	1.873	3.516	5.211	7.420
2015	0.068	0.587	1.756	3.406	4.973	6.787
2016	0.071	0.553	1.712	3.253	5.143	7.215
2017	0.057	0.551	1.818	3.229	4.689	7.933
2018	0.059	0.460	1.682	3.276	5.173	6.909
2019	0.056	0.421	1.682	3.410	4.707	7.408
2020	0.059	0.457	1.712	3.351	5.030	7.424
2021	0.078	0.444	1.692	3.346	4.970	7.272

Table 4.5b. Cod in Subarea 4, Division 7.d and Subdivision 20: Proportion mature by age-group.

	Age					
	1	2	3	4	5	6+
1978	0.016	0.098	0.148	0.483	0.683	1.000
1979	0.000	0.047	0.217	0.524	0.615	1.000
1980	0.003	0.068	0.119	0.255	0.619	1.000
1981	0.003	0.035	0.168	0.412	0.506	1.000
1982	0.000	0.036	0.120	0.434	0.553	1.000
1983	0.000	0.035	0.174	0.392	0.761	1.000
1984	0.006	0.031	0.254	0.436	0.673	1.000
1985	0.000	0.026	0.158	0.508	0.685	1.000
1986	0.001	0.100	0.151	0.313	0.581	1.000
1987	0.000	0.028	0.258	0.537	0.815	1.000
1988	0.003	0.047	0.176	0.445	0.528	1.000
1989	0.232	0.179	0.272	0.529	0.770	1.000
1990	0.004	0.088	0.255	0.432	0.707	1.000
1991	0.000	0.068	0.322	0.445	0.745	1.000
1992	0.000	0.190	0.460	0.827	0.678	1.000
1993	0.000	0.075	0.356	0.618	0.747	1.000
1994	0.000	0.146	0.470	0.783	0.897	1.000
1995	0.004	0.042	0.342	0.733	0.874	1.000
1996	0.000	0.159	0.462	0.825	0.880	1.000
1997	0.000	0.191	0.590	0.659	0.792	1.000
1998	0.023	0.120	0.530	0.816	0.948	1.000
1999	0.014	0.385	0.467	0.709	0.981	1.000
2000	0.009	0.250	0.670	0.825	0.879	1.000
2001	0.016	0.189	0.454	0.777	0.974	1.000
2002	0.012	0.345	0.553	0.865	1.000	1.000
2003	0.000	0.198	0.455	0.705	0.961	1.000
2004	0.000	0.224	0.788	0.761	0.869	1.000
2005	0.005	0.218	0.626	0.843	0.928	1.000
2006	0.012	0.224	0.495	0.792	0.844	1.000
2007	0.017	0.188	0.594	0.823	0.979	1.000
2008	0.034	0.385	0.725	0.825	0.946	1.000
2009	0.016	0.246	0.696	0.870	0.918	1.000
2010	0.008	0.182	0.710	0.826	0.963	1.000
2011	0.082	0.157	0.731	0.898	0.985	1.000
2012	0.004	0.250	0.523	0.803	0.949	1.000
2013	0.018	0.096	0.474	0.855	0.900	1.000
2014	0.017	0.150	0.511	0.882	0.951	1.000
2015	0.018	0.279	0.441	0.786	0.865	1.000
2016	0.033	0.144	0.290	0.688	0.817	1.000
2017	0.013	0.144	0.496	0.747	0.859	1.000
2018	0.000	0.145	0.441	0.761	0.978	1.000
2019	0.000	0.312	0.607	0.779	0.971	1.000
2020	0.010	0.168	0.684	0.862	0.917	1.000
2021	0.000	0.089	0.331	0.602	0.837	1.000

Table 4.5c. Cod in Subarea 4, Division 7.d and Subdivision 20: Natural mortality by age-group (left). The values on the right show the final Ms after application of the ad-hoc adjustment to mimic emigration of older cod to 6.aN.

	Age					
y	1	2	3	4	5	6+
1963	1.176	0.711	0.216	0.2	0.2	0.2
1964	1.176	0.711	0.216	0.2	0.2	0.2
1965	1.176	0.711	0.216	0.2	0.2	0.2
1966	1.176	0.711	0.216	0.2	0.2	0.2
1967	1.176	0.711	0.216	0.2	0.2	0.2
1968	1.176	0.711	0.216	0.2	0.2	0.2
1969	1.176	0.711	0.216	0.2	0.2	0.2
1970	1.176	0.711	0.216	0.2	0.2	0.2
1971	1.176	0.711	0.216	0.2	0.2	0.2
1972	1.176	0.711	0.216	0.2	0.2	0.2
1973	1.176	0.711	0.216	0.2	0.2	0.2
1974	1.176	0.711	0.216	0.2	0.2	0.2
1975	1.185	0.706	0.218	0.2	0.2	0.2
1976	1.195	0.701	0.221	0.2	0.2	0.2
1977	1.204	0.697	0.223	0.2	0.2	0.2
1978	1.213	0.694	0.226	0.2	0.2	0.2
1979	1.220	0.693	0.228	0.2	0.2	0.2
1980	1.226	0.694	0.231	0.2	0.2	0.2
1981	1.228	0.696	0.233	0.2	0.2	0.2
1982	1.228	0.700	0.235	0.2	0.2	0.2
1983	1.223	0.705	0.237	0.2	0.2	0.2
1984	1.216	0.709	0.240	0.2	0.2	0.2
1985	1.207	0.715	0.242	0.2	0.2	0.2
1986	1.197	0.721	0.244	0.2	0.2	0.2
1987	1.186	0.728	0.246	0.2	0.2	0.2
1988	1.176	0.736	0.249	0.2	0.2	0.2
1989	1.167	0.745	0.251	0.2	0.2	0.2
1990	1.158	0.754	0.253	0.2	0.2	0.2
1991	1.151	0.763	0.256	0.2	0.2	0.2
1992	1.144	0.771	0.259	0.2	0.2	0.2
1993	1.139	0.779	0.263	0.2	0.2	0.2
1994	1.135	0.787	0.268	0.2	0.2	0.2
1995	1.131	0.796	0.275	0.2	0.2	0.2
1996	1.128	0.806	0.283	0.2	0.2	0.2
1997	1.124	0.818	0.293	0.2	0.2	0.2
1998	1.122	0.833	0.305	0.2	0.2	0.2
1999	1.121	0.849	0.317	0.2	0.2	0.2
2000	1.121	0.866	0.330	0.2	0.2	0.2
2001	1.125	0.886	0.343	0.2	0.2	0.2
2002	1.133	0.906	0.355	0.2	0.2	0.2
2003	1.144	0.926	0.365	0.2	0.2	0.2
2004	1.157	0.945	0.371	0.2	0.2	0.2
2005	1.170	0.961	0.374	0.2	0.2	0.2
2006	1.183	0.973	0.373	0.2	0.2	0.2
2007	1.194	0.981	0.368	0.2	0.2	0.2
2008	1.202	0.984	0.362	0.2	0.2	0.2
2009	1.209	0.985	0.354	0.2	0.2	0.2
2010	1.213	0.982	0.346	0.2	0.2	0.2
2011	1.215	0.978	0.339	0.2	0.2	0.2
2012	1.215	0.972	0.332	0.2	0.2	0.2
2013	1.212	0.965	0.327	0.2	0.2	0.2
2014	1.208	0.958	0.322	0.2	0.2	0.2
2015	1.201	0.951	0.318	0.2	0.2	0.2
2016	1.192	0.943	0.314	0.2	0.2	0.2
2017	1.181	0.935	0.310	0.2	0.2	0.2
2018	1.168	0.928	0.305	0.2	0.2	0.2
2019	1.154	0.920	0.301	0.2	0.2	0.2
2020*	1.154	0.920	0.301	0.2	0.2	0.2

3	4	5	6+
0.501	0.364	0.363	0.363
0.495	0.364	0.363	0.363
0.489	0.363	0.363	0.363
0.485	0.362	0.363	0.363
0.481	0.362	0.363	0.363
0.476	0.362	0.363	0.363
0.472	0.361	0.363	0.363
0.468	0.361	0.363	0.363
0.463	0.361	0.363	0.363
0.463	0.361	0.363	0.363

***A new key run was performed in 2020 with data up to 2019 (ICES WGSAM 2020), so the 2020 M–value is assumed equal to 2019.**

Table 4.6. Cod in Subarea 4, Division 7.d and Subdivision 20: Survey tuning indices and standard deviations for IBTS–Q1 and Q3 (NS–IBTS Delta–GAM indices). A third index for recruits is derived from the IBTS–Q3 index. Data used in the assessment are highlighted in bold font.

IBTS_Q1_gam

1983	2021						Standard deviations					
1	1	0	0.25									
1	5						1	2	3	4	5	6
1	**2674.51**	**9372.77**	**1508.59**	**820.87**	**305.58**	357.84	**0.17121**	**0.162327**	**0.159281**	**0.151419**	**0.146367**	0.164608
1	**6972.16**	**3411.35**	**1508.61**	**347.07**	**293.53**	197.82	**0.142034**	**0.138351**	**0.137004**	**0.137331**	**0.132737**	0.168787
1	**355.71**	**9316.45**	**1449.02**	**755.41**	**176.45**	215.10	**0.190364**	**0.134476**	**0.147048**	**0.164459**	**0.153467**	0.158229
1	**7105.06**	**1893.44**	**2219.76**	**854.99**	**339.21**	227.79	**0.137337**	**0.151683**	**0.130318**	**0.135354**	**0.130594**	0.153709
1	**3346.76**	**10158.58**	**427.82**	**529.70**	**152.25**	172.50	**0.160451**	**0.130339**	**0.119753**	**0.129798**	**0.136498**	0.145897
1	**2569.24**	**2665.09**	**2286.51**	**220.25**	**237.02**	202.97	**0.21821**	**0.13973**	**0.129584**	**0.184525**	**0.126226**	0.161927
1	**4965.85**	**2420.04**	**1749.81**	**821.05**	**112.18**	218.73	**0.159509**	**0.14538**	**0.134254**	**0.132961**	**0.131523**	0.151184
1	**1119.71**	**5268.56**	**738.13**	**333.47**	**280.43**	139.79	**0.195351**	**0.142666**	**0.144718**	**0.141827**	**0.127872**	0.161901
1	**1278.44**	**2071.47**	**1373.12**	**326.31**	**153.16**	210.28	**0.192053**	**0.165878**	**0.139011**	**0.134145**	**0.131379**	0.143365
1	**4924.82**	**1943.98**	**475.30**	**359.74**	**88.68**	110.71	**0.156177**	**0.13786**	**0.134348**	**0.168743**	**0.146944**	0.165391
1	**2420.54**	**6388.10**	**727.63**	**262.54**	**155.43**	74.34	**0.201261**	**0.136821**	**0.132595**	**0.128039**	**0.129807**	0.178458
1	**4094.16**	**1368.78**	**1092.73**	**355.09**	**151.12**	113.45	**0.153496**	**0.125945**	**0.141694**	**0.145772**	**0.131523**	0.169281
1	**3635.40**	**7540.02**	**1221.71**	**478.60**	**133.68**	79.66	**0.167583**	**0.125215**	**0.125636**	**0.141122**	**0.13007**	0.171617
1	**1228.18**	**4118.23**	**1681.02**	**305.39**	**188.15**	88.22	**0.177322**	**0.146252**	**0.123466**	**0.122954**	**0.119249**	0.172271
1	**7505.75**	**2182.25**	**802.12**	**377.15**	**127.05**	97.48	**0.125834**	**0.125081**	**0.124821**	**0.13715**	**0.144191**	0.159604
1	**488.67**	**8006.43**	**831.07**	**383.01**	**192.49**	114.08	**0.203631**	**0.125158**	**0.109629**	**0.114331**	**0.123362**	0.148072
1	**1089.59**	**389.95**	**2454.37**	**355.43**	**155.06**	122.09	**0.225126**	**0.153109**	**0.107442**	**0.12159**	**0.119334**	0.162547
1	**1585.77**	**2051.18**	**376.06**	**704.38**	**118.03**	142.47	**0.143901**	**0.157479**	**0.131521**	**0.115556**	**0.126061**	0.137861
1	**842.60**	**2845.02**	**596.18**	**127.80**	**91.64**	65.11	**0.24825**	**0.122854**	**0.113907**	**0.122919**	**0.126438**	0.153015
1	**2265.90**	**1131.53**	**1308.84**	**216.99**	**47.64**	60.95	**0.200791**	**0.145206**	**0.118384**	**0.12296**	**0.14837**	0.18484
1	**199.58**	**1260.10**	**416.03**	**366.38**	**134.96**	57.56	**0.236958**	**0.136127**	**0.122607**	**0.124128**	**0.13472**	0.166778
1	**2400.15**	**757.34**	**583.11**	**126.58**	**140.63**	72.85	**0.240358**	**0.143797**	**0.125351**	**0.136734**	**0.154618**	0.17949
1	**721.52**	**1211.98**	**311.47**	**247.35**	**53.82**	89.20	**0.18888**	**0.165578**	**0.133146**	**0.126833**	**0.147025**	0.181043
1	**2502.26**	**598.39**	**428.61**	**104.40**	**64.77**	85.61	**0.190684**	**0.170804**	**0.149003**	**0.157775**	**0.153092**	0.202816
1	**987.14**	**2180.39**	**485.92**	**169.04**	**60.73**	71.29	**0.216625**	**0.13637**	**0.123368**	**0.157332**	**0.178198**	0.204811
1	**972.59**	**620.90**	**866.79**	**178.38**	**123.83**	45.17	**0.182186**	**0.152158**	**0.138311**	**0.127037**	**0.128664**	0.170657
1	**617.21**	**908.60**	**390.80**	**325.02**	**81.96**	78.18	**0.237196**	**0.145953**	**0.130808**	**0.161**	**0.146481**	0.1858
1	**1589.44**	**1300.79**	**558.82**	**171.95**	**136.20**	64.03	**0.169477**	**0.140874**	**0.126118**	**0.143035**	**0.139864**	0.168131
1	**479.34**	**1956.73**	**551.85**	**233.93**	**113.49**	99.42	**0.249574**	**0.136886**	**0.143517**	**0.156179**	**0.142923**	0.161764
1	**1216.70**	**949.28**	**1727.01**	**481.52**	**147.98**	64.56	**0.269806**	**0.12727**	**0.153996**	**0.158367**	**0.134056**	0.168505
1	**822.73**	**1272.30**	**596.74**	**541.41**	**270.27**	88.37	**0.203169**	**0.190724**	**0.135574**	**0.15281**	**0.128377**	0.158666
1	**1064.65**	**1416.63**	**615.87**	**293.01**	**290.25**	95.34	**0.158362**	**0.172295**	**0.166104**	**0.197782**	**0.171224**	0.208267
1	**707.16**	**2553.08**	**1152.85**	**372.70**	**112.00**	94.55	**0.174261**	**0.136166**	**0.149995**	**0.147115**	**0.135674**	0.171971
1	**364.83**	**819.26**	**1578.64**	**590.51**	**231.70**	133.25	**0.209209**	**0.159942**	**0.14763**	**0.146061**	**0.127282**	0.153827
1	**3031.70**	**672.07**	**997.03**	**919.66**	**438.28**	149.43	**0.137393**	**0.144636**	**0.162742**	**0.147671**	**0.135348**	0.163009
1	**218.36**	**2082.72**	**457.93**	**306.56**	**191.36**	174.40	**0.220113**	**0.139307**	**0.161877**	**0.187114**	**0.140586**	0.172574
1	**512.41**	**330.92**	**728.16**	**104.61**	**76.40**	58.23	**0.184504**	**0.150636**	**0.153033**	**0.170518**	**0.176651**	0.2251
1	**1775.00**	**758.90**	**204.90**	**247.97**	**48.83**	40.64	**0.222628**	**0.165745**	**0.155274**	**0.164744**	**0.180004**	0.230383
1	**775.34**	**2050.59**	**807.91**	**207.27**	**103.93**	83.21	**0.201331**	**0.155313**	**0.139645**	**0.148406**	**0.14671**	0.196378

IBTS_Q3_gam

1992	2020										
1	1	0.50	0.75								
1	4						1	2	3	4	5
1	**11777.76**	**1596.03**	**439.69**	**188.94**	132.66		**0.115752**	**0.164296**	**0.144226**	**0.137533**	0.204894
1	**2413.87**	**3095.88**	**479.26**	**140.92**	145.35		**0.13038**	**0.154644**	**0.178685**	**0.164204**	0.228848
1	**13893.16**	**1833.52**	**806.84**	**145.66**	99.48		**0.119566**	**0.118989**	**0.147819**	**0.171911**	0.213895
1	**6999.25**	**4680.32**	**660.50**	**239.43**	78.20		**0.123698**	**0.132664**	**0.155702**	**0.163253**	0.237897
1	**3298.00**	**1900.24**	**632.52**	**167.30**	126.45		**0.129797**	**0.161972**	**0.152668**	**0.163528**	0.203844
1	**22663.22**	**2519.02**	**598.12**	**188.31**	111.80		**0.154691**	**0.20272**	**0.232101**	**0.282932**	0.304471
1	**707.16**	**6874.58**	**509.07**	**130.11**	127.27		**0.174424**	**0.136099**	**0.148425**	**0.165146**	0.212455
1	**3022.61**	**433.49**	**1174.24**	**113.95**	48.36		**0.171852**	**0.153902**	**0.129057**	**0.137381**	0.23701
1	**4671.57**	**917.01**	**89.05**	**226.76**	60.19		**0.303547**	**0.284456**	**0.198715**	**0.238074**	0.275464
1	**1299.49**	**1618.00**	**284.43**	**56.25**	94.81		**0.190555**	**0.134853**	**0.143585**	**0.170899**	0.259845
1	**3670.73**	**808.23**	**591.77**	**190.41**	64.99		**0.192295**	**0.156213**	**0.130756**	**0.157388**	0.191585
1	**531.33**	**917.57**	**186.32**	**162.47**	170.46		**0.160981**	**0.148622**	**0.165106**	**0.178769**	0.217594
1	**2983.60**	**579.54**	**356.69**	**72.92**	81.36		**0.213332**	**0.139702**	**0.155934**	**0.182029**	0.20704
1	**970.45**	**693.03**	**189.39**	**92.12**	65.58		**0.176493**	**0.157074**	**0.140239**	**0.153904**	0.204611
1	**3786.96**	**613.00**	**457.53**	**85.78**	38.20		**0.154053**	**0.160097**	**0.183677**	**0.171477**	0.221705
1	**1637.32**	**2123.97**	**362.78**	**145.89**	121.69		**0.195152**	**0.160014**	**0.171978**	**0.177843**	0.184009
1	**1913.66**	**802.47**	**841.31**	**176.89**	108.77		**0.183765**	**0.161421**	**0.166164**	**0.141374**	0.175992
1	**1657.02**	**665.65**	**221.77**	**217.63**	85.65		**0.212095**	**0.157782**	**0.190957**	**0.202218**	0.229473
1	**1932.37**	**1273.76**	**403.55**	**137.44**	104.88		**0.128214**	**0.139855**	**0.135951**	**0.141194**	0.157453
1	**842.50**	**2310.73**	**1041.85**	**280.66**	187.86		**0.157709**	**0.138222**	**0.184163**	**0.147875**	0.175628
1	**1643.78**	**775.36**	**977.05**	**308.49**	114.01		**0.190998**	**0.156907**	**0.134796**	**0.139792**	0.180599
1	**1579.41**	**843.06**	**386.23**	**431.56**	195.94		**0.154015**	**0.154163**	**0.148663**	**0.150165**	0.169378
1	**1930.07**	**1196.54**	**529.12**	**220.40**	286.32		**0.129759**	**0.135498**	**0.142651**	**0.137433**	0.153693
1	**960.87**	**2178.51**	**858.18**	**348.23**	249.39		**0.164959**	**0.135799**	**0.134125**	**0.133938**	0.164663
1	**682.14**	**796.95**	**1087.79**	**598.01**	263.39		**0.168021**	**0.140532**	**0.131396**	**0.120015**	0.138242
1	**3653.17**	**468.80**	**385.96**	**357.64**	268.32		**0.130521**	**0.143285**	**0.16501**	**0.145131**	0.161576
1	**503.96**	**1533.71**	**282.42**	**182.48**	209.43		**0.14945**	**0.141404**	**0.133804**	**0.155399**	0.173805
1	**1215.29**	**335.20**	**438.11**	**88.91**	111.29		**0.134072**	**0.150792**	**0.155422**	**0.165294**	0.205624
1	**2172.76**	**874.14**	**137.06**	**167.78**	96.88		**0.159774**	**0.138606**	**0.168275**	**0.163209**	0.204947

Table 4.6 condt. Cod in Subarea 4, Division 7.d and Subdivision 20: Survey tuning indices and standard deviations for IBTS–Q1 and Q3 (NS–IBTS Delta–GAM indices). A third index for recruits is derived from the IBTS–Q3 index. Data used in the assessment are highlighted in bold font.

IBTS_Q3_gam_age0_y+1				
1993	2021			
1	1	0	0	
1	1			1
1	**5832.18**			**0.259682**
1	**5334.16**			**0.276146**
1	**11376.22**			**0.274945**
1	**5909.27**			**0.294992**
1	**15047.11**			**0.280689**
1	**136.68**			**0.423235**
1	**7924.63**			**0.429592**
1	**1868.37**			**0.354192**
1	**1085.32**			**0.810498**
1	**9431.83**			**0.426878**
1	**312.72**			**0.618655**
1	**4041.62**			**0.469566**
1	**1896.52**			**0.624468**
1	**2991.29**			**0.301513**
1	**2219.77**			**0.429719**
1	**5140.50**			**0.457959**
1	**636.23**			**0.559663**
1	**936.45**			**0.486799**
1	**133.32**			**0.536685**
1	**6163.59**			**0.678114**
1	**693.00**			**0.655943**
1	**279.25**			**0.498571**
1	**413.34**			**0.476929**
1	**26.58**			**0.748053**
1	**3199.94**			**0.265731**
1	**230.95**			**0.576461**
1	**174.23**			**0.53508**
1	**2087.59**			**0.431797**
1	**863.89**			**0.394011**

Table 4.7a. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run model specification.

```
# Configuration saved: Thu Apr 22 17:54:35 2021
#
# Where a matrix is specified rows corresponds to fleets and columns to ages.
# Same number indicates same parameter used
# Numbers (integers) starts from zero and must be consecutive
# Negative numbers indicate that the parameter is not included in the model
#
$minAge
# The minimium age class in the assessment
 1

$maxAge
# The maximum age class in the assessment
 6

$maxAgePlusGroup
# Is last age group considered a plus group for each fleet (1 yes, or 0 no).
 1 0 0 0

$keyLogFsta
# Coupling of the fishing mortality states processes for each age (normally only
# the first row (= fleet) is used).
# Sequential numbers indicate that the fishing mortality is estimated individually
# for those ages; if the same number is used for two or more ages, F is bound for
# those ages (assumed to be the same). Binding fully selected ages will result in a
# flat selection pattern for those ages.
   0   1   2   3   4   5
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1

$corFlag
# Correlation of fishing mortality across ages (0 independent, 1 compound symmetry,
# 2 AR(1), 3 separable AR(1).
# 0: independent means there is no correlation between F across age
# 1: compound symmetry means that all ages are equally correlated;
# 2: AR(1) first order autoregressive - similar ages are more highly correlated than
# ages that are further apart, so similar ages have similar F patterns over time.
# if the estimated correlation is high, then the F pattern over time for each age
# varies in a similar way. E.g if almost one, then they are parallel (like a
# separable model) and if almost zero then they are independent.
# 3: Separable AR - Included for historic reasons . . .  more later
 2

$keyLogFpar
# Coupling of the survey catchability parameters (nomally first row is
# not used, as that is covered by fishing mortality).
  -1  -1  -1  -1  -1  -1
   0   1   2   3   4  -1
   5   6   7   8  -1  -1
   9  -1  -1  -1  -1  -1

$keyQpow
# Density dependent catchability power parameters (if any).
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1

$keyVarF
```

```
# Coupling of process variance parameters for log(F)-process (Fishing mortality
# normally applies to the first (fishing) fleet; therefore only first row is used)
   0   1   1   1   1   2
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  -1

$keyVarLogN
# Coupling of the recruitment and survival process variance parameters for the
# log(N)-process at the different ages. It is advisable to have at least the first age
# class (recruitment) separate, because recruitment is a different process than
# survival.
 0 1 1 1 1 1

$keyVarObs
# Coupling of the variance parameters for the observations.
# First row refers to the coupling of the variance parameters for the catch data
# observations by age
# Second and further rows refers to coupling of the variance parameters for the
# index data observations by age
   0   1   2   2   2   2
   3   4   4   4   4  -1
   5   6   6   6  -1  -1
   7  -1  -1  -1  -1  -1

$obsCorStruct
# Covariance structure for each fleet ("ID" independent, "AR" AR(1), or "US" for unstruc-
tured). | Possible values are: "ID" "AR" "US"
 "ID" "AR" "AR" "ID"

$keyCorObs
# Coupling of correlation parameters can only be specified if the AR(1) structure is
chosen above.
# NA's indicate where correlation parameters can be specified (-1 where they cannot).
#V1 V2 V3 V4 V5
  NA  NA  NA  NA  NA
   0   1   1   1  -1
   2   3   3  -1  -1
  -1  -1  -1  -1  -1

$stockRecruitmentModelCode
# Stock recruitment code (0 for plain random walk, 1 for Ricker, 2 for Beverton-Holt, and
3 piece-wise constant).
 0

$noScaledYears
# Number of years where catch scaling is applied.
 0

$keyScaledYears
# A vector of the years where catch scaling is applied.


$keyParScaledYA
# A matrix specifying the couplings of scale parameters (nrow = no scaled years, ncols =
no ages).

$fbarRange
# lowest and higest age included in Fbar
 2 4

$keyBiomassTreat
```

```
# To be defined only if a biomass survey is used (0 SSB index, 1 catch index, 2 FSB index,
3 total catch, 4 total landings and 5 TSB index).
 -1 -1 -1 -1

$obsLikelihoodFlag
# Option for observational likelihood | Possible values are: "LN" "ALN"
 "LN" "LN" "LN" "LN"

$fixVarToWeight
# If weight attribute is supplied for observations this option sets the treatment (0
relative weight, 1 fix variance to weight).
 0

$fracMixF
# The fraction of t(3) distribution used in logF increment distribution
 0

$fracMixN
# The fraction of t(3) distribution used in logN increment distribution
 0

$fracMixObs
# A vector with same length as number of fleets, where each element is the fraction of
t(3) distribution used in the distribution of that fleet
 0 0 0 0

$constRecBreaks
# Vector of break years between which recruitment is at constant level. The break year
is included in the left interval. (This option is only used in combination with stock-
recruitment code 3)


$predVarObsLink
# Coupling of parameters used in a prediction-variance link for observations.
  -1  -1  -1  -1  -1  -1
  -1  -1  -1  -1  -1  NA
  -1  -1  -1  -1  NA  NA
  NA  NA  NA  NA  NA  NA

$stockWeightModel
# Integer code describing the treatment of stock weights in the model (0 use as known, 1
use as observations to inform stock weight process (GMRF with cohort and within year
correlations))
 0

$keyStockWeightMean
# Coupling of stock-weight process mean parameters (not used if stockWeightModel==0)
 NA NA NA NA NA NA

$keyStockWeightObsVar
# Coupling of stock-weight observation variance parameters (not used if stockWeight-
Model==0)
 NA NA NA NA NA NA

$catchWeightModel
# Integer code describing the treatment of catch weights in the model (0 use as known, 1
use as observations to inform catch weight process (GMRF with cohort and within year
correlations))
 0

$keyCatchWeightMean
# Coupling of catch-weight process mean parameters (not used if catchWeightModel==0)
```

```
 NA NA NA NA NA NA

$keyCatchWeightObsVar
# Coupling of catch-weight observation variance parameters (not used if catchWeight-
Model==0)
 NA NA NA NA NA NA

$matureModel
# Integer code describing the treatment of proportion mature in the model (0 use as known,
1 use as observations to inform proportion mature process (GMRF with cohort and within
year correlations on logit(proportion mature)))
 1

$keyMatureMean
# Coupling of mature process mean parameters (not used if matureModel==0)
 0 1 2 3 4 5

$mortalityModel
# Integer code describing the treatment of natural mortality in the model (0 use as known,
1 use as observations to inform natural mortality process (GMRF with cohort and within
year correlations))
 0

$keyMortalityMean
#
 NA NA NA NA NA NA

$keyMortalityObsVar
# Coupling of natural mortality observation variance parameters (not used if mortali-
tyModel==0)
 NA NA NA NA NA NA

$keyXtraSd
# An integer matrix with 4 columns (fleet year age coupling), which allows additional
uncertainty to be estimated for the specified observations
```

Table 4.7b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run model fitting diagnostics, parameter estimates and correlation matrix.

Model fitting		
log(L)	#par	AIC
680.602	38	-1285.2

	value	std.dev	logFpar_0	logFpar_1	logFpar_2	logFpar_3	logFpar_4	logFpar_5	logFpar_6	logFpar_7	logFpar_8	logFpar_9	logSdLogFsi	logSdLogFsi	logSdLogFsi	logSdLogN	logSdLogN	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	logSdLogO	transfIRAR	transfIRAR	transfIRAR	itrans_rho	logPhiMO_	logPhiMO_	logSdProcL	meanLogit	meanLogit	meanLogit	meanLogit	meanLogit	logSdMO_
logFpar_0	-5.29	0.08	1																																		
logFpar_1	-3.69	0.05	0.14	1																																	
logFpar_2	-3.08	0.04	0.06	0.46	1																																
logFpar_3	-2.83	0.05	0.06	0.25	0.51	1																															
logFpar_4	-2.68	0.06	0.07	0.17	0.32	0.59	1																														
logFpar_5	-4.01	0.08	0.16	0.15	0.08	0.07	0.09	1																													
logFpar_6	-3.22	0.05	0.12	0.22	0.15	0.14	0.18	0.34	1																												
logFpar_7	-2.92	0.05	0.08	0.14	0.23	0.24	0.29	0.18	0.53	1																											
logFpar_8	-2.8	0.06	0.08	0.14	0.21	0.35	0.45	0.14	0.34	0.61	1																										
logFpar_9	-4.95	0.19	0.08	0.06	0.03	0.03	0.03	0.09	0.06	0.04	0.04	1																									
logSdLogFsta_0	-1.73	0.2	-0.03	0.01	0	0	0	-0.01	0	0.01	0.01	-0.01	1																								
logSdLogFsta_1	-2.09	0.12	-0.01	-0.03	-0.04	-0.04	-0.06	-0.02	-0.05	-0.04	-0.06	-0.01	0.49	1																							
logSdLogFsta_2	-1.7	0.18	-0.03	-0.05	-0.08	-0.13	-0.2	-0.04	-0.08	-0.12	-0.19	-0.01	0.15	0.32	1																						
logSdLogN_0	-0.22	0.11	-0.04	-0.01	-0.01	-0.01	0	-0.02	0	-0.01	-0.02	-0.02	-0.01	-0.01	-0.01	1																					
logSdLogN_1	-2.09	0.11	-0.03	0	-0.02	-0.02	0.01	-0.01	0.03	-0.04	-0.04	-0.03	-0.03	-0.05	-0.04	0.24	1																				
logSdLogObs_0	-0.53	0.11	0	-0.01	0	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.08	-0.01	0.01	-0.08	-0.08	1																			
logSdLogObs_1	-1.51	0.13	-0.02	-0.04	0	0	-0.01	-0.03	-0.01	0	-0.01	-0.01	-0.01	0.02	0.01	-0.03	-0.06	0.06	1																		
logSdLogObs_2	-2.75	0.22	0	0	-0.01	-0.02	-0.05	0	-0.01	-0.02	-0.03	0.01	-0.09	-0.17	-0.04	-0.07	-0.38	0.06	-0.02	1																	
logSdLogObs_3	0.85	0.13	0.02	0.01	0.01	0.01	0.01	0.03	0.01	0.02	0.02	0.03	0.01	0.01	0	-0.15	-0.19	0.03	0.01	0.06	1																
logSdLogObs_4	0.62	0.07	0.02	0.03	0.03	0.02	0.02	0.01	0	0.03	0.03	0.01	0.01	-0.02	0	-0.06	-0.11	0.02	0	-0.03	0.04	1															
logSdLogObs_5	0.85	0.16	0.03	0	-0.01	-0.01	-0.03	0.02	-0.03	-0.01	-0.02	0.03	0.03	0.02	0.02	-0.18	-0.26	0.05	-0.02	0.09	0.16	0.06	1														
logSdLogObs_6	0.44	0.1	0.04	0.06	0.07	0.11	0.16	0.05	0.09	0.13	0.18	0.02	0.02	-0.03	-0.06	-0.03	-0.04	-0.02	-0.03	-0.09	0.01	0.05	0.02	1													
logSdLogObs_7	0.89	0.13	0	0	-0.01	-0.01	-0.01	0	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.01	-0.04	-0.07	0	-0.01	0.02	0.05	0.01	0.07	0	1												
transfIRARdist_0	3.41	864.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1											
transfIRARdist_1	0.15	0.25	0	-0.03	-0.03	-0.01	-0.01	-0.02	-0.02	0	-0.01	0	0.03	0.04	0	-0.02	-0.03	0	-0.01	-0.07	0	-0.45	0.02	0.01	0.02	0	1										
transfIRARdist_2	0.74	0.71	0.03	0.02	0.03	0.04	0.05	0	-0.02	0.03	0.05	0.01	0.01	-0.01	-0.02	-0.1	-0.08	-0.01	-0.04	-0.02	0.06	0.05	-0.11	0	0.02	0	0.05	1								
transfIRARdist_3	0.03	0.34	-0.01	-0.02	-0.03	-0.05	-0.07	-0.02	-0.05	-0.08	-0.08	0	0	0.03	0.03	0	0.01	0	-0.06	-0.05	0	0	0.03	-0.47	0.02	0	0.03	0.02	1							
itrans_rho_0	1.83	0.23	-0.01	-0.01	-0.02	-0.03	-0.03	-0.02	0	-0.04	-0.05	-0.01	0.16	0.35	0.15	0.02	0.12	0.13	0.08	0.09	-0.02	-0.02	-0.02	-0.04	-0.01	0	-0.01	-0.02	-0.01	1						
logPhiMO_0	6.27	1.49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1						
logPhiMO_1	5.97	1.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.65	1					
logSdProcLogitMO_0	2.31	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.95	0.79	1				
meanLogitMO_0	-5.01	0.54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.03	-0.06	-0.05	1			
meanLogitMO_1	-2.06	0.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	-0.05	-0.05	0.93	1		
meanLogitMO_2	-0.55	0.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.05	-0.04	-0.05	0.92	0.97	1	
meanLogitMO_3	0.63	0.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.04	-0.05	-0.05	0.9	0.96	0.97	1
meanLogitMO_4	1.68	0.51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.03	-0.05	-0.04	0.89	0.94	0.96	0.97
meanLogitMO_5	5.89	0.55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.08	-0.03	-0.04	0.78	0.87	0.89	0.9
logSdMO_0	-3.47	0.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.1	-0.25	-0.04	-0.15	-0.03	-0.01	0.01

Table 4.8. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated fishing mortality at age.

Year/Age	1	2	3	4	5	6+	Fbar 2-4
1963	0.088	0.444	0.508	0.461	0.458	0.415	0.471
1964	0.099	0.483	0.561	0.507	0.502	0.472	0.517
1965	0.115	0.536	0.622	0.549	0.534	0.507	0.569
1966	0.12	0.548	0.631	0.548	0.535	0.514	0.576
1967	0.132	0.588	0.676	0.587	0.581	0.581	0.617
1968	0.145	0.626	0.713	0.619	0.609	0.612	0.653
1969	0.135	0.591	0.666	0.58	0.577	0.567	0.613
1970	0.154	0.642	0.704	0.598	0.584	0.561	0.648
1971	0.196	0.754	0.804	0.673	0.65	0.644	0.744
1972	0.232	0.839	0.873	0.728	0.703	0.725	0.813
1973	0.233	0.827	0.838	0.694	0.666	0.66	0.786
1974	0.228	0.8	0.793	0.656	0.637	0.624	0.75
1975	0.26	0.871	0.855	0.703	0.681	0.68	0.81
1976	0.296	0.948	0.917	0.738	0.712	0.718	0.868
1977	0.279	0.902	0.871	0.695	0.686	0.693	0.823
1978	0.318	0.991	0.983	0.787	0.776	0.819	0.92
1979	0.282	0.896	0.903	0.715	0.693	0.69	0.838
1980	0.316	0.972	0.999	0.793	0.751	0.776	0.921
1981	0.313	0.971	1.015	0.808	0.752	0.785	0.931
1982	0.354	1.07	1.146	0.922	0.848	0.94	1.046
1983	0.339	1.045	1.125	0.915	0.832	0.917	1.028
1984	0.308	0.976	1.051	0.869	0.79	0.858	0.965
1985	0.285	0.928	1.001	0.843	0.762	0.818	0.924
1986	0.305	0.984	1.08	0.931	0.838	0.944	0.998
1987	0.285	0.948	1.051	0.921	0.825	0.928	0.974
1988	0.287	0.959	1.078	0.949	0.843	0.955	0.995
1989	0.291	0.972	1.1	0.983	0.874	1.01	1.018
1990	0.262	0.906	1.025	0.92	0.816	0.914	0.95
1991	0.247	0.874	1.007	0.925	0.832	0.944	0.935
1992	0.23	0.837	0.98	0.914	0.821	0.915	0.91
1993	0.244	0.881	1.058	0.981	0.877	1.001	0.973
1994	0.226	0.84	1.038	0.949	0.845	0.94	0.942
1995	0.197	0.772	0.974	0.88	0.782	0.832	0.875
1996	0.193	0.769	1.012	0.927	0.85	0.946	0.902
1997	0.189	0.763	1.046	0.98	0.908	1.027	0.93
1998	0.233	0.892	1.268	1.209	1.118	1.362	1.123
1999	0.228	0.883	1.295	1.253	1.171	1.442	1.144
2000	0.227	0.884	1.313	1.285	1.204	1.477	1.161
2001	0.156	0.672	0.991	0.974	0.915	0.979	0.879
2002	0.198	0.796	1.192	1.167	1.082	1.222	1.052
2003	0.129	0.579	0.864	0.835	0.769	0.731	0.76
2004	0.14	0.614	0.921	0.873	0.806	0.765	0.803
2005	0.145	0.628	0.942	0.878	0.827	0.783	0.816
2006	0.129	0.57	0.845	0.776	0.75	0.679	0.731
2007	0.112	0.51	0.769	0.706	0.688	0.585	0.662
2008	0.104	0.482	0.742	0.681	0.682	0.582	0.635
2009	0.097	0.457	0.718	0.664	0.671	0.555	0.613
2010	0.076	0.379	0.603	0.562	0.572	0.435	0.515
2011	0.054	0.293	0.468	0.446	0.466	0.327	0.403
2012	0.048	0.269	0.432	0.415	0.436	0.292	0.372
2013	0.047	0.263	0.43	0.412	0.431	0.282	0.368
2014	0.048	0.266	0.441	0.42	0.441	0.286	0.376
2015	0.049	0.268	0.451	0.434	0.468	0.314	0.384
2016	0.048	0.267	0.453	0.431	0.464	0.3	0.384
2017	0.057	0.299	0.516	0.488	0.523	0.351	0.434
2018	0.079	0.38	0.67	0.624	0.677	0.508	0.558
2019	0.075	0.367	0.652	0.607	0.673	0.501	0.542
2020	0.058	0.305	0.539	0.499	0.557	0.376	0.448

Table 4.9. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated population numbers at age (start of year; thousands).

Year/Age	1	2	3	4	5	6+	Total
1963	446529	180484	20288	10373	8278	5804	671755
1964	727964	125464	52141	11555	5257	7505	929887
1965	985009	214875	40464	22970	6209	5808	1275333
1966	1193302	264645	67817	16357	9345	6377	1557842
1967	1012126	322778	72880	28447	7953	8191	1452375
1968	500385	279617	90064	28690	14272	6980	920008
1969	435718	132267	72765	34112	11401	10114	696376
1970	1479665	123107	39001	32378	15391	8546	1698087
1971	1956201	403257	33559	14920	15962	10418	2434316
1972	479664	507918	90500	12043	5910	12251	1108286
1973	698722	114146	106004	29796	4930	6847	960444
1974	689808	170487	23734	36375	10912	5452	936768
1975	1197898	163510	36861	9646	16298	6870	1431083
1976	820106	288393	33920	13562	3771	9336	1169088
1977	2002052	174274	51226	10714	5053	5757	2249075
1978	1177574	457184	30885	18608	5573	4194	1694018
1979	1478518	263506	81472	8887	7266	3274	1842922
1980	2370072	312464	59406	24556	3949	4293	2774739
1981	931094	497921	59579	17610	8671	3259	1518134
1982	1459702	191346	93973	17070	6539	4939	1773568
1983	831936	308201	34119	21284	5479	3908	1204927
1984	1526121	178040	52373	8149	6749	3386	1774818
1985	376392	330357	33551	14909	2816	3761	761785
1986	1825626	87368	57597	10405	5570	2570	1989135
1987	701797	420715	16490	15338	3033	2901	1160274
1988	471493	161989	72250	5378	4877	1987	717974
1989	846975	108077	31153	16991	1828	2492	1007516
1990	340447	193230	20302	7805	4946	1366	568096
1991	398707	81787	31014	5904	2605	2485	522501
1992	957698	98286	15861	8627	1984	1686	1084141
1993	436538	222505	19216	5262	2848	1313	687682
1994	1078364	108545	36377	5388	1663	1360	1231696
1995	687763	255870	22879	9517	1681	994	978703
1996	469770	168386	42290	6044	3404	1174	691069
1997	1542688	130570	32001	11202	2183	1566	1720210
1998	144395	415464	27880	8802	3750	1179	601470
1999	312967	38327	63484	6010	2218	1317	424323
2000	452949	79405	8942	10285	1503	800	553885
2001	183390	125746	13225	1981	1928	479	326749
2002	265362	51186	27530	4189	639	764	349671
2003	120876	64278	9028	5832	891	326	201231
2004	241790	37547	14360	2930	1921	437	298986
2005	192080	62102	8746	3586	1030	869	268412
2006	423208	53151	13430	2203	1092	726	493811
2007	190907	112919	10988	4182	971	645	320613
2008	214364	48978	25562	3266	1608	793	294571
2009	240060	56682	12052	7995	1410	930	319128
2010	302150	67827	14327	4127	3349	934	392714
2011	143866	89265	17161	5011	1934	2229	259466
2012	222046	42719	25541	7068	2133	1920	301427
2013	251482	60921	13820	10298	3231	1818	341570
2014	313474	74510	19248	5878	4570	2201	419882
2015	147284	99594	24106	7315	2474	3523	284296
2016	102928	43049	30169	11286	3304	2470	193206
2017	313264	30118	14071	11643	5151	2480	376727
2018	67402	79236	10161	5521	4288	3490	170099
2019	145193	19138	17753	2935	2142	2912	190073
2020	271264	44490	5694	4708	1172	1791	329120
2021	185468	80510	13696	2356	1839	1323	285191

Table 4.10. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated catches at age (thousands).

Year/Age	1	2	3	4	5	6+
1963	22288	47508	7335	3501	2779	1798
1964	40720	35398	20353	4200	1896	2580
1965	63761	65773	17039	8877	2349	2111
1966	80152	82515	28860	6311	3540	2343
1967	74686	106283	32592	11568	3207	3302
1968	40167	96483	41833	12125	5963	2927
1969	32664	43723	32222	13736	4572	4005
1970	125803	43293	17950	13334	6233	3355
1971	208970	159555	16912	6700	6988	4532
1972	59752	216475	48147	5714	2737	5795
1973	87292	48168	54913	13678	2197	3031
1974	84369	70352	11853	16037	4708	2318
1975	164552	71665	19319	4465	7381	3106
1976	126329	133930	18578	6492	1762	4386
1977	290932	78412	27122	4921	2300	2639
1978	191885	218983	17618	9309	2761	2155
1979	215429	118274	44054	4164	3329	1496
1980	381743	147883	34149	12340	1913	2127
1981	148643	235216	34546	8963	4205	1626
1982	259443	95952	58369	9458	3435	2771
1983	142842	152037	20961	11735	2844	2159
1984	241541	84005	30915	4347	3385	1793
1985	55693	150541	19225	7796	1378	1929
1986	288198	41254	34479	5796	2905	1445
1987	104862	193475	9711	8488	1565	1613
1988	71053	74796	43141	3032	2554	1125
1989	129670	50181	18800	9784	979	1459
1990	47623	85430	11744	4316	2534	753
1991	53024	35171	17732	3276	1352	1397
1992	119813	40910	8912	4748	1020	930
1993	57727	95665	11288	3024	1530	765
1994	133247	45036	21077	3033	872	762
1995	75119	99687	12725	5106	837	516
1996	50225	65178	23998	3349	1791	661
1997	162087	50059	18449	6421	1198	927
1998	18391	176629	17815	5681	2329	813
1999	39159	16080	40829	3951	1413	933
2000	56496	33132	5764	6846	973	573
2001	16131	42834	7236	1128	1064	275
2002	29035	19570	16697	2649	390	498
2003	8787	19246	4491	3015	439	155
2004	19015	11680	7425	1559	976	215
2005	15540	19526	4581	1916	532	433
2006	30338	15446	6562	1087	529	328
2007	11891	29947	5048	1935	443	261
2008	12399	12378	11487	1474	729	320
2009	12994	13716	5311	3548	631	362
2010	12875	14059	5579	1622	1336	301
2011	4385	14817	5143	1533	613	526
2012	6072	6574	7189	2039	640	412
2013	6720	9229	3885	2951	962	377
2014	8533	11419	5534	1713	1384	463
2015	4089	15451	7071	2188	786	803
2016	2850	6664	8895	3362	1042	542
2017	10163	5173	4612	3829	1789	622
2018	3028	16805	4064	2191	1806	1184
2019	6255	3950	6979	1141	898	977
2020	9164	7832	1940	1575	427	476

Table 4.11. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated maturity at age.

Year/Age	1	2	3	4	5	6+
1963	0.004	0.064	0.238	0.505	0.744	0.995
1964	0.004	0.064	0.237	0.504	0.743	0.995
1965	0.004	0.064	0.237	0.504	0.743	0.995
1966	0.003	0.063	0.236	0.503	0.742	0.995
1967	0.003	0.063	0.235	0.501	0.742	0.995
1968	0.003	0.062	0.234	0.5	0.741	0.995
1969	0.003	0.062	0.232	0.498	0.74	0.995
1970	0.003	0.061	0.231	0.497	0.738	0.995
1971	0.003	0.061	0.229	0.494	0.737	0.995
1972	0.003	0.06	0.226	0.492	0.735	0.995
1973	0.003	0.059	0.224	0.489	0.734	0.995
1974	0.003	0.058	0.22	0.485	0.732	0.995
1975	0.003	0.057	0.216	0.48	0.729	0.995
1976	0.003	0.056	0.211	0.472	0.726	0.995
1977	0.003	0.056	0.205	0.462	0.719	0.995
1978	0.004	0.06	0.192	0.458	0.699	0.995
1979	0.003	0.057	0.193	0.446	0.671	0.995
1980	0.004	0.057	0.177	0.367	0.654	0.994
1981	0.003	0.055	0.186	0.402	0.612	0.994
1982	0.003	0.055	0.178	0.427	0.637	0.994
1983	0.003	0.056	0.195	0.42	0.701	0.994
1984	0.004	0.055	0.213	0.439	0.69	0.994
1985	0.004	0.058	0.195	0.458	0.691	0.995
1986	0.004	0.069	0.202	0.419	0.679	0.995
1987	0.005	0.068	0.233	0.471	0.724	0.995
1988	0.006	0.08	0.231	0.476	0.678	0.995
1989	0.007	0.106	0.264	0.5	0.73	0.995
1990	0.007	0.11	0.293	0.494	0.732	0.995
1991	0.006	0.113	0.348	0.533	0.744	0.995
1992	0.006	0.127	0.398	0.673	0.752	0.996
1993	0.006	0.116	0.397	0.666	0.801	0.996
1994	0.006	0.123	0.423	0.713	0.847	0.997
1995	0.008	0.116	0.406	0.719	0.86	0.997
1996	0.008	0.153	0.446	0.741	0.867	0.997
1997	0.009	0.171	0.513	0.729	0.87	0.998
1998	0.014	0.179	0.514	0.777	0.901	0.998
1999	0.016	0.253	0.521	0.771	0.92	0.998
2000	0.016	0.238	0.592	0.809	0.917	0.998
2001	0.017	0.228	0.54	0.828	0.941	0.999
2002	0.015	0.256	0.546	0.82	0.965	0.999
2003	0.011	0.234	0.546	0.778	0.939	0.999
2004	0.011	0.221	0.638	0.784	0.913	0.999
2005	0.015	0.216	0.594	0.812	0.911	0.999
2006	0.018	0.232	0.555	0.809	0.909	0.998
2007	0.02	0.25	0.593	0.811	0.926	0.998
2008	0.021	0.303	0.649	0.821	0.923	0.999
2009	0.018	0.272	0.66	0.841	0.923	0.999
2010	0.017	0.238	0.658	0.842	0.932	0.999
2011	0.016	0.213	0.637	0.847	0.937	0.999
2012	0.014	0.215	0.558	0.822	0.929	0.999
2013	0.014	0.175	0.52	0.814	0.917	0.999
2014	0.014	0.18	0.497	0.803	0.914	0.998
2015	0.014	0.198	0.46	0.762	0.896	0.998
2016	0.013	0.181	0.425	0.73	0.881	0.998
2017	0.012	0.178	0.479	0.744	0.886	0.998
2018	0.009	0.183	0.486	0.759	0.912	0.998
2019	0.008	0.198	0.54	0.765	0.913	0.998
2020	0.008	0.155	0.542	0.777	0.899	0.998
2021	0.007	0.131	0.424	0.715	0.884	0.998

Table 4.12a. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated stock and management metrics, together with the lower and upper bounds of the pointwise 95% confidence intervals. Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), catches and average fishing mortality for ages 2 to 4 (Fbar 2–4).

Year	Recruits age 1 ('000)	Low	High	TSB (tonnes)	Low	High	SSB (tonnes)	Low	High	Catches (tonnes)	Low	High	Fbar 2-4	Low	High
1963	446529	321966	619281	316909	261051	384719	131187	78755	218526	117862	104623	132777	0.471	0.403	0.55
1964	727964	526131	1007225	360719	305841	425444	140120	84982	231032	144765	131138	159808	0.517	0.45	0.595
1965	985009	715333	1356350	459169	396157	532205	163823	99526	269660	198425	177139	222269	0.569	0.495	0.654
1966	1193302	867006	1642398	545229	475283	625469	183167	113104	296630	241275	215839	269709	0.576	0.503	0.658
1967	1012126	735076	1393595	609506	533557	696267	206032	130737	324690	288624	257746	323202	0.617	0.543	0.702
1968	500385	362511	690696	590165	523317	665552	210716	131869	336705	294748	267336	324972	0.653	0.572	0.744
1969	435718	313878	604853	481914	424717	546814	209070	138341	315962	224898	207616	243619	0.613	0.539	0.696
1970	1479665	1072818	2040800	537469	472586	611259	213550	148068	307991	251648	221126	286382	0.648	0.574	0.731
1971	1956201	1413516	2707235	647446	570832	734344	219837	160622	300883	353767	303802	411950	0.744	0.663	0.834
1972	479664	346319	664352	614171	544896	692252	201530	146718	276820	368362	322287	421025	0.813	0.726	0.912
1973	698722	505031	966697	454365	412698	500238	166750	116695	238274	258676	235578	284038	0.786	0.701	0.882
1974	689808	497909	955667	434111	390720	482322	177838	130971	241477	234352	209688	261918	0.75	0.667	0.843
1975	1197898	857767	1672902	417838	375503	464946	168209	131812	214656	245668	214644	281176	0.81	0.724	0.905
1976	820106	583430	1152792	397450	354752	445286	145059	115967	181451	248870	215895	286882	0.868	0.775	0.971
1977	2002052	1433422	2796253	413843	367141	466485	121682	97348	152097	260972	215794	315607	0.823	0.735	0.92
1978	1177574	841376	1648111	514224	452393	584505	116822	96448	141500	358503	297035	432691	0.92	0.825	1.027
1979	1478518	1058000	2066177	517641	466379	574538	117511	96765	142704	331362	285250	384929	0.838	0.751	0.936
1980	2370072	1688976	3325825	562222	500545	631499	117719	98074	141300	387096	322733	464295	0.921	0.829	1.024
1981	931094	664966	1303729	580859	517420	652077	127896	107717	151856	392571	335308	459613	0.931	0.839	1.033
1982	1459702	1054901	2019840	511429	463432	564397	129629	110076	152656	377364	322879	441044	1.046	0.946	1.157
1983	831936	616716	1122263	436977	392001	487113	108283	92559	126678	314373	269535	366670	1.028	0.93	1.136
1984	1526121	1140924	2041366	391175	354339	431840	96066	81840	112765	273083	233922	318801	0.965	0.873	1.067
1985	376392	273971	517103	362934	325796	404305	91854	78291	107766	238404	207562	273829	0.924	0.835	1.022
1986	1825626	1368117	2436128	325102	292355	361517	80288	68428	94203	232018	194681	276516	0.998	0.904	1.102
1987	701797	523942	940026	392845	346697	445135	82608	70233	97164	270149	228515	319369	0.974	0.882	1.074
1988	471493	348063	638694	304219	278635	332152	77578	64911	92718	210121	186344	236931	0.995	0.902	1.098
1989	846975	629030	1140434	257290	233387	283641	74208	63813	86296	181107	156103	210116	1.018	0.923	1.123
1990	340447	252205	459563	215906	195246	238753	65876	56785	76423	141315	123517	161677	0.95	0.858	1.053
1991	398707	298956	531742	186391	170401	203882	65972	57037	76306	120877	107154	136358	0.935	0.846	1.034
1992	957698	732453	1252210	228508	205096	254593	67467	58919	77256	144934	122774	171092	0.91	0.826	1.003
1993	436538	336918	565612	241493	217065	268669	69739	59985	81080	158451	137430	182686	0.973	0.883	1.073
1994	1078364	831267	1398912	231406	210393	254519	72155	62368	83477	148967	129216	171737	0.942	0.854	1.039
1995	687763	531786	889489	284550	256061	316209	77792	67297	89922	169224	146144	195949	0.875	0.79	0.969
1996	469770	362453	608862	259678	237385	284065	92444	80222	106528	157791	139975	177873	0.902	0.817	0.997
1997	1542688	1189378	2000950	304147	271637	340548	94210	83217	106655	181845	153885	214884	0.93	0.845	1.023
1998	144395	108078	192916	277619	246474	312700	98224	83813	115113	187054	161863	216166	1.123	1.028	1.228
1999	312967	236541	414085	153330	142422	165073	79094	69186	90422	110270	100633	120829	1.144	1.049	1.247
2000	452949	347232	590851	133653	120656	148050	55878	49499	63078	91567	79541	105411	1.161	1.059	1.272
2001	183390	139227	241562	107549	97306	118870	43323	37406	50177	59831	52724	67897	0.879	0.794	0.973
2002	265362	201122	350121	93931	86412	102103	46869	41046	53519	62427	56242	69291	1.052	0.95	1.164
2003	120876	91416	159831	73721	67063	81041	34964	30509	40070	38694	34605	43265	0.76	0.676	0.853
2004	241790	183054	319372	63619	57870	69940	33092	29148	37569	35194	31921	38803	0.803	0.72	0.896
2005	192080	145231	254040	72196	64972	80223	31978	27683	36938	41959	37057	47509	0.816	0.732	0.91
2006	423208	325278	550622	89534	79754	100513	34362	29372	40199	32938	29138	37233	0.731	0.649	0.823
2007	190907	145525	250440	106752	95226	119674	45667	38811	53735	53443	46925	60865	0.662	0.584	0.75
2008	214364	164414	279489	125550	112952	139553	65201	55828	76147	51990	47276	57176	0.635	0.557	0.724
2009	240060	181712	317144	122692	109037	138058	66101	56388	77487	54558	49373	60288	0.613	0.531	0.708
2010	302150	233401	391149	134667	117956	153746	69172	57747	82857	48930	44447	53865	0.515	0.442	0.601
2011	143866	108669	190462	136933	117432	159671	77527	62887	95574	43131	39262	47381	0.403	0.346	0.468
2012	222046	168037	293415	143177	123153	166456	81688	66134	100901	39255	36400	42335	0.372	0.319	0.433
2013	251482	191761	329801	143987	123680	167627	82352	66727	101635	41035	37810	44534	0.368	0.317	0.428
2014	313474	241919	406192	157206	136285	181339	80119	64988	98773	44769	41032	48847	0.376	0.325	0.434
2015	147284	112986	191993	171985	149155	198309	85085	68605	105522	50160	45920	54792	0.384	0.335	0.441
2016	102928	78587	134808	154273	134088	177496	85860	69782	105641	50072	46612	53789	0.384	0.334	0.441
2017	313264	237280	413582	141555	122628	163404	84416	69067	103177	46439	43322	49780	0.434	0.38	0.497
2018	67402	51419	88354	121840	104680	141813	73006	59223	89997	48834	44816	53212	0.558	0.486	0.641
2019	145193	109871	191869	87765	73477	104830	56169	44019	71672	36757	34093	39629	0.542	0.461	0.637
2020	271264	183492	401022	81174	66670	98834	39390	29794	52077	24188	21645	27030	0.448	0.365	0.549
2021	185468	86218	398970	100006	77144	129643	37912	27703	51884						

Table 4.12b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM final run estimated landings, discards (including BMS landings from 2016) and catch (=landings + discards). Landings and discards are derived by applying the landing fraction from landings and discards data to the SAM estimate of catch.

Year	Landings	Discards	Catch
1963	106849	11007	117862
1964	134922	9845	144760
1965	180696	17743	198424
1966	214339	26992	241279
1967	261140	27446	288619
1968	277361	17367	294752
1969	215470	9454	224903
1970	231458	20198	251641
1971	293846	59938	353770
1972	333207	35115	368355
1973	233853	24813	258675
1974	208360	26018	234353
1975	208966	36659	245664
1976	203987	44929	248874
1977	182343	78729	260975
1978	310373	48103	358511
1979	272946	58448	331356
1980	290702	96574	387097
1981	341344	51164	392568
1982	319806	57550	377363
1983	279876	34549	314379
1984	208486	64524	273082
1985	211387	27018	238401
1986	170430	61659	232020
1987	235355	34681	270146
1988	195020	15027	210119
1989	139127	42019	181104
1990	117057	24245	141312
1991	104187	16657	120879
1992	111157	33728	144934
1993	130389	28041	158456
1994	105822	43129	148966
1995	135126	34141	169219
1996	134938	22819	157788
1997	134669	47213	181846
1998	145269	41716	187055
1999	95923	14364	110271
2000	75000	16572	91566
2001	47219	12588	59830
2002	51240	11189	62426
2003	33421	5263	38695
2004	27246	7948	35195
2005	30039	11923	41957
2006	23014	9922	32937
2007	24022	29423	53439
2008	26864	25131	51990
2009	32943	21606	54554
2010	36248	12691	48935
2011	33449	9686	43129
2012	32065	7191	39256
2013	30545	10495	41032
2014	34396	10374	44769
2015	37640	12518	50154
2016	38129	11941	50073
2017	37674	8772	46440
2018	40476	8348	48829
2019	32737	4031	36760
2020	19883	4298	24186

Table 4.13. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch scenarios based on the SAM assessment and assuming a 37% overshoot of the TAC in the intermediate year. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar(2021)	0.288
SSB(2022)	53406
R(2021)	186075
R(2022)	222046
Catch(2021)	21798
Landings(2021)	16747
Discards(2021)	5051

Catch scenarios

Basis	Catch (2022)	Landings (2022)	Discards (2022)	F_{total} (2022)	$F_{landings}$ (2022)	$F_{discards}$ (2022)	SSB (2023)	% SSB change	% TAC change	% advice change	Risk
MSY approach	16311	13573	2738	0.156	0.125	0.031	79031	48	2.5	10.5	0.28
MAP	11111	9252	1859	0.103	0.083	0.0200	83308	56	-30	-25	0.199
F=0	0	0	0	0.00	0.00	0.00	92503	73	-100	-100	0.070
Fpa	44319	36540	7779	0.49	0.39	0.097	56552	5.9	179	200	0.81
FP.05 wo AR	38341	31693	6648	0.41	0.33	0.081	61164	14.5	141	160	0.72
Flim	50556	41494	9062	0.58	0.46	0.115	51836	-2.9	220	240	0.89
SSB(2023)=Blim	27714	22953	4761	0.28	0.22	0.056	69841	31	74	88	0.50
SSB(2023)=Btrigger=Bpa	0	0	0	0.00	0.00	0.00	92503	73	-100	-100	0.070
TAC(2021)-20%	12729	10597	2132	0.119	0.096	0.023	82025	54	-20.0	-13.7	0.23
TAC(2021)-15%	13524	11258	2266	0.127	0.102	0.025	81449	53	-15.0	-8.3	0.25
TAC(2021)-10%	14321	11924	2397	0.135	0.109	0.026	80796	51	-10.0	-2.9	0.26
TAC(2021)-5%	15115	12588	2527	0.143	0.115	0.028	80141	50	-5.0	2.4	0.27
Constant TAC	15911	13245	2666	0.151	0.122	0.029	79386	49	0.00	7.8	0.28
TAC(2021)+5%	16707	13901	2806	0.160	0.128	0.032	78649	47	5.0	13.2	0.30
TAC(2021)+10%	17502	14556	2946	0.168	0.135	0.033	78007	46	10.0	18.6	0.32
TAC(2021)+15%	18298	15223	3075	0.176	0.141	0.035	77393	45	15.0	24	0.33
TAC(2021)+20%	19093	15885	3208	0.185	0.148	0.037	76781	44	20.0	29	0.35
F=F2021	28387	23525	4862	0.29	0.23	0.057	69286	30	78	92	0.52
Fmsy lower	19220	15992	3228	0.186	0.149	0.037	76673	44	21	30	0.35
Fmsy	27752	22984	4768	0.28	0.22	0.055	69808	31	74	88	0.50
Fmsy upper	41374	34115	7259	0.45	0.36	0.089	58811	10.1	160	180	0.77

Table 4.14. Cod in Subarea 4, Division 7.d and Subdivision 20: Catch scenarios based on the SAM assessment and assuming an F of 0.37 (lowest observed F in the time series) in the intermediate year as used to give advice. Units are tonnes (SSB, landings, discards and catch) or thousands (recruitment).

Forecast assumptions

Fbar(2021)	0.37
SSB(2022)	49433
R(2021)	186075
R(2022)	222046
Catch(2021)	27153
Landings(2021)	20790
Discards(2021)	6363

Catch scenarios

Basis	Catch (2022)	Landings (2022)	Discards (2022)	F_{total} (2022)	F_{land} (2022)	$F_{discard}$ (2022)	SSB (2023)	% SSB change	% TAC change	% advice change	Risk
MSY approach	14276	11779	2497	0.144	0.115	0.029	75484	52.7	-10.3	-3.2	0.369
MAP	9701	8011	1690	0.095	0.076	0.019	79425	60.7	-39.0	-34.3	0.285
F=0	0	0	0	0	0	0	87254	76.5	-100.0	-100.0	0.137
Fpa	41914	34250	7664	0.49	0.393	0.097	53444	8.1	163.4	184.1	0.864
FP.05 wo AR	36231	29674	6557	0.41	0.329	0.081	57902	17.1	127.7	145.6	0.786
Flim	47805	38801	9004	0.58	0.465	0.115	49118	-0.6	200.5	224.0	0.922
SSB(2023)=Blim	21340	17598	3742	0.222	0.178	0.044	69841	41.3	34.1	44.6	0.500
SSB(2023)=Btrigger=Bpa	0	0	0	0	0	0	87254	76.5	-100.0	-100.0	0.137
TAC(2021)-20%	12729	10493	2236	0.127	0.102	0.025	76741	55.2	-20.0	-13.7	0.353
TAC(2021)-15%	13524	11158	2366	0.135	0.109	0.026	76100	53.9	-15.0	-8.3	0.359
TAC(2021)-10%	14320	11816	2504	0.144	0.115	0.029	75445	52.6	-10.0	-2.9	0.370
TAC(2021)-5%	15116	12473	2643	0.153	0.122	0.031	74779	51.3	-5.0	2.4	0.379
Constant TAC	15912	13131	2781	0.161	0.129	0.032	74116	49.9	0.0	7.8	0.399
TAC(2021)+5%	16707	13788	2919	0.17	0.136	0.034	73494	48.7	5.0	13.2	0.413
TAC(2021)+10%	17502	14447	3055	0.179	0.144	0.035	72843	47.4	10.0	18.6	0.429
TAC(2021)+15%	18298	15112	3186	0.188	0.151	0.037	72197	46.1	15.0	24.0	0.448
TAC(2021)+20%	19093	15760	3333	0.197	0.158	0.039	71572	44.8	20.0	29.4	0.467
F=F2021	33282	27259	6023	0.37	0.297	0.073	60299	22.0	109.2	125.6	0.750
Fmsy lower	18130	14971	3159	0.186	0.149	0.037	72341	46.3	13.9	22.9	0.441
Fmsy	26169	21575	4594	0.28	0.225	0.055	65905	33.3	64.5	77.4	0.597
Fmsy upper	39128	31980	7148	0.45	0.361	0.089	55565	12.4	145.9	165.2	0.839

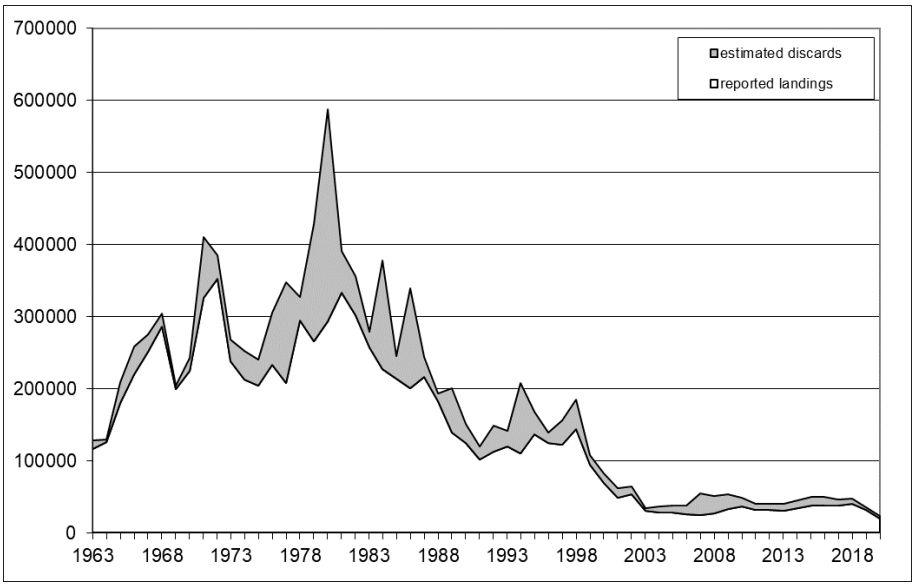

Figure 4.1a. Cod in Subarea 4, Division 7.d and Subdivision 20: stacked area plot of reported landings and estimated discards (including BMS landings; in tonnes).

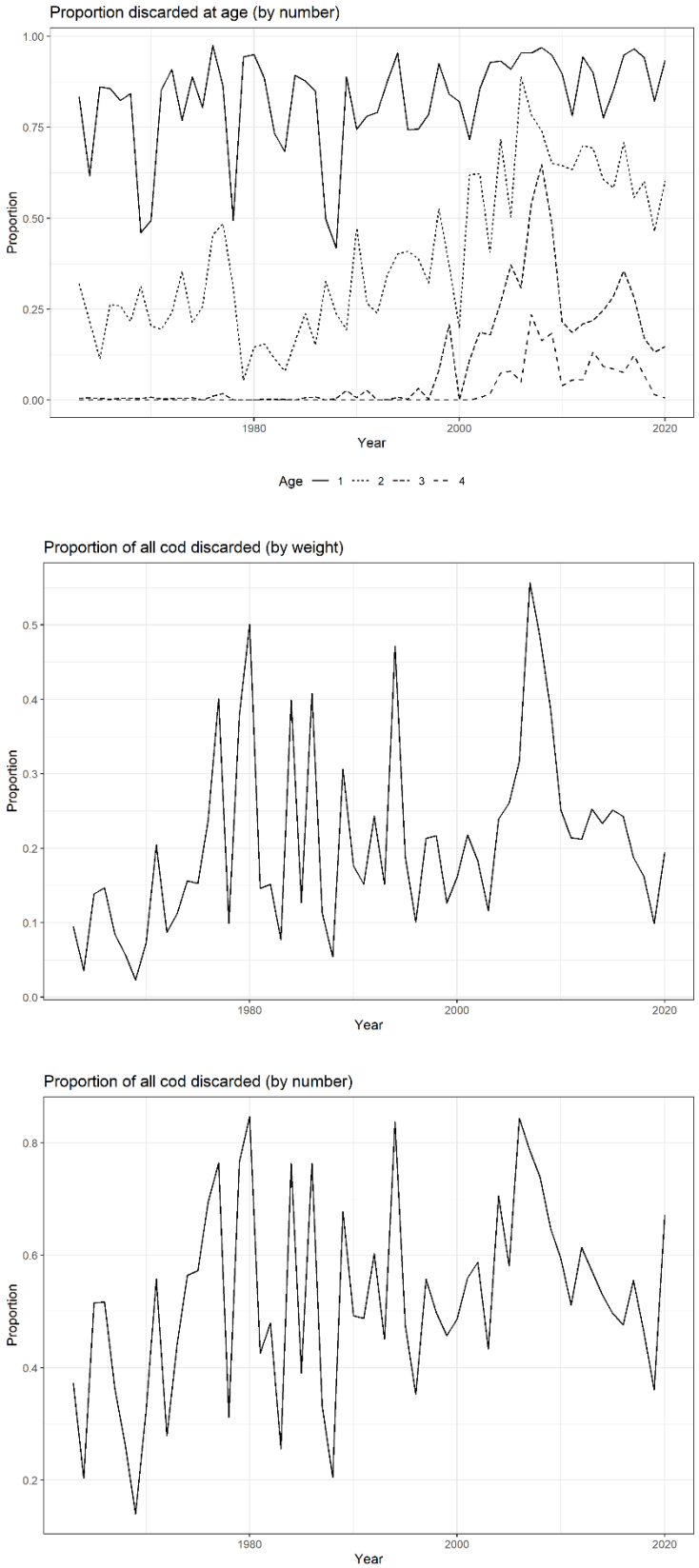

Figure 4.1b. Cod in Subarea 4, Division 7.d and Subdivision 20: (top) proportion of total numbers caught at age that are discarded; (middle) proportion of total weight caught that is discarded; and (bottom) proportion of the total numbers caught that are discarded.

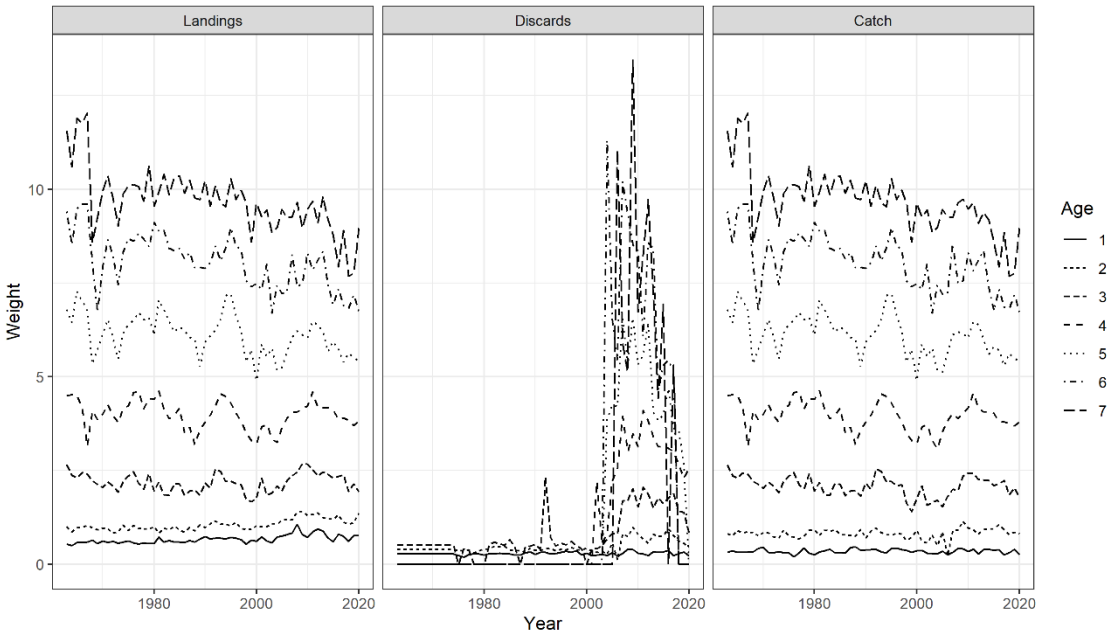

Figure 4.2a. Cod in Subarea 4, Division 7.d and Subdivision 20: Mean weights at age by catch component for ages 1–7.

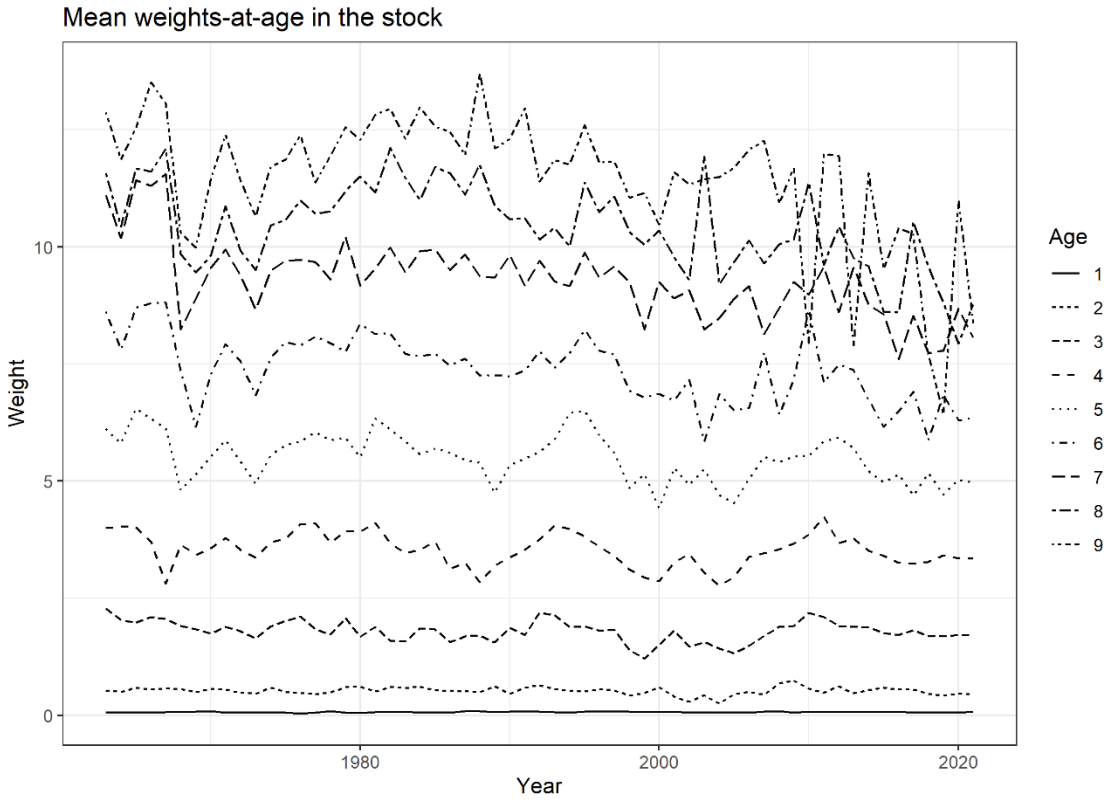

Figure 4.2b. Cod in Subarea 4, Division 7.d and Subdivision 20: Mean weights at age in the stock.

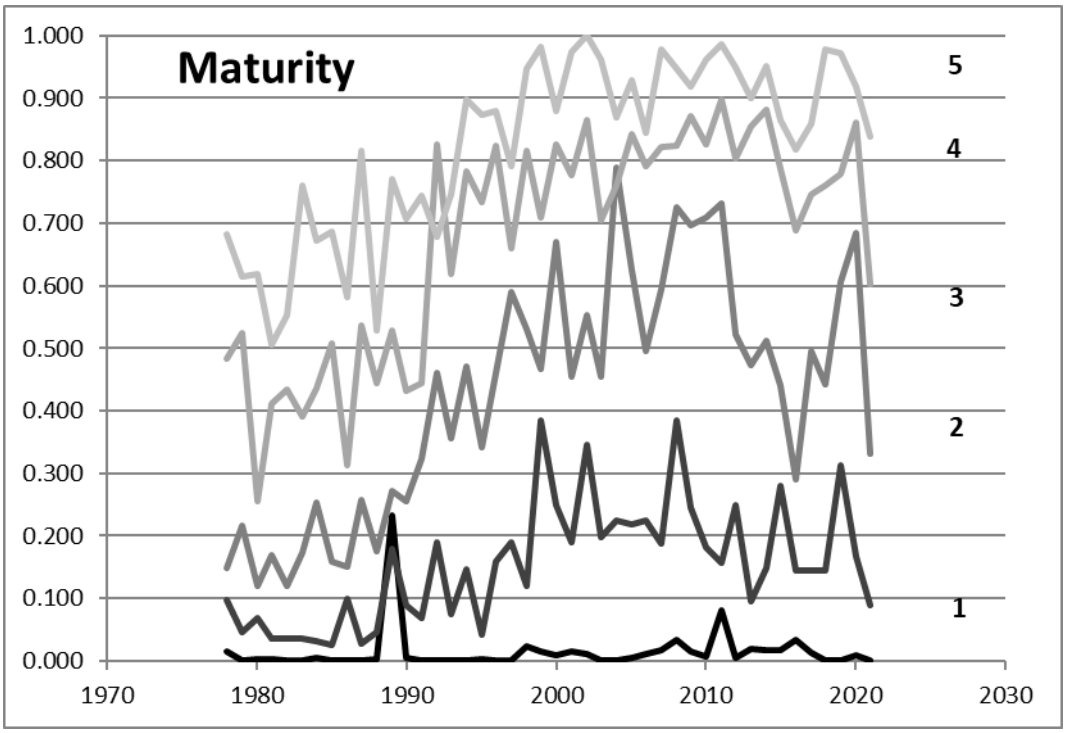

Figure 4.2c. Cod in Subarea 4, Division 7.d and Subdivision 20: Annually varying maturity-at-age.

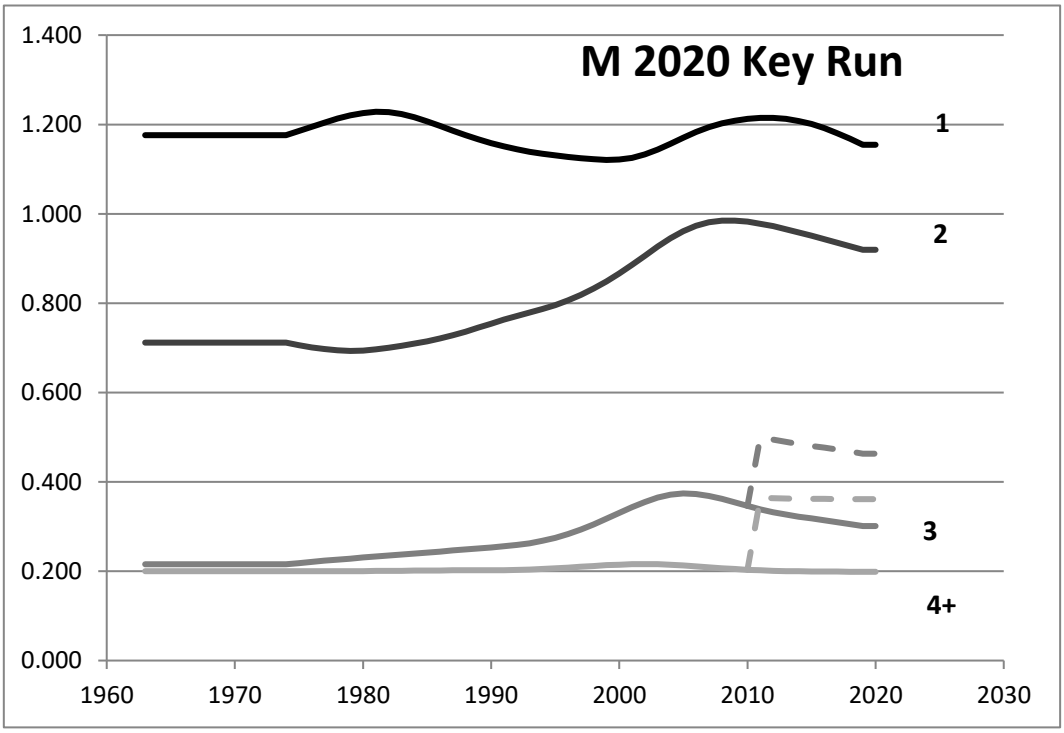

Figure 4.2d. Cod in Subarea 4, Division 7.d and Subdivision 20: Smoothed, annually varying natural mortality from the 2020 key run (solid lines; ICES WGSAM, 2020). Values for 1963–1973 are set equal to the 1974 value, while values for 2020 are set equal to 2019. An ad hoc adjustment is made for ages 3+ to mimic a 15% emigration from the assessment area from 2011 (dashed lines).

Figure 4.3a. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2002–2021 in the North Sea.

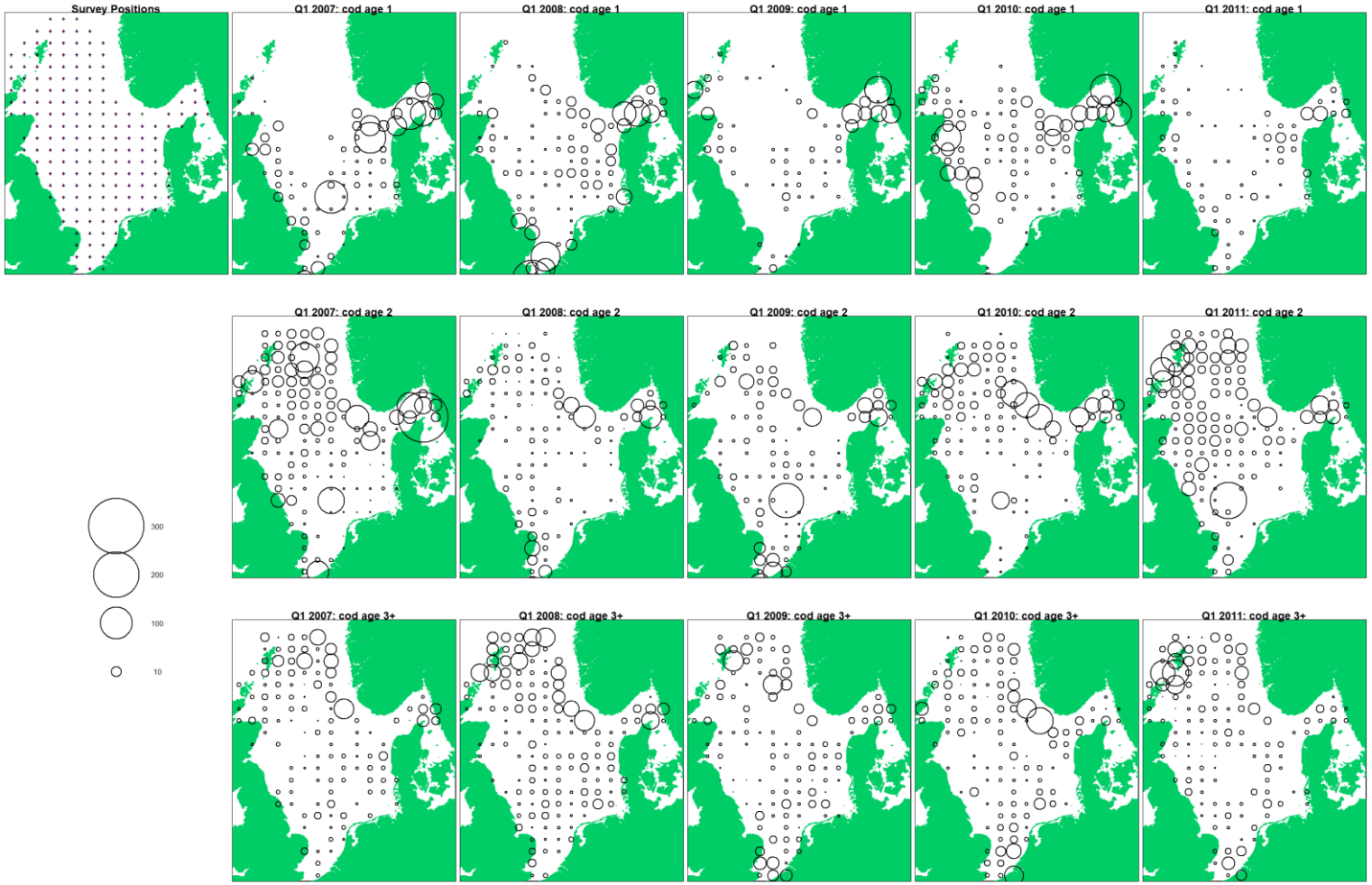

Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2002–2021 in the North Sea.

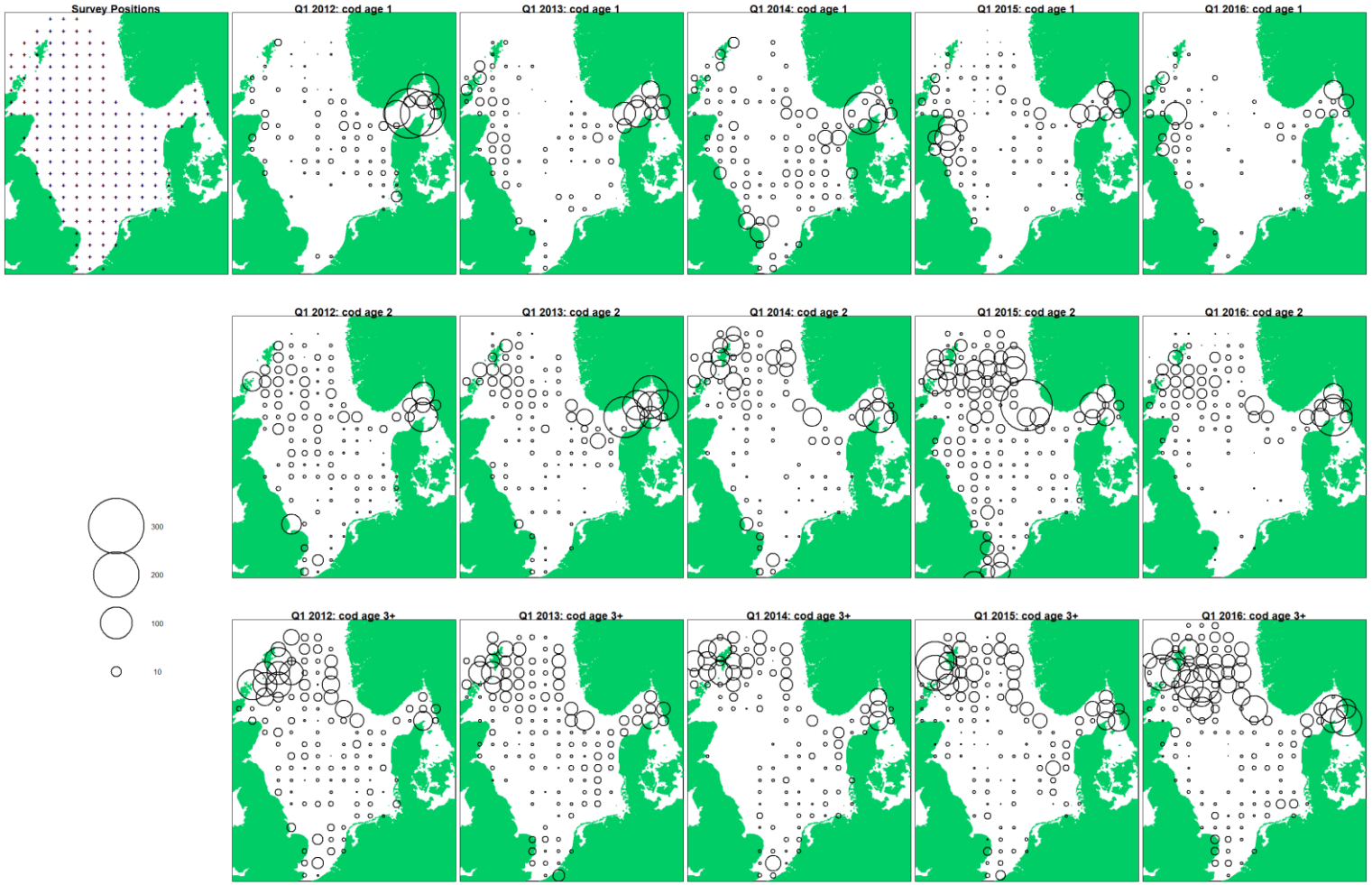

Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2002–2021 in the North Sea.

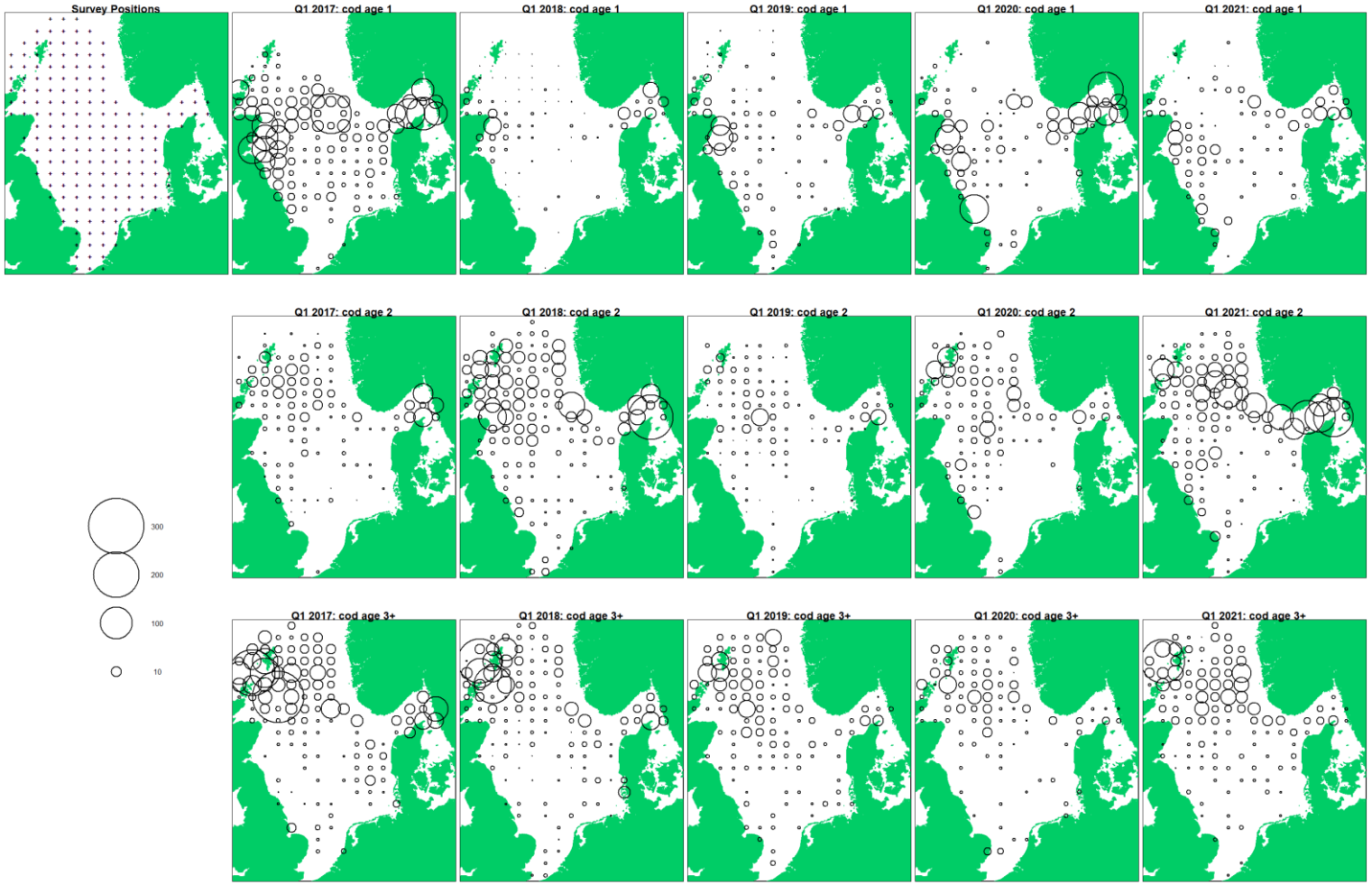

Figure 4.3a contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q1 survey 2002–2021 in the North Sea.

Figure 4.3b. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2002–2020 in the North Sea.

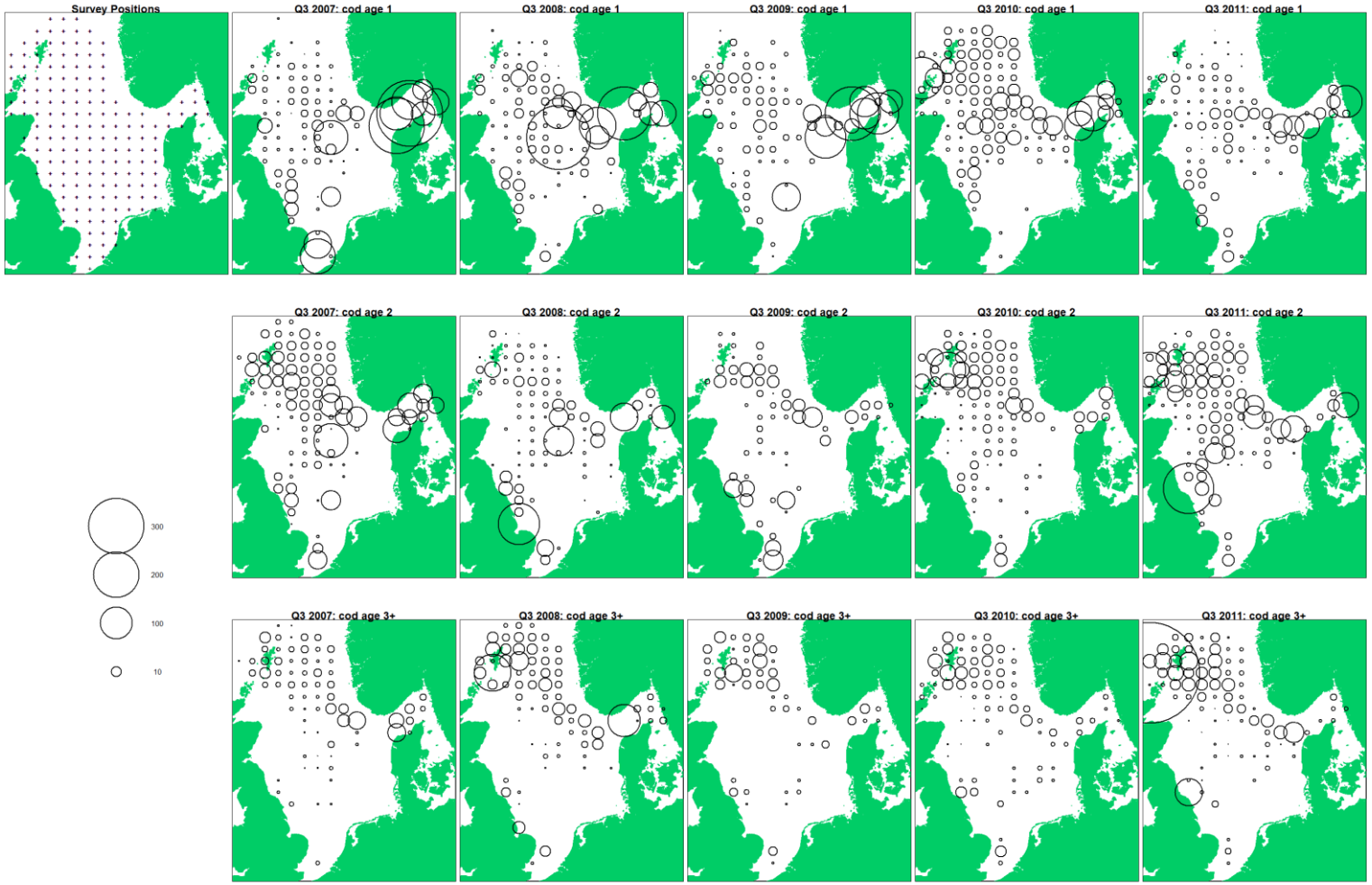

Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2002–2020 in the North Sea.

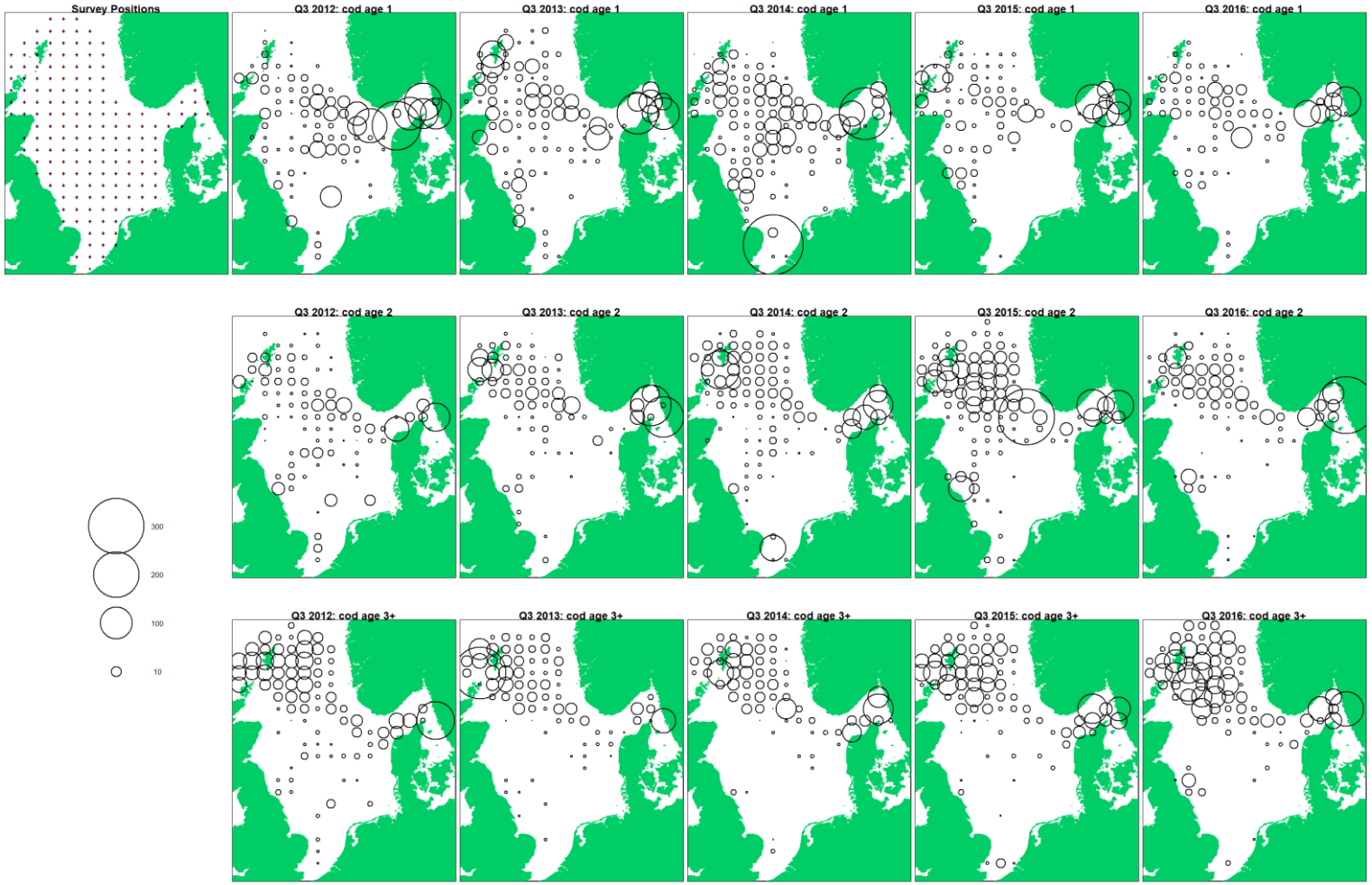

Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2002–2020 in the North Sea.

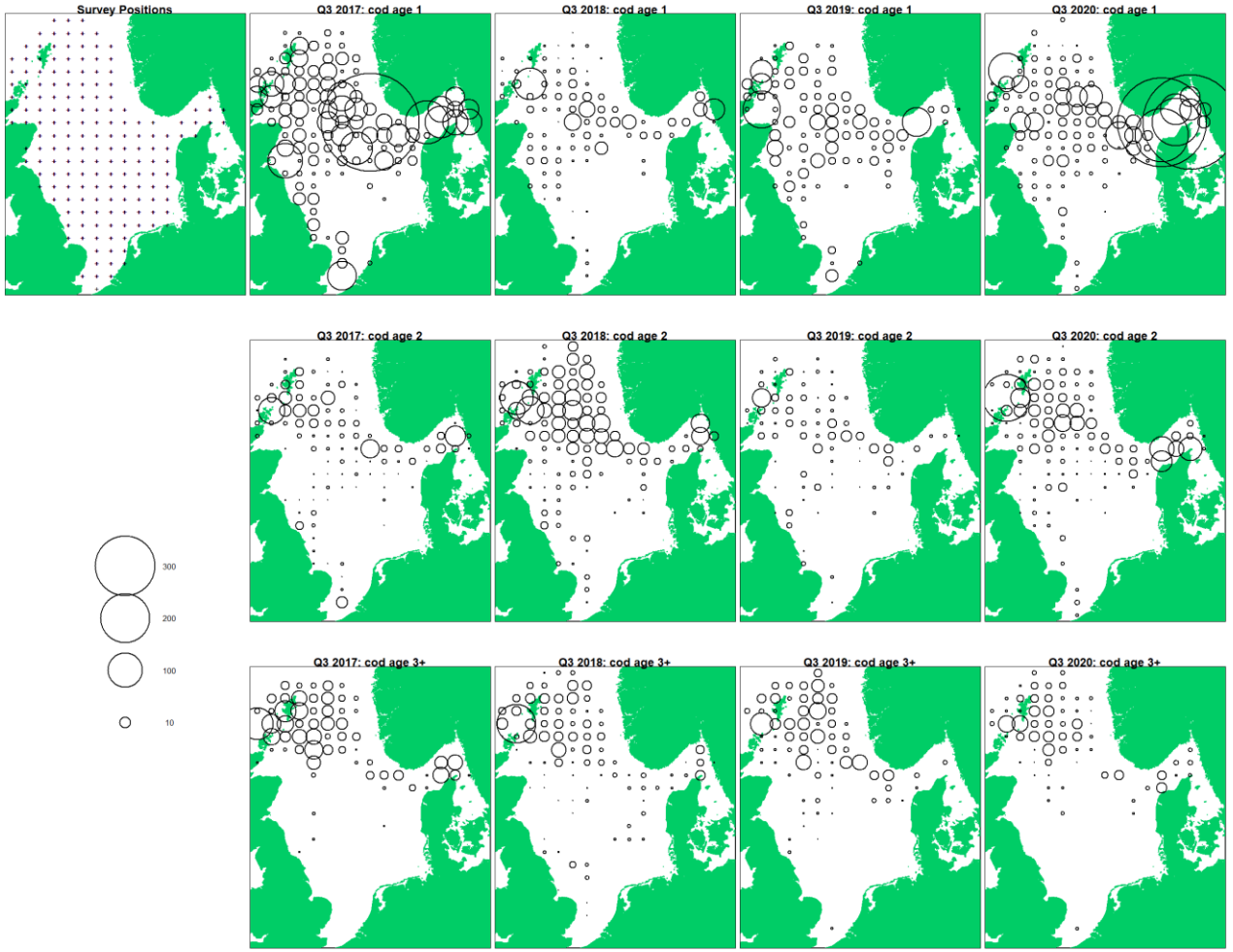

Figure 4.3b contd. Cod in Subarea 4, Division 7.d and Subdivision 20: Distribution charts of cod ages 1–3+ caught in the IBTS–Q3 survey 2002–2020 in the North Sea.

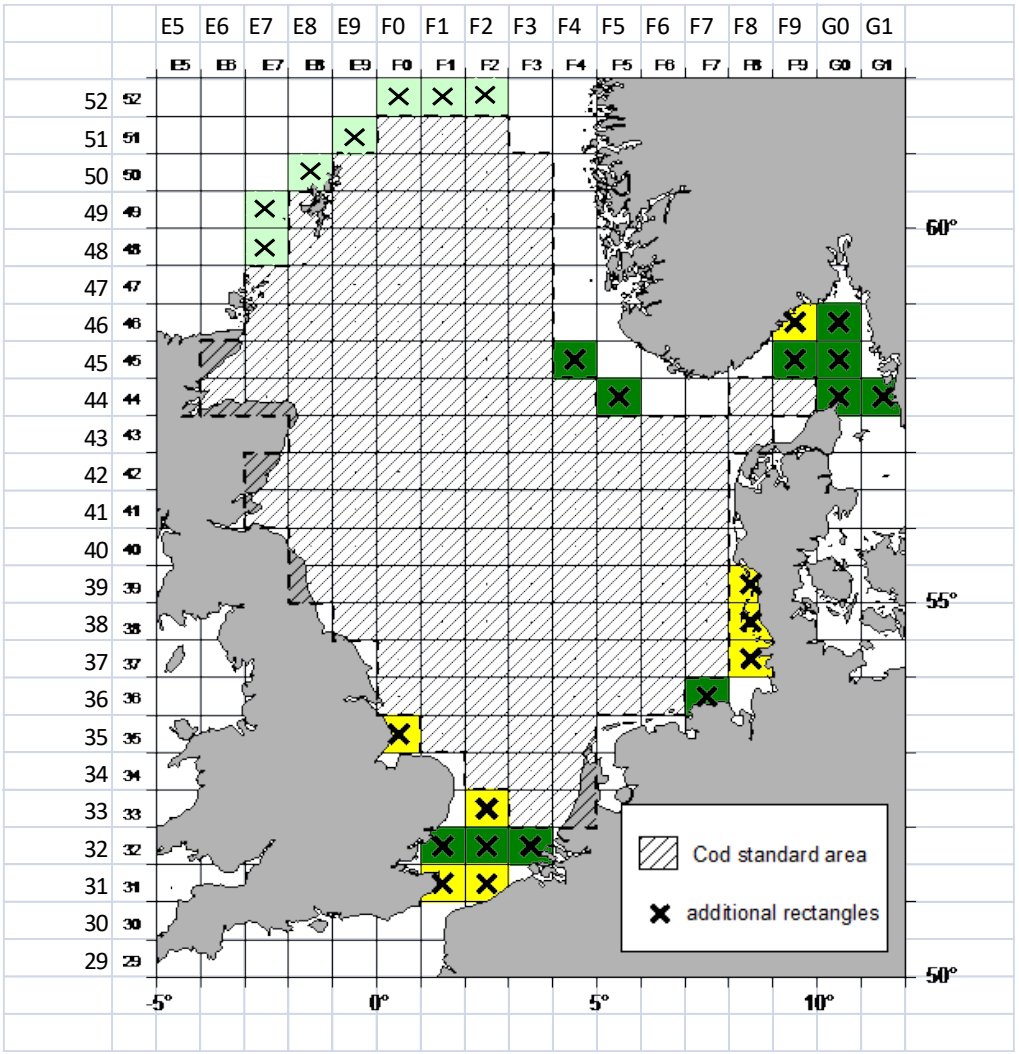

Figure 4.3c. Cod in Subarea 4, Division 7.d and Subdivision 20: Extension of cod standard area used for the NS–IBTS extended index. Crosses indicate suggested extensions to the survey (ICES WKROUND, 2009; ICES WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate data is available; yellow squares indicate where intermittent coverage does not allow inclusion and the IBTS WG considered should be omitted; light green squares indicate the recommended extension around Shetland (ICES WKCOD, 2011).

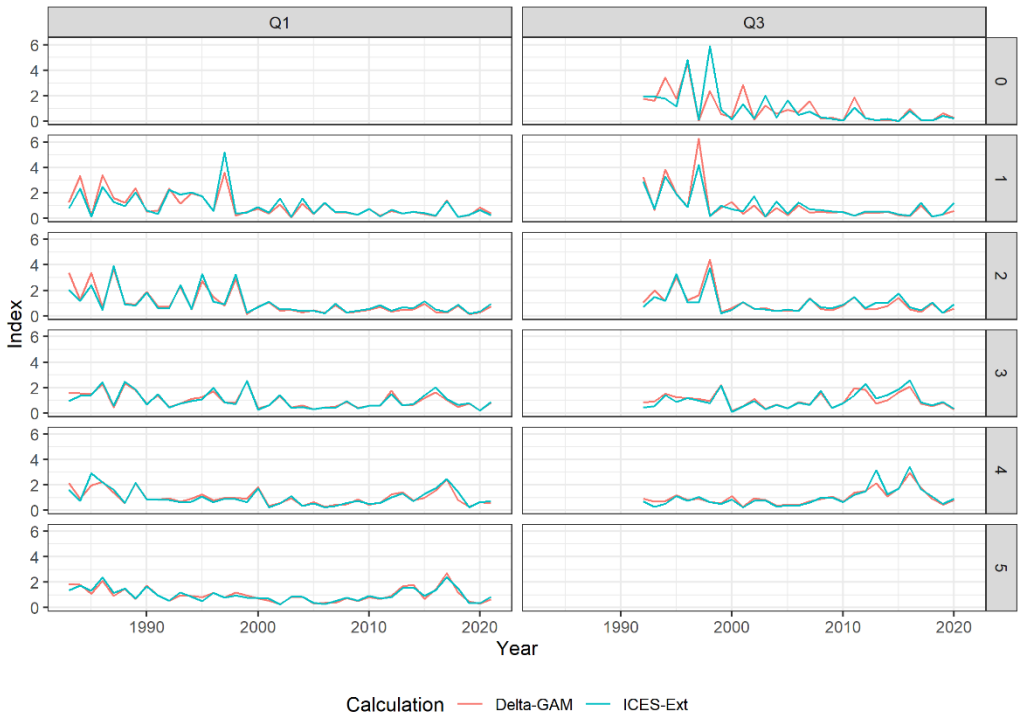

Figure 4.3d. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS Delta–GAM indices used in the assessment to the corresponding NS–IBTS extended indices (ICES-Ext). The indices are mean-standardised. Note the index for age 0 is forward shifted to represent age 1 in the assessment.

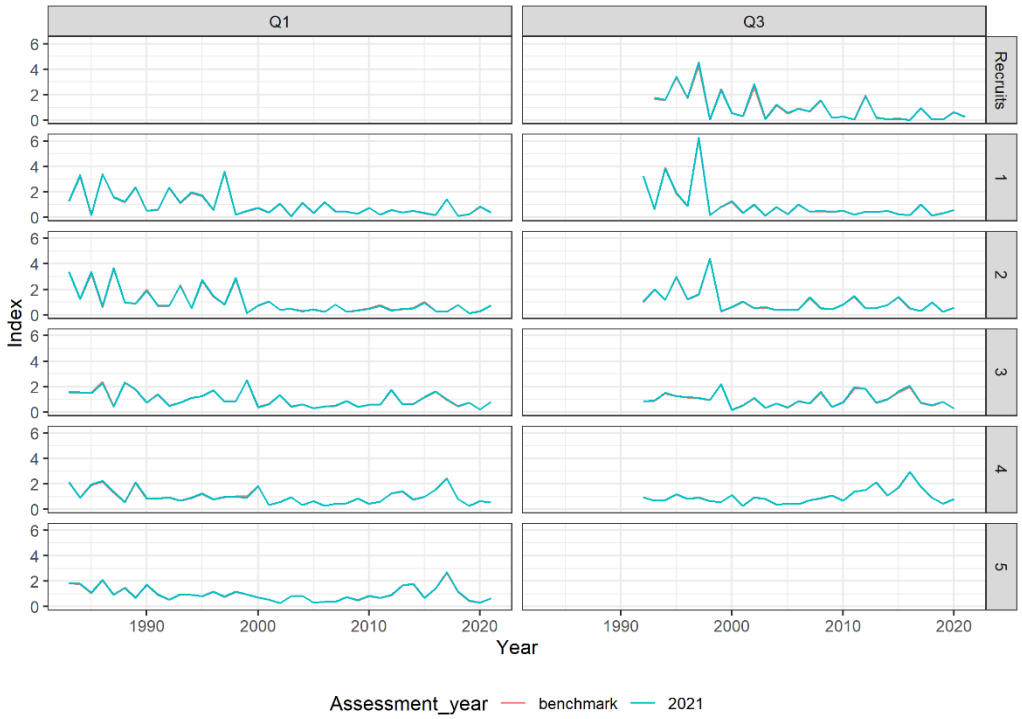

Figure 4.3e. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the Q1 and Q3 NS–IBTS Delta–GAM indices used in the assessment to the corresponding Delta-GAM indices used in the 2021 benchmark (ICES WKNSEA 2021). The indices are mean-standardised.

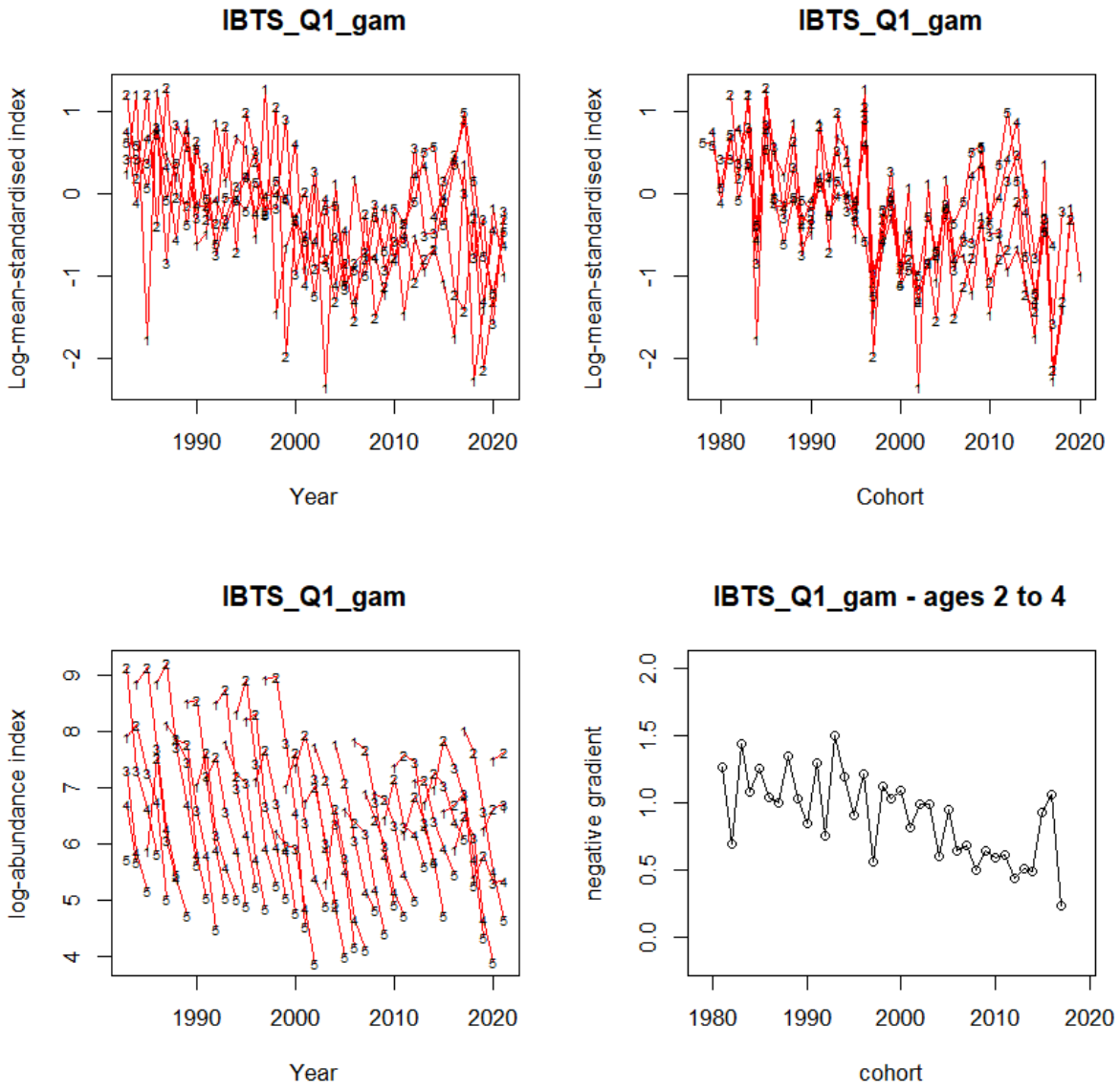

Figure 4.4a. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q1 groundfish survey (NS–IBTS Delta–GAM index).

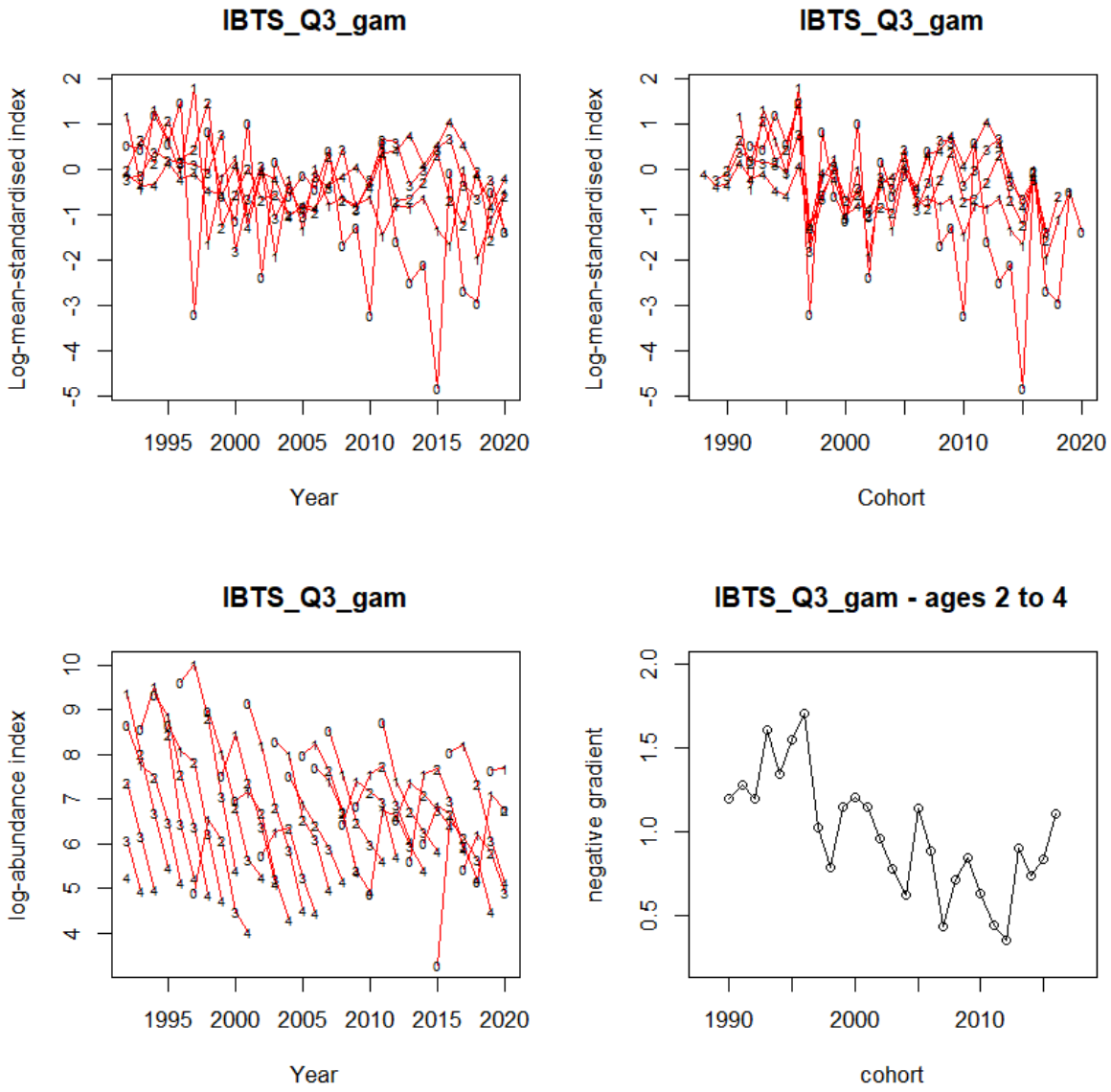

Figure 4.4b. Cod in Subarea 4, Division 7.d and Subdivision 20: Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2–4 (bottom right), for the IBTS–Q3 groundfish survey (NS–IBTS Delta–GAM index).

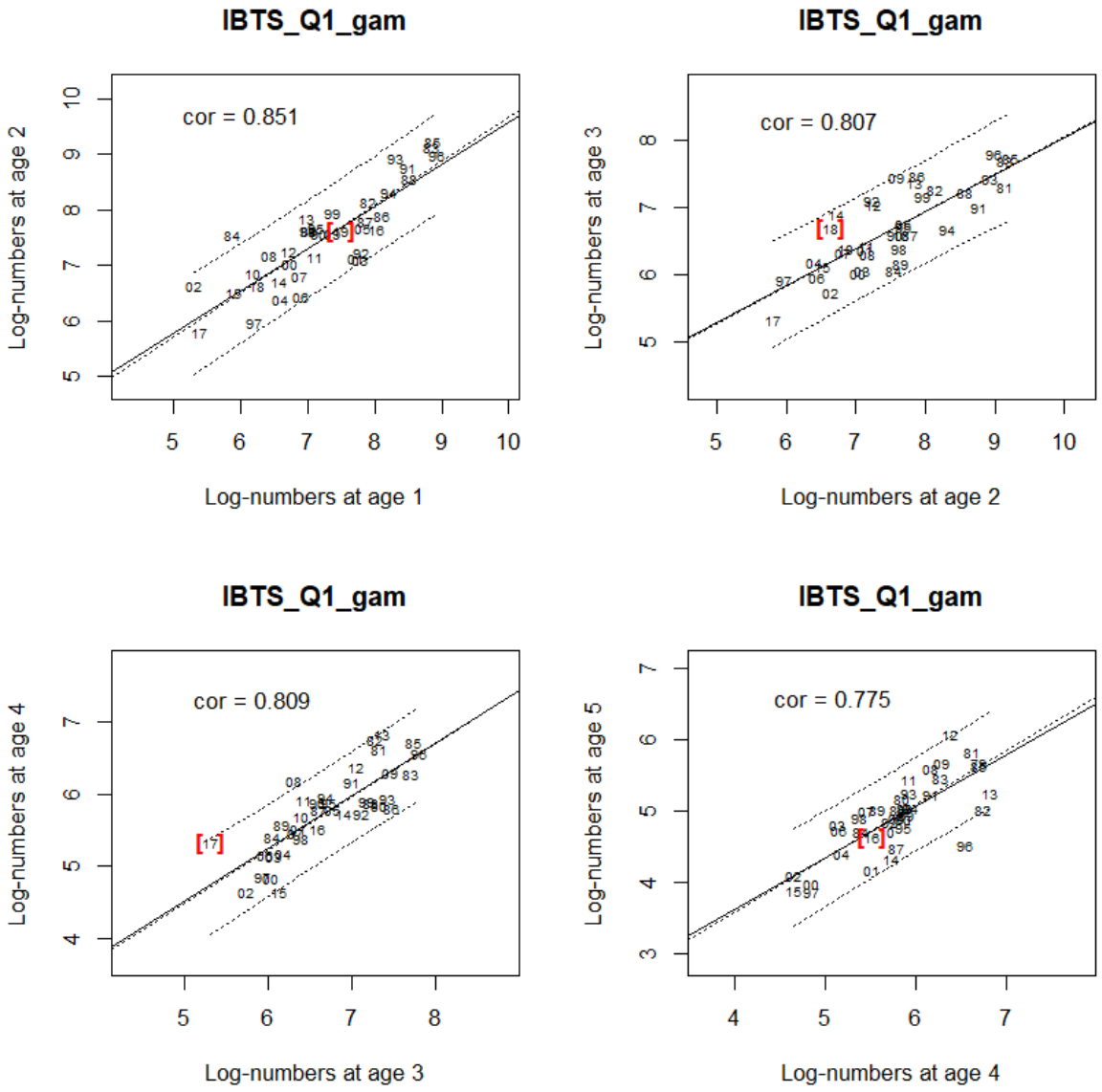

Figure 4.5a. Cod in Subarea 4, Division 7.d and Subdivision 20: Within survey correlations for IBTS–Q1 (NS–IBTS Delta–GAM index) for the period 1983–2021. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

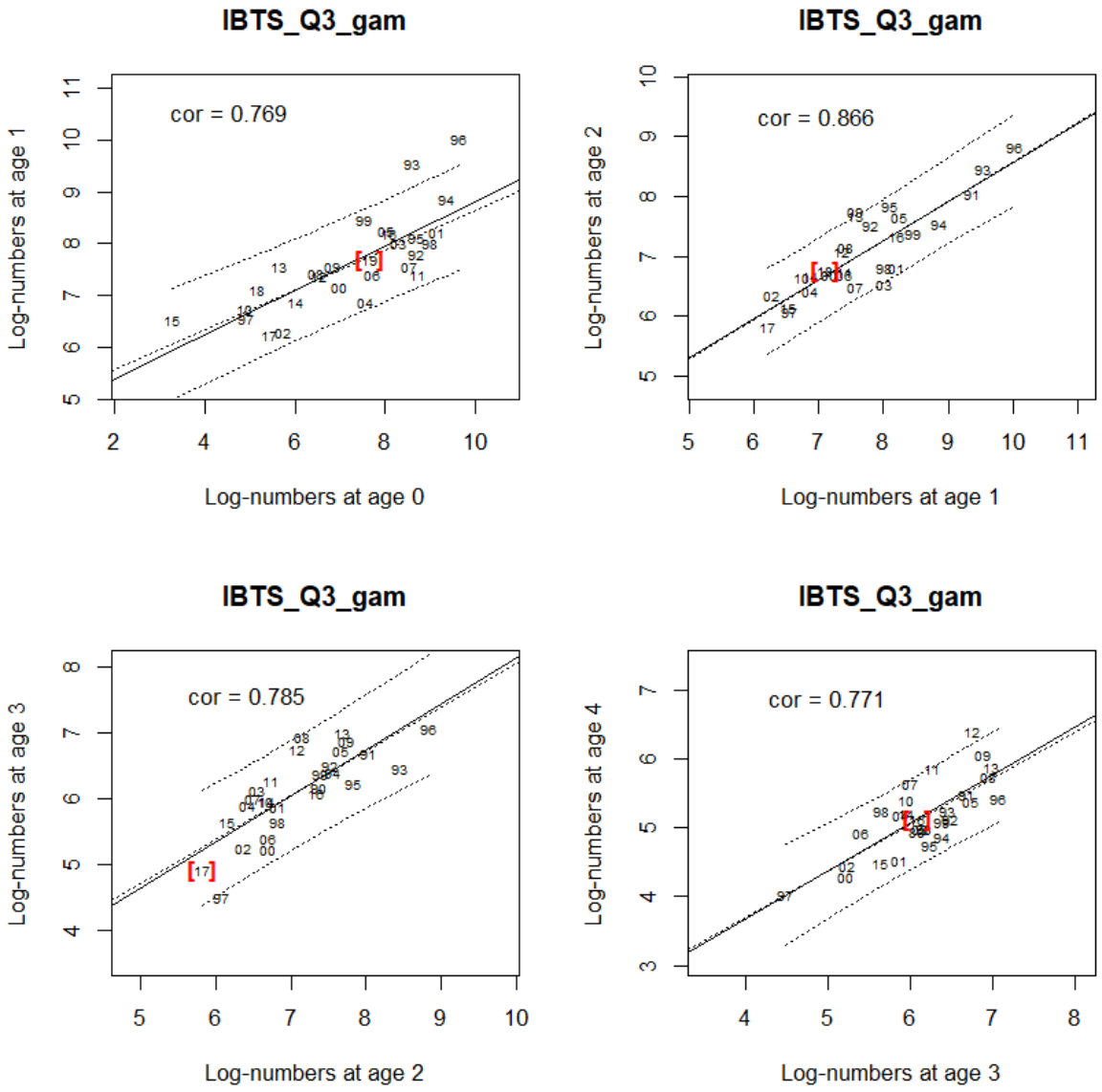

Figure 4.5b. Cod in Subarea 4, Division 7.d and Subdivision 20: Within-survey correlations for IBTS–Q3 (NS–IBTS Delta–GAM index) for the period 1992–2020. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

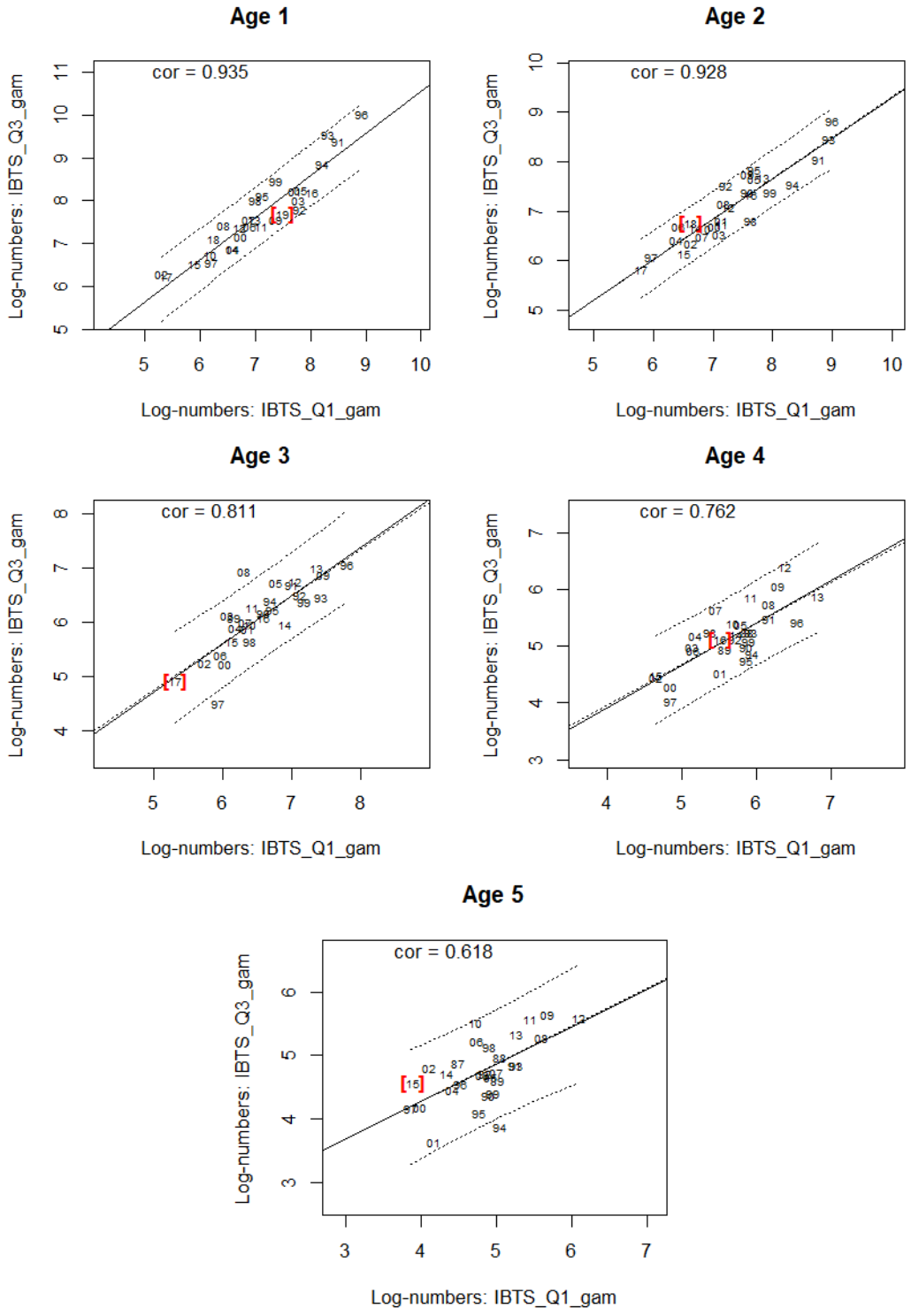

Figure 4.5c. Cod in Subarea 4, Division 7.d and Subdivision 20: Between-survey correlations for IBTS–Q1 and Q3 surveys (NS–IBTS Delta–GAM indices) for the period 1992–2020. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

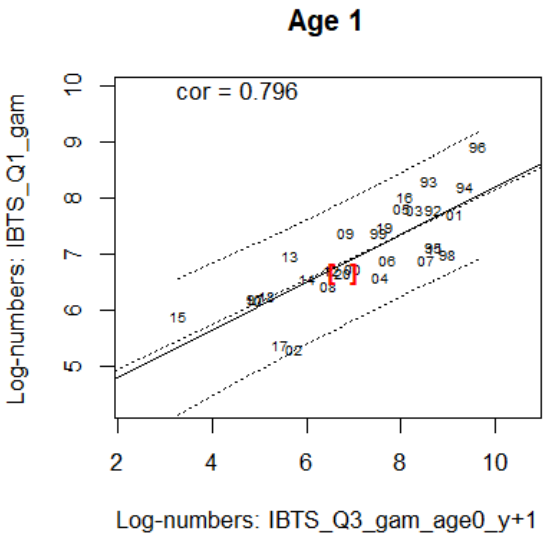

Figure 4.5d. Cod in Subarea 4, Division 7.d and Subdivision 20: Between-survey correlations for the IBTS–Q1 age 1 and IBTS–Q3 recruitment indices (age 0 forward shifted to 1st January the following year) for the period 1993–2021. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in red square brackets.

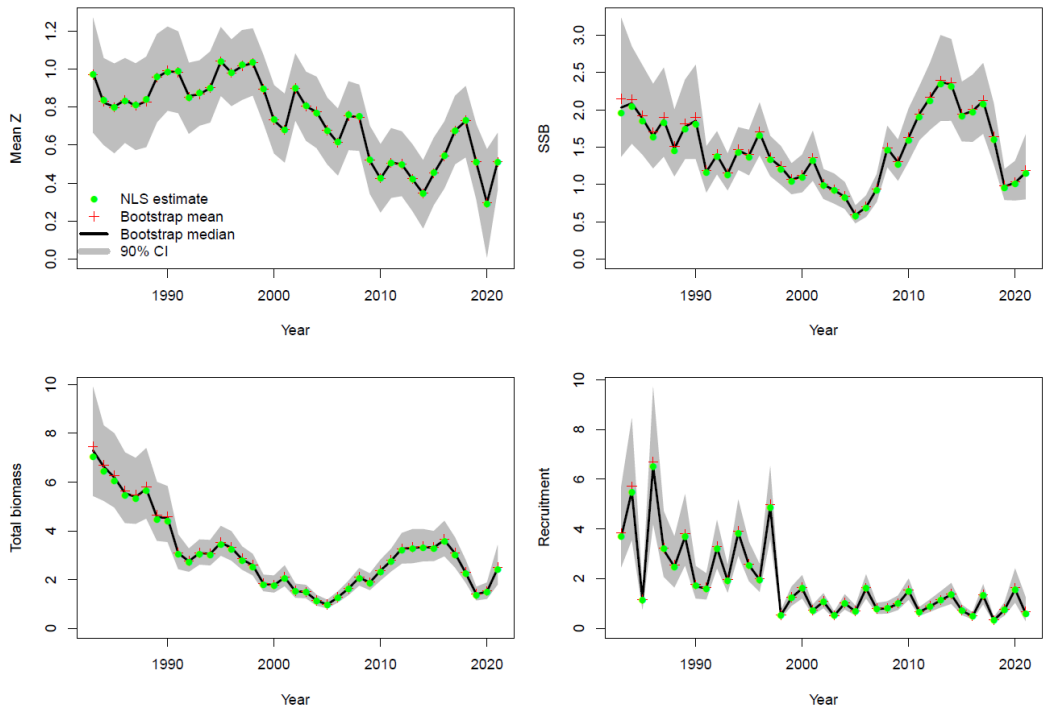

Figure 4.6a. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for a combined SURBAR run with both surveys (Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3. The shaded area represents 90% confidence bounds.

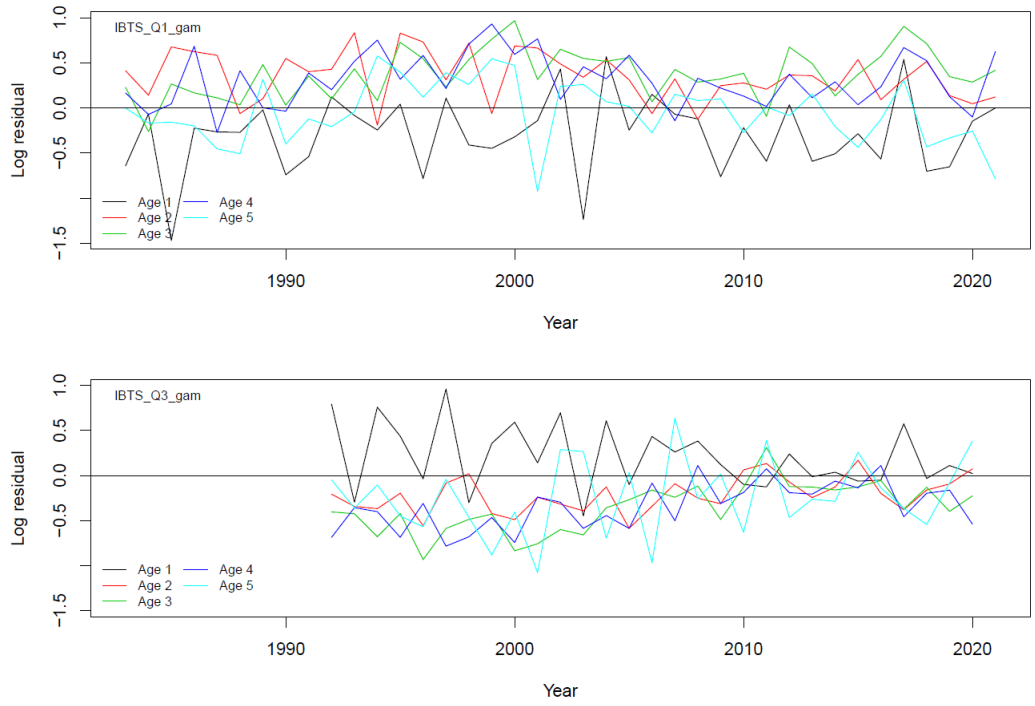

Figure 4.6b. Cod in Subarea 4, Division 7.d and Subdivision 20: SURBAR residual plots for a combined SURBAR run with both surveys (Q1 and Q3 NS–IBTS Delta–GAM indices, ages 1–5). The smoothing parameter l is set to 3, and reference age at 3.

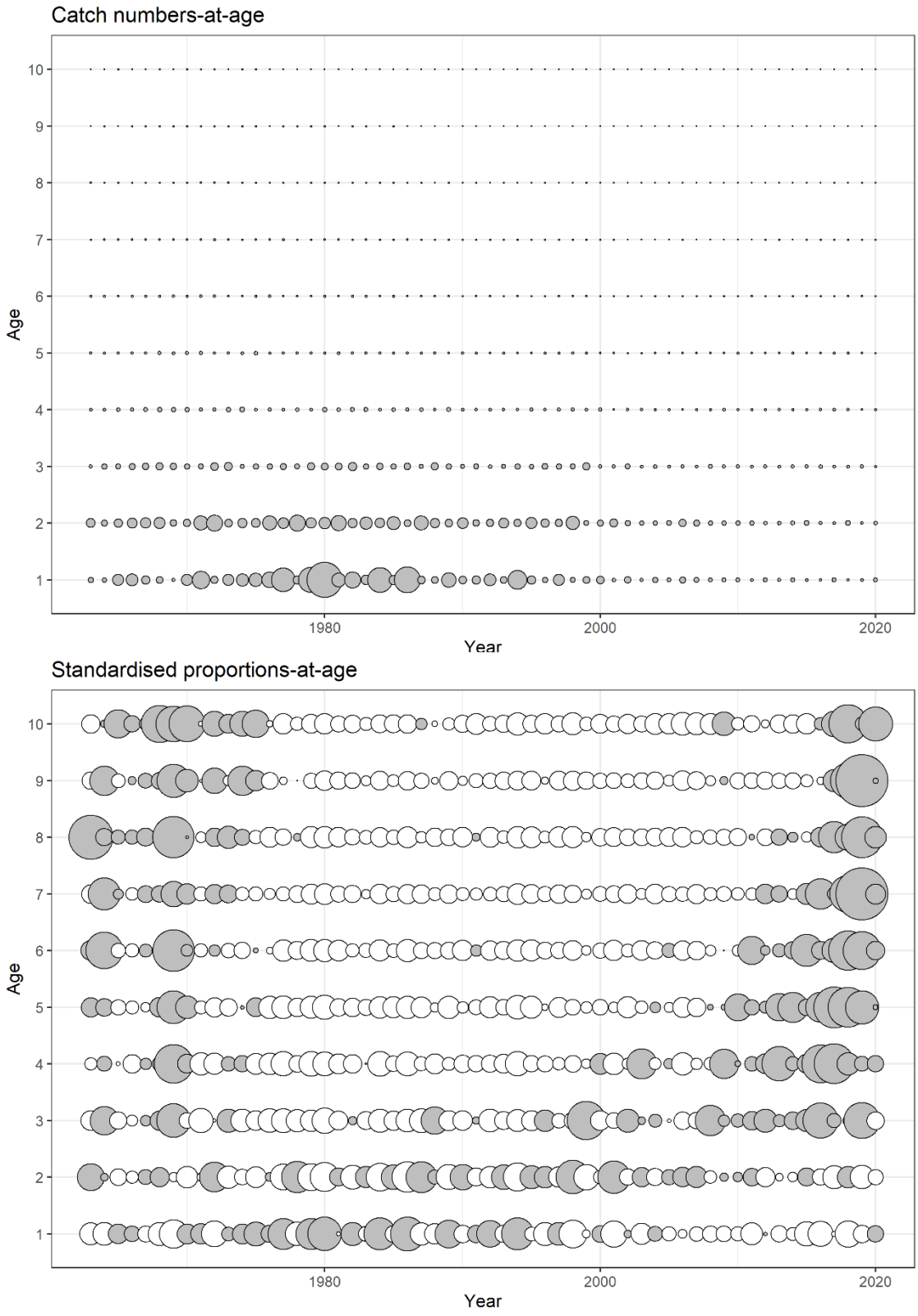

Figure 4.7. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catch-at-age matrix expressed as (top) numbers-at-age and (bottom) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.

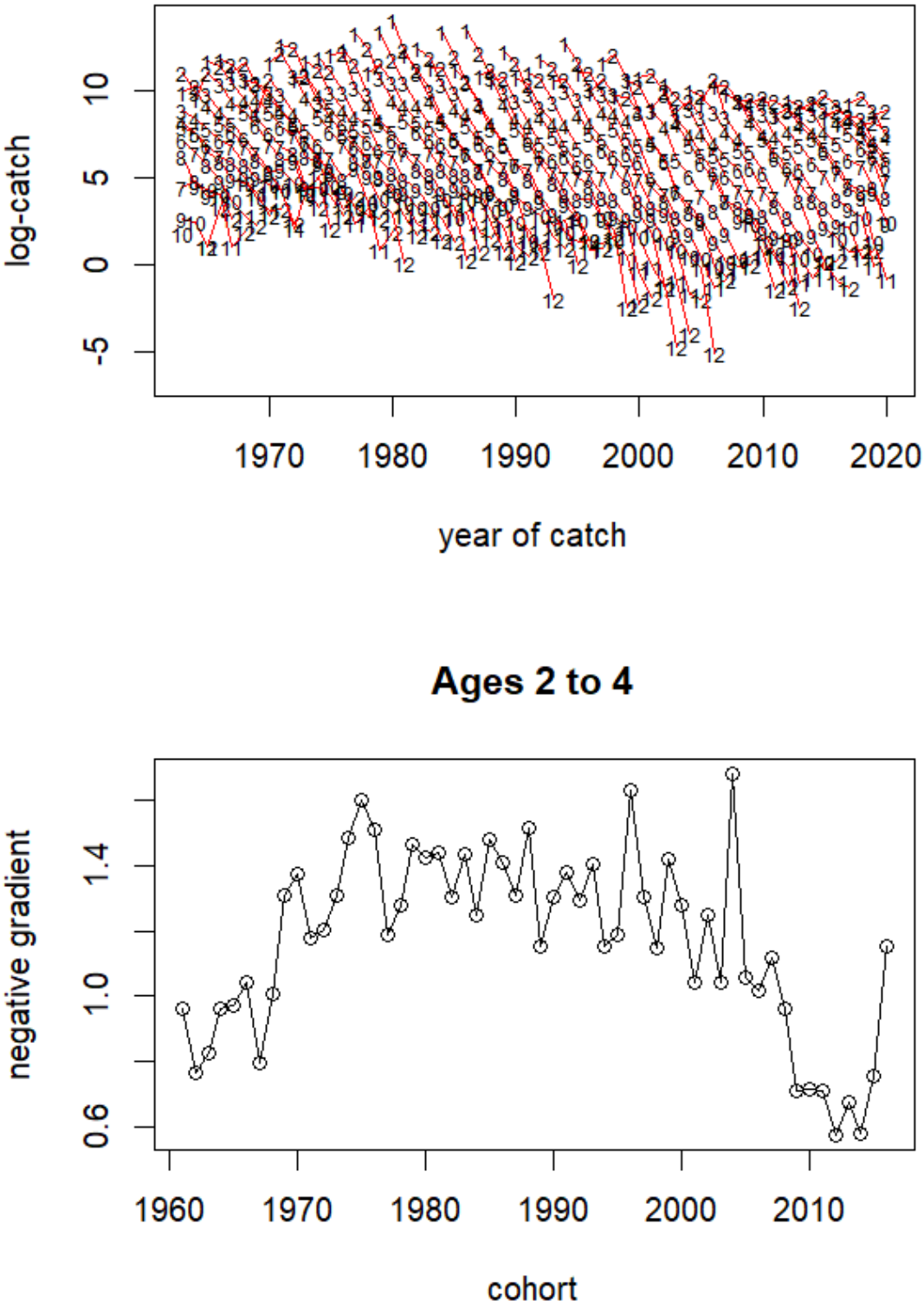

Figure 4.8. Cod in Subarea 4, Division 7.d and Subdivision 20: Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2–4.

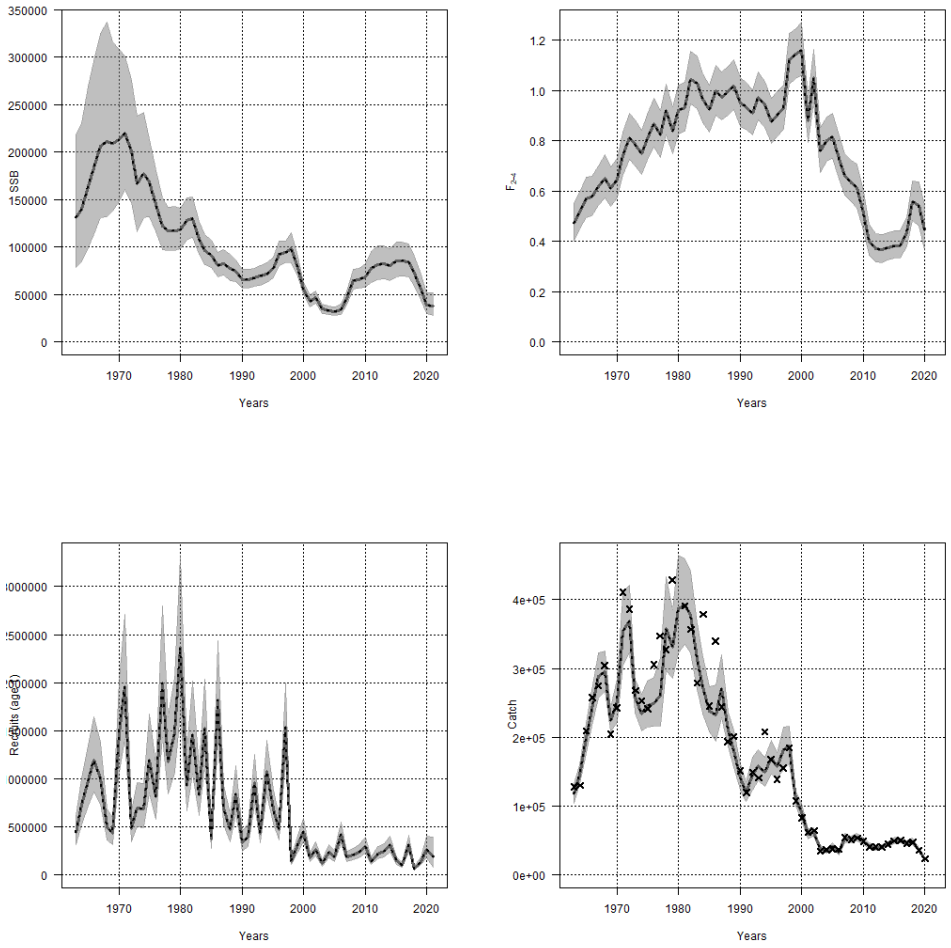

Figure 4.9. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimated SSB, F (2–4), recruitment (age 1) and catch from the SAM assessment (black lines = estimate and shaded area = corresponding pointwise 95% confidence intervals).

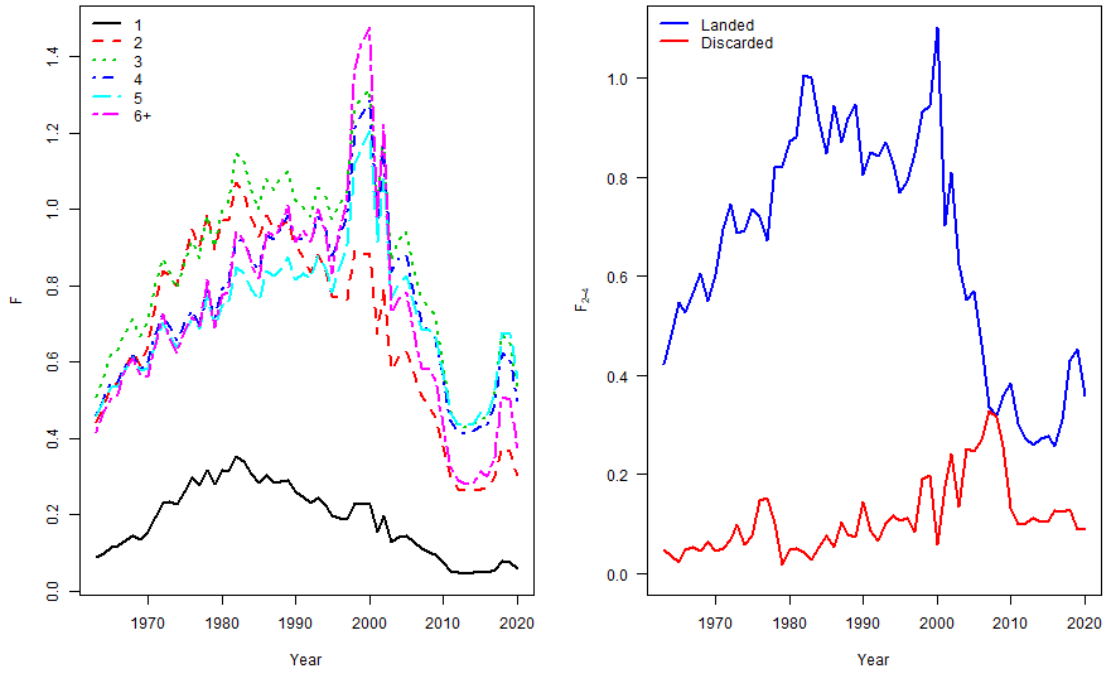

Figure 4.10a. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM estimates of fishing mortality. The left panel shows fishing mortality for each age while the right panel shows mean fishing mortality for ages 2–4 (shown in Figure 4.9) but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data.

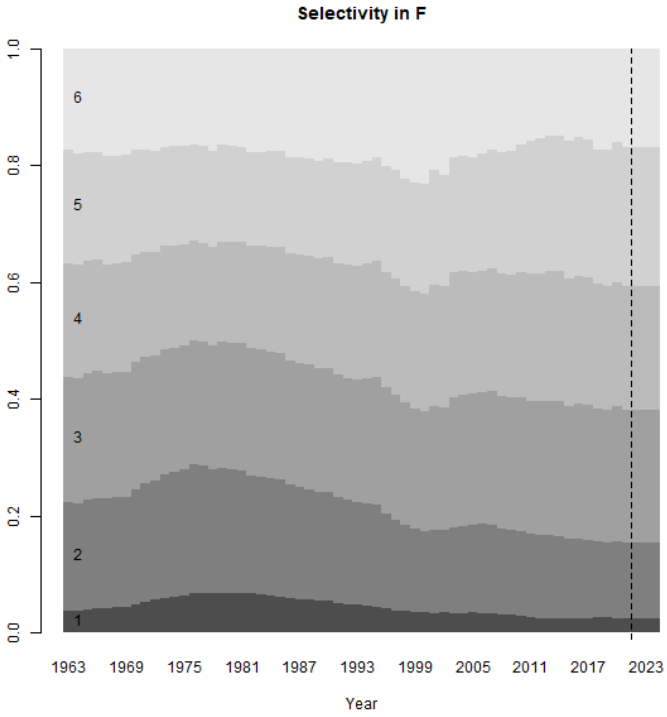

Figure 4.10b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM estimates of selectivity derived as the proportions of total fishing mortality at age over time. The dashed line represents the beginning of the forecast period.

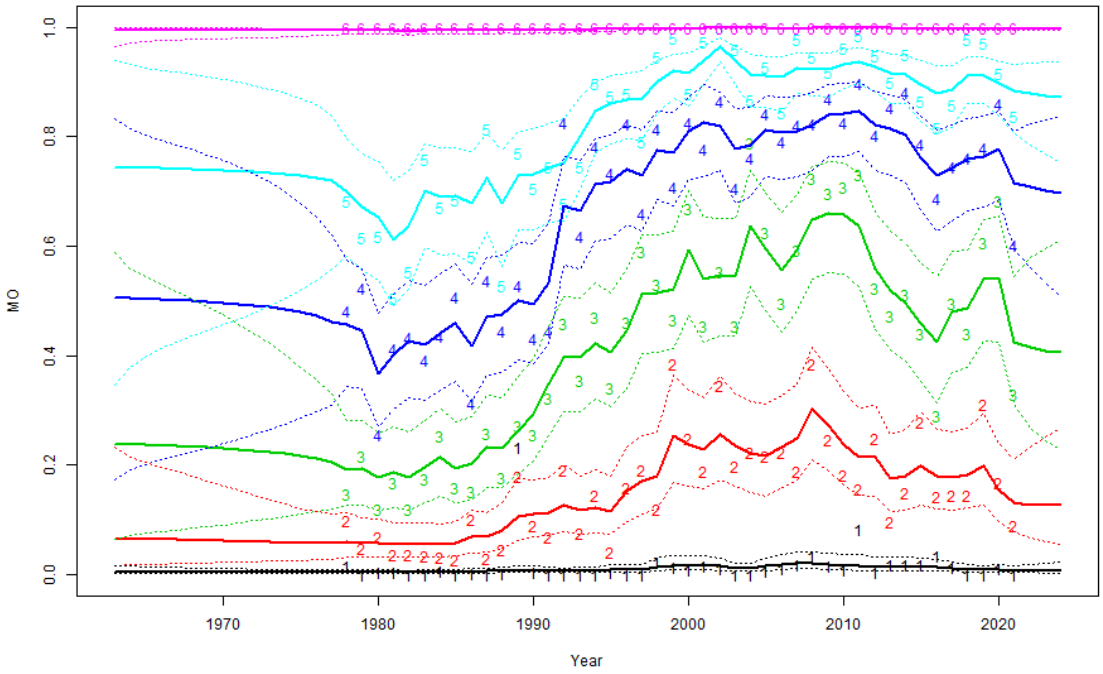

Figure 4.11. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM fits to maturity data. Numbers are the input data shown in Table 4.5b and Figure 4.2c. The solid lines are the SAM estimates of maturity-at-age, extending to the forecast period, with the dotted lines showing 95% confidence intervals.

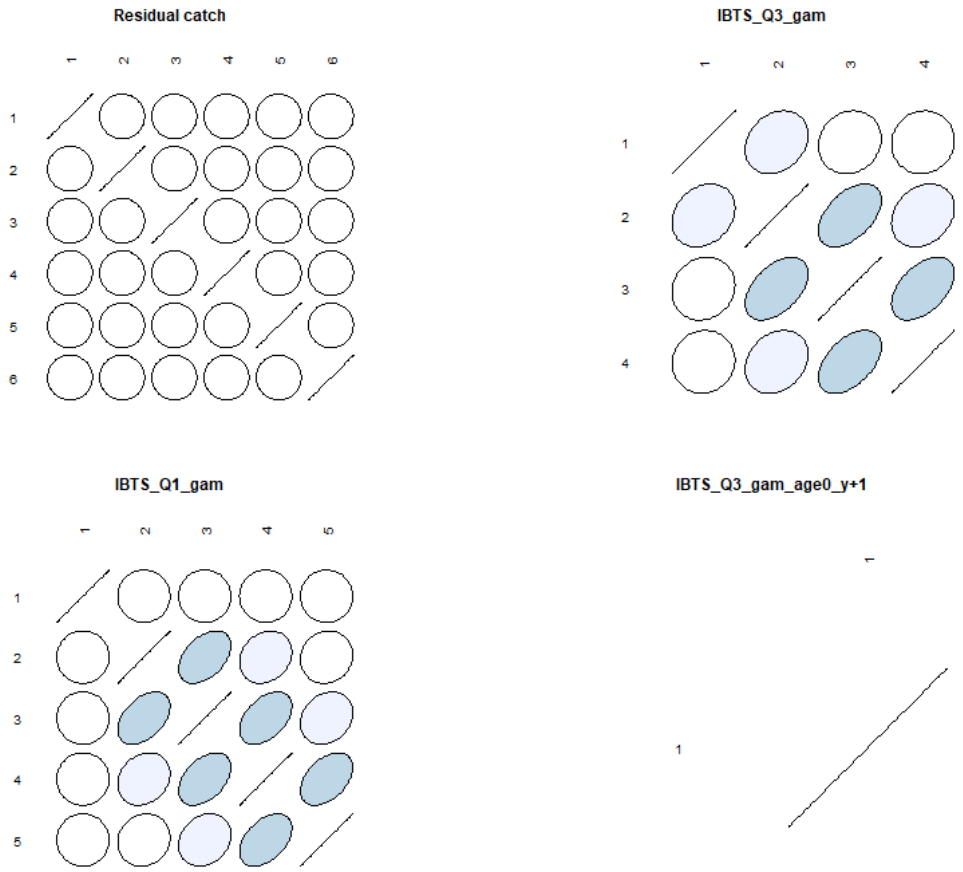

Figure 4.12. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimated correlation matrices between ages for the (top left) total catch, (bottom left) IBTS–Q1, (top right) IBTS–Q3 and (bottom right) the IBTS–Q3 recruitment index.

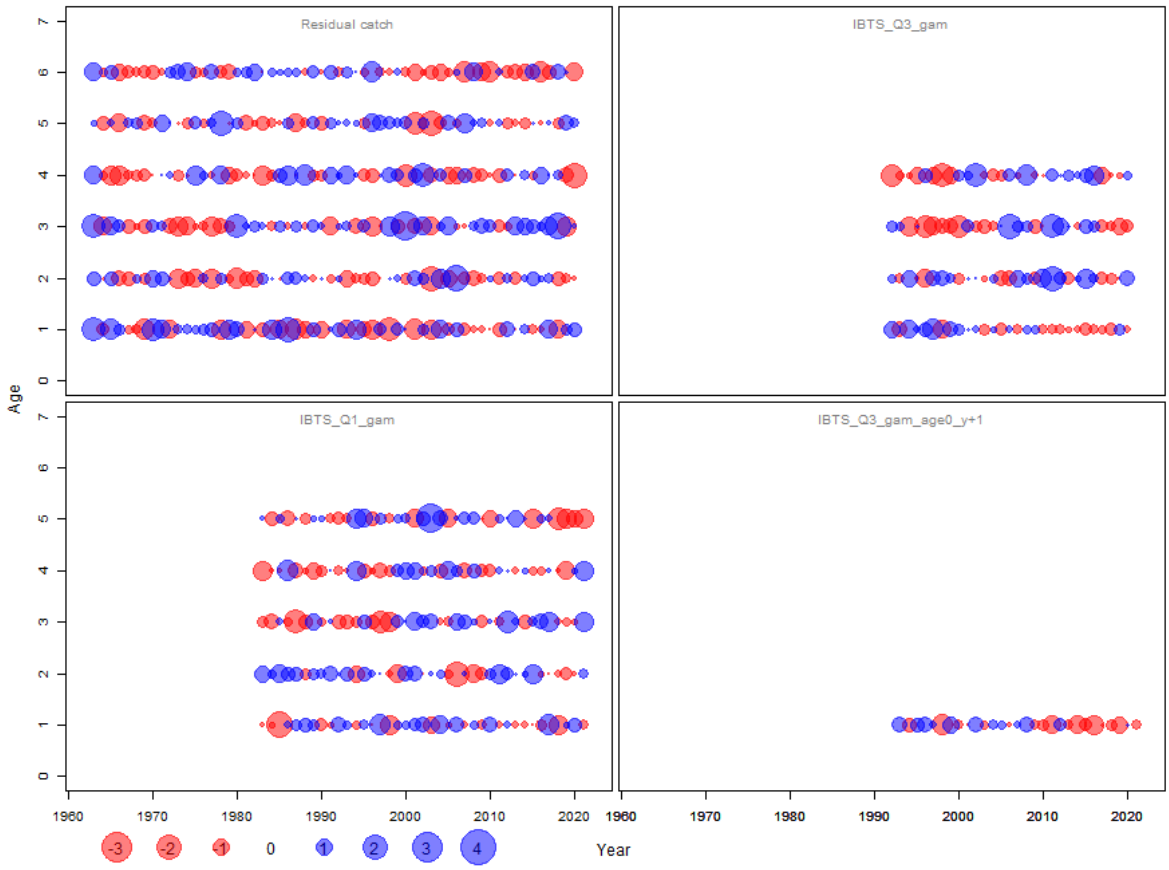

Figure 4.13a. Cod in Subarea 4, Division 7.d and Subdivision 20: One step ahead (OSA) residuals for the SAM assessment for (top left) total catch, (bottom left) IBTS–Q1, (top right) IBTS–Q3 and (bottom right) the IBTS–Q3 recruitment index. Blue circles indicate a positive residual and red circles a negative residual.

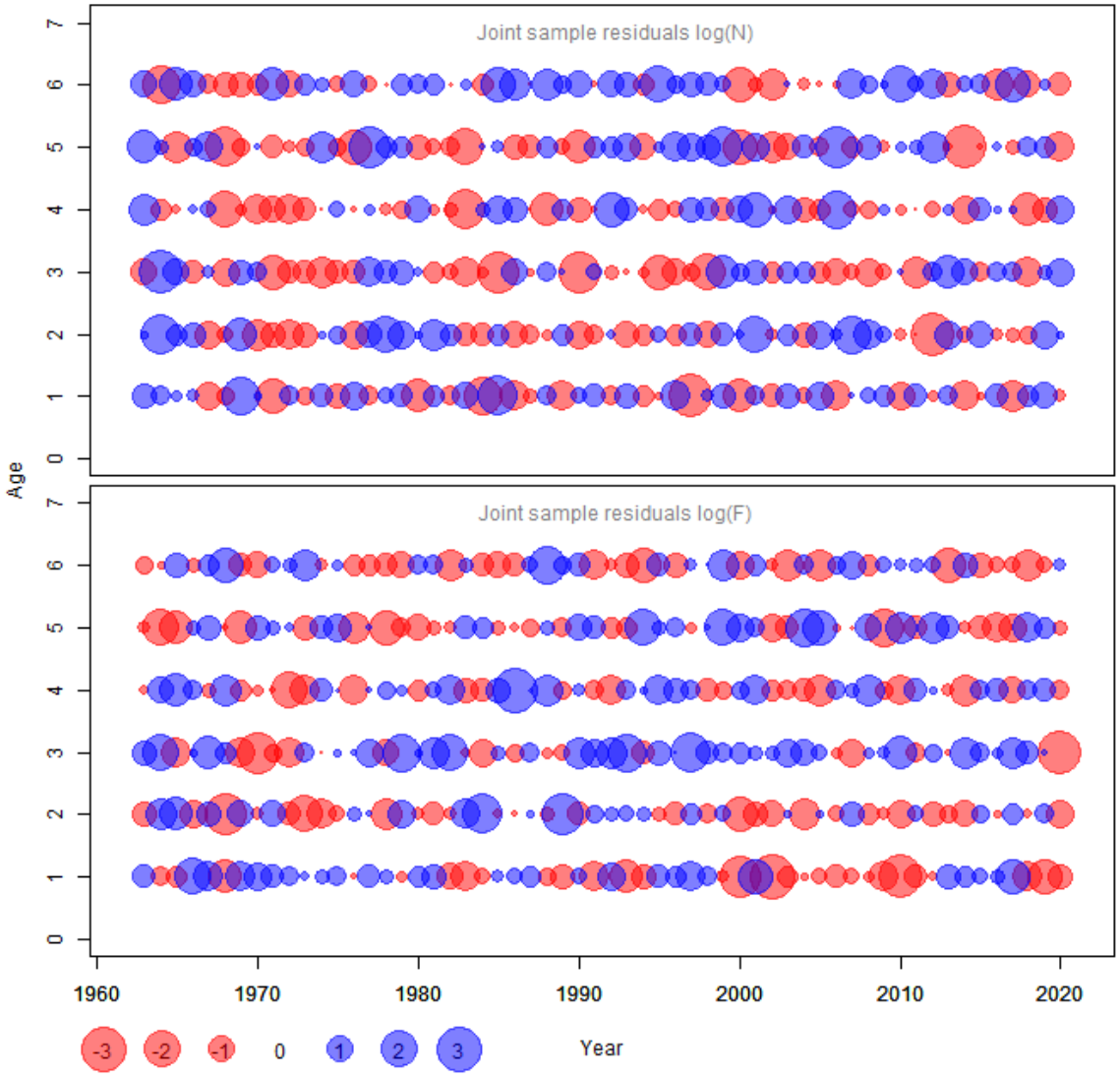

Figure 4.13b. Cod in Subarea 4, Division 7.d and Subdivision 20: SAM standardised joint-sample residuals of process increments for (top) stock numbers and (bottom) fishing mortality. Blue circles indicate a positive residual and red circles a negative residual.

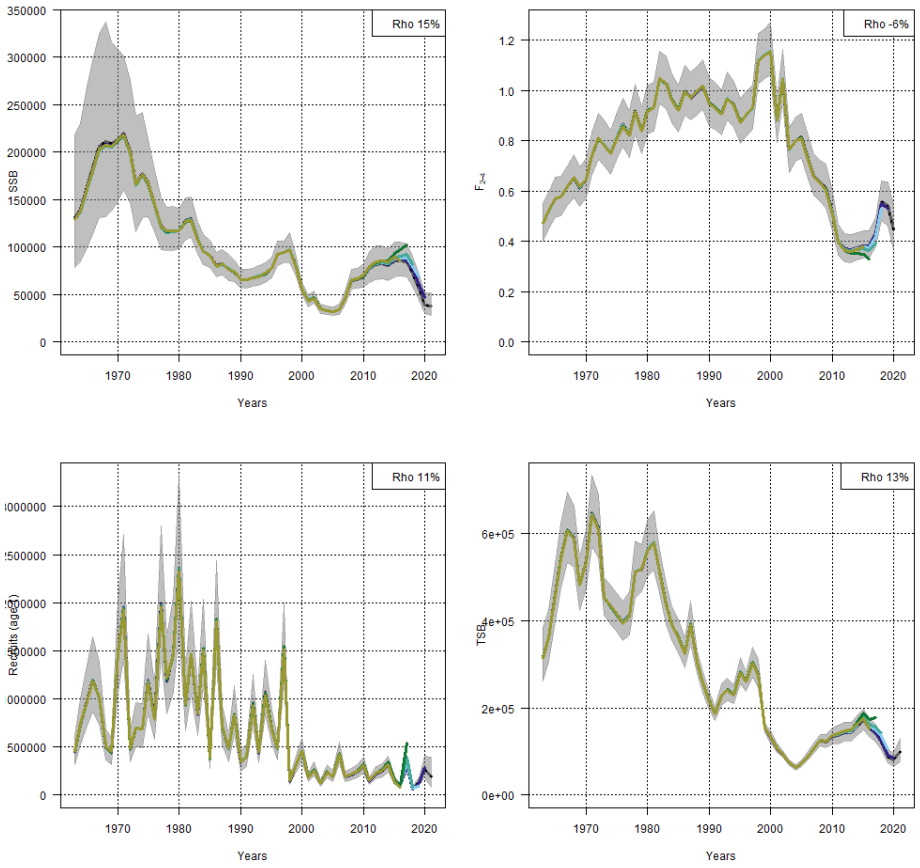

Figure 4.14. Cod in Subarea 4, Division 7.d and Subdivision 20: Retrospective estimates (5 years) from the SAM assessment. Estimated yearly SSB (top left), average fishing mortality (top right), recruitment age 1 (bottom left) and TSB (bottom right), together with corresponding pointwise 95% confidence intervals.

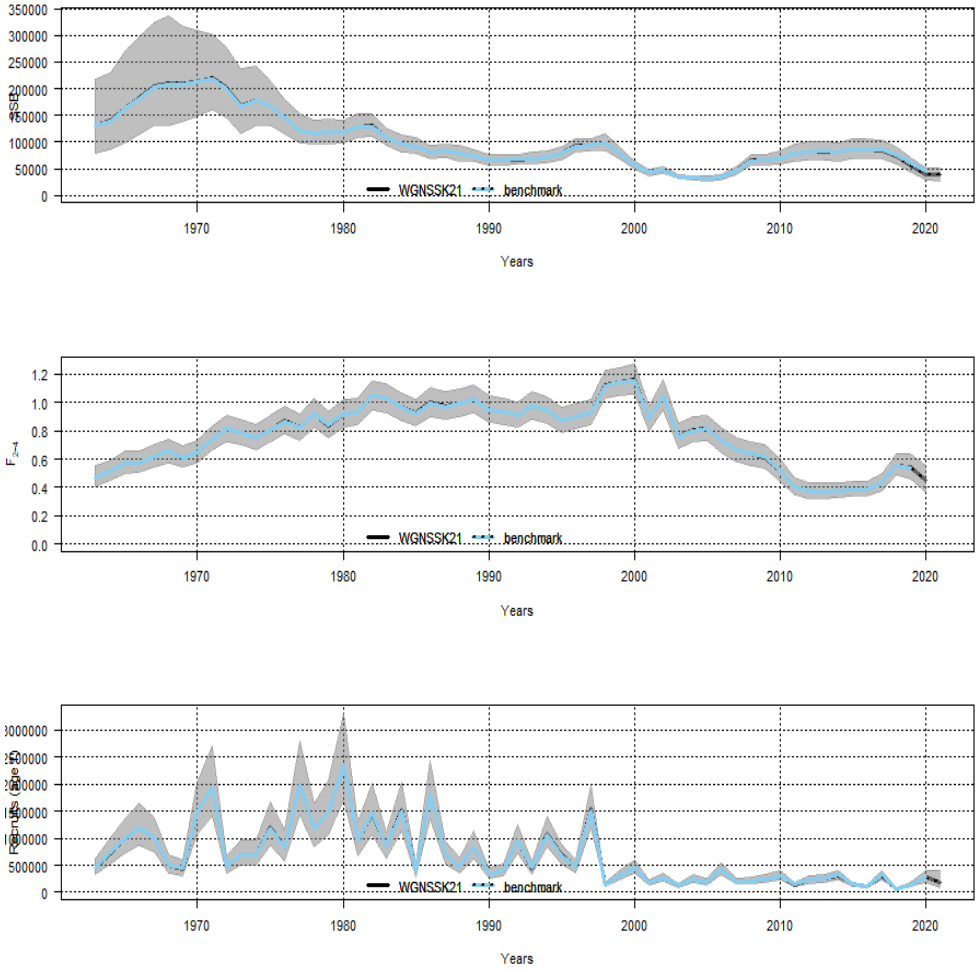

Figure 4.15a. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the final SAM assessment for 2021 with the final SAM benchmarked assessment (ICES WKNSEA 2021). Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding pointwise 95% confidence intervals.

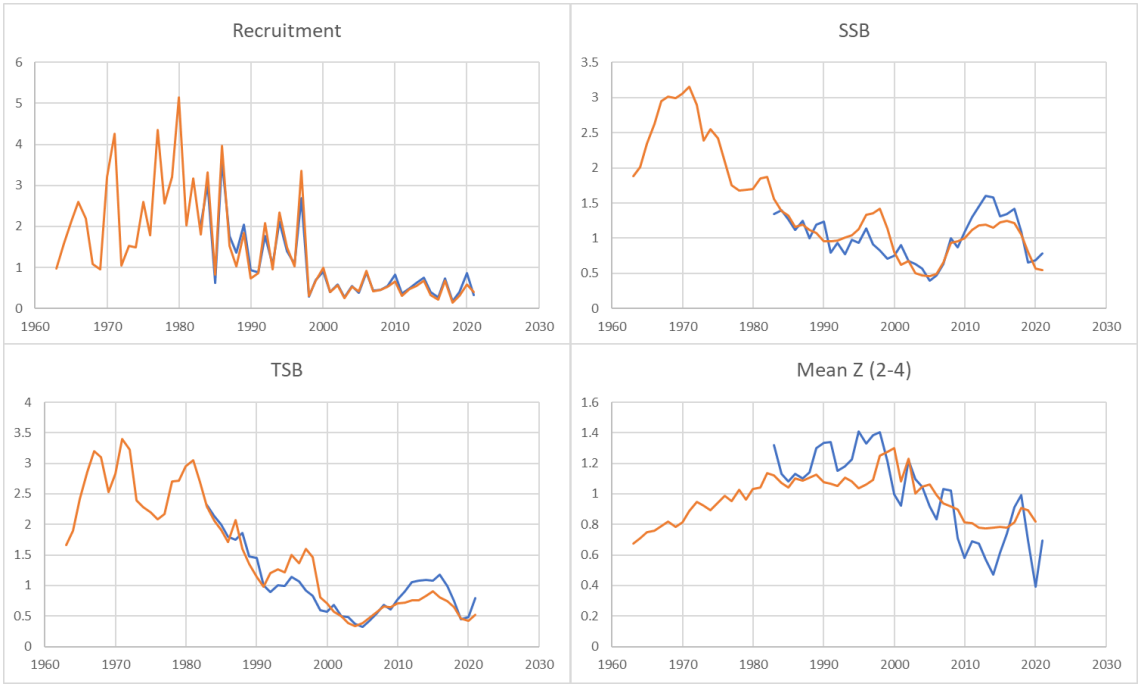

Figure 4.15b. Cod in Subarea 4, Division 7.d and Subdivision 20: Comparison of the final SAM assessment for 2021 (orange) with the SURBAR survey-based assessment (blue). All values have been mean-standardised using the year range for which estimates are available for both models.

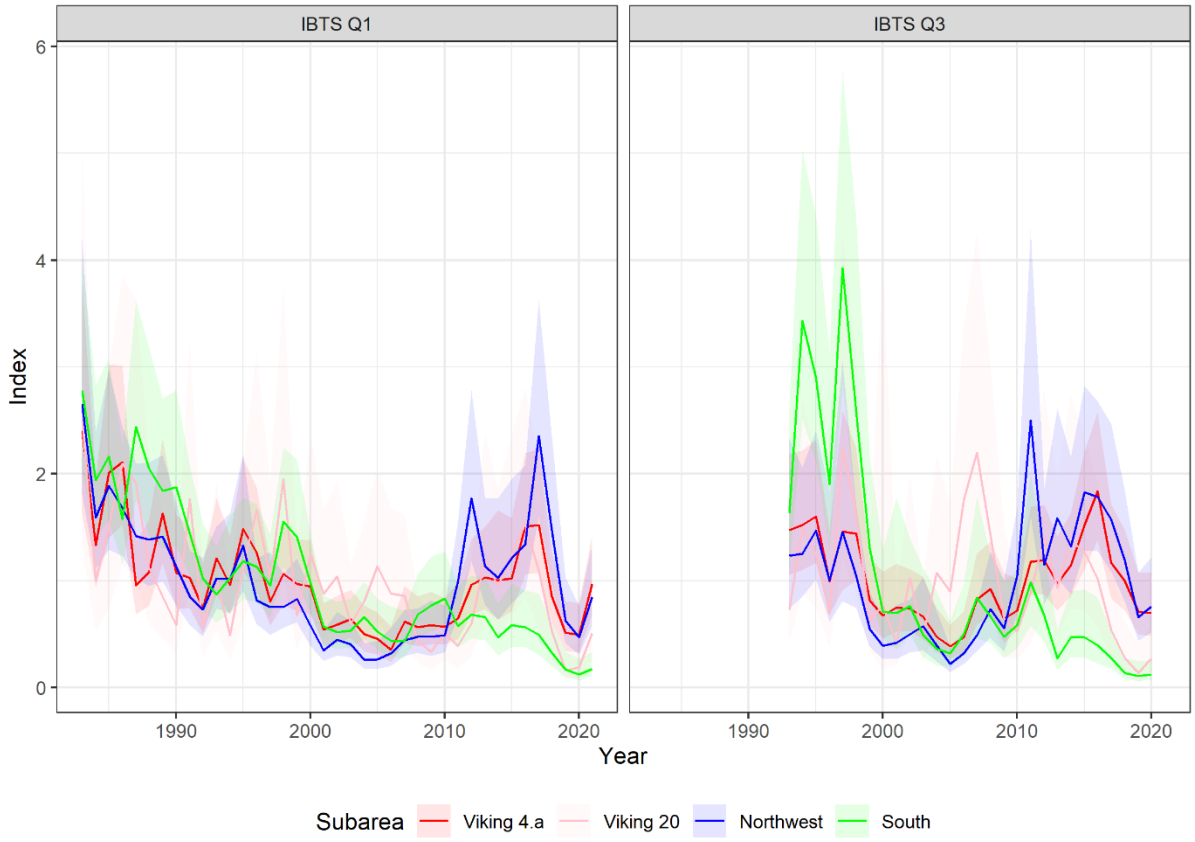

Figure 4.16a. Cod in Subarea 4, Division 7.d and Subdivision 20: Biomass indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data. The biomass indices are derived by fitting a non-stationary Delta–GAM model to numbers-at-age for the entire dataset and integrating the fitted abundance surface over each of the subregions to obtain indices-at-age by area. These are then multiplied by smoothed weight-at-age estimates and summed to get the biomass indices. Shading represents 95% confidence intervals. Indices and confidence intervals are standardised by the mean of the index for each subregion.

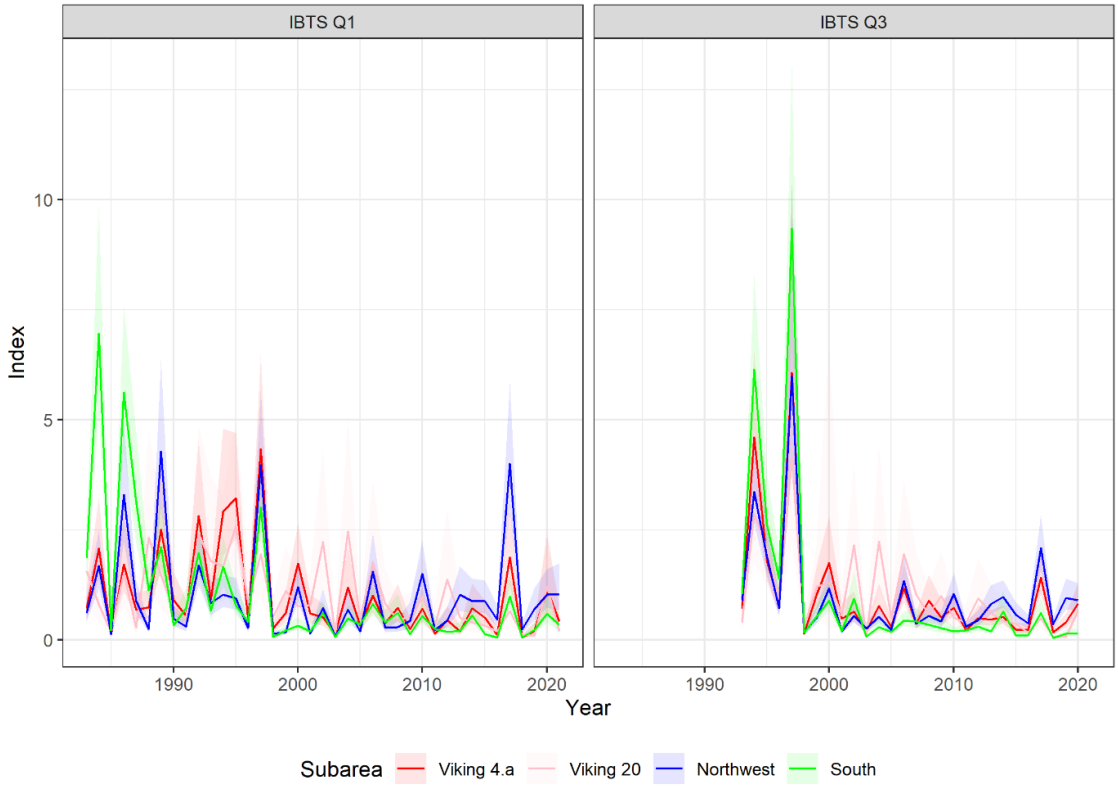

Figure 4.16b. Cod in Subarea 4, Division 7.d and Subdivision 20: Recruitment indices by subregion (see Figure 4.16c), based on NS–IBTS–Q1 and Q3 data. Indices and confidence intervals are standardised by the mean of the index for each subregion.

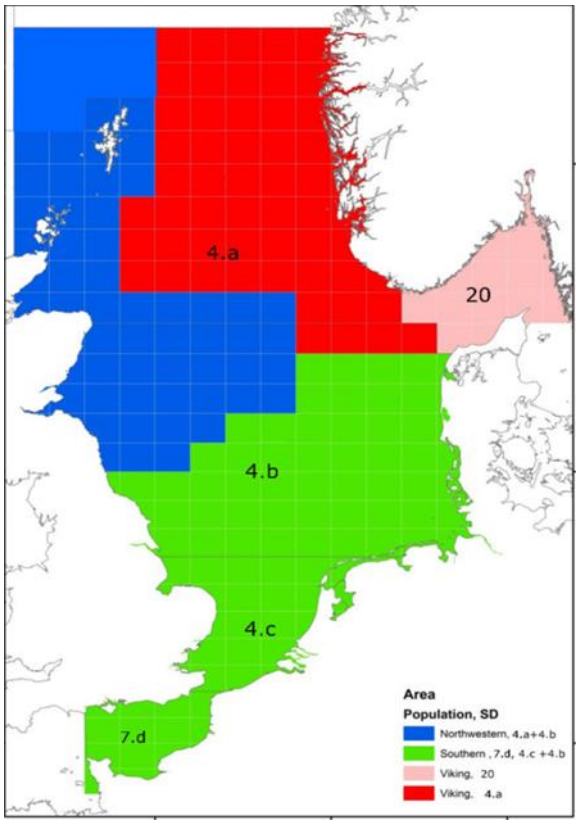

Figure 4.16c. Cod in Subarea 4, Division 7.d and Subdivision 20: Subregions used to derive area-specific biomass indices based on NS–IBTS–Q1 and Q3 data.

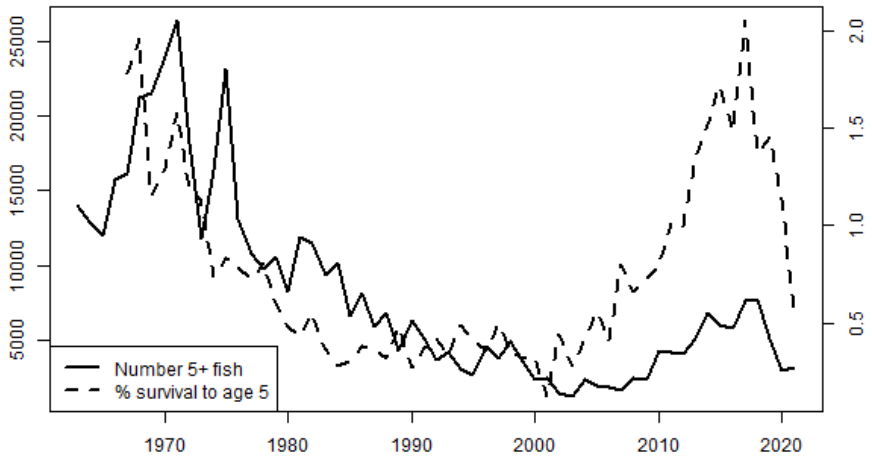

Figure 4.17. Cod in Subarea 4, Division 7.d and Subdivision 20: Estimates of the number of 5-year-old and older cod in the population (solid line; thousands) and the percentage of 1-year olds by number that have survived to age 5 in the given year (hashed line).

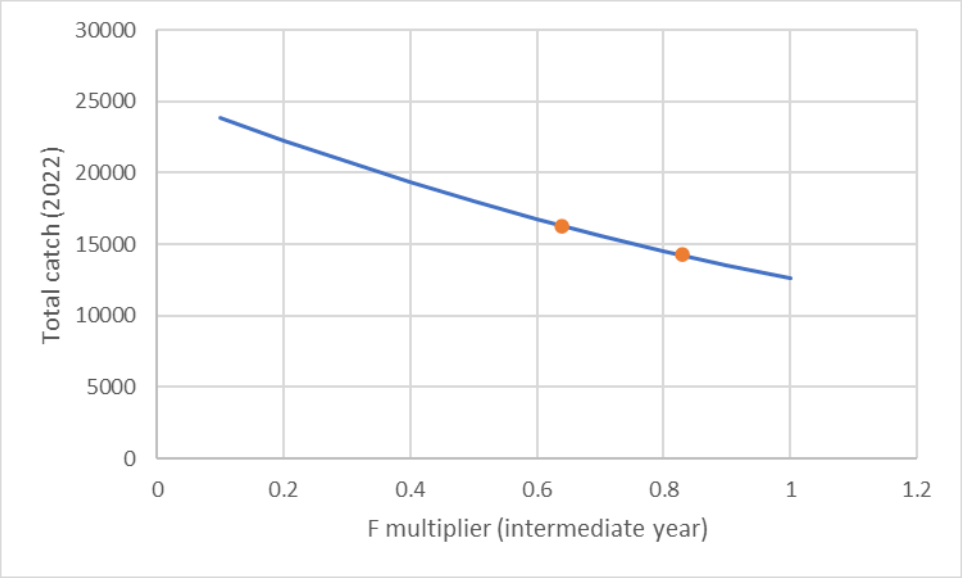

Figure 4.18. Cod in Subarea 4, Division 7.d and Subdivision 20: Total catches in 2022 corresponding to the MSY approach (i.e. $F=F_{MSY}\times SSB_{2022}/B_{trigger}$) assuming different multipliers on F(2020) in the intermediate year. The orange dots correspond to a 37% overshoot of the TAC in 2021 (F multiplier of 0.64) and an F of 0.37 (F multiplier of 0.83).