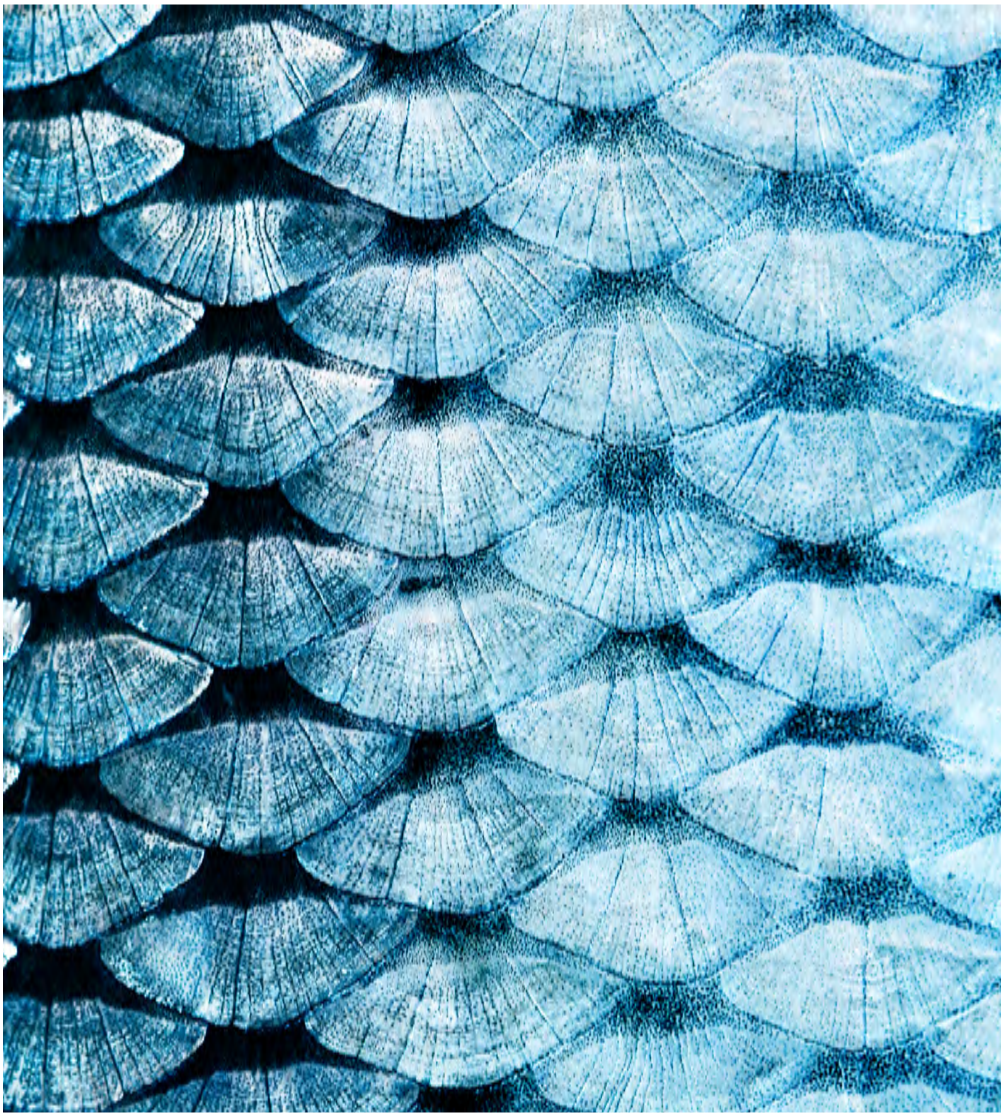
Cod (Gadus morhua) in ICES subareas 1 and 2 north of 67°N

October
2023

ICES STOCK ANNEXES



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Recommended citation:

ICES. 2023. Stock Annex: Cod (Gadus morhua) in subareas 1 and 2, north of 67°N (Norwegian Sea and Barents Sea), northern Norwegian coastal cod. ICES Stock Annexes. HM pp. https://doi.org/10.17895/ices.pub.24411667

Contents

i Summary

Stock

Cod (Gadus morhua), Stock code: cod.27.1-2coastN

Area

ICES subareas 1 and 2 north of 67°N (Norwegian Sea and Barents Sea)

Authorship and revision process

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Created

18 March 2021 Arctic Fisheries Working Group (AFWG)

Last updated:

October 2023

Produced under the auspices of

Arctic Fisheries Working Group (AFWG)

Changes since the last version

This stock annex updates (give previous edition/version citation).

Location	Summary of changes
ICES. 2023. Stock Annex: Cod (Gadus morhua) in subareas 1 and 2, north of 67°N (Norwegian Sea and Barents Sea), northern Norwegian coastal cod. ICES Stock Annexes. 13 pp. https://doi.org/10.17895/ices.pub.22133387	New format. Minor Changes.

1 General

1.1 Stock definition

Cod (*Gadus morhua*) in the Barents and Norwegian Seas live under variable environmental conditions and differ in migration pattern, growth, maturation rates, and genetic markers. ICES gives advice on three cod stocks in these waters: the highly migratory Northeast Arctic cod (NEAC), and the more resident Norwegian coastal cod (NCC), which is divided into two stocks by 67°N (see below). While the main distribution areas of NCC and NEAC differ, both types of cod can be found together on spawning grounds during the spawning period, as well as in inshore and offshore catches all year round. Stock identity (NCC vs NEAC) for ages 2+ is confirmed based on otolith shape (Rollefsen, 1933), while younger fish cannot be reliably separated by otolith shape. NCC and NEAC may also be separated by genetic analysis, which has been explored as a basis for real-time monitoring of the fishery (Dahle *et al*., 2018a). There are genetic differences within the coastal cod stock as well, with both south-north and inshore-offshore gradients in population structure (Johansen *et al*., 2020, Breistein et al., 2022). NCC can therefore be viewed as a stock complex, with several more or less resident stocks inhabiting different fjords and shelf areas along the coast.

Cod in Norwegian waters spawn in fjords as well as offshore along the coast. Tagging experiments of cod inhabiting fjords indicate only short migrations (Jakobsen, 1987; Nøstvik and Pedersen, 1999; Skreslet *et al*., 1999). The spawning season of NCC extends from March to late June, with peak spawning in early April. The 0 and 1-group of NCC inhabit shallow water both in fjords and in coastal areas and are hardly found in areas accessible to trawling until reaching about 25 cm. Afterwards they gradually move towards deeper water. NCC reaches 50% maturity around age 5 and migrates towards spawning grounds in early winter.

At the WKBarFar 2021 benchmark, it was decided to split the NCC stock complex in two based on differences in data quality south and north of Vestfjorden (approximately 67°N). Most of the biomass (about 75%) is distributed north of 67°N and this is also where most of the catches are taken (80 %). The northern area is more consistently surveyed than the area between 62 and 67°N, as the survey usually runs from north to south and any delays or loss of survey days (due to, e.g., weather conditions) tend to impact the southern coverage. In addition, the narrow southern fjords are more difficult to survey than the more open and deeper fjords in the north. A split around 67°N is also supported by genetic analysis, with coastal cod in northern Norway having allele frequencies for a particular gene that are more similar to the Northeast Arctic cod, while the extent of this gene incursion is smaller in cod further south (Dahle *et al*., 2018b). There is however, no clear cut biological stock boundary, and future work should attempt to identify biologically relevant population structure within (and mixing between) the two stock areas in order to refine, if necessary, the stock definitions.

The assessment area for Cod in subareas 1 and 2 north of 67°N (northern Norwegian coastal cod) is the Norwegian catch reporting areas 0, 3, 4, and 5. The catch reporting separates catches inside and outside the 12 nautical mile limit, but the two areas are combined in the assessment. In the map in Figure A1.1, each statistical rectangle is split along the 12-mile limit so that area 300+301 is area 3, 400+401 is 4 etc. On average (2022-2022), 80 % of catches are taken in the inner areas (approximately 90 % for the southern Norwegian coastal cod, Table A1.1).

Table A1.1: Annual and average 2020-2022 landings of coastal cod split by statistical area and aggregated in strata inside/outside 12 nmi from the coast. Most strata have been combined in groups of two for the estimation to get enough biological samples. The total landings presented here differ slightly from the official numbers used in the assessments, due to different units of estimation in the ECA-model.

Stratum	Landings 2020	Landings 2021	Landings 2022	Average landings 2020-2022
300, 400	5190	4382	3635	4402
301, 401	19447	9819	15828	15031
500	3788	5201	3167	4052
0, 501	14696	17797	15077	15857
Sum inside 12 nmi limit	34143	27616	30905	30888
Sum outside 12 nmi limit	8978	9583	6802	8454
600, 700*	393	426	276	365
601, 701*	3087	3227	2557	2957

*Southern Norwegian coastal cod stock area.

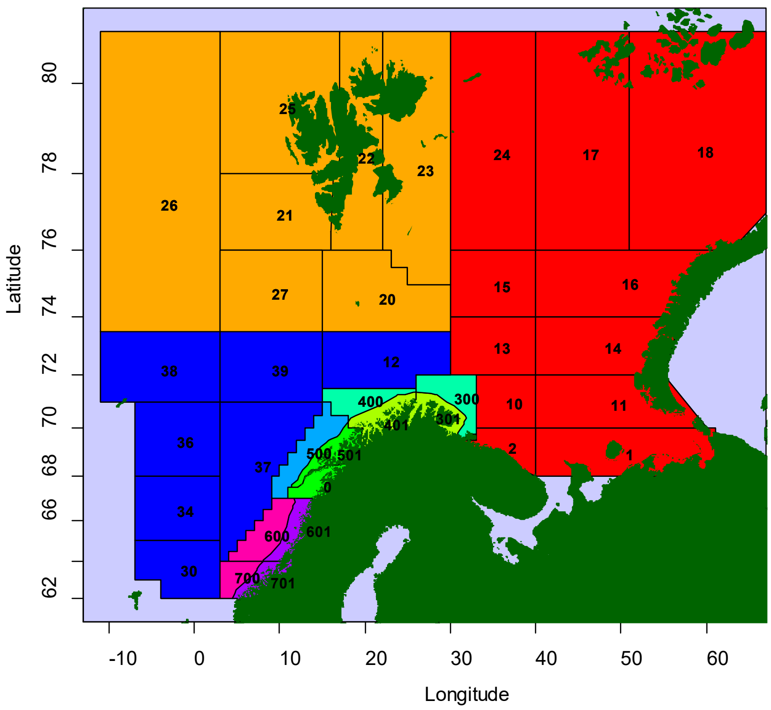

Figure A1.1. Norwegian statistical rectangles. Areas 3-7 are here split along the 12 nautical mile limit (300 and 301, 400 and 401, etc.). The assessment area for northern Norwegian coastal cod stock are rectangles 300, 301, 400, 401, 500, 501, and 0.

1.2 Fishery

Coastal cod is mainly fished by coastal vessels using traditional fishing gears like gillnet, longline, handline and Danish seine, but some is also fished by trawlers and larger longliners fishing at the coastal banks. The fishery is dominated by gillnet (50%), while longline/handline account for about 20%, Danish seine 20% and bottom trawl 10% of the total catch. There was a shift around 1995 in the portion caught by the different gears. Before 1995 the portion taken by longline and handline was higher, while the portion taken by Danish seine was lower. Norwegian vessels take all the reported catch. However, trawlers from other countries probably take a small amount of NCC when fishing for NEAC and Northeast Arctic haddock near the Norwegian coast.

Cod catches are not identified to stock at landing, and therefore no landings are counted against a separate coastal cod quota. When setting the annual cod quota, an expected catch of coastal cod is added to the Norwegian TAC for NEAC, giving a total combined TAC to distribute on fishing vessels. When the fishing year is finished, the catches of coastal cod are estimated from otolith sampling.

All regulations for NEAC also apply to coastal cod. These include minimum catch size, minimum mesh size, maximum bycatch of undersized fish, and closure of areas having high densities of juveniles. In addition, trawl fishing for cod is not allowed within 6 nautical miles from the coast, and since the mid-1990s the fjords in Finnmark and northern Troms (areas 3 and 4) have been closed for fishing with Danish seine. Since 2000, large longliners are not allowed to fish within 4 nautical miles from the coast. Since the coastal cod is fished under a combined NCC/NEAC quota, these regulations are supposed to turn parts of the traditional coastal fishery over from catching coastal cod in the fjords to catch more cod outside the fjords where the proportion of NEAC is higher. In 2004, "fjord-lines" were implemented along the coast to close the fjords for direct cod fishing with vessels larger than 15 meters. An area closed for all fishing gears except handline and fishing rod has been defined in the Henningsvær-Svolvær area. This is an area where spawning concentrations of coastal cod are usually observed and where the catches of coastal cod have been high. Further restrictions were introduced in 2007 by not allowing pelagic gillnet fishing for cod and by reducing the allowed bycatch of cod when fishing for other species inside fjord lines from 25% to 5%, and outside fjord-lines from 25% to 20%. Since 2009 a fjord area near Ålesund has been closed in the spawning season for fishing with all gears except handline and fishing rod. In 2023, several new regulations were put in place in the cod fishery north of 62°N with the aim to reduce fishing pressure on coastal cod. This included an increase in minimum catch size from 44 to 55 cm within 4 nautical miles from the coast (effective January 1st 2024) to better reflect size at first maturation.

1.2.1 Recreational and tourist fishing

Recreational and tourist fishing occurs all along the coast. In 2010 and later years 7000 t of the Norwegian cod quota has been set aside to cover the catches taken in the recreational and tourist fisheries and to cover catches taken by young fishers (to motivate young people to become fishers). The total amount of coastal cod taken in recreational and tourist fisheries is considered to be rather large but the data basis for estimating this catch along the entire coast is poor. A recent field study provided catch estimates of around 2 000 t cod in the hook-and-line fishery (tourist and resident recreational catches combined) in Troms County (Ferter et al., 2023). This estimate has been scaled up to all gears and areas north of 67°N for use in the assessment, with considerable uncertainty.

2 Data

2.1 Commercial and recreational catch

Catch data for NCC was revised for the 2021 benchmark. The data include commercial catches and an estimate of recreational catches. The revision of commercial catches included an update to the most recent catch statistics and adjusting conversion factors between gutted and round weight to seasonal values for some parts of the fleet. The revised catch series (1994–2019) was produced by the ECA software (Hirst et al., 2012). From catch year 2020, the software StoX R-ECA is used. StoX R-ECA uses the same algorithms as the older ECA software but has considerably improved documentation of the calculations, ensuring reproducibility.

The data series on recreational and tourist fisheries were updated with new information until and including 2019 at the benchmark. The main new information was due to Vølstad et al. (2011) estimating what had been fished by tourists north of 62N associated with registered tourist businesses/ companies in 2009, and a new project conducted in the period 2017-2020 by IMR in collaboration with several Norwegian institutions (NINA, Akvaplan-niva, NMBU and Nordland Research), and a number of international partners to develop cost-effective methods to map catches and socio-economic dimensions of marine recreational fisheries (MRF) in Norway from three study areas Troms, Hordaland, and Oslofjord. Results from this project have later been published in Ferter et al. (2023). Details on the estimation procedure currently applied for recreational catches is detailed in WD-04 to AFWG 2023 (Nedreaas, 2023). There is a need to improve the recreational catch estimate, including obtaining more biological samples to estimate age structure, which is currently borrowed from the commercial catches for most of the recreational segment.

We assume that all fish caught commercially are landed, i.e., no discards, as discarding is banned in Norwegian waters. Some minor discards may occur, mainly in gillnet fisheries (less than 1% in weight of total cod catch), where scavengers occasionally reduce the catch quality (Berg, 2019; Berg and Nedreaas, 2021). The recreational catches include estimates of discards (mainly from catch-and-release) for which the assumption is 20% mortality (Nedreaas, 2023).

Norway accounts for all NCC landings. The text table below shows which kind of data are collected:

			DATA TYPE		
Country	Caton (catch in weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway	X	X	X	X	X

2.2 Biological parameters

Weight-at-age in the stock from 1995 onwards is obtained from the Norwegian coastal survey in autumn (NOcoast-Aco-4Q). Data from fixed bottom trawl hauls and pelagic/bottom trawl hauls set out on acoustic registrations are used (same samples that are included in the acoustic tuning index, see below). Mean weight-at-age weighted by abundance in the trawl haul is calculated with the StoX software. Average weights-at-age in 1995–1997 are used for the starting year 1994, when there is catch data but no survey data. Weights for ages 8–10+ is set equal to weight-at-age in the catch due to few samples in survey data that gives unreasonably large variation between years.

The maturity ogive is calculated from the same survey data used for stock weights. Coastal cod spawn in March–June, while the survey data come from October-November. Therefore, few individuals are classified as maturing or mature. To get a more robust estimate of maturity at age, spent individuals (stage 4) are included in the maturity ogive as this results in an ogive that is more similar to that observed in fishery-dependent data sampled closer to the spawning season (WD-26 to WKBarFar 2021).

There are no empirical estimates of natural mortality for this stock. Some fjord studies (Pedersen and Pope, 2003a and b; Mortensen, 2007; Pedersen *et al.*, 2007) indicate that the main predators on young cod are larger cod, cormorants and saithe. To introduce some biological realism, a size-based estimate is used (Lorenzen, 1996, equation including marine fish only). Here, M at age (M_a) is calculated from mean (stock) weight-at-age W_a according to Equation 1. M at age is thus allowed to vary over time following variations in stock weight-at-age.

$$M_a = 3.69{W_a}^{-0.305} \quad (1)$$

Both the proportion of natural mortality before spawning (M_{prop}) and the proportion of fishing mortality before spawning (F_{prop}) are set to 0.8 in the model, representing the time of the year corresponding to the middle of the survey. With this setting, 80% of the annual F and M are applied before calculating SSB. While the cod spawns in spring, the spawning is shifted to late October (approximately October 20) in the model since the data on weight in the stock and maturity ogive comes from this time of year. This means that reference points in the management plan consistently relate to SSB in late October.

2.3 Surveys at sea

Coastal cod is surveyed once a year in the Norwegian annual coastal survey in autumn (NO-coast-Aco-4Q). The survey has run since 1995 in October–November (sometimes in September prior to 2003) each year over approximately four weeks. Before 2003, two separate surveys by different institutes ran in parallel – one trawl-acoustic survey for cod and one acoustic survey for saithe. In 2003, the two surveys were combined into one and run by a single institute, the number of vessels increased from one (in each survey) to two, and the fixed bottom trawl stations from the cod survey were used as a basis for the trawl coverage. The survey covers the fjords and coastal areas from Varangerfjord close to the Russian border and southwards to 62°N. For NCC, the aim of the survey is to obtain fishery-independent data of the abundance of both commercial-size cod and the younger pre-recruits. The survey therefore covers the main areas where the commercial fishery takes place, normally dominated by 4–7-year-old fish. The 0- and 1-year-old coastal cod, mainly inhabiting shallow water (0–50 m) near the coast and in the fjords, are also represented in the survey, but in highly variable proportions from year to year. The 0-group cod caught in the survey is impossible to classify to NCC or NEAC by the otoliths and the classification of 1-year-olds is also uncertain since the first winter zone is used in this separation. Before 2017, a total number of about 150 trawl hauls were conducted annually during the survey. In recent years, the number of hauls has increased to approximately 230 to obtain data on other species (redfish, deep-sea prawn) but these stations are taken in areas less relevant for coastal cod.

The biological sampling is length-stratified; in each trawl haul, one cod per 5 cm length group is randomly chosen for sampling of age, sex, and maturity stage.

An acoustic index (1995–) from this survey has been used in previous assessments of the entire coastal cod complex but this index was revised for the 2021 benchmark. The revision included collating older datasets and using new software for index calculation. This led to downwards revision of the index in the early part of the time-series. The index was also split by the southern/northern areas corresponding to the new split of the stock complex, and a new swept area index (2003–) was calculated.

The survey indices are calculated with the StoX software, developed at the Institute of Marine Research in Bergen (Johnsen *et al.*, 2019). StoX uses standard swept-area and acoustic estimation algorithms but uses imputation of age rather than a traditional age–length key. In the imputation, individuals that have been length measured but not aged are assigned an age by random draw from aged individuals of the same length group in the same trawl haul. Should there be none, the draw extends first to trawl hauls within the same survey strata, and last to all trawl hauls taken during the survey. In addition to age, other biological variables such as maturity stage and otolith type are imputed. The latter is crucial for NCC as it allows separation of NEAC and NCC in the survey index under the assumption that the proportion of NEAC/NCC in age samples reflect their proportion in the trawl haul. StoX estimates uncertainty through bootstrapping, in which primary sampling units (trawl stations and/or acoustic transects) are resampled with replacement and the age imputation process repeated.

Both the new acoustic index and the swept area index are used in tuning. The acoustic index is split in two periods: 1995–2002 and 2003– due to a change in catchability when the two surveys were merged (WD-26 to WKBarFar 2021). The age range in all three tuning indices is 2–10, where 10 is a plus group. The acoustic and trawl indices are not completely independent as trawl catches are a source of information in the allocation of acoustic backscatter to species and length distributions from trawls are used to split the acoustic backscatter by age. However, there are many areas along the coast that are only accessible with acoustic gear due to irregular topography. Further, acoustic registrations are made throughout the water column, while the trawl samples near-bottom distributions. In cases where pelagic acoustic registrations are allocated to cod, pelagic trawl hauls targeting the registrations are also used to split the acoustic backscatter on NCC and NEAC, and the NCC by age. The indices therefore contain some independent information as well. The 2021 benchmark meeting concluded that age information could be used in both indices (WD-26 to WKBarFar 2021), while a re-evaluation of this decision during the Workshop on the evaluation of Northern Norwegian Coastal cod Harvest Control Rules (WKNCCHCR, ICES, 2022) concluded that the age information in the acoustic index was too uncertain and that this index should be included as an aggregated biomass index Therefore, the acoustic index has been included in the assessment as an aggregated biomass index from the 2022 assessment.

2.4 Commercial CPUE

No commercial cpue is available for this stock.

3 Assessment methods and settings

3.1 Model

Model used: SAM (State–space assessment model) (https://www.stockassessment.org; Nielsen and Berg, 2014).

Software used: Template Model Builder (TMB) and R.

Age range of assessment: 2–10, where 10 is a plus group.

Start year of assessment: 1994

The following settings are used in SAM:

```
# Configuration saved: Thu Oct 21 15:33:05 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
 2

$maxAge
# The maximum age class in the assessment
 10

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

$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  5  5  6
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -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 -1 -1 -1
  0 -1 -1 -1 -1 -1 -1 -1 -1
  1 -1 -1 -1 -1 -1 -1 -1 -1
  2  3  4  5  5  5  5  5  6

$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 -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  0  0  0  0  0  0  0  0
 -1 -1 -1 -1 -1 -1 -1 -1 -1
 -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 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  0  0  0  0  0  0  0  0
  1 -1 -1 -1 -1 -1 -1 -1 -1
  2 -1 -1 -1 -1 -1 -1 -1 -1
  3  3  3  3  3  3  3  3  3

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

```
$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).
#2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10
 NA  NA  NA  NA  NA  NA  NA  NA
 -1  -1  -1  -1  -1  -1  -1  -1
 -1  -1  -1  -1  -1  -1  -1  -1
  0   1   1   1   2   3   3   3

$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
 4 8

$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 5 5 -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
NA NA NA NA NA NA NA NA NA
NA NA NA NA NA NA NA NA NA
-1 -1 -1 -1 -1 -1 -1 -1 -1

$hockeyStickCurve
#
20

$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 NA NA NA

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

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

$keyMatureMean
Coupling of mature process mean parameters (not used if matureModel==0)
NA NA NA NA NA NA NA NA NA

$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 NA NA NA

$keyMortalityObsVar
Coupling of natural mortality observation variance parameters (not used if mortalityModel==0)
NA NA NA 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

3.2 Input data

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Canum (cn)	Catch in numbers	1994–last data year	2–10+	Yes
Weca (cw)	Weight-at-age in the commercial catch	1994–last data year	2–10+	Yes
West (sw)	Weight-at-age in the stock	1994–last data year	2–10+	Yes/No – average 1995–1997 used for 1994. Weca used as West for ages 8–10+
Mprop (pm)	Proportion of natural mortality before spawning	1994–last data year	2–10+	No, set to 0.8 for all ages and years
Fprop (pm)	Proportion of fishing mortality before spawning	1994–last data year	2–10+	No, set to 0.8 for all ages and years
Matprop (mo)	Proportion mature at age	1994–last data year	2–10+	Yes/No – average 1995–1997 used for 1994
Natmor (nm)	Natural mortality-at-age	1994–last data year	2–10+	Yes/No– average 1995–1997 used for 1994. Size-based M based on annual changes in West

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Norw-Coast-Ac-Q4-1995 (Aco)	1995–2002	2–10+ (aggregated biomass)

Tuning fleet 2	Norw-Coast-Ac-Q4-2003 (Aco)	2003–last data year	2–10+ (aggregated biomass)
Tuning fleet 3	Norw-Coast-Ac-Q4-2003 (BTr)	2003–last data year	2–10+

4 Projections

4.1 Short-term forecast

The built-in forecast option in SAM is used for short-term prediction. In the forecast, process noise is included (i.e. processNoiseF=FALSE) and averages from the last five years are used for stock weights, catch weights and maturity-at-age. Recruitment is resampled from the last ten years. The ICES advice basis is the Norwegian management plan, providing the catch corresponding to a constant fishing mortality of F0.1. In addition, projections are made for the following scenarios: 1) F *status quo*, and 2) F *status quo* then F = 0. The Norwegian management plan is valid down to an SSB-level corresponding to the lowest estimated SSB in the time series ($SSB_{lowerbound}$). The initial HCR evaluation was done on a truncated time series, giving an $SSB_{lowerbound}$ of 67 743 tonnes (ICES, 2022). After extending the HCR simulation to the full time series, $SSB_{lowerbound}$ was revised down to 46 723 tonnes in 2024 (see annex to AFWG report 2024; ICES, 2024).

4.2 Medium-term projections

The issue was not addressed during the 2021 benchmark and no projections were made.

4.3 Long-term projections

Long-term perspectives on candidate HCRs were investigated during the 2022 WKNCCHCR workshop using long-term stochastic simulations in the EqSim framework (ICES, 2022).

5 Biological reference points

The WKNCCHCR workshop concluded that no reliable B_{lim} estimate could be produced for this stock. Following from this, none of the standard reference points for fishing mortality used in the ICES Advice Rule could be reliably estimated. In order to arrive at a HCR which could be evaluated as precautionary and form a basis for potential ICES advice, WKNCCHCR proposed a HCR based on F0.1. In addition to the theoretical basis for F0.1 as a fishing level that should drive the stock to safe and productive levels, the F0.1 estimate was rather stable to the range of data and model options tested, and at similar previous fishing pressures the stock had increased. Further, in all cases, F0.1 fell below all potential values of Fp0.5 (as estimated from simulations without a trigger in the HCR and taking account of the uncertainty around B_{lim}). The HCR with Ftarget=F0.1 was therefore evaluated as precautionary within the observed range of SSB in the part of the time series considered in the stock-recruit simulations (2003-2020) and was later adopted by the managers. In 2024, the HCR was evaluated as precautionary for the full observed range of SSB.

Type	**Value**	**Technical basis**	**Source**
F_{mgt}	0.176	F0.1, as estimated with 1994–2020 data.	ICES, 2022
$SSB_{lowerbound}$	46 723	Lowest observed stock size; used only as the limit above which the management plan is considered precautionary.	ICES, 2022; ICES, 2024

6 Other relevant information

6.1 Mixed-fishery considerations

The commercial catches of this stock occur as part of a mixed fishery with the Northeast Arctic cod. The 2021 benchmark therefore recommended that future advice sheets include a line in the catch options table showing the expected impact on the Norwegian coastal cod North of the advised catch for NEAC under the recent catch split between the two stocks.

6.2 Research

The following areas of future research and improvements of the assessment are indicated for this stock (in unprioritized order):

- Develop and apply methodology for estimation of catch in recreational and tourist fishing.
- Extend coastal cod landings statistics back to 1984.
- Establish routines for including estimates of discards and other unreported catches in the catch estimate.
- Examine whether survey index uncertainty can be improved, e.g., by adjusting the survey design or the post-stratification applied to calculate indices.
- Reread subsamples of otoliths from the first part of the survey (1995–2002) as these readings are expected to be less precise.
- Investigate if it is possible to verify/classify uncertain typed otoliths (from both catch and survey sampling) as coastal cod or Northeast Arctic cod using genetics.
- Investigate the age distribution in pelagic versus bottom trawl hauls in the coastal survey – does distribution in the water column vary by size and how does this affect survey indices?
- Extend the swept area index back to 1995.
- Investigate use of survey data for ages 8–9 weight in stock if/when more data on these ages become available.
- Investigate ways of handling poor catch estimates in SAM – we may get better estimates of recreational catch for recent years once longer time-series of this fishery has been obtained. Should the earlier, more uncertain recreational catches be downweighted?
- Continue to investigate SAM configurations, particularly the correlation structures.
- Continue to work on natural mortality; improving the size-based estimates, looking further into changes in M over time, and exploring other methods of estimation.
- Investigate inclusion of external variance estimates for survey indices in SAM.
- Investigate the use of longer periods for recruitment sampling in the short-term forecast.
- Develop and apply methodology for investigating the degree of stationarity and mixing of difference populations in the stock complex using a combination of methods (e.g., genetics, mark-recapture, and otolith microchemistry). To be used as basis for potential future refinement of stock boundaries.

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Annex 1: Version history

Version/ edition	Publication date	Summary of changes	DOI
2	October 2023		https://doi.org/10.17895/ices.pub.22133387
1	March 2021		