



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Ecosystems and
Oceans Science

Sciences des écosystèmes
et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2025/048

Newfoundland and Labrador Region

Assessment of the Northern Cod (*Gadus morhua*) Stock in NAFO Divisions 2J3KL in 2024

Paul M. Regular, Katherine Skanes, Rajeev Kumar, Rick M. Rideout, Emilie Novaczek,
Fatemeh Hatefi, Robert S. Gregory, Mariano Koen-Alonso, and Karen S. Dwyer

Fisheries and Oceans Canada
Northwest Atlantic Fisheries Center
St. John's, NL A1C 5X1

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

[http://www.dfo-mpo.gc.ca/csas-sccs/
DFO.CSAS-SCAS.MPO@dfo-mpo.gc.ca](http://www.dfo-mpo.gc.ca/csas-sccs/DFO.CSAS-SCAS.MPO@dfo-mpo.gc.ca)



© His Majesty the King in Right of Canada, as represented by the Minister of the Department of Fisheries and Oceans, 2025

This report is published under the [Open Government Licence - Canada](#)

ISSN 1919-5044

ISBN 978-0-660-78262-1 Cat. No. Fs70-5/2025-048E-PDF

Correct citation for this publication:

Regular, P.M., Skanes, K., Kumar, R., Rideout, R.M., Novaczek, E., Hatefi, F., Gregory, R.S., Koen-Alonso, M., and Dwyer, K.S. 2025. Assessment of the Northern Cod (*Gadus morhua*) Stock in NAFO Divisions 2J3KL in 2024. DFO Can. Sci. Advis. Sec. Res. Doc. 2025/048. v + 126 p.

Aussi disponible en français:

Regular, P.M., Skanes, K., Kumar, R., Rideout, R.M., Novaczek, E., Hatefi, F., Gregory, R.S., Koen-Alonso, M. et Dwyer, K.S. 2025. Évaluation du stock de morue du Nord (Gadus morhua) dans les divisions 2J3KL de NAFO en 2024. Secr. can. des avis sci. du MPO. Doc. de rech. 2025/048. v + 130 p.

TABLE OF CONTENTS

ABSTRACT	v
INTRODUCTION	1
REPORTED LANDINGS OF COD	2
COMMERCIAL FISHERIES	2
RECREATIONAL FISHERIES	3
CATCH AT AGE	3
Historic Pattern in Catch at Age	3
Catch at Age from the Last Five Years	4
TAGGING	4
TAGGING BASED ESTIMATES OF RECREATIONAL CATCH	4
Results	5
DFO RESEARCH VESSEL BOTTOM-TRAWL SURVEYS OF 2J3KL	6
SURVEY DESIGN	6
FALL SURVEYS	7
Fall Abundance and Biomass Indices	7
Fall Survey Mean Catch at Age	7
Fall Survey Catch Distribution	8
DIVISION 2H	8
DIVISION 3L SPRING	8
MATURITY	8
GROWTH	9
TRENDS IN MEAN RELATIVE CONDITION BY DIVISION AND SURVEY	9
INDEX OF STARVATION-INDUCED MORTALITY	10
EXTENDED NORTHERN COD ASSESSMENT MODEL (XTENCAM)	10
DATA INPUTS FOR XTENCAM	11
Fall DFO Research Vessel (RV) survey	11
Inshore Acoustic Biomass Estimates and DFO RV Survey Catchability Parameter (q)	12
Sentinel Surveys	12
Juvenile Surveys	13
Catch and Catch Bounds	13
Tagging	14
Capelin as a Predictor of Natural Mortality	15
RESULTS FROM XTENCAM	15
Effect of Capelin Availability	16
Stock-recruitment Relationship	16
Reference Points	16
Stock Size and Mortality Rates	16
Retrospective Analysis	17

Projections	17
Conclusions.....	18
ACKNOWLEDGEMENTS	18
REFERENCES CITED.....	18
TABLES	23
FIGURES	89
APPENDIX A: ASSESSMENT MODEL DIAGNOSTICS	113

ABSTRACT

The Northern Cod (*Gadus morhua*) stock inhabits waters off southern Labrador and eastern Newfoundland eastward to the edge of the continental shelf in the Northwest Atlantic Fisheries Organization (NAFO) Divisions (Divs.) 2J3KL. This stock was assessed through a Regional Peer Review Process (RPR) conducted March 18–21, 2024, in St. John's, Newfoundland and Labrador (NL) to address terms of reference provided by Fisheries Management. The general objective of this meeting was to provide advice on stock status and trends, to consider the effects of environmental conditions, and provide short- to medium-term projections of the stock.

This is the first application of the updated assessment model and new Limit Reference Point (LRP) defined at the October 2023 Framework process. The assessment model was extended, through the inclusion of additional data, back to 1954 (previously starting at 1983). The longer term perspective provided by this model informed a revision of the LRP. While estimates of stock size since 1983 were similar, the previous LRP was roughly 40% higher. Following this revision, the stock was determined to be out of the Critical Zone since 2016.

Under the current assessment, the 2024 Spawning Stock Biomass (SSB) is estimated to be 1.2 times the LRP, with a 95% confidence interval (CI) of 0.7 to 2.1. There is an estimated 22% probability that the stock is in the Critical Zone. An upper stock reference has not been defined, however given the proximity to the LRP the stock is considered to be in the Cautious Zone.

Following a period of growth from 2010 to 2016, SSB has remained unchanged. SSB in 2024 was estimated at 342 Kt (95% CI = 246–475 Kt). Estimated numbers of recruits (age 0) have remained unchanged since the mid-2010s, corresponding to about 80% of pre-collapse (1954–90) levels. Natural mortality (M, ages 5+) has varied between 0.29 and 0.90 since 1995 (mean = 0.47) and in 2023 was above average [0.59 (95% CI = 0.32–1.12)]. Fishing mortality (F, ages 5+) has been below 0.05 since 2004 and in 2023 was 0.02 (95% CI = 0.01–0.03).

Mortality rates of Northern Cod increase when there are insufficient prey in the system to support the population. Capelin are a key prey species for Northern Cod, and their collapse, coupled with sustained low productivity, has impeded the recovery and growth of the cod stock. Capelin are expected to remain around 10% of their pre-collapse levels, which limits prospects for cod stock growth.

Projections of SSB to 2027 show that if total removals for 2023 are set to zero, the probability of the stock declining into the Critical Zone is 42%. However, if removals are doubled to 27,034 t (two times the model-estimated total of 13,517 t), this probability increases to 52%. With total removal levels examined here (0 to 27,033 t) the risk of stock decline from 2024 to 2027 is moderately high to high, ranging from 62% to 76%. There is no level of removals that gives a neutral to high ($\geq 50\%$) probability of stock growth. Under current ecosystem conditions and total removals, the stock has not grown since 2016 and short-term prospects for stock growth are limited even under zero removals. Although primarily driven by ecosystem factors and natural mortality, increases in removals further add to the risk of stock decline into the Critical Zone.

INTRODUCTION

This document gives an account of the 2024 assessment of the Northern cod (*Gadus morhua*) stock that inhabits waters off southern Labrador and eastern Newfoundland eastward to the edge of the continental shelf in Northwest Atlantic Fisheries Organization (NAFO) Divisions (Divs.) 2J3KL (Figure 1). The current evaluation was conducted through a Regional Peer Review Process (RPR) on March 18–21, 2024, in St. John's, Newfoundland and Labrador (NL) using available data up to the end of 2023. A Science Advisory Report (SAR) for the 2J3KL stock from this meeting will be produced. Details of previous assessments and stock updates for Northern Cod to 2016 are reported elsewhere (Lilly et al. 2006; Bratley et al. 2008a, 2009, 2010, 2018).

The last stock assessment was in 2021 (DFO 2022). Since 2016, an integrated state-space, catch-censored population dynamics model developed specifically for Northern Cod (NCAM) has been used to assess the stock (Cadigan 2015, 2016b). In 2021, this model indicated that the Spawning Stock Biomass (SSB) was at 52% of the Limit Reference Point (LRP or B_{lim}), in the Critical Zone of Fisheries and Ocean's Canada's (DFO's) Precautionary Approach (PA) Framework (DFO 2009, 2022). This LRP was defined as the average SSB from the 1980s (DFO 2010; DFO 2019a). Projections under six catch scenarios, with removals ranging from zero to 1.3 times (15,360 t) the model estimated catch for 2020 (11,816 t), showed that the probability that SSB will reach the LRP by 2022 is less than 0.02.

Partial coverage of the stock area by the standard offshore Research Vessel (RV) survey program prevented a typical update of the assessment in 2022 and 2023 since the leading indicator of stock size could not be calculated. Mechanical issues with ageing research vessels led to partial coverage of the stock area in 2021, and targeted sampling for comparative fishing took precedence over standard survey sampling in 2022 (DFO 2024a). Comparative fishing was prioritized, as data from that program were necessary to quantify differences in catchability between the outgoing vessels Canadian Coast Guard Ship (CCGS) *Alfred Needler* and CCGS *Teleost* with the new CCGS *John Cabot* and CCGS *Capt. Jacques Cartier*. Data from this program were essential for ensuring the continuity of the RV survey time-series. The absence of assessments, however, provided time to organize and prepare an assessment framework meeting, which was held October 16–20, 2023, in St. John's, NL (DFO 2024b). The general objective of this meeting was to advance the assessment by addressing several research recommendations from previous assessments of Northern Cod.

A series of extensions to NCAM were reviewed and accepted at the framework to produce a revised model that is hereafter referred to as xteNCAM. Nearly 30 years of historic data were added to the revised model, extending the series back to 1954. Historic landings (Schijns et al. 2021) and tagging (Taggart et al. 1995) data were particularly useful for broadening the scope of the assessment model. Additionally, juvenile survey data from two inshore monitoring programs (Fleming survey, Lewis et al. 2022; Newman Sound survey, Gregory et al. 2019) were integrated into the model, which enabled the implementation of a stock-recruitment relationship. An index of Capelin, a key prey species for cod and driver of cod productivity (Koen-Alonso et al. 2021; Regular et al. 2022), was also integrated into the model to predict changes in rates of natural mortality of cod. These revisions provided an opportunity to revisit the LRP for Northern Cod. In alignment with PA guidelines (DFO 2009, 2023a), the new LRP was established at 40% B_{MSY} (SSB that produces the maximum sustainable yield [MSY]).

Under this new framework, SSB was estimated at 1.16 times the LRP in 2021, with a 29% probability of being below the LRP (DFO 2024b). This contrasts with the 2021 assessment, which estimated the stock to be 52% of the previous LRP (DFO 2022). While this changed the

2021 stock status from Critical to Cautious, it is important to note that both NCAM and xteNCAM provide comparable estimates of SSB in 2021 (approximately 400 kt). The difference in status stems from the change in the LRP, as the estimate of 40% B_{MSY} is roughly 40% lower than the average SSB from the 1980s.

In the current assessment, xteNCAM was used to assess the status of the stock with updated input data. In addition to the assessment model results, several other sources of information were reviewed at the assessment (e.g., physical and biological oceanography, information on Capelin, predators, prey, inshore pre-recruit surveys, tagging, industry surveys, etc.).

REPORTED LANDINGS OF COD

Reported landings from this stock from the 1950s until 2015 are described in detail in previous documents (Lilly et al. 2006; Bratney et al. 2018). Reported landings for 2016–23 are added to the time-series (Table 1; Figures 2–3). Fixed gear landings (from 1975) are also updated to 2023 (Table 2; Figure 4) and show that most of the catch throughout 2006–23 was taken by gillnets. Finally, catch estimates by fishery type (Recreational, Sentinel, and Commercial) are shown in Figure 5. Under the Privacy Act, the Department can no longer provide landings and catch information for a specific fishery when that fishery has fewer than five fishing enterprises, five fishing vessels, and/or five buyers participating in a fishery. As such, aggregate catch statistics are presented to protect the privacy and economic interests of participants in the fishery.

COMMERCIAL FISHERIES

The directed inshore stewardship fishery and a recreational fishery for cod were re-opened in 2006. Note that the management year extends from April 1 to March 31 of the following year (since 2000), but catch statistics are reported in calendar year as there have been no significant landings from this stock from January to March. There has been no formal Total Allowable Catch (TAC) set since 2006; instead, commercial fishers are allocated a fixed annual allowance per licence holder. Beginning in 2016, the 2J3KL Northern Cod stewardship fishery has been managed using variable weekly catch limits, gear restrictions, seasons, and in 2018 a maximum authorized harvest amount (MAH; 9,500 t) was introduced. The MAH for the stewardship fishery has been 12,999 t since 2021. Provisional total reported landings in 2023 were 12,998 t.

Recreational landings are regulated by number of days and number of fish per person (five per person, for a maximum of 15 fish per boat). Currently there is no requirement to report recreational landings. Some effort has gone in to obtaining estimates of recreational landings (see Bratney et al. 2018); currently tagging is used to determine a general approximation. There are known to be discards of cod in the shrimp fishery that operates offshore in Divs. 2J3K. This has been investigated in the past and shows that although the weight of removals is small, the number of small fish removed can be large.

Monthly reported landings of cod from NAFO Divs. 2J3KL from 1983–2023 were also compiled from available catch statistics databases for Canada-NL, Canada-Maritimes, and non-Canadian catches (Table 3). Since 2006, most of the landings in the commercial fishery are taken from August to November; catches in the remaining months came mostly from the sentinel fishery and bycatch. These monthly values were used in the assessment model (see below) in conjunction with tag recapture information. These values were used to estimate the fraction of harvesting that took place in any year before tagged fish were released in that year.

There remains no mechanism to estimate high-grading (i.e., discarding of smaller fish) or discard rates in the historical catch statistics. Further, recreational fishery landings are not directly measured (see below). The amount of discarding in recreational fisheries is unknown.

RECREATIONAL FISHERIES

The recreational fishery operates inshore in NL from June to October. Over the past 17 years (2006–23), estimates of recreational fishery landings have only been available for 2006, 2008, 2011, and 2012. These estimates were obtained using a combination of methods, including phone surveys and surveillance.

Analyses of tag return information from commercial versus recreational fishers suggests that removals from recreational fisheries have been large and, in some years, higher than reported by Fisheries Officers (see Bratley et al. 2010), averaging about 30% of reported fishery removals during 1997–2018 (see tagging section). In the past three years, this number has been slightly lower (25%) due to increases in the commercial harvest. Estimates from this method are annually quite variable (Bratley et al. 2009, 2010) and are not used in formal compilation of landings statistics. Nevertheless, results suggest that recreational landings are large and that total removals are higher than reported landings by an unknown and varying annual amount.

Some sampling of the recreational catch takes place at sea and dockside by Conservation and Protection officers. In the past, there have been signs of discarding or high-grading, but it is difficult to determine whether this is currently ongoing.

CATCH AT AGE

The age composition and mean length-at-age of the cod landings were initially calculated by gear, unit area, and quarter as described in Gavaris and Gavaris (1983). Sampling of cod lengths and ages (otoliths) from the various sectors of the commercial fishery has been extensive from 2011–23. General sampling objectives for the fishery were to obtain a representative length frequency from each commercial area fished (i.e., NAFO statistical unit area such as 2Jm, 3Kd, 3La, etc.) for each gear type and fishing period. Fishing was generally carried out from July to October and three gear types (gillnet, hand-line, and longline) account for most (greater than 95%) of the landings (Table 2). Sampling aims to measure a minimum of 2,000 fish from each unit area, gear type, and season. A minimum sample of 200 fish per catch is measured, or the entire catch if less than 200 fish are available. In addition, the objective is to collect five otoliths per centimeter (cm) length group, per unit area, gear type, and fishing period. Additional sampling of sentinel fishery catches is conducted by sentinel fishers following a separate protocol described elsewhere (Maddock Parsons 2014; Mello and Simpson 2023).

Historic Pattern in Catch at Age

The time-series of catch-at-age from the fishery for Northern Cod (inshore and offshore combined) extends from 1962–2023 (Table 4). For the post-moratorium period, almost all of the catch has come from the stewardship fishery which is dominated by gillnets. Descriptions of historical trends in catch-at-age can be found in previous assessment reports (Bratley et al., 2018). Generally, the age composition of catches from the beginning of the last five years show a shift in central tendency from ages of approximately 3–8 in 1980 and 1990 to ages of approximately 5–10 in 2010 and 2020 (Figure 6).

Catch at Age from the Last Five Years

In the past five years, most of the catch consists of ages 6–11 (Table 4; Figure 6) which is typical of a fishery dominated by gillnets. In assembling the catch-at-age for the recent period (2011–23), there were no major discrepancies in the sum of the products (estimated catch numbers-at-age times weight-at-age) relative to reported landings. The ratio of the sum of products to reported landings was close to 1 in each year.

TAGGING

For Northern Cod, an extensive time-series of mark-recapture information is available. The tagging data are in two parts:

1. The earlier (i.e., pre-1997) tagging data are summarized in Taggart et al. (1995) and were analyzed by Myers et al. (1996) and Myers et al. (1997). Disc tags were the main tag type used in the tagging program between 1962–66 and they continued to be used extensively between 1978–91, after which they were phased out and T-bar (floy) tags became the main type (Table 5).
2. The current tagging program began in 1997 and are reported in Bratney and Healey (2007) and Bratney et al. (2018). The use of high-reward and low-reward floy tags in the current program allows for the estimation of reporting rates (Konrad et al. 2016).

In 2021, 4,143 tags were released, with a further 3,165 deployed in 2022 and 3,972 deployed in 2023 (Table 5). Twenty percent of these tags were “high value” (\$100 reward), with the remaining eighty percent as “low value” (\$10 reward between 1997–2022; \$25 reward since 2023). Tagging occurred in Divs. 2J3KL in 2021–22, and in 3KL in 2023 (Figure 8). Recaptured tags received in 2021–23 were caught in NAFO Divs. 2J, 3K, 3L, 3P, and 4R, with the vast majority (88%) caught in 3KL, coinciding with the location of inshore fishing effort for cod (Figure 8).

TAGGING BASED ESTIMATES OF RECREATIONAL CATCH

Tag returns from the commercial and recreational fishery provide an annual estimate of recreational catch. Since the commercial landings are reported annually, and the ratio of tags reported by commercial fishers and recreational fishers is also known, a simple ratio estimator can be used to calculate recreational catch using the following equation:

$$\frac{C_{rec,y}}{C_{comm,y}} = \frac{R_{rec,y}}{R_{comm,y}},$$

where $C_{rec,y}$ is the catch/total landings from recreational (rec) and commercial (comm) fisheries in year y , and R is the number of tags returned by recreational and commercial fishers in year y . $C_{comm,y}$ is reported annually with no error reported. The total numbers of tags associated with each fishery is a function of the total number of tags reported, which is the number of high reward tags reported ($N(H)$), and the number of low reward tags reported ($N(S)$) adjusted by the fishery-specific (type) reporting rate (λ) for low reward tags. That is,

$$E(R_{type,y}) = N(H)_{type,y} + \frac{N(S)_{type,y}}{\lambda_{type,y}}.$$

Reporting rates (λ) are calculated with a random-walk model developed by Konrad et al. (2016), which are region (2J3KL versus 3Ps) and year-specific for the commercial fishery and constant over the years for the recreational fishery. Assuming that the proportion of tags removed from

the two fisheries is estimated from the number of tags (corrected) removed in each fishery, the number of tags (corrected) returned by each fishery can be treated as a random variable where,

$$R_{\text{rec},y} \sim \text{Bin} \left(E(R_{\text{rec},y}), \frac{E(R_{\text{rec},y})}{E(R_{\text{rec},y}) + E(R_{\text{comm},y})} \right), \text{ and}$$

$$R_{\text{comm},y} = \left(E(R_{\text{rec},y}) + E(R_{\text{comm},y}) \right) - R_{\text{rec},y}.$$

To incorporate the random variables, random normal variates were drawn for annual reporting rates and random binomial variates were drawn for $R_{\text{rec},y}$ to calculate the recreational catch ($C_{\text{rec},y}$). This process was repeated 1,000 times to obtain a sample of $C_{\text{rec},y}$, and a mean and standard deviation were extracted from those 1,000 samples.

The approach of using tag return data from commercial and recreational fisheries to estimate total recreational landings makes a few critical assumptions. The first, and likely most important, is that the general behavior of the two fisheries is similar. In other words, if the commercial fishery requires 1,000 tonnes of catch to return 10 tags, then 1,000 tonnes of recreational catch would be needed to return the same number of tags. Reporting rate differences in the two fisheries are taken into account directly, so any differences in reporting rate by different fisher types can be addressed explicitly. It is differences in the fish themselves and whether the population of fish exposed to the commercial fishery and the recreational fishery is more or less the same, and most importantly, have a similar distribution of tags available to the two fisheries that are most important. For the 2J3KL fishery, the recreational and commercial catch are both summer to early fall and inshore fisheries, so are most likely pursuing similar fish. The gears used are different; 5" gillnets are the main gear used in the commercial fishery, while the recreational fishery is conducted with handlines. Gillnets are size-selective, with fish ranging in lengths between 60–80 cm being most vulnerable. In theory, handlines are less size-selective; however, hook size will influence the size of fish captured, and fisher behavior will lead to some size selectivity (recreational fishers are expected to move to other grounds if they catch a few small fish). The tagging program only tags fish greater than 44 cm fork length (FL), so only fish of this size or greater are sampled by tag returns. If the proportion of fish less than 45 cm FL in the commercial and recreation catch differs substantially and makes up a non-trivial component of total landings, the estimate of recreational catch based on tag returns alone may be biased.

Another assumption is that the tagged fish are equally available to each fishery. Tagging efforts are distributed throughout 2J3KL but are concentrated in certain areas, and the spatial distribution of tags deployed in each year is not entirely consistent. If many tags are deployed in areas of intense commercial fishing but modest recreational fishing, estimates of recreational catch will be biased low. Timing of tagging may also lead to biases; tagging takes place from July to October in 2J3KL, and the recreational fishery opens before the Stewardship Fishery in 2J3KL. If a large number of tags are deployed in August, for example, a time when the recreational fishery is well underway (and tending to taper off) but the stewardship fishery has yet to open, then the commercial fishery may have more tags available for capture, again leading to a recreational catch estimate that is biased low.

Results

Annual tag returns are presented in Table 5. The number of tags returned in recent years is low for the time series, likely a function of lower tagging efforts in 2017–20 and declining reporting rates (Figure 7).

Estimated reporting rate from the commercial fishery has declined consistently from a high of 0.85 in 2001 to an average of 0.46 in recent years (2019–23). The reporting rate from the

recreational fishery is estimated as a constant for the time series, and also sits at 0.46 (Figure 9). These return numbers may increase slightly as fishers continue to send in the tags they captured in the past year. To get enough returns for this method, tagging numbers must be kept relatively high and reporting should be encouraged among participants of both fisheries. In addition to increased tagging efforts since 2020, the value of low-reward tags was increased from \$10 to \$25, with the first deployment of the new tags in 2023.

The ratio of tags returned by recreational fishers over commercial fishers in 2J3KL has varied considerably over the time series. Some years are very low, including years with no recreational fishery (2004–05), while in other years (e.g., 2014) almost as many tags were returned by recreational fishers as commercial fishers. The ratio of recreational:commercial tag returns was generally low and stable in the early years (1997–2006) with a mean of 0.14 (range = 0–0.32), high and variable between 2007–2015 (mean = 0.54, range = 0.25–0.85), and has returned to a low and stable period since 2016 (mean = 0.20, range = 0.07–0.26; Figure 10).

Estimated recreational catch in 2J3KL has ranged in the hundreds of tonnes to a few thousand tonnes in years with a recreational fishery (Figure 11). Recreational catch estimates range from 0.14–3.9 kt, with no recreational catch in 1997, 2004, or 2005. Generally, recreational catch varied between 0.0–1.5 kt (mean = 0.63 kt) in the early period (1997–2006), and have increased since 2007, varying between 0.7–3.9 kt (mean = 2.3 kt). In 2023, the estimate of recreational catch was 2.2 ± 0.63 kt.

In the absence of reported recreational catch, this method provides an independent estimate of the general level of removals by the recreational fishery. In some years, total fishing removals can be much higher than the reported commercial landings due to substantial recreational catch. This estimate is not directly integrated into the assessment model, however, to date the catch bounds applied within xtenCAM are sufficient to account for the levels of recreational catch estimated from tag returns.

DFO RESEARCH VESSEL BOTTOM-TRAWL SURVEYS OF 2J3KL

Research bottom trawl surveys have been conducted by Canada during the fall in NAFO Divs. 2J, 3K, and 3L since 1977, 1978, and 1981, respectively, and the information from these surveys was updated to 2023. Spring surveys have been conducted by Canada in Div. 3L during the years 1971–82 and 1985–23. In 2020, due to Covid-19, there was no spring survey. Both the spring and fall surveys were interrupted in 2021 and 2022 by necessary comparative fishing sampling efforts aimed at quantifying differences in catchability between the outgoing and new CCGS vessels (DFO 2024a); however, there was a fall survey of Divs. 2J and 3K in 2021.

SURVEY DESIGN

Details of the stratified random trawl survey design as well as changes in gear and vessels are described in previous documents (Lilly et al. 2005, 2006; Bratney et al. 2008a; Wheeland and Rideout 2023). Additional information on surveys conducted by DFO since the introduction of the Campelen trawl in 1995 is provided by Rideout and Ings (2021) and references therein. Details of survey performance statistics, timing, and spatial coverage are summarized elsewhere (see Power et al. 2016 and references therein). Note that all the survey catch rate information presented below for the 1983–94 period are in Campelen equivalent units, while values for 1995 onwards are based on actual Campelen catches.

The fall 2023 survey of Divs. 2J3KL took place earlier than average, particularly in Div. 2J (Figure 12). It is uncertain if the earlier timing resulted in a different underlying cod distribution than during the fall survey in previous years.

FALL SURVEYS

Fall Abundance and Biomass Indices

Indices of cod abundance and biomass are based on the stratum-area weighted arithmetic mean catch (numbers and weights) per standard tow using an R based version of STRAP (Stratified Analysis Programs; Smith and Somerton 1981), called Rstrap, with inconsistently (or non) fished strata being omitted from the calculations.

There have been some changes over time in the depths covered during the survey; consequently, trends in the indices of abundance and biomass of cod have been monitored for those strata that have been fished most consistently since the start of the surveys. These “offshore index strata” are those in the depth range 100–500 m in Div. 2J and 3K and 55–366 m (30–200 fathoms) in Div. 3L. The inshore strata fished intermittently from 1996 onwards are not included in this index, nor are deep-water strata (greater than 200 fathoms in Div. 3L or greater than 500 m in Div. 2J and 3K). Separate estimates of abundance and biomass by stratum have been calculated for the inshore and deep-water strata (see Bratley et al. 2008a), but coverage in these areas has been poor for several years, and few cod have been observed in the deep-water strata, so these are not updated here. Lilly et al. (2006) provides details on the interpretation of the fall survey data with respect to depth and timing of the survey.

The full-time series of fall DFO research vessel survey index values for Divs. 2J, 3K, and 3L begins in 1983 and shows that the abundance and biomass indices have been low since the start of the moratorium in 1992 (Table 6; Figure 13). Both abundance and biomass indices increased since 2011, however there has been no clear trend in either direction. Most of the abundance and biomass (greater than 75%) is found in the northern portion of the stock area (Divs. 2J and 3K; Figure 14). The average abundance and biomass indices from the last three years are approximately 30% of the average during the 1980s. The 2023 survey abundance and biomass index values were 407 million fish and 340 kt, respectively.

The decrease in numbers of older fish from the 2017 survey could be due to changes in the timing of cod being inshore later than usual and not fully in the survey area at the time of the RV survey or that some of the older cod were in poor condition and did not make it through the summer to be caught in the RV survey. It is possible that 2017 was a survey effect.

Fall Survey Mean Catch at Age

Rstrap was used to calculate index values through the entire time series. Survey numbers-at-age were obtained by applying age-length keys (ALKs) to the numbers of fish at length in the samples from indexed strata.

A time series of survey catch rates at-age, expressed as mean numbers per tow at-age for Divs. 2J3KL combined, is given in Table 7 and Figure 15. Mean catch per tow was generally high (mostly 50–200 fish per tow) in the 1980s, but declined rapidly to generally less than 10 fish per tow during 1990–93. The age structure also contracted during the collapse period, with few old cod (age 6+) in the survey catches by the early 1990s. The catch rates at-age remained low for more than a decade, but catch rates have been increasing since about 2010. Generally, age structure had been expanding since 2012, with cod spawned in the early 2000s onwards surviving through to older ages in recent surveys (Table 7).

Fall Survey Catch Distribution

An extensive time series of age-aggregated and disaggregated distribution plots of fall survey catch numbers and catch weights per tow are available but, for brevity, only a subset of these are shown here to illustrate key changes in cod distribution in the recent period. A detailed history and description of changes in the distribution of cod at the time of the surveys to 2009 is given elsewhere (Shelton et al. 1996; Lilly et al. 2006; Bratley et al. 2010).

Patterns of distribution in the most recent four years indicate that both number and weight per tow are generally spread widely throughout Div. 2J, 3K, and northern 3L (Figure 16). In some years, there are large tows of fish on the edge of the continental shelf. In 2020 and 2021, there are some large tows of cod (greater than 500 fish per tow) in Div. 2J, however there were fewer large tows of cod in 2023. Additionally, the distribution in 2020 and 2023 shows more tows with cod in southern 3L than in the recent past (Figure 16).

Distribution of cod aged 2–4 indicate that cod at ages 2–4 were generally found further inshore in 2021 (Divs. 2J3K only) than in 2020, however they are distributed fairly evenly over the survey area in 2023 (Figure 17). There were few large (less than 500 cod per tow) catches of cod aged 2–4 in 2023.

DIVISION 2H

Trends in the abundance and biomass indices and length frequencies were examined from bordering Div. 2GH to the north. Div. 2G has not been surveyed since 1999, and Div. 2H has been covered intermittently from 1999–10. After 2010, Division 2H has been covered as part of regular multispecies surveys. Cod in Div. 2H showed a large increase in both abundance and biomass indices in 2015, which was likely spillover from Div. 2J (Figure 18). Distribution plots show that these fish were found close to the northern part of Div. 2J (not shown).

DIVISION 3L SPRING

The spring survey covers only part of the stock area, but this time of year may be important in showing certain trends, such as condition related to starvation (Regular et al. 2022). As expected, there is more variation in the estimates of abundance and biomass in this area during spring (fish may be moving into and out of the survey area) but generally there is a trend of increased numbers in fish since 2013 (Figure 19).

MATURITY

Annual estimates of age at 50% maturity (A_{50}) and proportions mature at-age for females from the 2J3KL cod stock, collected during annual fall DFO research bottom trawl surveys, were calculated as described by Morgan and Hoenig (1997). A cohort-specific binomial logistic regression model was used to estimate the proportion mature as a function of age and these estimated proportions (Table 8) are used in the calculation of spawning stock biomass. The estimated age at 50% maturity (A_{50}) is used as a metric for monitoring changes in age at maturity. A_{50} was generally between 6.0 and 7.0 among cohorts produced in the late 1950s and around 6.0 among those produced during the late 1960s to the early 1980s but declined thereafter (Figure 20). Age at maturity has remained low but variable (4.8–5.7) for the 1990–2016 cohorts, with no clear trend. Estimates for the last cohort (2018) are often more uncertain because only younger ages (1–5 years) are available to estimate A_{50} . The estimate of A_{50} for the 2010 cohort (5.8) is unusual and is the highest observed in the recent period; the confidence intervals for the fit to this recent cohort are not large and close inspection of the raw data indicate consistently lower observed proportions mature at each age. Estimates of A_{50} for the 1990 cohort onwards from the previous stock assessment in 2021 are overlaid on the 2024

assessment results (Figure 20). This comparison shows that the addition of one more year of data resulted in very minor retrospective changes in A50 among 2013–16 cohorts. Males show a similar trend in A50 over time (data not shown) but tend to mature about one year earlier than females.

GROWTH

The lengths-at-age and weights-at-age of cod sampled during the fall surveys were calculated following equations in Morgan and Hoenig (1997) and are shown in Figures 21 and 22. There was a strong decline in length-at-age in Div. 2J and Div. 3K from the late 1970s to the early 1990s followed by an increase in length-at-age, while there was little or no decline in Divs. 3L over that period. Mean length-at-age was mainly above average in 2011–14 in all Divs. However, since then, mean length at-age was below average for almost every age in all divisions.

Weight-at-age also showed a steep decline in Divs. 2J and 3K during the same period that lengths were declining and as with length-at-age there was less of a trend in Divs. 3L. Mean weight-at-age was above average in 2011–14 in all divisions and near average in 2015. Since then, mean weight-at-age was below average for most ages in all Divs.

Annual variation in mean weight-at-age for Div. 2J3KL combined was examined over ages 3–7 by analyzing deviation from the average as a proportion over the time series for each age. The average mean weight-at-age from 1981–2023 was calculated for each age (Figure 23). Deviation was calculated for each age in each year by subtracting the mean for the age for the time series from the annual observation for that age and then dividing this by the mean for that age. Mean weight-at-age decreased from the beginning of the time series to the early 1990s. It increased to well above average by 1997. From 1997 to 2015, mean weight-at-age fluctuated but remained at or above average. Mean weight-at-age from 2011–13 was among the highest in the time series, but this was followed by a steady decline to below average since then.

Beginning-of-year and mid-year weights-at-age were also generated for the assessment, where beginning-of-year weights were used in the calculation of SSB and mid-year-weights were used in the calculation of predicted landings. These weights were generated using a cohort-based Von Bertalanffy growth model developed for Northern Cod (Cadigan 2016a). This model is fit to the aforementioned mean weights-at-age from the RV survey, providing estimates that smooth through the variation in the means, while also filling gaps in the time-series and allowing adjustment of timing (i.e., expected weight at the beginning and middle of the year). Estimates of beginning-of-year and mid-year weights-at-age are presented in Table 9 and Table 10, respectively.

TRENDS IN MEAN RELATIVE CONDITION BY DIVISION AND SURVEY

Relative condition was calculated by first fitting a log-log regression of gutted weight as a function of length for cod sampled by the spring and fall RV surveys and the Sentinel survey. Individual weights were then divided by weights predicted by the length-weight regression to compute relative condition values. These values were averaged by division and survey to obtain trends in mean relative condition from the spring RV survey (primarily May–June in Div. 3L), summer Sentinel survey (primarily July–September in Divs. 3K3L), and fall RV survey (primarily October–December in 2J3KL) (Figure 24). Cod caught in the spring survey of 3L tend to be in the lowest condition. Condition is relatively stable in the fall across all divisions, varying with little trend around a level slightly above 1. In the fall, cod in Divs. 2J and 3K showed lower relative condition in the early 1990s and all divisions showed a peak in condition around 2011. There are no clear trends in condition in the summer in 2J; however, these averages are based on

relatively few samples (<100). Mean relative condition showed local maxima around 1996, 2005, and 2013 and minima around 2010 and 2016 in the 3K and 3L Sentinel series and the 3L spring RV series. The most pronounced decline in mean relative condition was observed during spring in 3L in the early 1990s. Focusing on the most recent years, condition appears to have improved slightly relative to 2016, especially in the fall; however, spring and summer condition remains at relatively low levels.

INDEX OF STARVATION-INDUCED MORTALITY

An index of starvation-induced mortality was calculated following methods outlined in Regular et al. (2022) using data from the spring RV survey, the summer Sentinel survey, and the fall RV survey. In short, the index is derived from a seasonal model of gutted condition where cod with residual levels below -0.18 are assumed to succumb to starvation (*sensu* Dutil and Lambert 2000; Casini et al. 2016). Since the actual critical condition level below which cod die from starvation is unknown, this metric is considered an index that is thought to be proportional to rates of mortality from poor condition. Patterns across ages 2–4, 5–7, and 8+ were calculated and are shown in Figure 25. The index exhibited a relatively low rate for both the 5 to 7 and 8+ age groups from 1977 to 1989. However, it showed a rapid increase in the early 1990s, increasing by approximately five times 1989 levels for the 5 to 7 and 8+ age groups. Since the early 1990s, the index has shown variability for the 5 to 7 and 8+ age groups, indicating peaks in starvation-induced mortality around 1998, 2003, 2009, and 2016. The index has declined across all ages since the last spike in 2016.

EXTENDED NORTHERN COD ASSESSMENT MODEL (XTENCAM)

Since 2016, Northern Cod has been assessed using an integrated state-space catch-censored population dynamics model developed specifically for this stock (Northern Cod assessment model (NCAM); Cadigan 2015, 2016b; DFO 2016a). This model integrates much of the existing information about the productivity of the stock and, as such, is capable of estimating annual rates of natural (M) and fishing (F) mortality. The model also estimates the catch, rather than assuming that reported landings are an exact measure of catch. An interval identifying a likely range of catch (lower and upper bounds) is specified, and this interval was determined during discussions with stakeholders present at the assessment meeting.

At a recent framework meeting (DFO 2024b), a series of stepwise changes were implemented to augment the base case NCAM (formulation accepted at the last framework; DFO 2016a), which served as the foundation of the extended assessment model, xteNCAM. Details of the extensions are outlined in Regular et al. 2025a, Regular et al. 2025b. Broadly, the objective of each step was to:

1. improve the fit of the model to catch composition data,
2. minimize conflicts between survey indices,
3. extend the time series back to 1954 (base case NCAM started in 1983),
4. integrate data from juvenile cod coastal monitoring programs,
5. implement a stock-recruitment relationship and calculate per-recruit reference points,
6. estimate baseline levels of natural mortality (M), and
7. quantify the effects of Capelin and seals on the cod stock.

Most of these objectives were listed as research recommendations from preceding Canadian Science Advisory Secretariat (CSAS) processes for Northern Cod (e.g., DFO 2019b, 2023b).

The current assessment is based on the xteNCAM formulation that estimates a constant baseline M and an age-invariant Capelin effect, as this was the formulation that was selected as the new assessment model (DFO 2024b).

DATA INPUTS FOR XTENCAM

The xteNCAM model uses the following data sources:

- age-disaggregated information from the fall DFO offshore bottom-trawl survey (ages 2–14, 1983–2003, 2005–20, 2023),
- inshore combined 2J3KL Sentinel 5½" mesh gillnet index (ages 3–10, 1995–2023),
- inshore acoustic estimates of biomass in Smith Sound (1995, 1997–2004, 2006–09),
- inshore juvenile indices from the Fleming (1959–64, 1992–97, 2001, 2020–21) and Newman Sound surveys (1996, 1998–2023),
- fishery catch age-composition information (ages 2–14, 1962–2023),
- partial fishery landings information (1954–2023),
- tagging information (release years: 1954–55, 1962–66, 1978–93, 1995–2023), and
- indices to calculate Capelin/cod biomass ratio [acoustic estimates of Capelin biomass in 3L (1985–92, 1996, 1999–2005, 2007–15, 2017–19, 2022–23) and total biomass estimates of cod from the fall DFO offshore bottom-trawl survey (1983–2003, 2005–20, 2023)].

Model process errors and observation equations are included for all data sources, and xteNCAM provides estimates of population parameters and variance parameters as well as modeled estimates for each of the data sources described above. Further details, including model likelihood equations for the various data sources, and likelihoods for random effects such as process errors, are also described in detail in Cadigan (2015); Cadigan (2016b) and Regular et al. 2025a and Regular et al. 2025b.

Fall DFO Research Vessel (RV) survey

The main source of information on trends in the status of Northern Cod is the fall DFO RV survey. This survey is based on a stratified random design, has a long time-series (1983–2023), captures a broad range of ages, and covers a large portion of the stock area. This survey is not intended to provide a direct estimate of stock size but can provide an age-disaggregated index of stock size, which can be used to scale the entire population provided the catchability coefficient (q) can be estimated for each age class in the population. Some cod can be outside the surveyed area, such as in shallow coastal water (e.g., small juveniles), or in deep water off the shelf edge, but provided there is no trend in the proportion of the population outside the area surveyed, the survey can still be used to infer stock trends.

The DFO RV survey index time series included the results of the latest (2023) survey and the age range 2–14 years. The survey catchability (q) was constrained to be equal for ages 6 to 14 and the 2004 and 2021 DFO RV survey indices were not used because of problems with survey coverage, and the 2022 survey was not conducted. Age-disaggregated stratified mean number per tow indices for ages 2–14, from 1983–2023, were used in xteNCAM (Table 7).

Inshore Acoustic Biomass Estimates and DFO RV Survey Catchability Parameter (q)

Following the collapse of the stock in the early 1990s, there is evidence from several sources that q changed for Northern Cod, through a distributional shift of the remnant stock to inshore regions that are not part of the fall DFO RV survey area. A relatively large aggregation of cod was observed in Smith Sound, Trinity Bay (Div. 3L) in the spring of 1995 (Rose et al. 2011). Subsequent surveys in winter and spring gave acoustic biomass estimates ranging from 10,000 to 26,000 t during 1995–2007, but the biomass estimates declined rapidly during 2007–09 to less than 1,000 t. Conventional tagging experiments and acoustic telemetry of cod in Smith Sound and neighboring areas indicated overwintering cod in Smith Sound dispersed around the coast in late spring and summer (Bratley et al. 2008b; Bratley 2013) and returned to Smith Sound in fall.

Furthermore, these studies showed that the decline in biomass during 2007–09 was not due to F or M, but was more likely a redistribution of these cod to other areas, including the offshore. The fall DFO RV survey indicated that the biomass of cod in the offshore was increasing, particularly for older cod, when the Smith Sound biomass was declining and further acoustic telemetry and conventional tagging of offshore cod released in 2008 confirmed that the seasonal shoreward migration of offshore cod was taking place, similar to the pattern observed in the pre-moratorium period. Cadigan (2015) concluded that this change in migration was highly plausible and should be included in the stock assessment model through the estimation of a multiplicative q at-age adjustment for the DFO RV survey during 1995–2009. The size of the Smith Sound component of the stock was estimated using published Rose et al. (2011) acoustic biomass estimates (Table 11) with samples (trawl and hand-line) taken during the acoustic survey providing age composition information (Table 12).

Sentinel Surveys

Sentinel surveys for cod in the inshore were conducted by fishing enterprises operating from many communities in Divs. 2J, 3K, and 3L at various times during summer and fall from 1995 onwards. Lilly et al. (2006) summarized sentinel data up to 2005, and the most recent detailed account of the sentinel program is provided by Kumar et al. (in prep¹), who extended the time series to 2023. The primary goal of these surveys was to obtain information on trends in the relative density of cod on traditional inshore fishing grounds during the moratorium. The sentinel surveys were also intended to provide samples that would yield information on various aspects of cod biology in the inshore, including age compositions, size-at-age, condition, maturity, and feeding.

An age-disaggregated index of standardized catch rates for cod in the inshore of 2J3KL was calculated from data gathered from sentinel fishing with gillnets (3¼" and 5½" mesh) and line-trawls (Stansbury et al. 2000). The methodology for calculating the index and full details of the sentinel fishery are described elsewhere (Kumar et al. in prep¹). The standardized age-disaggregated catch rate index (fish/net, ages 3–10) from 5½" mesh gillnets (fixed) from Div 2J3KL combined was updated, and results from 1995–2023 were used as an index in xteNCAM (Table 13). Sentinel survey q was assumed to follow a 2D age-year autoregressive process as the portion of the stock that makes itself available to the inshore sentinel survey may change through time (Regular et al. 2025a).

¹ Kumar, R., et.al. In prep. Sentinel Surveys 1995–2023 – Catch Rates and Biological Information on Atlantic Cod (*Gadus morhua*) in NAFO Divisions 2J3KL. DFO Can. Sci. Advis. Sec. Res. Doc.

Juvenile Surveys

There are two long-term surveys designed to monitor the abundance of juvenile cod:

1. the Fleming survey (see Lewis et al. 2022 for details), and
2. the Newman Sound survey (see Gregory et al. 2019 for details).

The Fleming survey was conducted along the Northeast Coast of Newfoundland from 1959 to 1964. The survey ceased in 1964, but was reinstated from 1992 to 1997, and again in 2020–21. The survey methods remained consistent over time, sampling the same season (October–September) and sites using a beach seine. Though the time series is fragmented, consistent methods permit direct comparisons of catch rates of cod aged 0–1. The Newman Sound survey uses similar methods as the Fleming survey, except it is isolated to Newman Sound, Bonavista Bay. The area is, however, sampled more intensely, sampling is conducted from July to November, and an index has been produced for nearly every year since 1995.

Both indices are used to inform trends in age 0 and 1 cod in the model. The Fleming survey offers an historic perspective on the relative abundance of recruits while the Newman Sound survey provides more recent trends. These data also proved to be useful for informing a stock-recruitment relationship (Regular et al. 2025a). The Newman Sound index has been updated to 2023 and these data are used in xteNCAM along with past indices from both surveys (Table 14). Independent q parameters are estimated for age 0 and 1 cod; however, q is assumed to be time-invariant and equal across both surveys.

Catch and Catch Bounds

A time-series of catch-at-age information is used to account for fishery removals and therefore provide key information about F in many assessment models; however, in xteNCAM, the catch data was treated somewhat differently, with separate likelihood components for the total removals (with bounds, see below) and the catch proportions-at-age based on the sampling of commercial (and recreational, where possible) landings. The total landings from 1954–2023 (second last column of Table 1), and catch-at-age from 1962–2023 (Table 4) converted to proportions with zeros replaced (see Cadigan 2015), were used as inputs to xteNCAM. Model-predicted landings were derived from the sum-product across age of predicted catch numbers-at-age and mid-year stock weights-at-age (Table 10).

In many fisheries, catch is not measured exactly, but it is an important quantity for scaling the total estimated population size. Issues that have typically generated concern about catch accuracy for Northern Cod are unreported or misreported landings (either domestic or non-Canadian), discarding due to quality concerns, and dumping / discarding based on size, particularly when size-based price-differentials are in place. In the post-moratorium period, the determination of the recreational catches has also been a concern, as recreational catches are difficult to estimate, and for Northern Cod, no standard procedures are in place to do so. The magnitude of these potential biases in overall catch reporting and how they change over time have not been quantified for Northern Cod.

For the current assessment model, an interval was required for the likely range of catch (C). According to Cadigan (2015), this approach is better than simply assuming an exact catch or ad-hoc adjustment of reported landings. Note that xteNCAM estimates catch almost freely within these bounds, unless there is a strong indication otherwise based on all other input data and the entire model structure.

In the 2016 assessment (DFO 2016b), and later at the 2023 framework meeting (DFO 2024b), participants at the meeting agreed that potential catch inaccuracies for Northern Cod likely

varied over time and decided to consider four time periods based on different fishery dynamics through the pre-moratorium and post-moratorium period, as well as different states of knowledge about potential catch inaccuracies:

1. A pre-200 nautical mile limit period (1954–77), where catches were high and may have been relatively unconstrained;
2. A pre-moratorium period (1978–91), when catches were high;
3. An early post-moratorium period (1992–2005) when there were small inshore commercial fisheries and recreational fisheries; and
4. A recent period (2006–23) when a directed inshore fishery took place for a few weeks during summer (stewardship fishery) and a dock-side catch monitoring program (DMP) which had been in place since the 1990s was redesigned to incorporate a tier-based approach. This period also included short seasonal recreational fisheries. Although the stewardship and recreational fisheries were expanded in 2016 and 2017, the catch bound estimates for these two years were status quo.

There are no direct estimates of recreational landings in the total reported catch for some years, but information from tagging suggested that recreational landings were a substantial fraction of commercial removals throughout the recent period (DFO 2016b). For all four time periods, the lower catch bound (CL) was considered by the meeting to be 10% above reported landings. This value was arbitrary but given the potential for discards and misreported landings, 10% seemed reasonable. The catch bounds were as follows: 1954–77 [CL, CU] = [1.1, 2] where a wide bound accounts for a broad range of possible catches through this period, 1978–91 [CL, CU] = [1.1, 1.5] with the upper bound to account mainly for discards and non-Canadian misreporting, 1992–2005 [CL, CU] = [1.1, 2] with the higher upper bound to account for the period of no DMP and more variable catch. During 2006–23, CL was again fixed at 1.1, but annual estimates of CU were made through differing adjustment up from reported commercial landings. Computation of CU for 2006–23 was based on a simple formula:

$$CU = 1.1 \times 1.3 \times 1.1 \times (\text{Commercial/Total})$$

The rationale for the first scaling factor (1.1) was a minimum adjustment to account for discarding and misreporting, and bias in visual estimation of catch weight evident from the confirmation of estimated weights on DMP authorization numbers. The second factor (1.3) was an adjustment to account for recreational fisher landings, where the analysis of tag returns indicated that recreational landings were on average about 30% of reported commercial landings. A third upward adjustment of 1.1 was included to account for other issues such as tagging estimates being based on numbers rather than weight and a general consideration that it was better to have the interval too wide rather than unreasonably narrow. The final ratio term (commercial/total) ensured that scaling factors were applied appropriately depending on whether estimates of recreational landings were already included in the total reported catch (i.e., 2007, 2009–10, and 2011–13). Thus, for years with no recreational landings estimate in the total reported catch, CU equals total reported catch times 1.573, but if estimated recreational catch was already included, the adjustment is proportionally less. Table 15 summarizes the catch bounds settings and includes estimates of recreational catch that were used to adjust the bounds in the recent period.

Tagging

The tagging data comprise an extensive series of tagging experiments, where batches of cod are tagged and released in a specific geographic area and time. Tagged fish are subjected to initial tagging mortality due to the stress of capture and handling in the year of release. In

addition, depending on the time of year fish were released and the timing of the fishery only a fraction of F and total mortality (Z) were applied in the year of release; the fraction of fishing that occurred was estimated from a table of monthly landings (Table 3). The population of tagged cod from an experiment diminishes over time due to a combination of initial tagging mortality, tag loss, as well as F and M . For all experiments during 1954–2023, irrespective of capture gear type, short-term tagging survival was assumed to be 97% for tag releases in November–June, and 78% for those from July to October (Brattey and Cadigan 2004). Coarse estimates of tag loss from Barrowman and Myers (1996) was used for disc tags, and loss of floy tags was estimated using double tagging and applied using Kirkwood’s model (Kirkwood 1981) with parameter estimates as described in Brattey and Healey (2007). Harvesters do not return the tags from all they fish that are captured; consequently, reporting rates have to be estimated and this was achieved using a high-reward tagging scheme initiated in 1997. Tag reporting rates for Northern Cod have been extensively studied (Cadigan and Brattey 2006; Konrad et al. 2016) and for the 1997 experiments onwards, reporting rates and uncertainties were estimated within xteNCAM. This was achieved by considering reporting rates in xteNCAM as random effects and adding a likelihood component for these reporting rates (Cadigan 2016b). The likelihood was based on the externally derived estimates and their estimated covariance matrix from the model described by Konrad et al. (2016).

Capelin as a Predictor of Natural Mortality

Capelin have long been known to be an important prey item for Northern Cod (Templeman 1965) and numerous studies have demonstrated links between Capelin biomass and cod productivity (e.g., Krohn et al. 1997; Rose and O’Driscoll 2002; Buren et al. 2014; Koen-Alonso et al. 2021). Further research demonstrated general correspondence between the availability of Capelin, an index of starvation rates of Northern Cod estimated using body condition data, and rates of M estimated by NCAM (Regular et al. 2022). These results are indicative of a mechanistic link between Capelin availability and rates of M experienced by Northern Cod. To move beyond post-hoc analyses and further test these potential links, Capelin data were incorporated into xteNCAM to use it as a predictor of the rates of M for Northern Cod. Specifically, we used the ratio of Capelin/cod biomass as a predictor of M (*sensu* Regular et al. 2022) since rates of starvation are expected to be worsened when there are insufficient Capelin to support the cod biomass currently in the system.

The Capelin-to-cod ratio requires an index of Capelin and cod biomass. For Capelin, the spring acoustic survey index of Capelin biomass was used as it is the best available data we have for the Capelin stock in Divs. 2J3KL (DFO 2025). The Capelin survey has been conducted for most years since 1985 and the latest estimates up to 2023 are used in xteNCAM. For cod, the biomass index from the fall RV survey is used (final column in Table 6). Since the RV survey is conducted in the fall, it is considered a better indicator of the cod population that will be in the system consuming Capelin through the winter and spring of the following calendar year. The RV survey index of cod was therefore lagged by one year to better indicate the biomass of cod relative to the biomass of Capelin in a given year.

RESULTS FROM XTENCAM

Several xteNCAM fit diagnostics to the various data sources are presented, and these show that the final model fit the productivity data for Northern Cod well. Several of these plots, showing observed and model-predicted values to each of the data sources along with various residual plots, as well as a 10 year retrospective analysis, are given in Appendix A. Key parameter estimates are shown in Table 16.

Effect of Capelin Availability

The collapse of Capelin in the early-1990s was followed by the collapse of cod, after which both populations slowly increased (Figure 26). Observed dynamics have resulted in periods of relatively high and low Capelin-to-cod biomass ratios (i.e., Capelin availability). Using this ratio as a predictor of M , variation in Capelin availability explains some of the variation in the realized rates of M estimated by xteNCAM (Figure 26). Further, the inclusion of Capelin in xteNCAM is effectively introducing mechanistic processes to explain changes in M , which previously were only done in an *post hoc* way through the M -shift formulation. Though the Capelin effect does not impose as large of a spike in M in the early 1990s as the M -shift formulation, the ratio does capture previously unexplained peaks in M around 2001, 2009, and 2017. These peaks also correspond to peaks in the starvation-induced mortality index (Figure 25; Regular et al. 2022). Both Capelin and cod biomass, and the Capelin-to-cod ratio has remained stable since 2017 (Figure 26).

Stock-recruitment Relationship

The use of data back to 1954, and the addition of juvenile survey data, enabled the estimation of a stock-recruit relationship. Several stock-recruitment relationships were tested for the framework; however, the standard formulation of the Beverton-Holt curve was most parsimonious and, as such, was accepted as a plausible description of the relationship between stock size and recruitment (DFO 2023b). This relationship appears to provide reasonable predictions of recruits for the most recent years (Figure 27).

Reference Points

The use of a stock-recruitment relationship also enabled the internal estimation of reference points such as SSB at maximum sustainable yield, B_{MSY} (Albertsen and Trijoulet 2020). These calculations underpin the new LRP for Northern Cod, which was set at 40% B_{MSY} in accordance with Canada's Precautionary Approach guidelines (DFO 2009; DFO 2023b). Refined with data up to 2023, these internal calculations yield the current LRP estimate of 276 Kt (95% CI = 180–423 Kt). An Upper Stock Reference point (USR) has yet to be defined for Northern Cod.

Stock Size and Mortality Rates

Trends in stock size and mortality rate estimates from xteNCAM are illustrated in Figure 28, and estimated values summarized in Tables 17-24.

The abundance of Northern Cod varied around approximately 4 billion individuals through the 1960s to the 1980s, but rapidly declined in the early-1990s. Abundance remained low through the 1990s, but increased in recent decades from 571 million (95% CI = 357–914 million) in 2005 to 3 billion (95% CI = 2–4 billion) in 2017. Growth in abundance has since stalled and levels in 2024 are similar those of 2017 (Figure 28; top panel). Levels of recruitment (age 0) fell to lowest observed levels around 1995, but recruitment has slowly improved and the average number of age 0s from the last five years correspond to about 80% of the average numbers of age 0s observed prior to 1990.

Total biomass shows a similar trend to abundance and increased from 86 Kt (95% CI = 71–105 Kt) in 2005 to 700 Kt (95% CI = 590–830 Kt) in 2017 (Figure 28; middle panel). Likewise, SSB increased from 26 Kt (95% CI = 22–31 Kt) in 2005 to 451 Kt (95% CI = 381–534 Kt) in 2017. Growth in both total biomass and SSB has stalled since 2017. Under the newly adopted LRP of 40% B_{MSY} , the stock has been out of the Critical Zone since 2016. As of 2024, the stock is 1.2 (95% CI = 0.7–2.1) times the LRP and, accounting for statistical uncertainties, there is an estimated 22% probability that the stock is in the Critical Zone.

Rates of mortality have been highly variable through the history of the stock. Average (ages 5+) F exceeded M through most of the 1950s to the 1980s; however, M has exceeded F since the collapse (Figure 28). Average F declined when the moratorium was imposed in 1992 and again when an inshore fishery was closed in 2003. While directed inshore fisheries for cod have continued throughout most of the post-moratorium period, average F has remained below 0.05 since 2004. Average F in 2023 is estimated to be 0.02 (95% CI = 0.01–0.03). Average M increased rapidly from levels below 0.4 to a peak of 2.5 around 1992–94, then declining to approximately 0.35 during 1995–99. Additional periods of high M are evident in 2000–03 (M approximately equal to 0.7 to 0.9), 2009–10 (M approximately equal to 0.6), and 2017 (M approximately equal to 0.6). Average M decreased to approximately 0.35 between each of these periods. In 2023, average M again appears to be elevated and is estimated to be 0.59 (95% CI = 0.32–1.12).

These results on the relative magnitudes of F and M around the time of the moratorium are different from some published studies which argue that the collapse can largely be attributed to illegal fishing (e.g., Hutchings and Myers 1995; Myers et al. 1996, 1997; Shelton and Lilly 2000; Rose and Walters 2019). In the xteNCAM model, the rate of M is estimated and the model can assign the sudden disappearance of cod from the DFO RV survey to either F or M. However, the model assigns much of the mortality to M to be consistent with the tagging data that are directly integrated into the model. Changing rates of M are further informed by changes in the relative abundance of Capelin, which indicates that the collapse of Capelin explains some of the spike in M during the early 1990s (Figure 26). This aligns with previous research which suggests that prey limitation contributed to the collapse of cod (Koen-Alonso et al. 2021; Regular et al. 2022). However, it remains possible that a portion of the M spike could be attributed to unreported catch by Canadian and/or non-Canadian fleets, especially if recaptured tags from these fish were not returned.

Retrospective Analysis

A 10-year retrospective analysis was carried out by removing one year of data at a time and re-running the model (Figure A14). The retrospective analysis indicated that overall, there are no systematic patterns of bias in estimates of stock size or rates, but in some years, the estimate of M can be overestimated, and the subsequent SSB underestimated. This is due, in part, to uncertainty in M in the terminal year because of the incomplete tagging from that year (all tags have yet to be returned). There were some signs of retrospective revisions to SSB relative to B_{lim} . This is due to revisions of estimates of B_{MSY} and, consequently, 40% B_{MSY} , given directional revisions of long-term average rates of M, fisheries selectivity, weights-at-age, maturity-at-age, as well as revisions to the stock-recruitment relationship parameter estimates.

Projections

Projections were conducted to meet the Terms of Reference, which specified the following objectives:

- Three-year projections of SSB, in relation to the LRP (with 95% CIs) assuming total removals are (0, 0.5, 1.0, 1.5, and 2) times the 2023 estimated value.
- The level of removals that provide estimates of growth of 10%, 20%, 30%, and 50% from the current SSB with a neutral to high probability (50%, 75%, and 95%) over the short-term (3 years). If possible, identify these levels of removals for the medium- to long-term (5 years).

Capelin are expected to remain at current levels in the short term⁴ and, as such, status quo levels of Capelin were assumed across all scenarios. These projections indicated low to

moderate probabilities (24–38%) of growth over the next three years (Table 25). Probabilities of exceeding the LRP remains neutral to moderately high under the 0 to 1.0 catch multiplier scenarios (53–69%), but they fall to moderate by 2027 under the 1.5 and 2.0 catch multiplier scenarios (48–51%; Table 26). Under current catch levels (approximately 13,517 t), SSB relative to B_{lim} is projected to be 1.06 (95% CI = 0.30–3.80) by 2027 (Table 27; Figure 29).

Given that even without directed fishing (catch multiplier = 0.0) the stock is not projected to be capable of achieving the lower 10% level of growth requested in the Terms of Reference (Table 25), there are no level of removals that can deliver any of the identified levels of growth.

Conclusions

Although the status of the stock has improved, growth in the stock has stalled since 2017 and, accounting for statistical uncertainties, there is an estimated 22% probability that the stock is in the Critical Zone. Following DFO's PA Framework, management actions must encourage stock growth in the short term and minimize risk of preventable decline (DFO 2009). Current catch levels increase the risk of pushing the stock into the Critical Zone in the short term.

ACKNOWLEDGEMENTS

We express our gratitude to the numerous individuals who contributed to the surveys and the processing of data that were used in this assessment, including the ship's crew, harvesters, and research personnel. These surveys received support from various organizations, including DFO, the Fish, Food and Allied Workers (FFAW) Union, the Natural Sciences and Engineering Research Council of Canada (NSERC) Fisheries Conservation Chair, and the Centre for Fisheries Ecosystems Research (CFER) at the Fisheries and Marine Institute, Memorial University of Newfoundland. We also thank Noel Cadigan for building the foundations of the Northern Cod assessment model and for continued discussions and advice. Finally, we thank the many scientists at DFO who built the foundations of this document and for those who reviewed earlier versions of this document.

REFERENCES CITED

- Albertsen, C.M., and Trijoulet, V. 2020. [Model-based estimates of reference points in an age-based state-space stock assessment model](#). Fisheries Research 230: 105618.
- Barrowman, N.J., and Myers, R.A. 1996. [Estimating tag-shedding rates for experiments with multiple tag types](#). Biometrics 54: 1410–1416.
- Bratley, J. 2013. [Harvest rates and movements of cod \(*Gadus morhua*\) in NAFO Divs. 3KL from tagging and acoustic telemetry](#). DFO Can. Sci. Advis. Sec. Res. Doc 2013/104: v + 31 p.
- Bratley, J., and Cadigan, N.G. 2004. [Estimation of short-term tagging mortality of adult Atlantic cod \(*Gadus morhua*\)](#). Fisheries Research 66: 223–233.
- Bratley, J., and Healey, B. 2007. [Exploitation and movements of Atlantic cod \(*Gadus morhua*\) in NAFO division 3KL: Tagging results from the reopened fishery in 2006](#). DFO Can. Sci. Advis. Sec. Res. Doc 2007/027: iv + 43 p.
- Bratley, J., Cadigan, N.G., Dwyer, K., Healey, B.P., Morgan, M.J., Murphy, E.F., Parsons, D., and Power, D. 2008a. [Assessments of the cod \(*Gadus morhua*\) stock in NAFO divisions 2J3KL \(April 2007 and April 2008\)](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2008/086: x + 150 p.

-
- Brattey, J., Healey, B., and Porter, D. 2008b. [Northern cod \(*Gadus morhua*\) 16 years after the moratorium: New information from tagging and acoustic telemetry](#). DFO Can. Sci. Advis. Sec. Res. Doc 2008/047: iv + 25 p.
- Brattey, J., Cadigan, N.G., Dwyer, K., Healey, B.P., Morgan, M.J., Murphy, E.F., Parsons, D., and Power, D. 2009. [Assessment of the cod \(*Gadus morhua*\) stock in NAFO divisions 2J3KL in 2009](#). DFO Can. Sci. Advis. Sec. Res. Doc 2009/061: viii + 92 p.
- Brattey, J., Cadigan, N.G., Dwyer, K., Healey, B.P., Morgan, M.J., Murphy, E.F., Maddock Parsons, D., and Power, D. 2010. [Assessment of the cod \(*Gadus morhua*\) stock in NAFO divisions 2J3KL in 2010](#). DFO Can. Sci. Advis. Sec. Res. Doc 2010/103: viii + 108 p.
- Brattey, J., Cadigan, N., Dwyer, K.S., Healey, B.P., Ings, D.W., Lee, E.M., Maddock Parsons, D., Morgan, M.J., Regular, P.M., and Rideout, R.M. 2018. [Assessment of the Northern cod \(*Gadus morhua*\) stock in NAFO divisions 2J3KL in 2016](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2018/018: v + 107p.
- Buren, A.D., Koen-Alonso, M., and Stenson, G.B. 2014. [The role of harp seals, fisheries and food availability in driving the dynamics of Northern cod](#). Marine Ecology Progress Series 511(10): 265–284.
- Cadigan, N. 2016a. [Weight-at-age growth models and forecasts for Northern cod \(*Gadus morhua*\)](#). DFO Can. Sci. Advis. Sec. Res. Doc 2016/016: v + 19 p.
- Cadigan, N.G. 2015. [A state-space stock assessment model for Northern cod, including under-reported catches and variable natural mortality rates](#). Canadian Journal of Fisheries and Aquatic Sciences 73(2): 296–308.
- Cadigan, N.G. 2016b. [Updates to a Northern cod \(*Gadus morhua*\) state-space integrated assessment model](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2016/022: v + 58 p.
- Cadigan, N.G., and Brattey, J. 2006. [Reporting and shedding rate estimates from tag-recovery experiments in Atlantic cod \(*Gadus morhua*\) in coastal Newfoundland](#). Canadian Journal of Fisheries and Aquatic Sciences 63: 1944–1958.
- Casini, M., Eero, M., Carlshamre, S., and Lövgren, J. 2016. [Using alternative biological information in stock assessment: Condition-corrected natural mortality of Eastern Baltic cod](#). ICES Journal of Marine Science 73(10): 2625–2631.
- DFO. 2009. [A fishery decision-making framework incorporating the precautionary approach](#).
- DFO. 2010. [Proceedings of the Newfoundland and Labrador Regional Atlantic Cod Framework Meeting: Reference Points and Projection Methods for Newfoundland cod stocks](#). DFO Can. Sci. Advis. Sec. Proceed. Ser. 2010/053.
- DFO. 2016a. [Proceedings of the Northern cod framework review meeting; November 30 — December 4, 2015](#). DFO Can. Sci. Advis. Sec. Proceed. Ser. 2016/031.
- DFO. 2016b. [Stock assessment of Northern cod \(NAFO Divs. 2J3KL\) in 2016](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep 2016/026.
- DFO. 2019a. [Evaluation of the biomass Limit Reference Point for Northern cod \(NAFO Divisions 2J3KL\)](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/058.
- DFO. 2019b. [Proceedings of the Regional Peer Review of the stock assessment of Northern cod \(Divisions 2J3KL\), March 19–23, 2018](#). DFO Can. Sci. Advis. Sec. Proceed. Ser. 2019/007.
-

-
- DFO. 2022. [Stock assessment of Northern cod \(NAFO divisions 2J3KL\) in 2021](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep 2022/041.
- DFO. 2023a. [Science advice on guidance for Limit Reference Points under the Fish Stocks Provisions](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep 2019/009.
- DFO. 2023b. [Proceedings of the Regional Peer Review for the evaluation of the Limit Reference Point \(LRP\) for 2J3KL Atlantic cod, January 22–24, 2019](#). DFO Can. Sci. Advis. Sec. Proceed. Ser. 2023/019.
- DFO. 2024a. [Newfoundland & Labrador Comparative Fishing Analysis – Part 1](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep 2024/002.
- DFO. 2024b. [Northern \(2J3KL\) Atlantic cod assessment framework](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep 2024/046.
- DFO. 2025. [Assessment of Divisions 2J+3KL Capelin to 2024](#). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2025/034.
- Dutil, J.-D., and Lambert, Y. 2000. [Natural mortality from poor condition in Atlantic cod \(*Gadus morhua*\)](#). Canadian Journal of Fisheries and Aquatic Sciences 57(4): 826–836.
- Gavaris, S., and Gavaris, C. 1983. Estimation of catch at age and its variance for groundfish stocks in the newfoundland region. Sampling commercial catches of marine fish and invertebrates. Edited by WG Doubleday and D. Rivard. Can. Spec. Publ. Fish. Aquat. Sci 66: 178–182.
- Gregory, R.S., Dalley, K.L., Newton, B.H., Sargent, P.S., and Cooke, E.L. 2019. [Relative strength of three cohorts \(2015-17\) of Atlantic cod, from nearshore surveys of demersal age 0 and 1 juveniles in Newman Sound, Bonavista Bay](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2019/012: v + 15p.
- Hutchings, J.A., and Myers, R.A. 1995. The biological collapse of Atlantic cod off Newfoundland and Labrador: An exploration of historical changes in exploitation, harvesting, technology and management. *In* The North Atlantic fisheries: Successes, failures and challenges. Edited by R. Arnason and L. Felt. Institute of Island Studies, Charlottetown, PEI, Canada. pp. 38–93.
- Kirkwood, G.P. 1981. [Generalized models for the estimation of rates of tag shedding by southern bluefin tuna \(*thunnus maccoyii*\)](#). Journal du Conseil / Conseil Permanent International pour l'Exploration de la Mer 39: 256–260.
- Koen-Alonso, M., Lindstrøm, U., and Cuff, A. 2021. [Comparative modeling of cod-capelin dynamics in the Newfoundland-Labrador shelves and Barents Sea ecosystems](#). Frontiers in Marine Science 8: 579946.
- Konrad, C., Bratley, J., and Cadigan, N.G. 2016. [Modelling temporal and spatial variability in tag reporting-rates for newfoundland cod \(*Gadus morhua*\)](#). Environmental and Ecological Statistics 23: 387.
- Krohn, M., Reidy, S., and Kerr, S. 1997. [Bioenergetic analysis of the effects of temperature and prey availability on growth and condition of Northern cod \(*Gadus morhua*\)](#). Canadian Journal of Fisheries and Aquatic Sciences 54(S1): 113–121.
- Lewis, R.S., Ings, D.W., and Rogers, B. 2022. [Demersal juvenile Atlantic cod \(*Gadus morhua*\) survey of the northeast coast of Newfoundland: 2020 Fleming survey](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2022/056: v + 32p.
-

-
- Lilly, G.R., Murphy, E.F., Healey, B.P., and Brattey, J. 2005. [An assessment of the cod \(*Gadus morhua*\) stock in NAFO Divisions 2J3KL in March 2005](#). DFO Can. Sci. Advis. Sec. Res. Doc 2005/018: iv + 211 p.
- Lilly, G.R., Murphy, E.F., Healey, B.P., and Brattey, J. 2006. [An assessment of the cod \(*Gadus morhua*\) stock in NAFO divisions 2J3KL in April 2006](#). DFO Can. Sci. Advis. Sec. Res. Doc 2006/043: vi + 159 p.
- Maddock Parsons, D. 2014. [Update of Sentinel survey results in NAFO Divisions 2J3KL for 1995–2012](#). DFO Can. Sci. Advis. Sec. Res. Doc 2014/014: v + 32 p.
- Mello, L.G.S., and Simpson, M.R. 2023. [Sentinel surveys 1995–2020 – catch rates and biological information on Atlantic cod \(*Gadus morhua*\) in NAFO Divisions 2J3KL](#). DFO Can. Sci. Advis. Sec. Res. Doc 2023/041: iv + 33 p.
- Morgan, M.J., and Hoenig, J.H. 1997. [Estimating maturity-at-age from length stratified sampling](#). Journal of Northwest Atlantic Fishery Science 21: 51–63.
- Myers, R.A., Barrowman, N.J., Hoenig, J.M., and Qu, Z. 1996. [The collapse of cod in eastern Canada: The evidence from tagging data](#). ICES Journal of Marine Science 53(3): 629–640.
- Myers, R.A., Barrowman, N.J., and Hutchings, J.A. 1997. [Inshore exploitation of newfoundland Atlantic cod \(*Gadus morhua*\) since 1948 as estimated from mark-recapture data](#). Canadian Journal of Fisheries and Aquatic Sciences 54(1): 224–235.
- Power, D., Ings, D.W., Rideout, R.M., and Healey, B.P. 2016. Performance and description of Canadian multi-species bottom trawl surveys in NAFO Subarea 2 + Divisions 3KLMNO, with emphasis on 2014–2015. NAFO SCR Doc. (16/28).
- Regular, P.M., Buren, A.D., Dwyer, K.S., Cadigan, N.G., Gregory, R.S., Koen-Alonso, M., Rideout, R.M., Robertson, G.J., Robertson, M.D., Stenson, G.B., and others. 2022. [Indexing starvation mortality to assess its role in the population regulation of Northern cod](#). Fisheries Research 247: 106180.
- Regular, P.M., Robertson, G.J., Kumar, R., Varkey, D.A., Gregory, R.S., Lewis, R.S., Skanes, K., Gullage, N., Koen-Alonso, M., and Dwyer, K.S. 2025a. [Extending the Northern Cod \(*Gadus morhua*\) Assessment Model - Part I: Bridging Gaps with Additional Data and Model Variations](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2025/034. iv + 79 p.
- Regular, P.M., Kumar, R., Varkey, D.A., Koen-Alonso, M., and Stenson, G.B. 2025b. [Extending the Northern Cod \(*Gadus morhua*\) Assessment Model - Part II: Quantifying the Impact of Capelin and Seals](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2025/035. iv + 36 p.
- Rideout, R.M., and Ings, D.W. 2021. Research vessel bottom trawl survey report (NL region): A stock-by-stock summary of survey information up to and including the 2019 spring and autumn surveys. Canadian Technical Report of Fisheries and Aquatic Sciences 3425: vii + 52.
- Rose, G.A., and Walters, C.J. 2019. [The state of Canada's iconic Northern cod: A second opinion](#). Fisheries Research 219: 105314.
- Rose, G., and O'driscoll, R. 2002. [Capelin are good for cod: Can the Northern stock rebuild without them?](#) ICES Journal of Marine Science 59(5): 1018–1026.
- Rose, G.R., Nelson, R.J., and Mello, L.G.S. 2011. [Isolation or metapopulation: Whence and whither the Smith Sound cod?](#) Canadian Journal of Fisheries and Aquatic Sciences 68: 152–169.
-

-
- Schijns, R., Froese, R., Hutchings, J.A., and Pauly, D. 2021. [Five centuries of cod catches in eastern Canada](#). ICES Journal of Marine Science 78(8): 2675–2683.
- Shelton, P.A., and Lilly, G.R. 2000. [Interpreting the collapse of the Northern cod stock from survey and catch data](#). Canadian Journal of Fisheries and Aquatic Sciences 57(11): 2230–2239.
- Shelton, P.A., Stansbury, D.E., Murphy, E.F., Lilly, G.R., and Bratley, J. 1996. An assessment of the cod stock in NAFO Divisions 2J3KL. NAFO SCR Doc. 96/62: 56 p.
- Smith, S.J., and Somerton, G.D. 1981. STRAP: A user oriented computer analysis system for groundfish research trawl survey data. Can. Tech. Rep. Fish. Aquat. Sci 1030: iv + 66 p.
- Stansbury, D.E., Maddock Parsons, D., and Shelton, P.A. 2000. [An age disaggregate index from the sentinel program for cod in 2J3KL](#). DFO Can. Stock Ass. Sec. Res. Doc: 64 p.
- Taggart, C., Penney, P., Barrowman, N., and George, C. 1995. The 1954-1993 Newfoundland cod-tagging database: Statistical summaries and spatial-temporal distributions. Canadian Technical Report of Fisheries and Aquatic Sciences 2042: 441 p.
- Templeman, W. 1965. Some instances of cod and haddock behaviour and concentrations in the Newfoundland and Labrador areas in relation to food. International Commission for the Northwest Atlantic Fisheries (ICNAF) Special Publication 6: 449–461.
- Wheeland, T., L., and Rideout, R.M. 2023. Coverage of the 2022 Canadian (Newfoundland and Labrador region) multi-species RV bottom trawl survey with notes on comparative fishing. NAFO SCR Doc. (23/042).

TABLES

Table 1. Reported landings (t) of cod from NAFO Divisions 2J3KL from 1954 onward. Proportion of Canadian catch (%) indicated in parentheses. Provisional catches for current year. A dot (.) indicates no data.

Year	2J Offshore Mobile gear	2J Fixed gear	2J Total	(% Can)	3K Offshore Mobile gear	3K Fixed gear	3K Total	(% Can)	3L Offshore Mobile gear	3L Fixed gear	3L Total	(% Can)	2J3KL overall Total	(% Can)	2J3KL TAC
1954	.	.	.	.	.	.	.	.	.	.	.	.	315,843 ^a	.	.
1955	.	.	.	.	.	.	.	.	.	.	.	.	232,858 ^a	.	.
1956	.	.	.	.	.	.	.	.	.	.	.	.	236,210 ^a	.	.
1957	.	.	.	.	.	.	.	.	.	.	.	.	254,456 ^a	.	.
1958	.	.	.	.	.	.	.	.	.	.	.	.	206,710 ^a	.	.
1959	46,372	17,533	63,905	(27%)	97,678	56,264	153,942	(37%)	56,030	85,695	141,725	(64%)	359,572	(46%)	.
1960	164,124	15,418	179,542	(9%)	75,052	47,676	122,728	(39%)	71,340	94,192	165,532	(61%)	467,802	(35%)	.
1961	243,145	17,545	260,690	(7%)	64,023	31,159	95,182	(33%)	78,574	70,659	149,233	(50%)	505,105	(25%)	.
1962	226,841	23,424	250,265	(9%)	47,015	42,816	89,831	(48%)	94,659	72,271	166,930	(46%)	507,026	(28%)	.
1963	197,869	23,767	221,636	(11%)	79,331	47,486	126,817	(37%)	87,461	73,295	160,756	(48%)	509,209	(29%)	.
1964	197,372	14,787	212,159	(7%)	121,423	40,735	162,158	(25%)	152,528	75,806	228,334	(38%)	602,651	(23%)	.
1965	246,650	25,117	271,767	(9%)	50,118	26,467	76,585	(35%)	137,740	58,943	196,683	(34%)	545,035	(22%)	.
1966	226,283	22,645	248,928	(9%)	58,920	32,208	91,128	(35%)	128,459	55,990	184,449	(35%)	524,505	(23%)	.
1967	217,283	27,721	245,004	(11%)	78,801	24,905	103,706	(24%)	213,821	49,233	263,054	(24%)	611,764	(19%)	.
1968	359,758	12,937	372,695	(5%)	121,627	40,768	162,395	(26%)	227,592	47,332	274,924	(23%)	810,014	(15%)	.
1969	405,261	4,328	409,589	(1%)	81,005	24,923	105,928	(24%)	170,200	67,973	238,173	(36%)	753,690	(15%)	.
1970	212,961	1,963	214,924	(1%)	78,366	21,512	99,878	(22%)	152,311	53,113	205,424	(33%)	520,226	(18%)	.
1971	154,700	3,313	158,013	(2%)	61,537	21,111	82,648	(26%)	160,742	38,115	198,857	(25%)	439,518	(17%)	.
1972	149,435	1,725	151,160	(1%)	133,376	14,054	147,430	(10%)	113,432	46,273	159,705	(32%)	458,295	(14%)	.
1973	54,108	3,619	57,727	(8%)	159,761	13,190	172,951	(8%)	98,992	24,839	123,831	(21%)	354,509	(12%)	666,000

Year	2J Offshore Mobile gear	2J Fixed gear	2J Total	(% Can)	3K Offshore Mobile gear	3K Fixed gear	3K Total	(% Can)	3L Offshore Mobile gear	3L Fixed gear	3L Total	(% Can)	2J3KL overall Total	(% Can)	2J3KL TAC
1974	119,463	1,804	121,267	(1%)	149,208	10,747	159,955	(7%)	68,798	22,630	91,428	(26%)	372,650	(10%)	657,000
1975	78,988	3,000	81,988	(4%)	112,867	15,518	128,385	(12%)	54,440	22,695	77,135	(30%)	287,508	(15%)	554,000
1976	30,785	3,851	34,636	(11%)	80,311	20,879	101,190	(21%)	43,185	35,209	78,394	(48%)	214,220	(29%)	300,000
1977	40,109	3,523	43,632	(9%)	27,827	28,818	56,645	(53%)	32,161	40,282	72,443	(63%)	172,720	(46%)	160,000
1978	22,228	6,638	28,866	(39%)	13,400	29,623	43,023	(85%)	21,476	45,194	66,670	(82%)	138,559	(74%)	135,000
1979	15,731	8,445	24,176	(73%)	38,462	27,025	65,487	(74%)	26,877	50,359	77,236	(84%)	166,899	(78%)	180,000
1980	21,029	17,210	38,239	(81%)	28,750	37,015	65,765	(90%)	29,486	42,298	71,784	(81%)	175,788	(84%)	180,000
1981	26,885	14,251	41,136	(88%)	26,959	23,002	49,961	(92%)	36,824	42,827	79,651	(81%)	170,748	(86%)	200,000
1982	67,307	14,429	81,736	(89%)	12,955	42,141	55,096	(93%)	36,452	56,490	92,942	(90%)	229,774	(90%)	230,000
1983	41,434	10,748	52,182	(92%)	34,436	40,683	75,119	(96%)	50,043	55,001	105,044	(90%)	232,345	(92%)	260,000
1984	12,013	13,150	25,163	(89%)	59,173	35,143	94,316	(88%)	63,641	49,351	112,992	(86%)	232,471	(87%)	266,000
1985	1,544	10,211	11,755	(99%)	81,825	30,368	112,193	(88%)	68,039	39,306	107,345	(71%)	231,293	(81%)	266,000
1986	13,593	12,916	26,509	(70%)	67,867	28,384	96,251	(94%)	111,751	32,202	143,953	(63%)	266,713	(75%)	266,000
1987	43,343	16,022	59,365	(93%)	45,846	27,442	73,288	(92%)	70,528	36,743	107,271	(76%)	239,924	(85%)	256,000
1988	41,477	17,112	58,589	(100%)	40,310	33,820	74,130	(100%)	84,553	51,405	135,958	(80%)	268,677	(90%)	266,000
1989	34,629	23,304	57,933	(98%)	38,529	20,711	59,240	(98%)	77,579	59,238	136,817	(73%)	253,990	(85%)	235,000
1990	18,066	14,505	32,571	(99%)	27,424	27,516	54,940	(99%)	56,675	75,266	131,941	(81%)	219,452	(88%)	199,262
1991	703	2,214	2,917	(97%)	30,423	13,332	43,755	(99%)	79,924	45,416	125,340 ^b	(60%)	172,012	(71%)	190,000
1992	0	18	18	(100%)	857	884	1,741	(84%)	28,237	10,960	39,197 ^c	(63%)	40,956	(64%)	0
1993	0	13	13	(100%)	0	541	541	(100%)	2,427	8,411	10,838 ^d	(78%)	11,392	(79%)	0
1994	0	9	9	(100%)	0	368	368	(100%)	1	936	937	(100%)	1,314 ^e	(100%)	0
1995	0	0	1	(100%)	0	122	122	(100%)	0	290	290	(100%)	413 ^f	(100%)	0
1996	0	3	3	(100%)	0	961	961	(100%)	2	908	910	(100%)	1,875 ^g	(100%)	0

Year	2J Offshore Mobile gear	2J Fixed gear	2J Total	(% Can)	3K Offshore Mobile gear	3K Fixed gear	3K Total	(% Can)	3L Offshore Mobile gear	3L Fixed gear	3L Total	(% Can)	2J3KL overall Total	(% Can)	2J3KL TAC
1997	0	4	4	(100%)	0	280	280	(100%)	0	592	592	(100%)	877	(100%)	0
1998	0	16	16	(100%)	0	1,994	1,994	(100%)	7	2,490	2,497	(100%)	4,507	(100%)	4,000
1999	0	33	33	(100%)	0	3,554	3,554	(100%)	1	4,938	4,939	(100%)	8,526	(100%)	9,000
2000	0	3	3	(100%)	0	1,410	1,410	(100%)	80	3,937	4,017	(99%)	5,430	(99%)	7,000
2001	0	21	21	(100%)	0	1,736	1,736	(100%)	89	5,124	5,212	(98%)	6,969	(99%)	5,600
2002	0	13	13	(100%)	0	647	647	(100%)	56	3,533	3,589	(99%)	4,249	(99%)	5,600
2003	0	2	2	(100%)	0	29	29	(100%)	26	937	963 ^h	(98%)	994	(98%)	0
2004	0	2	2	(100%)	0	152	152	(100%)	12	482	494	(99%)	649	(99%)	0
2005	0	6	6	(100%)	1	555	556	(100%)	2	767	769	(100%)	1,331	(100%)	0
2006	0	65	65	(100%)	5	1,103	1,109	(100%)	22	1,506	1,528	(99%)	2,701	(99%)	0
2007	0	71	71	(100%)	0	1,178	1,178	(100%)	13	1,668	1,682	(99%)	2,931	(100%)	0 ^j
2008	0	71	71	(100%)	0	1,518	1,518	(100%)	45	1,750	1,795	(98%)	3,385	(99%)	0 ^j
2009	0	57	57	(100%)	0	1,186	1,186	(100%)	18	1,856	1,874	(99%)	3,116 ⁱ	(99%)	0 ^j
2010	0	64	64	(100%)	12	1,160	1,172	(100%)	60	1,666	1,726	(97%)	2,962 ⁱ	(98%)	0 ^j
2011	0	54	54	(100%)	0	1,458	1,458	(100%)	294	1,964	2,258	(87%)	3,770	(92%)	0 ^j
2012	0	75	75	(100%)	2	1,845	1,847	(100%)	132	1,817	1,949	(93%)	3,871	(97%)	0 ^j
2013	1	133	134	(100%)	0	2,215	2,215	(100%)	150	2,007	2,157	(94%)	4,506 ⁱ	(97%)	0 ^j
2014	0	119	119	(100%)	0	2,326	2,326	(100%)	117	2,308	2,425	(95%)	4,870 ⁱ	(98%)	0 ^j
2015	0	139	139	(100%)	0	2,256	2,256	(100%)	82	1,959	2,041	(97%)	4,436 ⁱ	(98%)	0 ^j
2016	0	214	214	(100%)	1	5,272	5,273	(100%)	189	4,429	4,618	(96%)	10,105 ⁱ	(98%)	0 ^j
2017	0	313	313	(100%)	1	6,334	6,335	(100%)	156	6,076	6,232	(98%)	12,881 ⁱ	(99%)	0 ^j
2018	9	271	281	(100%)	0	4,430	4,430	(100%)	81	4,663	4,744	(99%)	9,456 ⁱ	(99%)	0 ^j
2019	0	444	444	(100%)	0	4,819	4,819	(100%)	50	5,191	5,241	(99%)	10,503 ⁱ	(100%)	0 ^j

Year	2J Offshore Mobile gear	2J Fixed gear	2J Total	(% Can)	3K Offshore Mobile gear	3K Fixed gear	3K Total	(% Can)	3L Offshore Mobile gear	3L Fixed gear	3L Total	(% Can)	2J3KL overall Total	(% Can)	2J3KL TAC
2020	0	1,129	1,129	(100%)	0	3,767	3,767	(100%)	111	5,253	5,364	(98%)	10,260 ⁱ	(99%)	0 ^j
2021	0	1,314	1,314	(100%)	0	4,387	4,387	(100%)	98	5,178	5,276	(98%)	10,977 ⁱ	(99%)	0 ^j
2022	0	1,836	1,836	(100%)	0	5,497	5,497	(100%)	78	5,065	5,143	(99%)	12,475 ⁱ	(99%)	0 ^j
2023	1	2,467	2,467	(100%)	0	5,598	5,598	(100%)	14	4,918	4,932	(100%)	12,998 ⁱ	(100%)	0 ^j

^a Historic estimates from Schijns et al. (2021).

^b Figure is 4,000 t less than Can. statistics (this quantity is 3NO catch misreported as 3L). Includes French catch and other foreign catch as estimated by Canadian surveillance.

^c Derived from reported catch and Canadian surveillance estimate of foreign catch. Includes 5,000 t catch from the recreational fishery after the moratorium was declared.

^d Canadian surveillance estimate of foreign catch. Includes 5,053 t estimated for the recreational fishery additional to that recorded by Canadian statistics.

^e 1,300 t is from the food fishery; the remainder is bycatch.

^f Includes 275 t caught in the sentinel survey and 138 t caught as bycatch.

^g Comprised of a sentinel survey catch of 296 t, a food fishery catch of 1,155 t and bycatch of 422 t.

^h 780 t of this catch was the result of a mass mortality in Smith Sound.

ⁱ Excludes recreational fishery.

^j There was no TAC in these years but there were annual allowances per licence holder for inshore vessels.

Table 2. Fixed gear landings (t) from 1975 onwards. Table excludes statistical areas other than for Newfoundland. Provisional catches for current year.

Year	Gillnet	Longline	Handline	Other	Total
1975	18,501	2,206	4,812	15,694	41,213
1976	22,519	3,628	7,310	26,482	59,939
1977	22,539	4,922	11,388	33,774	72,623
1978	23,844	8,816	11,376	37,419	81,455
1979	30,625	15,611	13,943	25,650	85,829
1980	36,194	17,657	12,390	30,282	96,523
1981	34,363	17,857	9,838	18,022	80,080
1982	46,987	11,919	9,027	45,127	113,060
1983	39,605	7,236	19,541	40,050	106,432
1984	35,463	6,702	16,801	38,678	97,644
1985	19,834	5,849	14,325	39,877	79,885
1986	25,295	4,156	9,454	34,597	73,502
1987	36,870	5,146	10,385	27,806	80,207
1988	39,657	5,211	13,153	44,316	102,337
1989	44,998	5,666	13,723	38,866	103,253
1990	46,026	9,036	15,250	46,975	117,287
1991	13,351	3,191	9,184	35,236	60,962
1992	1,234	27	9,401	1,200	11,862
1993	130	90	8,731	14	8,965
1994	46	22	1,238	6	1,312
1995	272	72	21	48	413
1996	519	61	1,184	0	1,500 ^a

Year	Gillnet	Longline	Handline	Other	Total
1997	579	105	53	128	865
1998	2,461	534	1,450	55	4,501
1999	7,568	184	724	49	8,525
2000	4,084	232	960	78	5,354
2001	3,643	200	2,834	203	6,880
2002	2,796	60	1,206	130	4,193
2003	178	8	782	0	968
2004	627	7	0	0	635
2005	1,315	12	1	0	1,328
2006	1,864	79	673	5	2,621
2007	1,911	36	963	6	2,917
2008	2,705	52	577	6	3,340
2009	2,318	67	710	0	3,094 ^b
2010	2,221	49	619	0	2,889 ^b
2011	2,639	40	789	0	3,468
2012	2,901	41	683	0	3,625
2013	3,866	25	438	14	4,342 ^b
2014	4,226	30	493	0	4,749 ^b
2015	3,669	56	610	0	4,335 ^b
2016	7,866	198	1,800	51	9,915 ^b
2017	10,513	295	1,845	70	12,724 ^b
2018	8,430	183	747	6	9,365 ^b
2019	8,609	485	1,342	17	10,453 ^b
2020	8,603	728	804	14	10,149 ^b

Year	Gillnet	Longline	Handline	Other	Total
2021	8,740	1,478	656	4	10,879 ^b
2022	11,045	1,042	310	0	12,397 ^b
2023	11,795	689	393	106	12,983 ^b

^a Comprised of a sentinel survey catch of 296 t, a food fishery catch of 1,155 t and bycatch of 422 t.

^b Excludes recreational fishery.

Table 3. Monthly reported landings of cod from NAFO Divisions 2J3KL combined since 1954. Provisional catches for current year.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1954 ^a	4,893	10,628	11,825	23,825	46,313	59,567	54,242	30,003	27,827	20,943	20,982	4,794
1955 ^a	3,607	7,836	8,718	17,565	34,145	43,916	39,990	22,120	20,516	15,440	15,469	3,534
1956 ^a	3,659	7,948	8,844	17,818	34,636	44,548	40,566	22,439	20,811	15,663	15,692	3,585
1957 ^a	3,942	8,562	9,527	19,195	37,312	47,990	43,699	24,172	22,419	16,873	16,904	3,862
1958 ^a	3,202	6,956	7,739	15,593	30,311	38,985	35,500	19,636	18,212	13,707	13,732	3,137
1959 ^a	5,570	12,099	13,462	27,124	52,726	67,814	61,752	34,157	31,680	23,843	23,887	5,458
1960	10,207	10,684	9,200	16,384	45,125	106,037	106,611	42,082	37,652	29,620	33,511	11,252
1961	10,414	35,671	16,242	22,668	85,138	90,306	69,833	46,060	44,770	30,993	38,731	7,252
1962	1,658	3,028	29,983	72,923	85,730	76,993	71,599	50,627	46,395	36,238	24,347	3,231
1963	870	13,741	12,971	94,337	67,204	62,953	80,757	55,647	38,395	35,412	23,857	4,740
1964	5,769	21,623	48,593	72,149	55,485	83,583	101,880	63,544	39,176	35,396	25,672	8,883
1965	19,046	46,889	50,582	73,027	53,356	59,992	82,872	58,037	33,328	24,616	23,656	8,527
1966	25,273	46,230	35,858	36,008	77,398	70,103	67,773	40,870	33,289	33,471	31,932	16,721
1967	27,611	42,571	26,362	54,936	73,783	67,038	82,540	44,881	54,981	53,754	45,925	25,620
1968	29,105	102,648	97,548	65,095	73,084	112,194	87,586	61,795	63,558	47,384	31,129	12,078
1969	29,789	138,034	118,989	80,040	59,783	91,170	82,725	41,274	34,568	20,804	15,882	7,326
1970	28,918	106,245	68,645	55,502	34,100	52,485	53,476	32,298	30,029	14,362	11,451	6,893
1971	51,469	83,301	47,576	41,641	28,650	40,722	41,467	27,168	26,912	17,152	9,733	4,726
1972	76,751	123,253	18,495	53,531	26,278	34,318	32,625	21,556	18,586	16,579	9,058	21,630
1973	80,138	81,421	8,780	36,152	39,418	26,886	26,703	17,484	12,867	6,724	4,489	10,898
1974	54,221	89,842	35,884	60,382	34,795	11,739	15,419	13,150	12,013	7,928	7,557	25,875
1975	34,745	64,243	23,258	37,464	11,813	14,263	23,118	16,766	18,604	14,554	10,660	15,424
1976	12,307	53,283	19,747	14,429	7,400	15,122	29,237	16,919	15,224	12,609	8,545	8,594

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	19,073	30,014	14,915	10,043	9,198	23,074	28,332	17,520	7,664	4,577	5,018	3,289
1978	10,236	10,302	8,850	6,596	6,278	20,264	34,954	20,772	8,983	5,536	3,397	2,391
1979	2,290	17,423	19,485	7,809	13,977	21,998	32,629	24,670	9,773	6,752	4,333	5,604
1980	59	11,450	11,354	18,083	20,139	18,018	33,039	27,653	19,170	7,293	3,961	5,563
1981	16,653	29,915	1,026	3,995	9,575	18,773	27,128	22,368	13,563	8,084	8,031	11,637
1982	3,863	20,345	26,647	25,672	19,292	23,326	50,354	28,654	10,681	5,062	6,687	9,191
1983	13,182	24,022	14,757	19,899	21,770	34,542	45,028	21,079	14,684	6,791	6,268	10,318
1984	21,737	23,674	18,299	15,230	17,802	26,175	45,687	28,698	13,819	6,810	4,187	10,353
1985	13,198	14,782	23,403	27,264	22,329	20,884	36,157	27,417	18,543	9,029	7,193	11,094
1986	34,059	39,630	24,595	31,055	14,922	18,782	34,065	23,933	13,784	8,952	9,985	12,918
1987	24,834	20,128	20,363	19,981	17,680	16,800	34,038	30,590	20,117	12,212	11,175	11,987
1988	25,804	26,017	24,739	26,414	16,725	17,755	46,679	36,191	15,745	12,201	10,032	10,375
1989	15,721	11,329	11,570	20,578	22,106	27,350	42,639	34,984	16,162	13,203	23,248	12,048
1990	12,663	12,476	11,572	12,871	6,812	13,071	49,531	44,611	20,610	9,538	14,757	10,940
1991	18,130	11,645	10,401	7,791	7,001	7,151	16,010	24,550	16,166	11,237	11,781	8,163
1992	8,959	6,560	273	3,803	2,469	1,410	842	734	1,877	1,214	621	140
1993	81	82	9	4	23	48	171	451	1,661	1,025	349	171
1994	17	0	0	0	7	12	17	424	830	2	0	5
1995	0	1	0	1	6	31	91	91	79	65	20	2
1996	0	1	0	1	8	36	284	217	1,263	41	19	7
1997	0	0	0	0	58	96	233	198	177	79	34	6
1998	0	0	0	0	18	122	253	505	2,201	1,103	16	4
1999	0	0	0	8	15	85	3,672	187	3,148	1,167	243	1
2000	1	1	0	31	14	114	1,460	132	1,862	816	408	0

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	4	12	27	24	16	40	1,154	1,707	1,080	500	420	12
2002	5	14	5	19	9	16	281	2,332	961	509	93	0
2003	0	1	6	792	2	15	137	83	37	5	17	0
2004	0	4	0	0	1	48	285	338	32	5	17	1
2005	1	0	0	0	0	39	106	1,129	35	4	13	1
2006	0	3	8	10	0	55	106	1,613	779	102	16	1
2007	1	0	2	10	3	24	760	763	976	436	8	0
2008	0	0	11	2	16	20	416	648	2,687	406	23	0
2009	1	2	4	0	1	22	288	403	4,983	460	10	1
2010	2	14	25	0	0	28	142	1,117	1,686	79	17	0
2011	2	2	107	74	0	53	191	1,534	1,670	35	58	33
2012	2	1	17	3	1	37	378	4,449	1,565	25	4	4
2013	1	10	12	0	1	27	179	2,770	1,167	15	23	3
2014	0	1	0	2	2	8	356	2,899	1,195	14	4	0
2015	0	0	0	10	2	3	10	2,200	1,834	29	13	0
2016	0	0	0	0	0	20	93	2,926	5,087	1,349	424	33
2017	0	0	0	34	6	36	119	4,187	5,356	2,461	566	14
2018	0	11	0	6	0	7	58	4,586	2,768	1,952	1	0
2019	1	0	0	0	2	12	41	3,580	4,678	1,671	470	0
2020	0	0	0	0	0	10	41	4,821	3,577	1,408	297	0
2021	0	0	1	0	5	10	1,795	5,227	2,430	927	489	0
2022	1	3	2	0	1	12	2,436	7,061	2,726	138	24	0
2023	0	1	0	0	1	3	1,150	7,804	3,883	36	0	0

^a Average portions between 1962-1964 were used to re-construct monthly landings across these years.

Table 4. Catch numbers-at-age (000s) for the commercial cod fishery in NAFO Divisions 2J3KL since 1962 for ages 0 to 14.

Year	0 ^a	1 ^a	2	3	4	5	6	7	8	9	10	11	12	13	14
1962	0	0	301	8,666	26,194	64,337	58,163	47,314	27,521	20,142	18,036	10,444	9,468	7,778	5,785
1963	0	0	1,446	5,746	27,577	60,234	118,112	58,996	29,349	15,520	11,612	8,248	4,204	3,942	2,933
1964	0	0	2,872	19,338	27,603	57,757	60,681	100,147	50,865	20,892	12,264	8,698	6,352	4,989	4,036
1965	0	0	85	5,177	28,709	46,800	66,946	64,360	68,176	33,819	14,913	6,945	3,729	3,948	3,730
1966	0	0	819	14,057	65,992	93,687	62,812	59,312	30,423	23,844	8,762	4,528	2,280	1,825	1,186
1967	0	0	790	15,262	77,873	100,339	96,759	54,996	38,691	17,146	16,084	5,949	3,367	2,108	1,529
1968	0	0	288	6,142	94,291	205,805	150,541	83,808	39,443	23,171	10,984	5,591	5,249	1,939	1,334
1969	0	0	59	4,330	39,626	100,858	163,228	107,509	52,661	19,651	12,370	6,389	4,479	3,004	1,557
1970	0	0	6,819	18,104	60,102	82,357	101,249	85,696	29,218	10,857	3,825	2,000	1,200	507	224
1971	0	0	33	12,876	71,557	95,384	98,111	57,865	25,055	11,732	4,470	2,223	1,287	1,140	720
1972	0	0	236	6,737	79,809	116,562	76,196	55,984	29,553	11,750	6,393	2,987	1,660	1,388	725
1973	0	0	0	3,963	40,785	94,844	59,503	35,464	27,351	14,153	7,566	3,815	2,153	1,173	450
1974	0	0	473	3,231	13,201	34,927	74,403	60,539	35,687	18,854	10,492	5,818	2,934	1,078	652
1975	0	0	420	3,968	14,101	25,370	34,426	39,105	36,485	13,421	7,514	2,315	1,179	808	372
1976	0	0	15	13,767	33,727	28,049	20,898	16,811	16,022	10,931	4,637	1,462	631	292	251
1977	0	0	108	7,128	65,510	40,462	12,107	5,397	3,396	2,730	1,381	532	296	149	75
1978	0	0	0	1,323	17,556	39,206	20,319	7,711	3,078	1,530	1,083	437	219	105	62
1979	0	0	0	1,152	12,361	37,493	29,202	10,982	3,460	1,300	757	560	183	116	51
1980	0	0	92	2,554	12,025	28,814	30,016	18,017	4,830	1,217	520	232	229	56	65
1981	0	0	0	2,185	7,172	13,191	24,800	22,014	11,848	3,175	779	309	195	125	48
1982	0	0	0	1,702	31,286	19,003	14,397	25,435	16,930	11,936	1,923	338	156	90	153
1983	0	0	18	2,585	13,616	42,602	19,028	12,044	14,701	8,934	6,341	1,018	248	90	41
1984	0	0	3	782	14,871	31,760	38,624	12,503	7,246	8,910	4,227	2,536	451	146	48

Year	0^a	1^a	2	3	4	5	6	7	8	9	10	11	12	13	14
1985	0	0	0	650	14,824	36,614	33,922	28,006	7,050	3,836	5,162	2,905	1,681	254	107
1986	0	0	1	831	15,219	44,168	45,869	26,025	14,722	3,104	2,000	1,977	1,101	574	116
1987	0	0	42	2,329	9,217	32,340	49,061	28,469	19,505	5,818	1,346	676	873	391	200
1988	0	0	25	2,779	14,651	20,184	47,917	45,725	18,608	9,026	4,337	774	422	366	223
1989	0	0	8	1,696	17,639	21,150	25,212	38,708	28,499	8,696	3,640	1,695	572	244	180
1990	0	0	58	7,693	40,557	36,410	22,695	16,390	17,940	9,156	2,865	1,084	478	103	98
1991	0	0	35	3,111	31,654	53,805	29,553	9,064	6,164	4,745	1,696	641	250	88	39
1992	0	0	0	430	3,860	14,535	12,211	4,526	1,372	376	199	104	18	9	4
1993	0	0	0	940	4,993	3,343	1,940	700	147	21	0	0	0	0	0
1994	0	0	0	105	379	575	177	74	22	2	0	0	0	0	0
1995	0	0	0	12	41	93	76	25	10	2	0	0	0	0	0
1996	0	0	1	35	157	304	401	131	24	7	2	0	0	0	0
1997	0	0	0	12	39	92	95	148	35	5	2	0	0	0	0
1998	0	0	3	96	229	395	689	384	236	74	10	5	2	1	0
1999	0	0	7	70	238	638	795	1,157	370	253	52	13	3	0	0
2000	0	0	5	141	258	419	437	328	294	151	136	33	5	3	1
2001	0	0	10	249	778	710	611	365	190	272	80	117	33	3	1
2002	0	0	6	166	296	399	335	235	124	77	113	50	52	10	2
2003	0	0	0	9	11	19	53	44	28	22	9	32	20	27	7
2004	0	0	1	10	24	33	47	59	32	14	7	3	5	2	2
2005	0	0	0	16	27	137	182	101	51	19	7	4	2	2	1
2006	0	0	0	12	159	307	381	168	79	30	13	5	2	1	2
2007	0	0	0	12	44	357	423	178	69	21	8	5	2	1	1
2008	0	0	0	11	84	172	649	422	147	37	12	6	2	1	1

Year	0^a	1^a	2	3	4	5	6	7	8	9	10	11	12	13	14
2009	0	0	0	25	96	124	170	410	248	68	15	5	1	1	0
2010	0	0	3	18	72	122	202	200	329	143	34	6	1	1	0
2011	0	0	4	27	74	92	186	247	188	202	78	17	2	1	0
2012	0	0	3	38	63	165	248	271	228	117	131	43	7	1	0
2013	0	0	0	22	137	287	432	357	231	153	75	55	24	6	1
2014	0	0	8	36	42	232	438	461	211	115	69	34	38	12	1
2015	0	0	0	3	26	87	450	397	266	115	52	49	21	21	4
2016	0	0	0	3	48	259	520	1,221	720	384	188	70	32	14	21
2017	0	0	0	1	34	224	836	706	1,318	689	354	123	59	41	20
2018	0	0	0	0	23	101	596	1,072	824	545	274	117	42	9	6
2019	0	0	0	1	46	104	384	859	1,364	568	418	165	88	19	25
2020	0	0	0	3	58	202	273	530	1,194	910	354	212	60	20	30
2021	0	0	0	3	50	203	512	471	917	968	808	290	126	44	20
2022	0	0	0	1	22	127	438	646	744	861	970	416	146	142	104
2023	0	0	0	0	17	159	617	1,353	1,140	665	405	288	257	80	63

^a Assumed to be 0.

Table 5. Number of tagging experiments and tags released in 2J3KL and recaptured by tag type and year of release and recapture.

Year	Disc tag experiments	Disc tags released	Disc tags recaptured	T-bar tag experiments	T-bar tags released	T-bar tags recaptured
1954	6	6,936	213	0	0	0
1955	1	1,071	787	0	0	0
1956	0	0	547	0	0	0
1957	0	0	322	0	0	0
1958	0	0	119	0	0	0
1959	0	0	81	0	0	0
1960	0	0	48	0	0	0
1961	0	0	31	0	0	0
1962	6	4,893	185	0	0	0
1963	8	8,828	924	0	0	0
1964	9	8,064	2,704	0	0	0
1965	3	3,069	1,774	0	0	0
1966	1	1,120	1,625	0	0	0
1967	0	0	653	0	0	0
1968	0	0	328	0	0	0
1969	0	0	159	0	0	0
1970	0	0	55	0	0	0
1971	0	0	35	0	0	0
1972	0	0	16	0	0	0
1973	0	0	4	0	0	0
1974	0	0	0	0	0	0
1975	0	0	0	0	0	0

Year	Disc tag experiments	Disc tags released	Disc tags recaptured	T-bar tag experiments	T-bar tags released	T-bar tags recaptured
1976	0	0	0	0	0	0
1977	0	0	0	0	0	0
1978	1	3,522	285	1	928	27
1979	3	2,441	418	3	2,547	186
1980	3	3,926	521	5	4,312	456
1981	6	3,907	504	9	4,537	386
1982	8	3,931	883	10	5,409	882
1983	6	3,882	620	7	5,360	670
1984	7	3,796	608	7	3,802	543
1985	6	2,897	769	6	2,661	699
1986	4	2,784	681	6	2,920	583
1987	5	3,200	768	5	3,067	603
1988	7	3,944	619	7	4,271	566
1989	6	3,084	389	7	4,456	434
1990	5	3,502	499	5	3,407	399
1991	9	7,296	917	8	8,057	869
1992	0	0	71	3	8,603	198
1993	0	0	4	2	1,089	37
1994	0	0	3	0	0	7
1995	0	0	3	3	2,769	17
1996	0	0	1	35	6,475	141
1997	0	0	3	8	3,450	110
1998	0	0	6	1	118	320

Year	Disc tag experiments	Disc tags released	Disc tags recaptured	T-bar tag experiments	T-bar tags released	T-bar tags recaptured
1999	0	0	2	35	8,267	1,173
2000	0	0	0	23	3,511	698
2001	0	0	1	14	5,961	1,073
2002	0	0	0	15	5,093	1,037
2003	0	0	0	1	472	534
2004	0	0	0	1	923	88
2005	0	0	0	5	1,026	77
2006	0	0	1	12	6,628	356
2007	0	0	1	9	3,792	210
2008	0	0	0	12	5,443	257
2009	0	0	0	11	3,245	213
2010	0	0	0	12	2,046	139
2011	0	0	0	8	2,012	118
2012	0	0	0	8	1,655	91
2013	0	0	0	7	2,308	99
2014	0	0	0	14	5,297	87
2015	0	0	0	19	5,864	140
2016	0	0	0	17	6,540	256
2017	0	0	0	12	1,562	203
2018	0	0	0	5	2,525	116
2019	0	0	0	7	2,614	124
2020	0	0	0	8	1,219	75
2021	0	0	0	10	4,143	84

Year	Disc tag experiments	Disc tags released	Disc tags recaptured	T-bar tag experiments	T-bar tags released	T-bar tags recaptured
2022	0	0	0	8	3,164	81
2023	0	0	0	9	3,972	69

Table 6. Cod abundance (000s) index (AI) and biomass (t) index (BI) for Northern cod from index strata in DFO autumn RV stratified random trawl surveys. A dot (.) indicates no data.

Year	AI Div. 2J	AI Div. 3K	AI Div. 3L	AI Total	BI Div. 2J	BI Div. 3K	BI Div. 3L	BI Total
1983	1,124,317	416,982	428,505	1,969,804	722,491	340,667	278,412	1,341,570
1984	743,236	451,517	993,964	2,188,717	557,162	368,512	477,355	1,403,028
1985	615,282	204,361	464,125	1,283,767	472,148	203,866	368,514	1,044,528
1986	1,249,076	886,567	358,606	2,494,250	1,285,761	960,060	387,438	2,633,258
1987	410,570	277,132	325,352	1,013,054	491,598	295,215	284,230	1,071,042
1988	508,714	405,232	256,383	1,170,330	598,477	165,186	274,553	1,038,216
1989	647,592	1,302,635	172,299	2,122,526	425,388	828,015	160,688	1,414,092
1990	260,266	949,766	395,569	1,605,601	128,352	616,316	405,668	1,150,336
1991	323,638	639,014	144,684	1,107,335	150,138	461,923	121,761	733,822
1992	30,960	60,184	147,159	238,303	12,794	34,683	126,323	173,799
1993	16,989	36,907	36,813	90,709	5,129	14,227	24,594	43,950
1994	8,145	9,361	4,292	21,798	2,694	4,241	2,873	9,808
1995	12,346	23,387	7,733	43,466	2,312	4,600	5,114	12,026
1996	13,625	18,518	7,066	39,209	4,447	5,455	6,140	16,042
1997	6,936	8,827	9,859	25,623	3,609	3,998	8,991	16,598
1998	6,669	15,612	6,454	28,735	4,483	7,280	4,804	16,567
1999	6,075	29,308	25,281	60,664	2,527	12,230	13,611	28,367
2000	7,524	35,774	29,010	72,307	3,076	11,994	15,070	30,140
2001	7,033	28,535	27,724	63,292	2,646	9,890	18,706	31,242
2002	9,534	41,853	10,984	62,371	3,680	11,889	7,460	23,030
2003	9,316	19,906	13,638	42,860	3,065	4,912	4,849	12,827
2004	9,503	34,468	18,605	62,576	4,921	9,609	5,266	19,795

Year	AI Div. 2J	AI Div. 3K	AI Div. 3L	AI Total	BI Div. 2J	BI Div. 3K	BI Div. 3L	BI Total
2005	18,519	33,834	8,780	61,133	5,719	16,696	5,118	27,533
2006	11,739	52,285	18,711	82,735	6,818	38,709	16,985	62,512
2007	26,656	54,600	47,248	128,504	8,755	58,513	35,771	103,039
2008	24,439	62,848	53,958	141,246	10,272	71,329	66,400	148,001
2009	15,250	47,949	111,782	174,981	6,473	51,106	85,410	142,989
2010	17,278	83,060	39,013	139,351	9,905	89,388	29,255	128,549
2011	17,937	59,233	29,204	106,374	8,542	71,541	41,615	121,698
2012	26,108	101,579	39,584	167,270	21,900	112,824	50,985	185,709
2013	97,136	170,174	58,344	325,654	37,986	181,106	78,927	298,020
2014	163,877	210,793	88,706	463,376	94,457	166,597	82,471	343,525
2015	154,411	281,296	64,706	500,413	120,154	256,608	70,820	447,581
2016	185,235	275,274	75,582	536,091	111,175	307,511	62,611	481,298
2017	181,998	194,664	61,043	437,704	132,400	144,518	72,993	349,910
2018	227,743	242,285	81,356	551,383	144,197	231,602	84,378	460,177
2019	338,767	162,861	65,339	566,968	254,766	169,670	56,302	480,738
2020	258,511	165,740	101,580	525,831	216,308	127,976	102,929	447,213
2021	320,296	155,521	.	.	280,960	111,350	.	.
2022	.	.	.	.	.	.	.	.
2023	181,873	93,768	131,156	406,798	157,250	90,656	91,750	339,656

Table 7. Mean number of cod per tow at-age in the index strata for the fall DFO RV bottom-trawl surveys of NAFO Divisions 2J3KL. A dot (.) indicates no data.

Year	2	3	4	5	6	7	8	9	10	11	12	13	14
1983	58.00	42.95	20.92	16.09	4.20	2.54	4.81	2.58	1.08	0.22	0.07	0.03	0.03
1984	56.92	47.82	33.36	16.57	10.66	2.37	1.25	2.02	1.10	0.42	0.19	0.04	0.03
1985	10.63	32.23	30.34	17.06	8.46	4.16	0.86	0.76	0.67	0.37	0.13	0.03	0.01
1986	14.80	20.78	63.37	57.56	29.38	11.53	5.09	1.25	0.50	0.60	0.35	0.10	0.05
1987	11.96	7.65	10.22	23.05	15.59	4.73	3.13	1.51	0.33	0.14	0.16	0.08	0.04
1988	18.86	13.24	7.68	10.34	13.93	10.21	2.45	1.34	0.67	0.14	0.09	0.07	0.04
1989	62.96	35.27	21.41	12.12	10.18	10.14	5.45	1.39	0.72	0.34	0.11	0.03	0.03
1990	15.56	47.28	28.51	12.95	7.10	4.14	5.28	2.40	0.72	0.33	0.14	0.04	0.03
1991	11.28	15.13	39.04	18.54	4.71	1.47	0.70	0.42	0.19	0.04	0.03	0.00	0.00
1992	2.51	5.12	3.44	5.91	2.10	0.37	0.04	0.02	0.01	0.00	0.01	0.00	0.00
1993	3.03	2.01	1.67	0.48	0.41	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.47	0.69	0.34	0.10	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.97	0.73	0.29	0.09	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	1.39	0.86	0.39	0.15	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.68	0.89	0.26	0.11	0.01	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.39	0.61	0.49	0.16	0.04	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00
1999	1.72	1.54	0.51	0.23	0.04	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
2000	1.61	1.53	0.97	0.21	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2001	1.53	1.78	0.69	0.32	0.05	0.01	0.01	0.01	0.00	0.02	0.01	0.00	0.00
2002	2.27	1.06	0.63	0.15	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.54	0.63	0.25	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	2.83	0.59	0.39	0.12	0.04	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
2005	1.01	2.02	0.76	0.21	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Year	2	3	4	5	6	7	8	9	10	11	12	13	14
2006	1.18	1.44	1.87	1.24	0.31	0.03	0.04	0.01	0.01	0.00	0.00	0.00	0.00
2007	2.27	1.88	1.35	1.79	0.71	0.17	0.04	0.01	0.01	0.00	0.00	0.00	0.00
2008	2.09	2.85	1.92	1.14	1.45	0.62	0.12	0.09	0.00	0.01	0.01	0.00	0.00
2009	2.59	4.38	3.75	1.82	0.61	0.55	0.13	0.03	0.00	0.00	0.00	0.00	0.00
2010	1.80	2.83	2.15	1.26	0.83	0.44	0.36	0.15	0.04	0.01	0.00	0.00	0.00
2011	2.56	2.23	1.39	0.79	0.66	0.39	0.25	0.25	0.09	0.01	0.00	0.00	0.00
2012	1.38	3.77	2.97	1.52	0.70	0.53	0.33	0.19	0.22	0.08	0.01	0.00	0.00
2013	5.95	2.75	4.01	2.86	1.70	0.92	0.54	0.22	0.21	0.16	0.07	0.01	0.00
2014	11.85	8.70	3.63	4.14	1.98	0.89	0.46	0.23	0.11	0.04	0.11	0.02	0.00
2015	8.39	11.37	8.40	3.72	3.66	1.45	0.74	0.36	0.14	0.12	0.05	0.04	0.02
2016	5.90	11.41	9.65	5.42	2.08	2.16	1.36	0.58	0.29	0.12	0.09	0.05	0.05
2017	6.85	6.59	7.85	6.42	3.02	0.94	0.77	0.25	0.11	0.06	0.03	0.01	0.01
2018	10.93	9.85	6.80	5.45	4.42	2.92	1.01	0.72	0.31	0.15	0.04	0.01	0.01
2019	8.10	10.84	9.02	4.92	4.26	3.49	2.12	0.75	0.39	0.21	0.17	0.06	0.01
2020	9.17	10.02	8.74	5.69	2.52	2.86	1.63	0.98	0.24	0.16	0.05	0.01	0.00
2021	.	.	.	.	.	.	.	.	.	.	.	.	.
2022	.	.	.	.	.	.	.	.	.	.	.	.	.
2023	5.31	7.61	6.20	5.84	3.03	1.92	1.10	0.47	0.39	0.18	0.12	0.05	0.01

Table 8. Estimated proportions mature for female cod from NAFO Div. 2J3KL from DFO RV fall bottom trawl surveys projected back to 1954. Estimates were obtained from a cohort-specific binomial logistic regression model fitted to observed proportions mature at-age. Lightly shaded cells are averages of the first or last three estimates extrapolated backward. Proportions mature between 1954–57 are assumed to equal proportions from 1958 (dark grey shaded cells).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.000	0.000	0.000	0.000	0.001	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1955	0.000	0.000	0.000	0.000	0.001	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1956	0.000	0.000	0.000	0.000	0.001	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1957	0.000	0.000	0.000	0.000	0.001	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1958	0.000	0.000	0.000	0.000	0.001	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1959	0.000	0.000	0.000	0.000	0.001	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1960	0.000	0.000	0.000	0.000	0.001	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1961	0.000	0.000	0.000	0.000	0.000	0.011	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1962	0.000	0.000	0.000	0.000	0.001	0.001	0.158	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1963	0.000	0.000	0.000	0.000	0.001	0.013	0.040	0.763	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1964	0.000	0.000	0.000	0.001	0.003	0.020	0.186	0.649	0.987	0.999	1.000	1.000	1.000	1.000	1.000
1965	0.000	0.000	0.001	0.003	0.010	0.040	0.247	0.799	0.988	0.999	1.000	1.000	1.000	1.000	1.000
1966	0.000	0.000	0.002	0.005	0.016	0.066	0.335	0.842	0.986	1.000	1.000	1.000	1.000	1.000	1.000
1967	0.000	0.000	0.000	0.008	0.027	0.092	0.360	0.858	0.989	0.999	1.000	1.000	1.000	1.000	1.000
1968	0.000	0.000	0.000	0.001	0.039	0.129	0.385	0.826	0.986	0.999	1.000	1.000	1.000	1.000	1.000
1969	0.000	0.000	0.000	0.000	0.009	0.166	0.440	0.795	0.973	0.999	1.000	1.000	1.000	1.000	1.000
1970	0.000	0.000	0.001	0.000	0.004	0.066	0.496	0.812	0.960	0.996	1.000	1.000	1.000	1.000	1.000
1971	0.000	0.009	0.001	0.003	0.000	0.045	0.364	0.829	0.960	0.993	0.999	1.000	1.000	1.000	1.000
1972	0.000	0.017	0.022	0.007	0.019	0.008	0.368	0.823	0.960	0.992	0.999	1.000	1.000	1.000	1.000
1973	0.000	0.000	0.042	0.054	0.037	0.092	0.200	0.879	0.974	0.992	0.999	1.000	1.000	1.000	1.000
1974	0.000	0.000	0.000	0.101	0.130	0.176	0.372	0.880	0.989	0.997	0.998	1.000	1.000	1.000	1.000
1975	0.000	0.000	0.000	0.000	0.222	0.299	0.543	0.874	0.995	0.999	1.000	1.000	1.000	1.000	1.000

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1976	0.000	0.000	0.001	0.002	0.004	0.422	0.597	0.869	0.984	1.000	1.000	1.000	1.000	1.000	1.000
1977	0.000	0.000	0.001	0.005	0.015	0.043	0.650	0.847	0.973	0.997	1.000	1.000	1.000	1.000	1.000
1978	0.000	0.000	0.000	0.005	0.028	0.114	0.355	0.826	0.949	0.995	1.000	1.000	1.000	1.000	1.000
1979	0.000	0.000	0.000	0.002	0.031	0.140	0.519	0.871	0.924	0.982	0.999	1.000	1.000	1.000	1.000
1980	0.000	0.000	0.000	0.000	0.017	0.166	0.475	0.901	0.988	0.969	0.993	1.000	1.000	1.000	1.000
1981	0.000	0.000	0.000	0.000	0.003	0.113	0.553	0.834	0.987	0.999	0.987	0.997	1.000	1.000	1.000
1982	0.000	0.000	0.001	0.002	0.004	0.044	0.479	0.885	0.965	0.998	1.000	0.995	0.999	1.000	1.000
1983	0.000	0.000	0.000	0.005	0.019	0.059	0.398	0.869	0.980	0.994	1.000	1.000	0.998	1.000	1.000
1984	0.000	0.000	0.000	0.000	0.024	0.142	0.481	0.905	0.980	0.997	0.999	1.000	1.000	0.999	1.000
1985	0.000	0.000	0.000	0.000	0.005	0.111	0.590	0.932	0.993	0.997	0.999	1.000	1.000	1.000	1.000
1986	0.000	0.000	0.000	0.001	0.003	0.053	0.388	0.926	0.995	1.000	1.000	1.000	1.000	1.000	1.000
1987	0.000	0.000	0.000	0.001	0.014	0.039	0.411	0.763	0.991	1.000	1.000	1.000	1.000	1.000	1.000
1988	0.000	0.000	0.000	0.002	0.013	0.122	0.380	0.897	0.942	0.999	1.000	1.000	1.000	1.000	1.000
1989	0.000	0.000	0.000	0.002	0.015	0.115	0.580	0.901	0.991	0.988	1.000	1.000	1.000	1.000	1.000
1990	0.000	0.000	0.000	0.001	0.017	0.098	0.569	0.932	0.993	0.999	0.998	1.000	1.000	1.000	1.000
1991	0.000	0.000	0.000	0.000	0.018	0.130	0.434	0.931	0.993	1.000	1.000	1.000	1.000	1.000	1.000
1992	0.000	0.002	0.001	0.001	0.013	0.250	0.567	0.844	0.993	0.999	1.000	1.000	1.000	1.000	1.000
1993	0.000	0.000	0.008	0.009	0.037	0.276	0.859	0.920	0.975	0.999	1.000	1.000	1.000	1.000	1.000
1994	0.000	0.000	0.000	0.029	0.071	0.511	0.916	0.991	0.990	0.996	1.000	1.000	1.000	1.000	1.000
1995	0.000	0.000	0.000	0.003	0.098	0.405	0.966	0.997	1.000	0.999	0.999	1.000	1.000	1.000	1.000
1996	0.000	0.002	0.001	0.002	0.034	0.282	0.858	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.000	0.001	0.008	0.008	0.029	0.294	0.588	0.982	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1998	0.000	0.000	0.003	0.030	0.076	0.311	0.834	0.838	0.998	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.000	0.000	0.000	0.014	0.109	0.464	0.872	0.984	0.949	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.000	0.000	0.000	0.004	0.067	0.325	0.900	0.990	0.999	0.985	1.000	1.000	1.000	1.000	1.000

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2001	0.000	0.001	0.001	0.001	0.040	0.263	0.654	0.990	0.999	1.000	0.996	1.000	1.000	1.000	1.000
2002	0.000	0.000	0.005	0.010	0.028	0.325	0.640	0.881	0.999	1.000	1.000	0.999	1.000	1.000	1.000
2003	0.000	0.000	0.001	0.026	0.080	0.380	0.849	0.898	0.967	1.000	1.000	1.000	1.000	1.000	1.000
2004	0.000	0.000	0.001	0.008	0.112	0.425	0.928	0.985	0.978	0.991	1.000	1.000	1.000	1.000	1.000
2005	0.000	0.001	0.003	0.007	0.056	0.380	0.863	0.996	0.999	0.995	0.998	1.000	1.000	1.000	1.000
2006	0.000	0.000	0.004	0.019	0.089	0.315	0.748	0.982	1.000	1.000	0.999	0.999	1.000	1.000	1.000
2007	0.000	0.001	0.001	0.023	0.118	0.560	0.782	0.935	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.000	0.000	0.003	0.006	0.109	0.487	0.943	0.965	0.986	1.000	1.000	1.000	1.000	1.000	1.000
2009	0.000	0.000	0.002	0.015	0.045	0.389	0.871	0.995	0.995	0.997	1.000	1.000	1.000	1.000	1.000
2010	0.000	0.002	0.003	0.013	0.077	0.268	0.768	0.979	1.000	0.999	0.999	1.000	1.000	1.000	1.000
2011	0.000	0.000	0.009	0.017	0.086	0.314	0.739	0.945	0.997	1.000	1.000	1.000	1.000	1.000	1.000
2012	0.000	0.000	0.000	0.045	0.102	0.404	0.714	0.956	0.989	1.000	1.000	1.000	1.000	1.000	1.000
2013	0.000	0.000	0.001	0.004	0.199	0.425	0.830	0.932	0.994	0.998	1.000	1.000	1.000	1.000	1.000
2014	0.000	0.000	0.001	0.005	0.027	0.565	0.827	0.972	0.987	0.999	1.000	1.000	1.000	1.000	1.000
2015	0.000	0.000	0.001	0.010	0.047	0.176	0.872	0.969	0.996	0.998	1.000	1.000	1.000	1.000	1.000
2016	0.000	0.000	0.002	0.007	0.079	0.321	0.624	0.973	0.995	0.999	1.000	1.000	1.000	1.000	1.000
2017	0.000	0.000	0.000	0.011	0.050	0.429	0.819	0.928	0.995	0.999	1.000	1.000	1.000	1.000	1.000
2018	0.000	0.001	0.000	0.005	0.071	0.270	0.868	0.978	0.990	0.999	1.000	1.000	1.000	1.000	1.000
2019	0.000	0.001	0.004	0.002	0.049	0.347	0.722	0.983	0.998	0.999	1.000	1.000	1.000	1.000	1.000
2020	0.000	0.001	0.004	0.019	0.039	0.367	0.786	0.948	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2021	0.000	0.001	0.003	0.019	0.083	0.489	0.866	0.962	0.992	1.000	1.000	1.000	1.000	1.000	1.000
2022	0.000	0.001	0.003	0.013	0.080	0.292	0.957	0.986	0.994	0.999	1.000	1.000	1.000	1.000	1.000
2023	0.000	0.001	0.003	0.013	0.067	0.281	0.654	0.998	0.999	0.999	1.000	1.000	1.000	1.000	1.000

Table 9. Beginning of year weight-at-age estimates (kg) from a generalized Von Bertalanffy (VonB2) growth model described in Cadigan (2016b) fitted by cohort to average weight-at-age data for cod from the fall bottom-trawl surveys in Divisions 2J3KL from 1983 onward. Lightly shaded cells are hindcasts from the model.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1955	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1956	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1957	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1958	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1959	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1960	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1961	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1962	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1963	0.000	0.014	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1964	0.000	0.013	0.076	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1965	0.000	0.013	0.075	0.231	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1966	0.000	0.013	0.072	0.228	0.520	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1967	0.000	0.013	0.070	0.217	0.514	0.978	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1968	0.000	0.013	0.068	0.207	0.483	0.966	1.629	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1969	0.000	0.013	0.068	0.200	0.456	0.901	1.611	2.485	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1970	0.000	0.013	0.068	0.200	0.440	0.844	1.492	2.457	3.540	4.776	6.165	7.669	9.245	10.852	12.448
1971	0.000	0.013	0.069	0.200	0.440	0.811	1.390	2.266	3.501	4.776	6.165	7.669	9.245	10.852	12.448
1972	0.000	0.012	0.071	0.208	0.441	0.812	1.331	2.102	3.221	4.726	6.165	7.669	9.245	10.852	12.448
1973	0.000	0.012	0.067	0.216	0.462	0.817	1.335	2.009	2.980	4.343	6.103	7.669	9.245	10.852	12.448
1974	0.000	0.012	0.062	0.197	0.486	0.864	1.346	2.016	2.843	4.012	5.610	7.596	9.245	10.852	12.448
1975	0.000	0.012	0.062	0.178	0.436	0.916	1.434	2.037	2.856	3.824	5.181	6.991	9.163	10.852	12.448
1976	0.000	0.012	0.064	0.177	0.382	0.809	1.531	2.182	2.889	3.844	4.936	6.460	8.452	10.762	12.448

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1977	0.000	0.013	0.065	0.182	0.379	0.694	1.336	2.343	3.108	3.893	4.965	6.156	7.822	9.957	12.353
1978	0.000	0.013	0.068	0.185	0.392	0.685	1.124	2.025	3.349	4.200	5.032	6.196	7.460	9.235	11.470
1979	0.000	0.013	0.068	0.193	0.394	0.709	1.106	1.679	2.877	4.535	5.436	6.283	7.510	8.818	10.670
1980	0.000	0.014	0.068	0.190	0.411	0.711	1.148	1.648	2.360	3.882	5.875	6.788	7.617	8.879	10.204
1981	0.000	0.014	0.070	0.187	0.400	0.741	1.146	1.712	2.310	3.159	5.024	7.334	8.225	9.006	10.275
1982	0.000	0.014	0.072	0.193	0.389	0.710	1.191	1.703	2.402	3.087	4.068	6.278	8.873	9.709	10.420
1983	0.000	0.014	0.069	0.199	0.400	0.682	1.128	1.767	2.381	3.211	3.969	5.072	7.618	10.451	11.208
1984	0.000	0.014	0.070	0.191	0.412	0.699	1.072	1.656	2.465	3.174	4.129	4.944	6.154	9.014	12.029
1985	0.000	0.014	0.073	0.195	0.394	0.721	1.094	1.557	2.289	3.280	4.072	5.141	5.994	7.297	10.435
1986	0.000	0.013	0.071	0.204	0.405	0.689	1.129	1.585	2.134	3.022	4.199	5.060	6.231	7.103	8.481
1987	0.000	0.013	0.070	0.198	0.427	0.710	1.078	1.635	2.166	2.797	3.844	5.208	6.122	7.379	8.254
1988	0.000	0.013	0.067	0.195	0.416	0.754	1.114	1.561	2.234	2.830	3.535	4.743	6.289	7.241	8.566
1989	0.000	0.013	0.067	0.189	0.411	0.737	1.194	1.617	2.132	2.918	3.567	4.339	5.706	7.425	8.399
1990	0.000	0.014	0.070	0.191	0.398	0.729	1.167	1.744	2.214	2.785	3.677	4.368	5.198	6.718	8.597
1991	0.000	0.014	0.075	0.203	0.408	0.707	1.156	1.709	2.403	2.898	3.511	4.500	5.221	6.100	7.766
1992	0.000	0.014	0.076	0.223	0.442	0.734	1.124	1.694	2.358	3.160	3.659	4.299	5.375	6.115	7.033
1993	0.000	0.014	0.074	0.226	0.496	0.808	1.180	1.650	2.339	3.106	4.005	4.485	5.138	6.290	7.037
1994	0.000	0.015	0.077	0.218	0.502	0.923	1.317	1.750	2.284	3.084	3.943	4.926	5.366	6.017	7.235
1995	0.000	0.015	0.078	0.222	0.475	0.934	1.524	1.975	2.442	3.017	3.919	4.856	5.907	6.289	6.926
1996	0.000	0.016	0.079	0.223	0.481	0.870	1.542	2.310	2.780	3.249	3.841	4.830	5.831	6.933	7.243
1997	0.000	0.016	0.084	0.223	0.475	0.876	1.420	2.335	3.276	3.724	4.160	4.742	5.805	6.853	7.992
1998	0.000	0.016	0.087	0.239	0.469	0.852	1.419	2.129	3.310	4.408	4.790	5.160	5.708	6.827	7.908
1999	0.000	0.017	0.089	0.247	0.506	0.832	1.365	2.115	2.996	4.451	5.682	5.959	6.234	6.724	7.883
2000	0.000	0.017	0.091	0.255	0.526	0.902	1.318	2.015	2.961	4.008	5.734	7.069	7.207	7.362	7.776
2001	0.000	0.017	0.091	0.260	0.543	0.940	1.434	1.927	2.798	3.945	5.148	7.129	8.532	8.509	8.527

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2002	0.000	0.018	0.091	0.255	0.554	0.971	1.497	2.102	2.653	3.702	5.050	6.391	8.599	10.037	9.841
2003	0.000	0.019	0.095	0.253	0.534	0.990	1.549	2.199	2.900	3.486	4.713	6.252	7.711	10.110	11.549
2004	0.000	0.019	0.099	0.263	0.521	0.939	1.578	2.277	3.037	3.816	4.413	5.813	7.528	9.079	11.625
2005	0.000	0.019	0.099	0.273	0.541	0.906	1.477	2.316	3.146	3.999	4.833	5.418	6.980	8.851	10.468
2006	0.000	0.018	0.098	0.273	0.561	0.936	1.409	2.143	3.197	4.142	5.066	5.933	6.483	8.194	10.196
2007	0.000	0.019	0.096	0.270	0.559	0.972	1.448	2.026	2.929	4.204	5.245	6.217	7.094	7.592	9.433
2008	0.000	0.019	0.100	0.265	0.552	0.966	1.504	2.072	2.746	3.822	5.319	6.433	7.429	8.297	8.728
2009	0.000	0.019	0.102	0.273	0.541	0.954	1.493	2.152	2.797	3.558	4.806	6.517	7.682	8.681	9.520
2010	0.000	0.019	0.101	0.279	0.557	0.933	1.473	2.133	2.904	3.610	4.447	5.862	7.775	8.969	9.950
2011	0.000	0.018	0.101	0.275	0.568	0.959	1.438	2.103	2.874	3.747	4.496	5.398	6.971	9.069	10.268
2012	0.000	0.017	0.093	0.274	0.560	0.974	1.475	2.052	2.832	3.703	4.663	5.439	6.396	8.116	10.374
2013	0.000	0.016	0.088	0.254	0.557	0.959	1.495	2.098	2.761	3.648	4.604	5.638	6.425	7.425	9.278
2014	0.000	0.016	0.083	0.240	0.516	0.953	1.470	2.122	2.817	3.554	4.536	5.561	6.655	7.439	8.472
2015	0.000	0.016	0.080	0.226	0.486	0.883	1.459	2.084	2.844	3.618	4.417	5.479	6.559	7.699	8.467
2016	0.000	0.016	0.080	0.217	0.459	0.833	1.354	2.067	2.790	3.646	4.486	5.333	6.462	7.584	8.756
2017	0.000	0.016	0.079	0.216	0.440	0.787	1.278	1.921	2.765	3.575	4.513	5.407	6.290	7.472	8.621
2018	0.000	0.016	0.079	0.216	0.439	0.755	1.209	1.816	2.574	3.539	4.422	5.431	6.365	7.272	8.495
2019	0.000	0.015	0.079	0.215	0.438	0.753	1.161	1.720	2.437	3.300	4.376	5.319	6.384	7.347	8.268
2020	0.000	0.015	0.079	0.214	0.437	0.752	1.157	1.654	2.311	3.129	4.088	5.260	6.250	7.360	8.341
2021	0.000	0.015	0.078	0.213	0.435	0.750	1.156	1.648	2.225	2.972	3.882	4.923	6.178	7.204	8.345
2022	0.000	0.015	0.076	0.212	0.433	0.747	1.153	1.646	2.217	2.864	3.692	4.682	5.794	7.117	8.167
2023	0.000	0.014	0.074	0.207	0.431	0.743	1.149	1.642	2.214	2.854	3.562	4.460	5.518	6.688	8.067

Table 10. Mid-year weight-at-age estimates (kg) from a generalized Von Bertalanffy (VonB2) growth model described in Cadigan (2016b) fitted by cohort to average weight-at-age data for cod from the fall bottom-trawl surveys in Divisions 2J3KL from 1983 onward. Lightly shaded cells are hindcasts from the model.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1955	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1956	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1957	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1958	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1959	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1960	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1961	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1962	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1963	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1964	0.003	0.036	0.139	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1965	0.003	0.035	0.138	0.356	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1966	0.003	0.034	0.132	0.352	0.726	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1967	0.003	0.033	0.126	0.332	0.717	1.278	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1968	0.003	0.033	0.123	0.315	0.671	1.264	2.031	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1969	0.003	0.033	0.122	0.305	0.631	1.174	2.008	2.988	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1970	0.003	0.033	0.122	0.305	0.608	1.097	1.856	2.955	4.137	5.454	6.905	8.451	10.048	11.654	13.230
1971	0.003	0.034	0.126	0.305	0.608	1.052	1.725	2.721	4.093	5.454	6.905	8.451	10.048	11.654	13.230
1972	0.003	0.032	0.130	0.318	0.611	1.054	1.650	2.521	3.762	5.398	6.905	8.451	10.048	11.654	13.230
1973	0.003	0.030	0.121	0.333	0.643	1.062	1.655	2.407	3.478	4.960	6.838	8.451	10.048	11.654	13.230
1974	0.003	0.030	0.110	0.301	0.679	1.127	1.671	2.416	3.316	4.581	6.288	8.373	10.048	11.654	13.230
1975	0.003	0.031	0.110	0.268	0.605	1.200	1.785	2.443	3.332	4.365	5.808	7.714	9.961	11.654	13.230
1976	0.003	0.032	0.113	0.266	0.524	1.052	1.912	2.623	3.373	4.390	5.534	7.133	9.201	11.561	13.230

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1977	0.003	0.033	0.115	0.274	0.518	0.893	1.660	2.822	3.634	4.447	5.569	6.799	8.524	10.715	13.133
1978	0.003	0.034	0.120	0.277	0.536	0.881	1.386	2.431	3.921	4.801	5.645	6.844	8.134	9.952	12.220
1979	0.003	0.034	0.119	0.289	0.539	0.913	1.362	2.004	3.361	5.188	6.100	6.941	8.190	9.509	11.385
1980	0.003	0.035	0.118	0.283	0.562	0.913	1.414	1.964	2.745	4.437	6.592	7.498	8.307	9.576	10.898
1981	0.003	0.036	0.122	0.277	0.542	0.951	1.409	2.042	2.685	3.601	5.638	8.096	8.963	9.712	10.974
1982	0.003	0.034	0.126	0.285	0.524	0.906	1.463	2.027	2.792	3.516	4.559	6.939	9.660	10.459	11.128
1983	0.003	0.035	0.121	0.294	0.537	0.865	1.378	2.101	2.764	3.657	4.446	5.604	8.311	11.243	11.953
1984	0.003	0.036	0.123	0.282	0.554	0.884	1.302	1.959	2.859	3.611	4.624	5.460	6.719	9.723	12.807
1985	0.003	0.035	0.128	0.289	0.530	0.913	1.328	1.834	2.644	3.727	4.556	5.677	6.542	7.885	11.146
1986	0.003	0.034	0.124	0.303	0.545	0.872	1.370	1.864	2.455	3.422	4.693	5.583	6.799	7.675	9.082
1987	0.003	0.033	0.123	0.295	0.577	0.899	1.308	1.923	2.488	3.157	4.285	5.740	6.676	7.969	8.840
1988	0.003	0.033	0.118	0.291	0.563	0.960	1.353	1.836	2.566	3.190	3.930	5.218	6.851	7.817	9.169
1989	0.003	0.034	0.119	0.281	0.556	0.938	1.455	1.904	2.449	3.288	3.961	4.763	6.207	8.007	8.987
1990	0.003	0.036	0.125	0.286	0.539	0.928	1.424	2.061	2.546	3.140	4.081	4.789	5.644	7.239	9.190
1991	0.003	0.036	0.136	0.308	0.556	0.902	1.411	2.020	2.769	3.269	3.898	4.931	5.663	6.563	8.298
1992	0.003	0.036	0.137	0.342	0.608	0.941	1.373	2.004	2.720	3.572	4.065	4.712	5.828	6.573	7.509
1993	0.004	0.037	0.134	0.346	0.688	1.044	1.449	1.954	2.700	3.514	4.457	4.920	5.573	6.760	7.507
1994	0.004	0.038	0.137	0.330	0.697	1.201	1.627	2.081	2.639	3.491	4.390	5.409	5.823	6.469	7.714
1995	0.004	0.039	0.138	0.336	0.654	1.215	1.894	2.360	2.831	3.418	4.366	5.336	6.415	6.763	7.388
1996	0.004	0.041	0.140	0.334	0.660	1.125	1.916	2.771	3.236	3.692	4.283	5.311	6.337	7.459	7.727
1997	0.004	0.042	0.149	0.332	0.647	1.128	1.755	2.801	3.822	4.243	4.650	5.218	6.311	7.377	8.528
1998	0.004	0.043	0.154	0.357	0.636	1.091	1.748	2.544	3.861	5.029	5.363	5.689	6.211	7.352	8.443
1999	0.004	0.044	0.158	0.371	0.687	1.059	1.673	2.520	3.485	5.077	6.364	6.575	6.792	7.247	8.419
2000	0.004	0.044	0.162	0.382	0.715	1.150	1.607	2.390	3.437	4.564	6.420	7.793	7.853	7.941	8.311
2001	0.004	0.045	0.160	0.390	0.739	1.200	1.751	2.276	3.235	4.484	5.758	7.857	9.282	9.173	9.117

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2002	0.004	0.047	0.159	0.379	0.753	1.241	1.830	2.486	3.057	4.195	5.640	7.043	9.352	10.794	10.509
2003	0.004	0.049	0.167	0.373	0.720	1.265	1.895	2.602	3.345	3.939	5.253	6.883	8.391	10.869	12.297
2004	0.004	0.049	0.173	0.388	0.699	1.192	1.929	2.695	3.504	4.313	4.907	6.389	8.185	9.773	12.374
2005	0.004	0.048	0.173	0.402	0.724	1.143	1.794	2.740	3.629	4.520	5.374	5.944	7.582	9.523	11.162
2006	0.004	0.048	0.171	0.401	0.751	1.178	1.704	2.522	3.686	4.681	5.632	6.507	7.033	8.811	10.869
2007	0.005	0.049	0.168	0.396	0.748	1.223	1.747	2.374	3.364	4.750	5.830	6.817	7.692	8.158	10.056
2008	0.005	0.050	0.173	0.389	0.738	1.215	1.815	2.423	3.141	4.304	5.909	7.052	8.052	8.907	9.300
2009	0.005	0.050	0.177	0.401	0.722	1.199	1.800	2.516	3.193	3.994	5.326	7.140	8.322	9.315	10.134
2010	0.004	0.050	0.175	0.409	0.743	1.172	1.774	2.491	3.315	4.045	4.916	6.411	8.419	9.618	10.585
2011	0.004	0.046	0.175	0.403	0.756	1.203	1.732	2.456	3.278	4.197	4.961	5.892	7.540	9.721	10.917
2012	0.004	0.044	0.162	0.402	0.745	1.220	1.773	2.395	3.231	4.145	5.145	5.927	6.907	8.696	11.024
2013	0.004	0.041	0.153	0.372	0.741	1.201	1.796	2.446	3.148	4.084	5.076	6.143	6.929	7.947	9.860
2014	0.004	0.040	0.144	0.350	0.686	1.192	1.765	2.472	3.208	3.978	5.001	6.056	7.175	7.952	8.998
2015	0.004	0.040	0.138	0.331	0.647	1.106	1.751	2.427	3.236	4.045	4.869	5.966	7.069	8.227	8.983
2016	0.004	0.040	0.138	0.317	0.611	1.044	1.626	2.406	3.174	4.073	4.941	5.807	6.965	8.101	9.285
2017	0.004	0.040	0.137	0.316	0.586	0.986	1.536	2.237	3.144	3.992	4.967	5.882	6.779	7.983	9.140
2018	0.004	0.039	0.137	0.316	0.584	0.947	1.454	2.117	2.929	3.951	4.866	5.904	6.854	7.769	9.008
2019	0.004	0.039	0.137	0.315	0.583	0.944	1.397	2.006	2.775	3.687	4.813	5.781	6.870	7.843	8.768
2020	0.004	0.039	0.136	0.314	0.582	0.943	1.392	1.930	2.633	3.499	4.500	5.715	6.725	7.852	8.839
2021	0.004	0.038	0.135	0.312	0.580	0.940	1.390	1.923	2.536	3.325	4.276	5.355	6.646	7.685	8.839
2022	0.004	0.037	0.132	0.311	0.577	0.937	1.387	1.920	2.527	3.207	4.071	5.096	6.238	7.591	8.650
2023	0.004	0.036	0.129	0.304	0.574	0.932	1.383	1.916	2.524	3.195	3.930	4.859	5.946	7.140	8.542

Table 11. Acoustic biomass estimates (t) for Smith Sound, Trinity Bay, from Rose et al. (2011). SE^2 equals the standard error squared of the biomass estimate.

Year	Month	Biomass	SE^2
1995	5.5	11,000	4,000
1997	6.0	14,800	4,500
1998	6.0	15,000	4,500
1999	1.0	15,000	5,000
2000	1.0	17,558	7,000
2001	1.0	25,363	8,800
2002	1.0	22,733	6,800
2003	1.0	19,628	2,720
2004	1.0	17,800	2,000
2006	1.0	17,322	1,273
2007	2.0	14,024	3,222
2008	2.0	7,147	1,053
2009	4.0	600	350

Table 12. Age composition of cod sampled during acoustic surveys in Smith Sound during 1995-2003. For details see Rose et al. (2011).

Age	1995	1998	1999	2000	2001	2002	2003
0	0	0	0	0	0	0	0
1	0	0	3	2	5	0	0
2	0	6	22	10	19	5	2
3	0	15	17	153	38	18	20
4	8	13	144	366	93	68	152
5	69	42	92	251	80	198	121
6	49	168	99	137	79	70	105
7	17	66	194	100	46	53	37
8	5	236	63	259	37	25	13
9	2	63	127	92	66	25	5
10	0	2	34	153	23	59	1
11	0	2	5	32	38	11	10
12	0	0	8	8	8	42	3
13	0	0	0	0	0	4	10
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0

Table 13. Standardized age-disaggregated sentinel gill-net (5½" mesh) catch rates (fish/net) of cod in NAFO Divisions 2J3KL from 1995 onward. A dot (.) indicates no data.

Year	3	4	5	6	7	8	9	10
1995	0.002	0.046	1.057	1.387	0.565	0.322	0.082	0.017
1996	0.031	0.129	0.887	4.915	2.044	0.594	0.131	0.034
1997	0.017	0.083	1.378	2.060	3.705	0.921	0.120	0.050
1998	0.032	0.079	1.058	5.202	3.371	1.848	0.514	0.067
1999	0.013	0.095	1.102	1.942	2.672	0.784	0.412	0.102
2000	0.015	0.066	0.680	1.124	0.787	0.975	0.436	0.208
2001	0.009	0.050	0.295	0.729	0.489	0.227	0.287	0.103
2002	0.019	0.051	0.369	0.583	0.486	0.218	0.118	0.141
2003	0.028	0.073	0.323	1.264	0.771	0.287	0.127	0.051
2004	0.012	0.117	0.708	1.221	1.279	0.398	0.137	0.040
2005	0.023	0.072	1.349	2.021	1.086	0.518	0.189	0.052
2006	0.012	0.308	1.051	2.489	1.211	0.412	0.192	0.067
2007	0.025	0.062	2.035	2.858	1.367	0.441	0.135	0.064
2008	0.020	0.075	0.417	4.280	2.711	0.814	0.218	0.062
2009	0.018	0.047	0.288	0.846	2.768	1.704	0.416	0.101
2010	0.010	0.024	0.246	1.285	1.232	2.152	1.003	0.236
2011	0.013	0.045	0.285	1.037	1.795	1.269	1.401	0.566
2012	0.029	0.083	1.074	2.150	2.354	1.598	0.877	0.914
2013	0.007	0.081	0.952	3.640	2.599	1.893	1.110	0.594
2014	0.027	0.103	2.038	4.500	4.467	1.829	1.025	0.436
2015	0.011	0.077	0.884	5.191	4.699	2.248	0.919	0.437
2016	0.002	0.034	0.406	1.641	4.163	2.560	1.348	0.631
2017	0.001	0.020	0.234	1.601	2.342	3.666	1.721	0.830

Year	3	4	5	6	7	8	9	10
2018	0.003	0.013	0.140	1.295	4.266	2.764	1.863	0.836
2019	0.004	0.017	0.093	0.518	2.095	4.134	2.079	1.907
2020	0.004	0.053	0.104	0.697	2.045	2.921	3.362	1.807
2021	.	0.027	0.316	1.186	1.686	2.188	2.642	1.721
2022	0.001	0.058	0.233	1.341	2.189	1.851	1.832	1.295
2023	0.009	0.020	0.268	1.595	2.587	3.186	1.944	1.129

Table 14. Number of cod per tow at-age in the Fleming and Newman Sound juvenile cod surveys from 1959 onward. Net material was changed from cotton to nylon in 1991. A dot (.) indicates no data.

Year	Fleming (Age 0)	Fleming (Age 1)	Newman Sound (Age 0)	Newman Sound (Age 1)
1958	.	.	.	.
1959	55.67	16.62	.	.
1960	12.61	36.24	.	.
1961	6.53	15.40	.	.
1962	15.04	3.25	.	.
1963	6.30	12.63	.	.
1964	6.59	20.63	.	.
1965	.	.	.	.
1991	.	.	.	.
1992	6.88	3.46	.	.
1993	9.92	6.84	.	.
1994	10.88	10.12	.	.
1995	11.69	1.00	.	.
1996	6.13	1.77	2.91	1.46
1997	10.81	0.91	.	.
1998	.	.	31.38	0.95
1999	.	.	62.07	1.01
2000	.	.	11.09	3.88
2001	5.51	1.67	6.27	4.63
2002	.	.	16.53	2.04
2003	.	.	2.12	5.61
2004	.	.	4.66	0.55

Year	Fleming (Age 0)	Fleming (Age 1)	Newman Sound (Age 0)	Newman Sound (Age 1)
2005	.	.	4.51	0.85
2006	.	.	1.78	0.02
2007	.	.	34.80	0.12
2008	.	.	8.68	2.15
2009	.	.	17.87	0.18
2010	.	.	1.96	0.55
2011	.	.	15.30	2.52
2012	.	.	44.08	0.93
2013	.	.	112.33	2.56
2014	.	.	54.47	12.63
2015	.	.	54.29	1.27
2016	.	.	70.18	6.44
2017	.	.	56.83	8.92
2018	.	.	10.66	4.02
2019	.	.	23.27	3.47
2020	10.69	1.35	8.97	1.12
2021	12.41	1.93	27.40	1.86
2022	.	.	4.43	0.62
2023	.	.	61.30	0.28

Table 15. Blocks of lower (CL) and upper (CU) catch bounds. Upper catch bounds were lowered when recreational catch estimates were available. A dot (.) indicates no data.

Years	Recreational Catch (t)	Lower bound (CL)	Upper bound (CU)
1954–77	.	1.1	2.000
1978–91	.	1.1	1.500
1992–2005	.	1.1	2.000
2006	380	1.1	1.352
2007	.	1.1	1.573
2008	1,089	1.1	1.190
2009–10	.	1.1	1.573
2011	289	1.1	1.449
2012	433	1.1	1.397
2013–23	.	1.1	1.573

Table 16. Estimates of model fits, population parameters and variance parameters, with coefficients of variation from xteNCAM (RV = DFO Research Vessel survey; SN = Sentinel survey; SS = Smith Sound; D = proportion of stock in Smith Sound; NB = negative binomial). A dot (.) indicates not applicable.

Quantity	Symbol	Estimate	CV
Number of parameters	k	203	.
Negative log-likelihood	$\ln(L)$	18,470	.
Akaike information criterion	AIC	37,346	.
RV survey observation error	σ_{RV}	0.434	0.048
SN survey observation error (age 3)	σ_{SN_a}	0.651	0.163
SN survey observation error (ages 4–14)		0.153	0.114
Age correlation in SN q	$\varphi_{SN_q,age}$	0.870	0.296
Year correlation in SN q	$\varphi_{SN_q,year}$	0.888	0.342
SN q variance parameter	σ_{SN_q}	0.796	0.139
Age composition error (ages 0–2)	σ_{P_a}	1.774	0.108
Age composition error (ages 3–4)		0.809	0.095
Age composition error (ages 5–14)		0.313	0.047
Age correlation in process errors	$\varphi_{\delta,age}$	0.823	0.379
Year correlation in process errors	$\varphi_{\delta,year}$	0.854	0.393
Process error variance	σ_{δ}	0.237	0.133
Age correlation in F	$\varphi_{F,age}$	0.904	0.355
Year correlation in F	$\varphi_{F,year}$	0.998	0.437
F variance parameter	σ_F	0.202	0.054
D variance parameter	σ_D	0.659	0.192
Age correlation in D	$\varphi_{D,age}$	0.870	0.478
Year correlation in D	$\varphi_{D,year}$	0.897	0.506
S-R relationship parameter	α_{SSB}	11.153	0.396

Quantity	Symbol	Estimate	CV
S-R relationship parameter	$\log(\beta_{SSB})$	-11.568	0.430
Variance of log-recruitment	σ_r	0.267	0.178
Baseline level of natural mortality	m	0.299	0.288
Effect of the capelin/cod ratio on M	β_{cap}	-0.395	0.114
Variance of tagging F deviations (pre-1997)	$\sigma_{f_{x,1}}$	0.949	0.079
Variance of tagging F deviations (post-1997)	$\sigma_{f_{x,2}}$	1.038	0.074
NB overdispersion parameter for pre-1997 tag experiments	κ_1	16.033	0.093
NB overdispersion parameter for post-1997 tag experiments	κ_2	8.080	0.149
Juvenile survey observation error	σ_{juv}	1.160	0.084
Limit reference point (kt)	B_{lim}	275.935	0.218
2024 spawning stock biomass (kt)	SSB_{2024}	341.682	0.168
2024 relative spawning stock biomass	SSB_{2024}/B_{lim}	1.238	0.273
2024 total biomass (kt)	B_{2024}	519.568	0.152
2023 average total mortality	$\bar{Z}_{5+,2023}$	0.612	0.313
2023 average natural mortality	$\bar{M}_{5+,2023}$	0.593	0.323
2023 average fishing mortality	$\bar{F}_{5+,2023}$	0.019	0.146

Table 17. Northern cod stock size estimates with lower and upper 95% confidence intervals indicated in parentheses.

Year	Abundance (lower CI, upper CI) in millions	Age 0 recruits (lower CI, upper CI) in millions	Biomass (lower CI, upper CI) in kt	SSB (lower CI, upper CI) in kt	SSB / Blim (lower CI, upper CI)
1954	3,507 (2,162, 5,688)	925 (462, 1,850)	1,715 (1,137, 2,588)	887 (519, 1,517)	3.22 (1.42, 7.27)
1955	3,566 (2,260, 5,627)	984 (526, 1,841)	1,715 (1,137, 2,588)	887 (519, 1,517)	3.22 (1.42, 7.27)
1956	3,754 (2,455, 5,743)	1,128 (638, 1,995)	1,725 (1,173, 2,537)	898 (558, 1,444)	3.25 (1.51, 7.00)
1957	4,214 (2,837, 6,259)	1,427 (839, 2,428)	1,785 (1,242, 2,565)	952 (618, 1,466)	3.45 (1.66, 7.18)
1958	4,303 (2,965, 6,247)	1,119 (645, 1,941)	1,901 (1,355, 2,666)	1,036 (692, 1,551)	3.76 (1.85, 7.63)
1959	4,451 (3,099, 6,393)	1,076 (602, 1,923)	2,177 (1,603, 2,957)	1,225 (854, 1,758)	4.44 (2.28, 8.65)
1960	4,430 (3,112, 6,305)	916 (502, 1,671)	2,471 (1,856, 3,289)	1,395 (996, 1,953)	5.06 (2.67, 9.56)
1961	4,533 (3,206, 6,408)	1,066 (603, 1,886)	2,703 (2,060, 3,548)	1,485 (1,076, 2,049)	5.38 (2.90, 9.97)
1962	4,712 (3,369, 6,590)	1,240 (724, 2,122)	2,838 (2,244, 3,589)	1,508 (1,149, 1,979)	5.46 (3.05, 9.78)
1963	4,826 (3,489, 6,676)	1,250 (736, 2,125)	2,844 (2,310, 3,502)	1,447 (1,145, 1,829)	5.24 (2.99, 9.20)
1964	4,640 (3,357, 6,414)	1,042 (596, 1,821)	2,589 (2,102, 3,190)	1,377 (1,107, 1,714)	4.99 (2.87, 8.68)
1965	4,431 (3,181, 6,173)	985 (553, 1,755)	2,184 (1,744, 2,735)	1,144 (902, 1,449)	4.14 (2.34, 7.34)
1966	4,397 (3,153, 6,133)	1,019 (576, 1,801)	2,075 (1,663, 2,590)	1,023 (801, 1,305)	3.71 (2.08, 6.61)
1967	4,534 (3,251, 6,321)	1,196 (694, 2,060)	2,005 (1,613, 2,493)	907 (707, 1,164)	3.29 (1.83, 5.90)
1968	4,856 (3,462, 6,812)	1,426 (824, 2,469)	2,029 (1,639, 2,512)	947 (746, 1,203)	3.43 (1.93, 6.10)
1969	4,527 (3,218, 6,368)	937 (504, 1,742)	1,897 (1,508, 2,386)	951 (741, 1,221)	3.45 (1.93, 6.15)
1970	4,239 (2,959, 6,073)	903 (447, 1,822)	1,724 (1,329, 2,237)	865 (647, 1,157)	3.14 (1.72, 5.72)
1971	3,952 (2,716, 5,750)	890 (441, 1,796)	1,664 (1,250, 2,214)	800 (581, 1,101)	2.9 (1.57, 5.34)
1972	3,691 (2,506, 5,436)	1,016 (559, 1,848)	1,591 (1,149, 2,203)	791 (562, 1,113)	2.87 (1.55, 5.29)
1973	3,678 (2,463, 5,493)	1,392 (815, 2,380)	1,378 (930, 2,042)	742 (495, 1,113)	2.69 (1.42, 5.10)
1974	3,441 (2,330, 5,082)	1,128 (652, 1,950)	1,094 (745, 1,607)	702 (474, 1,039)	2.54 (1.36, 4.76)
1975	3,397 (2,310, 4,996)	1,071 (589, 1,947)	830 (588, 1,174)	549 (378, 797)	1.99 (1.07, 3.69)

Year	Abundance (lower CI, upper CI) in millions	Age 0 recruits (lower CI, upper CI) in millions	Biomass (lower CI, upper CI) in kt	SSB (lower CI, upper CI) in kt	SSB / Blim (lower CI, upper CI)
1976	3,078 (2,119, 4,471)	626 (323, 1,212)	671 (510, 882)	351 (260, 473)	1.27 (0.71, 2.29)
1977	2,896 (2,045, 4,101)	597 (330, 1,077)	656 (510, 842)	219 (164, 292)	0.79 (0.44, 1.42)
1978	3,223 (2,374, 4,377)	1,111 (706, 1,750)	706 (562, 886)	189 (145, 246)	0.69 (0.39, 1.20)
1979	3,474 (2,667, 4,526)	1,129 (748, 1,702)	764 (624, 936)	261 (210, 326)	0.95 (0.56, 1.60)
1980	3,790 (2,980, 4,820)	1,158 (771, 1,738)	847 (710, 1,011)	359 (299, 431)	1.3 (0.79, 2.14)
1981	4,480 (3,539, 5,672)	1,521 (1,011, 2,290)	936 (807, 1,086)	435 (371, 509)	1.57 (0.98, 2.54)
1982	4,876 (3,877, 6,132)	1,324 (858, 2,042)	1,070 (938, 1,221)	464 (402, 536)	1.68 (1.06, 2.68)
1983	4,577 (3,666, 5,714)	727 (433, 1,220)	1,171 (1,028, 1,334)	427 (372, 490)	1.55 (0.98, 2.45)
1984	4,350 (3,449, 5,487)	668 (378, 1,182)	1,331 (1,153, 1,538)	488 (421, 566)	1.77 (1.12, 2.80)
1985	4,389 (3,402, 5,662)	931 (539, 1,607)	1,518 (1,303, 1,768)	593 (505, 696)	2.15 (1.34, 3.44)
1986	4,793 (3,679, 6,244)	1,380 (852, 2,234)	1,659 (1,407, 1,954)	611 (515, 725)	2.21 (1.38, 3.54)
1987	5,458 (4,163, 7,157)	1,711 (1,060, 2,764)	1,836 (1,523, 2,214)	779 (632, 959)	2.82 (1.75, 4.55)
1988	5,067 (3,891, 6,599)	1,066 (616, 1,845)	1,659 (1,351, 2,039)	853 (672, 1,083)	3.09 (1.91, 5.00)
1989	4,962 (3,781, 6,512)	1,086 (594, 1,986)	1,569 (1,310, 1,879)	864 (696, 1,072)	3.13 (1.93, 5.07)
1990	4,866 (3,670, 6,453)	1,072 (565, 2,035)	1,547 (1,299, 1,841)	738 (592, 919)	2.67 (1.65, 4.33)
1991	4,474 (3,355, 5,966)	907 (467, 1,760)	1,512 (1,263, 1,810)	600 (478, 754)	2.18 (1.34, 3.52)
1992	3,457 (2,465, 4,848)	868 (445, 1,694)	959 (744, 1,238)	352 (265, 468)	1.28 (0.77, 2.11)
1993	1,793 (1,169, 2,750)	463 (216, 992)	243 (179, 331)	79 (54, 115)	0.29 (0.16, 0.50)
1994	828 (495, 1,386)	197 (86, 454)	78 (55, 110)	22 (15, 31)	0.08 (0.05, 0.14)
1995	365 (201, 663)	145 (69, 304)	28 (22, 36)	10 (8, 13)	0.04 (0.02, 0.06)
1996	341 (194, 598)	144 (67, 309)	36 (29, 45)	15 (12, 19)	0.06 (0.03, 0.09)
1997	416 (239, 725)	206 (100, 425)	44 (37, 53)	20 (17, 23)	0.07 (0.05, 0.11)
1998	525 (301, 914)	261 (126, 540)	54 (46, 63)	28 (25, 32)	0.1 (0.07, 0.16)

Year	Abundance (lower CI, upper CI) in millions	Age 0 recruits (lower CI, upper CI) in millions	Biomass (lower CI, upper CI) in kt	SSB (lower CI, upper CI) in kt	SSB / Blim (lower CI, upper CI)
1999	683 (395, 1,182)	337 (165, 688)	67 (57, 78)	35 (31, 39)	0.13 (0.08, 0.20)
2000	769 (453, 1,305)	315 (153, 648)	81 (67, 98)	34 (31, 38)	0.12 (0.08, 0.19)
2001	722 (435, 1,199)	259 (125, 537)	84 (68, 104)	31 (27, 35)	0.11 (0.07, 0.17)
2002	726 (440, 1,198)	336 (174, 648)	71 (56, 90)	25 (22, 28)	0.09 (0.06, 0.14)
2003	563 (339, 937)	154 (67, 354)	62 (50, 76)	23 (21, 26)	0.08 (0.05, 0.13)
2004	502 (304, 829)	187 (88, 397)	61 (50, 75)	21 (18, 25)	0.08 (0.05, 0.12)
2005	571 (357, 914)	225 (111, 457)	86 (71, 105)	26 (22, 31)	0.09 (0.06, 0.15)
2006	698 (439, 1,111)	287 (141, 585)	125 (104, 150)	41 (35, 48)	0.15 (0.09, 0.23)
2007	997 (605, 1,641)	496 (244, 1,008)	165 (138, 198)	83 (70, 98)	0.3 (0.19, 0.48)
2008	1,243 (762, 2,029)	549 (276, 1,091)	198 (164, 239)	117 (95, 143)	0.42 (0.27, 0.67)
2009	1,344 (840, 2,151)	576 (301, 1,103)	192 (157, 235)	99 (81, 121)	0.36 (0.22, 0.58)
2010	1,234 (790, 1,928)	420 (215, 820)	197 (160, 242)	91 (76, 110)	0.33 (0.21, 0.53)
2011	1,336 (883, 2,022)	603 (343, 1,060)	200 (167, 240)	90 (75, 108)	0.33 (0.21, 0.52)
2012	1,613 (1,090, 2,388)	708 (405, 1,237)	243 (206, 287)	112 (96, 132)	0.41 (0.26, 0.64)
2013	1,928 (1,306, 2,845)	759 (412, 1,398)	328 (280, 385)	167 (142, 196)	0.6 (0.39, 0.95)
2014	2,153 (1,464, 3,165)	730 (386, 1,382)	439 (373, 515)	238 (202, 280)	0.86 (0.55, 1.35)
2015	2,437 (1,668, 3,561)	915 (506, 1,655)	533 (454, 625)	273 (235, 319)	0.99 (0.63, 1.57)
2016	2,771 (1,933, 3,974)	1,103 (647, 1,881)	620 (528, 729)	339 (291, 395)	1.23 (0.78, 1.94)
2017	2,799 (1,976, 3,965)	885 (498, 1,572)	700 (590, 830)	451 (381, 534)	1.63 (1.04, 2.57)
2018	2,868 (1,983, 4,149)	1,127 (636, 1,996)	579 (483, 694)	369 (303, 448)	1.34 (0.83, 2.15)
2019	2,674 (1,854, 3,855)	679 (332, 1,388)	648 (548, 767)	400 (335, 479)	1.45 (0.91, 2.30)
2020	2,682 (1,837, 3,916)	877 (451, 1,706)	694 (574, 839)	414 (340, 505)	1.5 (0.94, 2.39)
2021	2,543 (1,723, 3,754)	858 (436, 1,688)	659 (536, 810)	423 (347, 516)	1.53 (0.95, 2.47)

Year	Abundance (lower CI, upper CI) in millions	Age 0 recruits (lower CI, upper CI) in millions	Biomass (lower CI, upper CI) in kt	SSB (lower CI, upper CI) in kt	SSB / Blim (lower CI, upper CI)
2022	2,410 (1,610,3,609)	779 (371, 1,636)	676 (526, 869)	462 (357, 598)	1.67 (1.02, 2.74)
2023	2,486 (1,642,3,762)	987 (498, 1,955)	635 (480, 841)	425 (314, 575)	1.54 (0.93, 2.56)
2024	2,419 (1,565,3,739)	900 (444, 1,822)	520 (385, 700)	342 (246, 475)	1.24 (0.72, 2.12)

Table 18. Northern cod mortality rate estimates with lower and upper 95% confidence intervals indicated in parentheses. Z = total mortality; M = natural mortality; and F = fishing mortality.

Year	Average Z (lower CI, upper CI) for Ages 5+	Average M (lower CI, upper CI) for Ages 5+	Average F (lower CI, upper CI) for Ages 5+
1954	0.476 (0.380, 0.597)	0.187 (0.086, 0.407)	0.289 (0.156, 0.536)
1955	0.472 (0.380, 0.587)	0.187 (0.086, 0.407)	0.285 (0.191, 0.425)
1956	0.449 (0.340, 0.592)	0.162 (0.064, 0.413)	0.287 (0.191, 0.431)
1957	0.423 (0.308, 0.582)	0.147 (0.053, 0.407)	0.276 (0.178, 0.428)
1958	0.355 (0.250, 0.504)	0.13 (0.045, 0.372)	0.225 (0.144, 0.349)
1959	0.371 (0.268, 0.512)	0.118 (0.041, 0.341)	0.253 (0.168, 0.379)
1960	0.406 (0.303, 0.543)	0.114 (0.040, 0.327)	0.292 (0.202, 0.422)
1961	0.42 (0.305, 0.578)	0.115 (0.042, 0.315)	0.305 (0.200, 0.465)
1962	0.425 (0.322, 0.562)	0.117 (0.045, 0.300)	0.309 (0.218, 0.436)
1963	0.555 (0.474, 0.650)	0.119 (0.046, 0.310)	0.435 (0.355, 0.535)
1964	0.704 (0.619, 0.800)	0.12 (0.046, 0.317)	0.583 (0.476, 0.714)
1965	0.625 (0.539, 0.724)	0.12 (0.044, 0.333)	0.504 (0.402, 0.633)
1966	0.624 (0.531, 0.734)	0.116 (0.042, 0.318)	0.508 (0.401, 0.645)
1967	0.55 (0.457, 0.663)	0.115 (0.044, 0.305)	0.435 (0.339, 0.558)
1968	0.639 (0.533, 0.765)	0.12 (0.045, 0.318)	0.519 (0.407, 0.662)
1969	0.682 (0.558, 0.834)	0.127 (0.046, 0.348)	0.556 (0.424, 0.728)
1970	0.61 (0.477, 0.781)	0.139 (0.053, 0.363)	0.471 (0.342, 0.649)
1971	0.579 (0.436, 0.769)	0.165 (0.069, 0.392)	0.414 (0.292, 0.589)
1972	0.627 (0.463, 0.849)	0.215 (0.094, 0.493)	0.412 (0.289, 0.586)
1973	0.678 (0.487, 0.943)	0.253 (0.104, 0.620)	0.425 (0.285, 0.633)
1974	0.77 (0.573, 1.033)	0.225 (0.082, 0.619)	0.544 (0.375, 0.791)
1975	0.875 (0.653, 1.171)	0.202 (0.071, 0.573)	0.673 (0.454, 0.997)

Year	Average Z (lower CI, upper CI) for Ages 5+	Average M (lower CI, upper CI) for Ages 5+	Average F (lower CI, upper CI) for Ages 5+
1976	0.849 (0.665, 1.083)	0.209 (0.077, 0.566)	0.64 (0.461, 0.889)
1977	0.755 (0.578, 0.988)	0.255 (0.103, 0.632)	0.501 (0.368, 0.681)
1978	0.65 (0.495, 0.853)	0.273 (0.132, 0.567)	0.377 (0.284, 0.499)
1979	0.564 (0.445, 0.716)	0.235 (0.124, 0.447)	0.329 (0.260, 0.417)
1980	0.56 (0.444, 0.705)	0.23 (0.123, 0.430)	0.329 (0.270, 0.402)
1981	0.562 (0.455, 0.694)	0.233 (0.133, 0.408)	0.328 (0.278, 0.388)
1982	0.675 (0.553, 0.824)	0.262 (0.151, 0.454)	0.413 (0.355, 0.480)
1983	0.617 (0.468, 0.814)	0.294 (0.167, 0.518)	0.323 (0.270, 0.386)
1984	0.583 (0.410, 0.830)	0.32 (0.167, 0.613)	0.263 (0.217, 0.319)
1985	0.555 (0.441, 0.698)	0.255 (0.155, 0.420)	0.3 (0.248, 0.363)
1986	0.43 (0.333, 0.555)	0.186 (0.110, 0.316)	0.243 (0.194, 0.305)
1987	0.632 (0.475, 0.842)	0.404 (0.262, 0.623)	0.228 (0.181, 0.287)
1988	0.633 (0.466, 0.861)	0.405 (0.246, 0.667)	0.228 (0.181, 0.287)
1989	0.644 (0.483, 0.858)	0.414 (0.264, 0.650)	0.23 (0.185, 0.286)
1990	0.672 (0.502, 0.900)	0.449 (0.291, 0.693)	0.223 (0.179, 0.279)
1991	1.265 (1.003, 1.595)	1.002 (0.757, 1.328)	0.262 (0.206, 0.334)
1992	2.684 (2.281, 3.158)	2.451 (2.046, 2.936)	0.233 (0.178, 0.305)
1993	2.897 (2.384, 3.520)	2.701 (2.176, 3.353)	0.196 (0.140, 0.275)
1994	2.04 (1.606, 2.592)	1.941 (1.499, 2.512)	0.099 (0.070, 0.142)
1995	0.43 (0.267, 0.693)	0.386 (0.225, 0.662)	0.044 (0.034, 0.058)
1996	0.431 (0.286, 0.649)	0.353 (0.211, 0.590)	0.078 (0.063, 0.096)
1997	0.4 (0.271, 0.590)	0.352 (0.225, 0.550)	0.048 (0.040, 0.057)
1998	0.465 (0.329, 0.656)	0.337 (0.206, 0.548)	0.128 (0.109, 0.151)

Year	Average Z (lower CI, upper CI) for Ages 5+	Average M (lower CI, upper CI) for Ages 5+	Average F (lower CI, upper CI) for Ages 5+
1999	0.627 (0.456, 0.862)	0.43 (0.266, 0.693)	0.198 (0.170, 0.230)
2000	0.824 (0.621, 1.092)	0.697 (0.498, 0.975)	0.127 (0.108, 0.149)
2001	1.055 (0.819, 1.358)	0.896 (0.661, 1.214)	0.159 (0.134, 0.188)
2002	0.893 (0.678, 1.176)	0.745 (0.531, 1.045)	0.148 (0.125, 0.175)
2003	0.842 (0.592, 1.198)	0.77 (0.521, 1.136)	0.072 (0.060, 0.088)
2004	0.422 (0.253, 0.705)	0.383 (0.217, 0.677)	0.039 (0.030, 0.051)
2005	0.363 (0.203, 0.651)	0.33 (0.173, 0.628)	0.033 (0.026, 0.042)
2006	0.412 (0.261, 0.650)	0.37 (0.223, 0.613)	0.042 (0.034, 0.053)
2007	0.444 (0.257, 0.767)	0.417 (0.233, 0.746)	0.027 (0.021, 0.034)
2008	0.747 (0.506, 1.103)	0.718 (0.479, 1.077)	0.029 (0.024, 0.035)
2009	0.641 (0.454, 0.903)	0.612 (0.427, 0.877)	0.029 (0.023, 0.037)
2010	0.655 (0.420, 1.022)	0.628 (0.394, 1.001)	0.027 (0.021, 0.035)
2011	0.453 (0.300, 0.685)	0.424 (0.272, 0.661)	0.029 (0.024, 0.036)
2012	0.314 (0.194, 0.508)	0.292 (0.174, 0.490)	0.023 (0.018, 0.028)
2013	0.304 (0.185, 0.501)	0.286 (0.168, 0.486)	0.018 (0.015, 0.023)
2014	0.365 (0.241, 0.555)	0.351 (0.227, 0.542)	0.014 (0.011, 0.018)
2015	0.356 (0.232, 0.545)	0.342 (0.219, 0.533)	0.014 (0.011, 0.017)
2016	0.336 (0.214, 0.527)	0.317 (0.197, 0.511)	0.018 (0.015, 0.023)
2017	0.658 (0.475, 0.911)	0.636 (0.454, 0.891)	0.022 (0.017, 0.027)
2018	0.367 (0.229, 0.590)	0.346 (0.209, 0.574)	0.021 (0.017, 0.026)
2019	0.42 (0.271, 0.651)	0.399 (0.251, 0.632)	0.021 (0.017, 0.027)
2020	0.512 (0.346, 0.760)	0.494 (0.329, 0.743)	0.018 (0.014, 0.024)
2021	0.403 (0.215, 0.755)	0.387 (0.202, 0.744)	0.015 (0.012, 0.020)

Year	Average Z (lower CI, upper CI) for Ages 5+	Average M (lower CI, upper CI) for Ages 5+	Average F (lower CI, upper CI) for Ages 5+
2022	0.476 (0.273, 0.830)	0.459 (0.258, 0.816)	0.017 (0.013, 0.023)
2023	0.612 (0.332, 1.130)	0.593 (0.315, 1.116)	0.019 (0.015, 0.026)

Table 19. Northern cod abundance-at-age estimates (millions) from xteNCAM.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	925	686	529	412	324	239	162	100	60	33	19	10	5	3	2
1955	984	686	529	412	324	239	162	100	60	33	19	10	5	3	2
1956	1,128	730	529	412	324	238	162	100	60	33	19	10	5	3	2
1957	1,427	836	570	414	325	239	161	100	63	36	21	11	6	3	2
1958	1,119	1,058	675	458	332	241	163	101	65	40	23	13	7	4	2
1959	1,076	830	887	564	379	252	171	109	71	46	29	17	10	6	3
1960	916	798	704	755	476	289	176	110	73	50	34	22	13	8	4
1961	1,066	679	673	597	638	361	199	108	69	49	35	25	16	10	6
1962	1,240	791	565	561	498	482	250	122	65	45	33	24	17	12	8
1963	1,250	919	659	470	466	374	337	156	72	40	28	20	15	11	8
1964	1,042	927	776	555	392	341	241	184	81	40	22	14	11	9	6
1965	985	772	789	660	466	286	207	106	75	36	19	11	8	6	5
1966	1,019	731	657	674	560	349	181	99	48	35	19	10	6	5	4
1967	1,196	756	617	560	575	423	220	85	43	23	16	9	5	3	3
1968	1,426	887	629	519	474	438	280	112	39	21	12	8	5	3	2
1969	937	1,058	730	523	435	353	272	131	45	18	11	6	4	3	2
1970	903	695	854	597	434	322	219	122	50	20	9	6	3	2	1
1971	890	669	522	660	478	317	205	110	52	25	11	6	4	2	2
1972	1,016	660	436	352	485	331	195	108	53	26	14	7	4	2	1
1973	1,392	753	366	244	223	303	186	102	54	26	14	8	4	2	1
1974	1,128	1,032	441	207	148	131	160	94	51	25	12	6	4	2	1
1975	1,071	836	728	302	143	91	69	76	42	20	10	4	2	1	1
1976	626	794	643	558	230	93	48	30	30	14	7	3	1	1	1
1977	597	464	627	513	444	153	47	20	12	10	4	2	1	1	0

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1978	1,111	442	359	495	407	291	76	21	9	5	4	2	1	1	0
1979	1,129	824	350	287	397	273	157	37	9	4	2	2	1	1	0
1980	1,158	837	703	299	240	276	159	87	20	5	2	1	1	1	0
1981	1,521	859	741	622	255	167	162	88	48	11	3	1	1	1	1
1982	1,324	1,128	772	667	537	173	94	90	52	28	6	2	1	1	1
1983	727	982	1,019	698	577	347	87	44	47	28	16	4	1	1	0
1984	668	539	893	932	617	391	187	45	24	26	16	9	2	1	0
1985	931	496	475	817	830	449	221	97	25	14	16	10	6	2	1
1986	1,380	690	431	434	733	641	277	115	50	14	8	9	6	3	1
1987	1,711	1,023	601	398	394	597	449	165	67	29	8	5	5	3	2
1988	1,066	1,269	875	520	330	293	372	206	75	34	15	4	2	3	2
1989	1,086	791	1,061	786	446	254	192	184	96	37	17	8	2	1	1
1990	1,072	805	634	935	662	337	163	99	81	45	18	8	4	1	1
1991	907	795	599	537	759	484	206	83	42	32	17	7	3	1	0
1992	868	672	532	384	322	410	185	59	13	5	3	2	1	0	0
1993	463	644	306	158	99	72	39	10	1	0	0	0	0	0	0
1994	197	343	166	60	32	22	5	2	0	0	0	0	0	0	0
1995	145	146	31	23	8	9	3	1	0	0	0	0	0	0	0
1996	144	107	43	19	14	6	6	2	0	0	0	0	0	0	0
1997	206	107	48	26	10	10	4	4	1	0	0	0	0	0	0
1998	261	152	49	30	14	7	6	3	3	1	0	0	0	0	0
1999	337	193	80	34	18	9	4	4	2	2	1	0	0	0	0
2000	315	250	102	57	21	12	5	2	2	1	1	0	0	0	0
2001	259	234	123	59	25	11	5	2	1	1	1	1	0	0	0
2002	336	192	103	59	19	9	3	1	1	0	1	0	0	0	0

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2003	154	249	81	48	18	6	3	1	1	0	0	0	0	0	0
2004	187	114	120	48	21	7	2	1	1	0	0	0	0	0	0
2005	225	138	56	93	35	15	4	1	1	0	0	0	0	0	0
2006	287	167	77	46	76	28	11	3	1	1	0	0	0	0	0
2007	496	213	95	63	38	61	21	6	2	1	0	0	0	0	0
2008	549	368	114	74	50	29	42	12	3	1	0	0	0	0	0
2009	576	407	160	76	51	32	16	17	6	2	0	0	0	0	0
2010	420	427	169	98	49	31	17	8	10	3	1	0	0	0	0
2011	603	311	196	99	61	29	16	9	4	5	2	0	0	0	0
2012	708	447	160	138	74	44	19	9	6	3	3	1	0	0	0
2013	759	525	278	127	115	61	34	13	6	4	2	2	1	0	0
2014	730	563	332	229	109	98	48	24	9	4	3	1	2	1	0
2015	915	541	315	256	188	90	75	32	14	5	3	2	1	1	0
2016	1,103	679	280	214	193	147	67	52	21	9	4	2	1	1	1
2017	885	818	388	186	158	148	111	47	35	13	6	2	1	1	0
2018	1,127	656	470	212	114	98	88	60	21	13	5	2	1	0	0
2019	679	836	385	327	160	87	71	62	40	13	8	3	1	1	0
2020	877	503	490	261	243	119	62	48	39	24	8	5	2	1	0
2021	858	650	223	285	175	167	79	38	28	20	12	4	2	1	0
2022	779	636	300	134	200	126	115	54	26	17	12	7	2	1	1
2023	987	578	291	176	90	139	84	72	33	14	9	7	4	1	1
2024	900	732	252	164	114	59	85	47	36	15	6	4	3	2	1

Table 20. Northern cod biomass-at-age estimates (kt) from xteNCAM.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.22	9.29	40.27	95.06	168.27	233.77	263.60	249.10	211.20	159.29	114.73	73.13	44.98	31.41	20.74
1955	0.23	9.29	40.27	95.06	168.27	233.77	263.60	249.10	211.20	159.29	114.73	73.13	44.98	31.41	20.74
1956	0.26	9.88	40.27	95.06	168.25	233.05	263.72	248.14	213.74	158.30	118.50	76.76	46.52	31.89	21.01
1957	0.33	11.32	43.37	95.58	168.89	233.25	263.03	248.44	222.98	171.62	126.81	86.28	54.44	35.89	22.95
1958	0.26	14.33	51.38	105.84	172.67	235.82	266.10	252.10	229.27	191.24	143.46	100.04	66.26	44.90	26.98
1959	0.25	11.24	67.54	130.29	197.22	246.53	278.44	270.88	249.84	221.34	180.98	133.39	89.25	61.02	39.07
1960	0.21	10.81	53.63	174.33	247.40	282.85	286.85	273.84	258.94	238.88	210.63	170.66	121.83	84.59	55.40
1961	0.25	9.20	51.24	137.75	331.53	353.28	323.52	268.76	244.07	235.53	217.51	190.96	151.42	112.89	75.42
1962	0.29	10.71	43.03	129.62	258.95	471.10	406.68	302.54	229.88	212.68	203.06	183.70	159.67	132.28	93.70
1963	0.29	12.45	50.20	108.50	242.03	365.94	549.29	388.63	255.83	193.43	170.86	153.09	136.78	123.06	93.80
1964	0.24	12.44	59.12	128.12	203.55	332.98	392.87	456.18	285.56	188.85	136.69	111.17	103.79	97.44	80.35
1965	0.23	10.13	59.43	152.33	242.17	279.84	337.16	262.81	264.42	173.86	116.58	83.10	71.63	68.86	61.18
1966	0.24	9.38	47.61	153.92	291.19	341.03	294.21	246.33	171.14	167.86	118.23	76.69	57.88	51.84	47.56
1967	0.28	9.55	43.10	121.29	295.38	413.74	358.00	212.16	152.55	107.48	100.60	71.18	49.31	37.51	32.86
1968	0.33	11.15	42.94	107.15	228.85	423.72	455.73	279.34	139.29	100.54	72.86	62.20	46.88	32.50	25.31
1969	0.22	13.24	49.60	104.80	198.36	318.01	437.41	325.83	160.13	86.17	65.89	45.94	40.97	29.37	21.00
1970	0.21	8.77	57.99	119.47	190.92	272.10	326.50	300.24	178.58	94.55	56.50	43.19	30.88	26.19	18.37
1971	0.21	8.52	36.20	132.23	210.25	257.44	284.37	248.35	180.79	117.26	67.76	42.74	33.64	24.08	20.19
1972	0.24	8.13	30.99	73.02	213.99	269.12	259.45	227.76	171.41	124.85	86.06	51.06	32.76	25.30	17.13
1973	0.32	8.93	24.44	52.61	103.21	247.98	248.75	203.94	160.31	113.89	84.07	57.68	34.58	21.64	15.50
1974	0.26	12.28	27.34	40.91	71.95	112.79	215.41	190.50	144.90	100.43	67.49	45.81	32.65	19.25	12.00
1975	0.25	10.16	45.11	53.66	62.34	83.74	98.68	155.12	121.24	78.36	49.22	27.85	19.62	15.30	9.72
1976	0.15	9.84	40.95	98.69	87.80	75.28	72.81	65.88	87.05	52.80	33.08	17.97	11.82	8.90	7.73
1977	0.14	5.98	40.62	93.52	168.06	105.79	63.39	47.76	36.19	39.80	20.95	13.32	8.74	6.30	5.16

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1978	0.26	5.81	24.28	91.30	159.20	199.33	85.09	42.53	28.85	19.48	21.24	10.62	7.92	5.46	4.19
1979	0.26	10.94	23.78	55.39	156.41	193.81	174.12	61.62	27.24	16.75	11.96	13.96	7.52	5.96	4.25
1980	0.27	11.48	47.63	56.90	98.84	196.50	182.13	144.09	46.29	19.42	12.25	9.03	11.24	6.19	5.04
1981	0.36	12.07	51.91	116.59	102.04	123.41	185.08	151.28	111.31	34.13	15.18	9.83	7.68	9.71	5.55
1982	0.31	15.33	55.69	128.85	208.69	123.03	111.99	152.94	124.48	87.52	26.10	12.16	8.15	6.40	8.57
1983	0.17	13.50	70.58	139.03	230.56	236.79	98.44	77.42	111.83	90.04	62.72	19.04	9.22	6.35	5.37
1984	0.16	7.54	62.94	177.98	254.27	273.17	199.89	73.77	58.21	82.51	67.94	46.52	14.16	7.07	5.33
1985	0.22	6.75	34.50	159.44	327.55	323.76	241.99	151.46	57.33	45.55	64.98	51.97	35.03	11.16	6.11
1986	0.32	9.28	30.46	88.37	296.59	441.75	312.96	182.46	107.37	41.87	34.41	44.00	35.07	24.44	9.15
1987	0.40	13.32	41.89	78.89	167.86	423.62	484.28	269.00	145.82	81.87	32.27	23.46	29.93	24.28	18.98
1988	0.25	16.24	58.90	101.72	137.15	221.39	414.19	321.79	168.25	96.67	52.74	20.11	15.06	18.94	16.03
1989	0.25	10.30	71.10	148.46	183.31	187.38	229.46	297.05	203.91	109.28	61.22	33.16	12.56	9.35	11.94
1990	0.25	10.88	44.30	178.60	263.22	245.32	189.94	172.68	179.66	126.64	67.05	36.41	19.35	7.03	5.36
1991	0.21	10.88	44.76	109.21	309.11	342.36	238.05	142.32	101.32	92.75	60.07	31.74	17.37	8.74	3.28
1992	0.20	9.22	40.31	85.59	142.46	300.95	207.92	99.82	30.75	15.01	11.78	7.79	4.16	2.28	1.06
1993	0.11	9.14	22.77	35.76	49.01	58.20	46.44	16.74	2.46	1.17	0.53	0.50	0.33	0.19	0.09
1994	0.05	5.02	12.73	13.12	16.25	19.93	6.58	3.02	0.57	0.24	0.14	0.08	0.08	0.05	0.02
1995	0.03	2.20	2.44	5.04	3.81	8.11	4.36	1.12	0.53	0.20	0.09	0.06	0.03	0.03	0.01
1996	0.03	1.69	3.41	4.17	6.61	5.04	8.82	4.16	0.96	0.48	0.18	0.08	0.05	0.03	0.02
1997	0.05	1.73	4.06	5.88	4.98	8.41	5.38	8.64	3.73	0.88	0.43	0.16	0.07	0.04	0.02
1998	0.06	2.51	4.23	7.09	6.40	5.77	8.83	5.47	8.52	3.71	0.84	0.40	0.14	0.06	0.03
1999	0.08	3.25	7.08	8.43	9.10	7.48	5.45	8.16	5.01	8.05	3.38	0.75	0.35	0.12	0.05
2000	0.07	4.27	9.29	14.61	11.25	10.56	6.21	3.65	6.04	4.21	6.85	2.90	0.63	0.29	0.10
2001	0.06	4.07	11.20	15.42	13.52	9.89	6.66	3.33	2.40	5.07	3.51	5.68	2.36	0.51	0.23
2002	0.08	3.50	9.38	15.08	10.61	8.64	4.82	2.78	1.85	1.74	3.78	2.62	4.12	1.69	0.37

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2003	0.04	4.68	7.71	12.20	9.64	6.22	5.12	2.63	1.69	1.28	1.25	2.81	1.94	3.06	1.26
2004	0.04	2.15	11.87	12.60	10.82	6.47	3.76	3.01	1.98	1.31	0.96	0.93	2.00	1.37	2.13
2005	0.05	2.59	5.58	25.50	19.00	13.25	6.61	3.35	2.75	1.87	1.22	0.88	0.84	1.79	1.20
2006	0.07	3.08	7.58	12.67	42.79	26.39	14.87	5.88	3.06	2.57	1.72	1.10	0.78	0.74	1.55
2007	0.12	4.06	9.15	17.10	21.28	59.65	29.80	11.67	4.47	2.38	1.98	1.31	0.83	0.59	0.54
2008	0.13	7.17	11.39	19.64	27.58	28.10	62.62	24.39	9.02	3.24	1.70	1.38	0.91	0.57	0.40
2009	0.13	7.86	16.30	20.83	27.40	30.59	23.28	37.27	17.79	5.83	2.01	1.03	0.83	0.55	0.34
2010	0.10	8.25	16.99	27.46	27.40	29.11	25.62	16.08	27.67	11.68	3.65	1.23	0.63	0.51	0.33
2011	0.14	5.62	19.73	27.33	34.68	27.65	22.54	18.54	12.52	19.46	7.91	2.41	0.80	0.41	0.32
2012	0.17	7.65	14.90	37.95	41.49	43.32	27.90	19.32	15.61	10.33	15.56	6.17	1.85	0.62	0.31
2013	0.18	8.54	24.45	32.32	64.13	58.61	50.71	27.94	17.66	14.00	9.00	13.25	5.15	1.54	0.51
2014	0.17	8.81	27.56	54.97	56.29	93.51	70.99	50.75	25.02	15.40	11.78	7.37	10.66	4.09	1.21
2015	0.21	8.46	25.10	57.77	91.35	79.27	108.89	66.65	39.53	19.67	11.68	8.69	5.32	7.59	2.87
2016	0.26	10.59	22.26	46.29	88.61	122.48	90.16	106.88	57.62	33.45	16.00	9.20	6.66	4.03	5.67
2017	0.21	12.74	30.81	40.09	69.39	116.80	141.79	90.46	95.76	47.77	26.67	12.30	6.93	4.97	2.96
2018	0.26	10.19	37.25	45.64	49.95	73.90	105.92	109.65	53.46	47.52	22.69	12.06	5.44	3.04	2.16
2019	0.16	12.91	30.40	70.47	70.01	65.21	82.87	105.98	97.94	43.73	37.00	16.79	8.72	3.91	2.20
2020	0.20	7.75	38.48	55.96	106.32	89.66	71.28	79.14	90.22	76.33	32.38	25.85	11.53	5.97	2.68
2021	0.20	9.80	17.42	60.85	76.18	125.18	91.23	63.20	61.49	59.87	48.33	19.63	15.22	6.75	3.47
2022	0.18	9.35	22.94	28.43	86.52	93.88	132.84	89.07	56.58	48.29	44.62	34.53	13.57	10.47	4.62
2023	0.23	8.31	21.65	36.52	38.95	103.29	96.30	118.12	73.27	40.31	32.61	29.00	21.82	8.48	6.45
2024	0.21	10.52	18.31	33.14	47.89	43.78	96.93	77.17	79.87	41.94	21.92	17.34	15.07	11.15	4.31

Table 21. Northern cod mature biomass-at-age estimates (kt) from xteNCAM.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.00	0.00	0.00	0.00	0.11	2.63	41.54	190.16	208.55	159.19	114.73	73.13	44.98	31.41	20.74
1955	0.00	0.00	0.00	0.00	0.11	2.63	41.54	190.16	208.55	159.19	114.73	73.13	44.98	31.41	20.74
1956	0.00	0.00	0.00	0.00	0.11	2.62	41.56	189.43	211.06	158.20	118.49	76.76	46.52	31.89	21.01
1957	0.00	0.00	0.00	0.00	0.11	2.62	41.45	189.66	220.18	171.52	126.81	86.28	54.44	35.89	22.95
1958	0.00	0.00	0.00	0.00	0.12	2.65	41.93	192.45	226.39	191.12	143.45	100.04	66.26	44.90	26.98
1959	0.00	0.00	0.00	0.01	0.13	2.77	43.88	206.79	246.71	221.21	180.97	133.39	89.25	61.02	39.07
1960	0.00	0.00	0.00	0.00	0.17	3.18	45.20	209.05	255.70	238.73	210.63	170.66	121.83	84.59	55.40
1961	0.00	0.00	0.00	0.01	0.01	3.97	50.98	205.17	241.01	235.38	217.51	190.96	151.42	112.89	75.42
1962	0.00	0.00	0.00	0.01	0.20	0.43	64.09	230.96	227.00	212.55	203.06	183.70	159.67	132.28	93.70
1963	0.00	0.00	0.01	0.03	0.30	4.78	21.76	296.68	252.62	193.32	170.85	153.09	136.78	123.06	93.80
1964	0.00	0.00	0.02	0.19	0.71	6.57	73.19	296.22	281.98	188.73	136.69	111.17	103.79	97.44	80.35
1965	0.00	0.00	0.06	0.40	2.36	11.26	83.23	209.88	261.28	173.76	116.58	83.10	71.63	68.86	61.18
1966	0.00	0.00	0.08	0.83	4.66	22.49	98.48	207.48	168.69	167.81	118.23	76.69	57.88	51.84	47.56
1967	0.00	0.00	0.01	0.99	8.11	37.92	128.79	182.01	150.81	107.39	100.60	71.18	49.31	37.51	32.86
1968	0.00	0.00	0.00	0.11	8.90	54.66	175.34	230.86	137.39	100.47	72.85	62.20	46.88	32.50	25.31
1969	0.00	0.00	0.00	0.03	1.70	52.90	192.61	259.01	155.84	86.08	65.89	45.94	40.97	29.37	21.00
1970	0.00	0.00	0.04	0.00	0.71	17.86	161.92	243.79	171.45	94.18	56.50	43.19	30.88	26.19	18.37
1971	0.00	0.07	0.05	0.46	0.06	11.49	103.43	205.90	173.55	116.48	67.72	42.74	33.64	24.08	20.19
1972	0.00	0.14	0.67	0.50	4.00	2.28	95.41	187.46	164.53	123.91	85.96	51.05	32.76	25.30	17.13
1973	0.00	0.00	1.03	2.83	3.83	22.92	49.85	179.19	156.18	112.93	83.95	57.67	34.58	21.64	15.50
1974	0.00	0.00	0.00	4.13	9.34	19.90	80.09	167.64	143.31	100.10	67.38	45.80	32.65	19.25	12.00
1975	0.00	0.00	0.01	0.02	13.86	25.04	53.61	135.62	120.67	78.29	49.20	27.84	19.62	15.30	9.72
1976	0.00	0.00	0.04	0.18	0.32	31.74	43.45	57.21	85.70	52.79	33.08	17.97	11.82	8.90	7.73
1977	0.00	0.00	0.03	0.49	2.52	4.55	41.22	40.46	35.22	39.70	20.95	13.32	8.74	6.30	5.16

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1978	0.00	0.00	0.01	0.46	4.53	22.64	30.24	35.12	27.37	19.38	21.23	10.62	7.92	5.46	4.19
1979	0.00	0.00	0.00	0.14	4.82	27.13	90.33	53.69	25.16	16.45	11.95	13.95	7.52	5.96	4.25
1980	0.00	0.00	0.00	0.01	1.71	32.53	86.47	129.78	45.74	18.81	12.17	9.03	11.24	6.19	5.04
1981	0.00	0.00	0.01	0.03	0.32	13.94	102.34	126.15	109.87	34.09	14.98	9.80	7.68	9.71	5.55
1982	0.00	0.00	0.05	0.28	0.88	5.37	53.63	135.39	120.17	87.39	26.10	12.10	8.14	6.40	8.57
1983	0.00	0.00	0.00	0.68	4.29	13.91	39.17	67.28	109.55	89.46	62.71	19.04	9.20	6.34	5.37
1984	0.00	0.00	0.00	0.07	6.14	38.70	96.05	66.79	57.02	82.23	67.86	46.52	14.16	7.07	5.33
1985	0.00	0.00	0.00	0.03	1.48	36.06	142.70	141.16	56.92	45.42	64.95	51.96	35.03	11.16	6.11
1986	0.00	0.00	0.00	0.13	0.81	23.56	121.57	168.96	106.84	41.85	34.40	44.00	35.06	24.44	9.15
1987	0.00	0.00	0.01	0.10	2.33	16.71	199.24	205.25	144.49	81.84	32.27	23.46	29.93	24.28	18.98
1988	0.00	0.00	0.01	0.22	1.74	27.08	157.38	288.52	158.53	96.57	52.74	20.11	15.06	18.94	16.03
1989	0.00	0.00	0.00	0.29	2.76	21.58	133.03	267.77	202.03	107.97	61.21	33.16	12.56	9.35	11.94
1990	0.00	0.00	0.00	0.18	4.42	23.95	108.11	160.90	178.35	126.55	66.90	36.41	19.35	7.03	5.36
1991	0.00	0.00	0.00	0.05	5.53	44.58	103.28	132.45	100.58	92.70	60.07	31.72	17.37	8.74	3.28
1992	0.00	0.02	0.04	0.12	1.86	75.23	117.98	84.29	30.53	15.00	11.78	7.79	4.16	2.28	1.06
1993	0.00	0.00	0.19	0.31	1.79	16.04	39.90	15.40	2.40	1.17	0.53	0.50	0.33	0.19	0.09
1994	0.00	0.00	0.00	0.38	1.16	10.18	6.03	2.99	0.56	0.24	0.14	0.08	0.08	0.05	0.02
1995	0.00	0.00	0.00	0.01	0.37	3.28	4.22	1.12	0.53	0.20	0.09	0.06	0.03	0.03	0.01
1996	0.00	0.00	0.00	0.01	0.22	1.42	7.57	4.15	0.96	0.48	0.18	0.08	0.05	0.03	0.02
1997	0.00	0.00	0.03	0.05	0.15	2.48	3.16	8.48	3.73	0.88	0.43	0.16	0.07	0.04	0.02
1998	0.00	0.00	0.01	0.21	0.49	1.80	7.36	4.59	8.50	3.71	0.84	0.40	0.14	0.06	0.03
1999	0.00	0.00	0.00	0.12	0.99	3.47	4.75	8.03	4.75	8.05	3.38	0.75	0.35	0.12	0.05
2000	0.00	0.00	0.00	0.05	0.75	3.43	5.60	3.61	6.03	4.15	6.85	2.90	0.63	0.29	0.10
2001	0.00	0.00	0.01	0.02	0.54	2.60	4.35	3.30	2.40	5.07	3.49	5.68	2.36	0.51	0.23
2002	0.00	0.00	0.05	0.15	0.30	2.81	3.08	2.45	1.84	1.74	3.78	2.61	4.12	1.69	0.37

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2003	0.00	0.00	0.01	0.31	0.77	2.36	4.34	2.37	1.63	1.28	1.25	2.81	1.94	3.06	1.26
2004	0.00	0.00	0.01	0.10	1.22	2.75	3.49	2.97	1.94	1.30	0.96	0.93	2.00	1.37	2.13
2005	0.00	0.00	0.01	0.19	1.06	5.03	5.70	3.34	2.75	1.86	1.21	0.88	0.84	1.79	1.20
2006	0.00	0.00	0.03	0.24	3.79	8.32	11.12	5.78	3.06	2.57	1.72	1.10	0.78	0.74	1.55
2007	0.00	0.00	0.01	0.39	2.52	33.38	23.29	10.91	4.46	2.38	1.98	1.31	0.83	0.59	0.54
2008	0.00	0.00	0.03	0.12	3.00	13.70	59.06	23.55	8.89	3.24	1.70	1.38	0.91	0.57	0.40
2009	0.00	0.00	0.03	0.32	1.24	11.89	20.27	37.10	17.70	5.81	2.01	1.03	0.83	0.55	0.34
2010	0.00	0.01	0.05	0.36	2.12	7.80	19.68	15.75	27.66	11.67	3.65	1.23	0.63	0.51	0.33
2011	0.00	0.00	0.18	0.47	2.99	8.68	16.66	17.52	12.48	19.46	7.91	2.41	0.80	0.41	0.32
2012	0.00	0.00	0.01	1.72	4.24	17.51	19.92	18.48	15.44	10.32	15.56	6.17	1.85	0.62	0.31
2013	0.00	0.00	0.01	0.11	12.75	24.88	42.07	26.03	17.55	13.97	9.00	13.25	5.15	1.54	0.51
2014	0.00	0.00	0.03	0.28	1.51	52.83	58.71	49.34	24.69	15.39	11.78	7.37	10.66	4.09	1.21
2015	0.00	0.00	0.03	0.56	4.27	13.95	94.92	64.56	39.37	19.62	11.68	8.69	5.32	7.59	2.87
2016	0.00	0.00	0.04	0.34	7.03	39.26	56.27	103.95	57.34	33.43	15.99	9.20	6.66	4.03	5.67
2017	0.00	0.00	0.01	0.44	3.46	50.17	116.20	83.96	95.25	47.73	26.67	12.30	6.93	4.97	2.96
2018	0.00	0.01	0.00	0.21	3.56	19.92	91.94	107.20	52.93	47.47	22.69	12.06	5.44	3.04	2.16
2019	0.00	0.01	0.13	0.12	3.46	22.61	59.81	104.17	97.71	43.67	36.99	16.79	8.72	3.91	2.20
2020	0.00	0.00	0.17	1.08	4.19	32.93	56.01	75.02	90.04	76.32	32.37	25.85	11.53	5.97	2.68
2021	0.00	0.01	0.05	1.17	6.29	61.20	79.04	60.80	61.02	59.85	48.32	19.63	15.22	6.75	3.47
2022	0.00	0.01	0.07	0.38	6.96	27.41	127.14	87.86	56.26	48.24	44.62	34.53	13.57	10.47	4.62
2023	0.00	0.01	0.06	0.49	2.63	29.04	62.97	117.89	73.18	40.28	32.60	29.00	21.82	8.48	6.45
2024	0.00	0.01	0.05	0.44	3.23	15.50	61.68	69.18	79.86	41.93	21.92	17.34	15.07	11.15	4.31

Table 22. Northern cod Z-at-age estimates from xteNCAM. Z = total mortality.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.299	0.260	0.251	0.240	0.303	0.391	0.479	0.519	0.582	0.583	0.669	0.673	0.519	0.552	0.530
1955	0.299	0.260	0.251	0.240	0.306	0.390	0.482	0.507	0.588	0.551	0.620	0.639	0.504	0.539	0.520
1956	0.299	0.248	0.245	0.237	0.305	0.390	0.482	0.461	0.519	0.477	0.536	0.530	0.420	0.466	0.445
1957	0.299	0.215	0.217	0.220	0.298	0.379	0.464	0.434	0.453	0.435	0.455	0.451	0.353	0.422	0.446
1958	0.299	0.177	0.179	0.189	0.276	0.345	0.404	0.363	0.335	0.310	0.291	0.301	0.243	0.276	0.294
1959	0.299	0.164	0.161	0.170	0.271	0.359	0.439	0.399	0.344	0.305	0.277	0.278	0.214	0.234	0.256
1960	0.299	0.170	0.166	0.168	0.276	0.376	0.487	0.469	0.394	0.349	0.316	0.307	0.236	0.252	0.271
1961	0.299	0.184	0.181	0.180	0.281	0.370	0.489	0.510	0.437	0.404	0.387	0.366	0.295	0.323	0.358
1962	0.299	0.182	0.185	0.187	0.286	0.357	0.467	0.522	0.472	0.474	0.501	0.482	0.421	0.481	0.545
1963	0.299	0.169	0.172	0.182	0.313	0.440	0.608	0.662	0.603	0.602	0.648	0.576	0.499	0.563	0.641
1964	0.299	0.161	0.163	0.175	0.314	0.498	0.824	0.899	0.796	0.738	0.716	0.626	0.570	0.603	0.623
1965	0.299	0.161	0.157	0.163	0.290	0.461	0.736	0.783	0.754	0.641	0.637	0.549	0.484	0.507	0.519
1966	0.299	0.170	0.161	0.159	0.281	0.462	0.749	0.833	0.765	0.767	0.726	0.629	0.594	0.593	0.611
1967	0.299	0.183	0.173	0.166	0.271	0.414	0.670	0.775	0.717	0.644	0.699	0.605	0.577	0.530	0.510
1968	0.299	0.195	0.185	0.175	0.295	0.479	0.758	0.910	0.780	0.678	0.679	0.604	0.628	0.574	0.567
1969	0.299	0.213	0.200	0.186	0.300	0.478	0.799	0.955	0.827	0.677	0.641	0.584	0.608	0.606	0.549
1970	0.299	0.287	0.258	0.222	0.313	0.455	0.692	0.861	0.720	0.588	0.497	0.437	0.409	0.398	0.359
1971	0.299	0.430	0.394	0.309	0.367	0.488	0.636	0.722	0.670	0.565	0.501	0.453	0.445	0.478	0.433
1972	0.299	0.590	0.580	0.455	0.469	0.576	0.652	0.700	0.708	0.651	0.618	0.577	0.575	0.627	0.551
1973	0.299	0.536	0.569	0.500	0.536	0.640	0.679	0.689	0.765	0.779	0.826	0.756	0.746	0.727	0.612
1974	0.299	0.350	0.379	0.371	0.483	0.640	0.743	0.800	0.911	0.969	1.105	1.035	0.918	0.821	0.716
1975	0.299	0.262	0.265	0.273	0.430	0.653	0.824	0.927	1.128	1.117	1.229	1.047	0.951	0.820	0.721
1976	0.299	0.236	0.226	0.229	0.409	0.673	0.847	0.953	1.081	1.180	1.131	0.912	0.793	0.683	0.624

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1977	0.299	0.256	0.238	0.233	0.422	0.700	0.815	0.861	0.920	0.884	0.901	0.712	0.638	0.551	0.500
1978	0.299	0.233	0.223	0.221	0.398	0.615	0.724	0.797	0.847	0.746	0.642	0.537	0.452	0.393	0.375
1979	0.299	0.159	0.159	0.179	0.362	0.543	0.588	0.626	0.638	0.571	0.503	0.409	0.362	0.313	0.311
1980	0.299	0.122	0.122	0.159	0.366	0.537	0.585	0.596	0.597	0.505	0.443	0.354	0.313	0.255	0.263
1981	0.299	0.106	0.106	0.148	0.387	0.572	0.587	0.534	0.530	0.521	0.444	0.378	0.349	0.271	0.248
1982	0.299	0.102	0.102	0.145	0.436	0.686	0.763	0.648	0.614	0.585	0.536	0.471	0.414	0.319	0.259
1983	0.299	0.095	0.089	0.124	0.389	0.621	0.672	0.618	0.592	0.533	0.518	0.490	0.433	0.315	0.235
1984	0.299	0.127	0.089	0.116	0.317	0.570	0.651	0.576	0.531	0.488	0.487	0.476	0.409	0.293	0.218
1985	0.299	0.140	0.089	0.109	0.259	0.482	0.653	0.659	0.592	0.527	0.607	0.586	0.530	0.348	0.273
1986	0.299	0.138	0.079	0.098	0.205	0.356	0.522	0.537	0.541	0.501	0.598	0.576	0.537	0.403	0.319
1987	0.299	0.157	0.144	0.188	0.294	0.473	0.779	0.781	0.678	0.674	0.683	0.632	0.625	0.564	0.474
1988	0.299	0.179	0.108	0.153	0.260	0.423	0.705	0.768	0.699	0.689	0.669	0.655	0.643	0.610	0.548
1989	0.299	0.220	0.126	0.171	0.282	0.447	0.664	0.817	0.743	0.720	0.722	0.719	0.743	0.702	0.643
1990	0.299	0.296	0.166	0.210	0.312	0.492	0.670	0.853	0.930	0.977	0.950	0.919	0.954	0.909	0.902
1991	0.299	0.401	0.446	0.511	0.615	0.962	1.251	1.854	2.183	2.297	2.245	2.210	2.190	2.253	2.369
1992	0.299	0.787	1.214	1.356	1.499	2.344	2.904	4.025	3.547	3.579	3.366	3.337	3.242	3.355	3.652
1993	0.299	1.355	1.625	1.587	1.521	2.668	3.127	3.704	2.615	2.367	2.081	2.072	2.105	2.254	2.646
1994	0.299	2.395	1.993	2.017	1.315	2.021	2.175	2.070	1.326	1.185	1.080	1.097	1.160	1.321	1.753
1995	0.299	1.223	0.514	0.499	0.326	0.418	0.464	0.494	0.380	0.355	0.327	0.343	0.402	0.526	0.836
1996	0.299	0.798	0.492	0.580	0.358	0.422	0.436	0.458	0.386	0.368	0.342	0.345	0.409	0.541	0.847
1997	0.299	0.785	0.487	0.658	0.436	0.434	0.389	0.363	0.302	0.299	0.287	0.290	0.337	0.428	0.656
1998	0.299	0.650	0.359	0.500	0.416	0.529	0.478	0.431	0.353	0.346	0.322	0.315	0.356	0.400	0.560
1999	0.299	0.637	0.329	0.466	0.429	0.646	0.791	0.638	0.465	0.416	0.371	0.365	0.346	0.329	0.415
2000	0.299	0.706	0.545	0.833	0.709	0.924	1.004	0.747	0.461	0.432	0.405	0.395	0.382	0.375	0.410

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2001	0.299	0.821	0.736	1.129	1.030	1.185	1.255	0.910	0.602	0.541	0.509	0.508	0.499	0.464	0.467
2002	0.299	0.868	0.756	1.186	1.115	0.991	0.988	0.821	0.641	0.574	0.509	0.488	0.460	0.433	0.429
2003	0.299	0.730	0.524	0.844	0.963	0.969	0.914	0.607	0.527	0.526	0.507	0.525	0.510	0.499	0.486
2004	0.299	0.703	0.253	0.309	0.351	0.431	0.501	0.413	0.333	0.311	0.293	0.284	0.275	0.272	0.269
2005	0.299	0.582	0.195	0.203	0.220	0.326	0.489	0.411	0.345	0.320	0.304	0.295	0.286	0.284	0.283
2006	0.299	0.564	0.199	0.200	0.217	0.315	0.605	0.588	0.525	0.498	0.482	0.463	0.444	0.444	0.446
2007	0.299	0.622	0.247	0.239	0.269	0.388	0.558	0.561	0.587	0.572	0.560	0.544	0.527	0.525	0.528
2008	0.299	0.833	0.405	0.382	0.442	0.623	0.877	0.616	0.696	0.705	0.702	0.685	0.660	0.658	0.659
2009	0.299	0.881	0.486	0.439	0.484	0.612	0.726	0.597	0.676	0.690	0.688	0.676	0.649	0.650	0.644
2010	0.299	0.778	0.530	0.477	0.533	0.689	0.679	0.549	0.607	0.609	0.610	0.602	0.580	0.584	0.577
2011	0.299	0.667	0.350	0.292	0.317	0.422	0.509	0.470	0.446	0.443	0.439	0.433	0.410	0.411	0.404
2012	0.299	0.476	0.228	0.183	0.193	0.271	0.351	0.387	0.362	0.356	0.350	0.347	0.333	0.330	0.322
2013	0.299	0.460	0.191	0.153	0.160	0.236	0.350	0.405	0.389	0.390	0.389	0.383	0.376	0.376	0.360
2014	0.299	0.581	0.260	0.200	0.196	0.274	0.413	0.543	0.491	0.494	0.494	0.490	0.486	0.483	0.466
2015	0.299	0.660	0.387	0.280	0.245	0.299	0.367	0.437	0.415	0.422	0.427	0.431	0.424	0.419	0.401
2016	0.299	0.559	0.411	0.304	0.263	0.282	0.346	0.401	0.435	0.440	0.450	0.449	0.438	0.435	0.421
2017	0.299	0.554	0.606	0.488	0.477	0.527	0.608	0.819	0.948	0.957	0.979	0.978	0.969	0.962	0.949
2018	0.299	0.534	0.361	0.280	0.274	0.316	0.352	0.407	0.450	0.462	0.486	0.486	0.473	0.452	0.453
2019	0.299	0.534	0.389	0.297	0.293	0.341	0.400	0.456	0.499	0.515	0.542	0.537	0.522	0.505	0.524
2020	0.299	0.815	0.541	0.400	0.377	0.413	0.474	0.549	0.662	0.673	0.686	0.691	0.678	0.668	0.694
2021	0.299	0.773	0.509	0.356	0.331	0.371	0.377	0.407	0.494	0.511	0.523	0.532	0.515	0.505	0.518
2022	0.299	0.781	0.534	0.394	0.363	0.405	0.471	0.492	0.592	0.611	0.620	0.624	0.614	0.610	0.623
2023	0.299	0.829	0.572	0.438	0.423	0.494	0.575	0.688	0.811	0.827	0.822	0.820	0.816	0.805	0.813

Table 23. Northern cod *M*-at-age estimates from xteNCAM. *M* = natural mortality.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.299	0.260	0.250	0.223	0.191	0.165	0.169	0.190	0.247	0.247	0.247	0.247	0.247	0.247	0.247
1955	0.299	0.260	0.250	0.223	0.191	0.165	0.169	0.190	0.247	0.247	0.247	0.247	0.247	0.247	0.247
1956	0.299	0.248	0.245	0.219	0.185	0.157	0.153	0.157	0.185	0.185	0.185	0.185	0.185	0.185	0.185
1957	0.299	0.215	0.217	0.203	0.174	0.150	0.146	0.141	0.150	0.150	0.150	0.150	0.150	0.150	0.150
1958	0.299	0.177	0.179	0.172	0.154	0.136	0.133	0.124	0.122	0.122	0.122	0.122	0.122	0.122	0.122
1959	0.299	0.164	0.161	0.153	0.139	0.126	0.125	0.113	0.103	0.103	0.103	0.103	0.103	0.103	0.103
1960	0.299	0.170	0.166	0.151	0.134	0.124	0.124	0.109	0.094	0.094	0.094	0.094	0.094	0.094	0.094
1961	0.299	0.184	0.181	0.162	0.138	0.125	0.126	0.109	0.090	0.090	0.090	0.090	0.090	0.090	0.090
1962	0.299	0.182	0.184	0.169	0.143	0.126	0.127	0.108	0.087	0.087	0.087	0.087	0.087	0.087	0.087
1963	0.299	0.169	0.172	0.164	0.143	0.130	0.131	0.109	0.086	0.086	0.086	0.086	0.086	0.086	0.086
1964	0.299	0.161	0.163	0.156	0.142	0.133	0.137	0.109	0.086	0.086	0.086	0.086	0.086	0.086	0.086
1965	0.299	0.161	0.157	0.146	0.132	0.127	0.137	0.115	0.090	0.090	0.090	0.090	0.090	0.090	0.090
1966	0.299	0.170	0.160	0.142	0.124	0.118	0.126	0.116	0.096	0.096	0.096	0.096	0.096	0.096	0.096
1967	0.299	0.183	0.173	0.149	0.126	0.117	0.121	0.112	0.099	0.099	0.099	0.099	0.099	0.099	0.099
1968	0.299	0.195	0.185	0.159	0.134	0.124	0.122	0.112	0.100	0.100	0.100	0.100	0.100	0.100	0.100
1969	0.299	0.213	0.200	0.170	0.144	0.134	0.130	0.115	0.102	0.102	0.102	0.102	0.102	0.102	0.102
1970	0.299	0.287	0.258	0.206	0.167	0.153	0.141	0.121	0.105	0.105	0.105	0.105	0.105	0.105	0.105
1971	0.299	0.430	0.393	0.292	0.222	0.194	0.164	0.132	0.112	0.112	0.112	0.112	0.112	0.112	0.112
1972	0.299	0.590	0.579	0.438	0.318	0.268	0.209	0.154	0.126	0.126	0.126	0.126	0.126	0.126	0.126
1973	0.299	0.536	0.569	0.482	0.383	0.327	0.247	0.170	0.135	0.135	0.135	0.135	0.135	0.135	0.135
1974	0.299	0.350	0.378	0.354	0.326	0.316	0.245	0.167	0.130	0.130	0.130	0.130	0.130	0.130	0.130
1975	0.299	0.262	0.265	0.256	0.261	0.286	0.231	0.158	0.124	0.124	0.124	0.124	0.124	0.124	0.124
1976	0.299	0.236	0.226	0.211	0.228	0.273	0.226	0.152	0.118	0.118	0.118	0.118	0.118	0.118	0.118

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1977	0.299	0.256	0.237	0.214	0.234	0.299	0.243	0.156	0.116	0.116	0.116	0.116	0.116	0.116	0.116
1978	0.299	0.233	0.223	0.202	0.228	0.301	0.246	0.152	0.110	0.110	0.110	0.110	0.110	0.110	0.110
1979	0.299	0.159	0.159	0.158	0.194	0.271	0.216	0.131	0.092	0.092	0.092	0.092	0.092	0.092	0.092
1980	0.299	0.122	0.122	0.134	0.190	0.286	0.222	0.122	0.082	0.082	0.082	0.082	0.082	0.082	0.082
1981	0.299	0.106	0.106	0.122	0.202	0.335	0.252	0.126	0.076	0.076	0.076	0.076	0.076	0.076	0.076
1982	0.299	0.102	0.101	0.119	0.212	0.403	0.306	0.138	0.072	0.072	0.072	0.072	0.072	0.072	0.072
1983	0.299	0.095	0.089	0.100	0.181	0.372	0.305	0.142	0.072	0.072	0.072	0.072	0.072	0.072	0.072
1984	0.299	0.127	0.089	0.099	0.160	0.361	0.370	0.172	0.084	0.084	0.084	0.084	0.084	0.084	0.084
1985	0.299	0.140	0.089	0.096	0.131	0.249	0.343	0.197	0.100	0.100	0.100	0.100	0.100	0.100	0.100
1986	0.299	0.138	0.079	0.087	0.105	0.170	0.253	0.181	0.103	0.103	0.103	0.103	0.103	0.103	0.103
1987	0.299	0.157	0.144	0.177	0.213	0.325	0.531	0.438	0.274	0.274	0.274	0.274	0.274	0.274	0.274
1988	0.299	0.179	0.108	0.143	0.185	0.278	0.472	0.482	0.378	0.378	0.378	0.378	0.378	0.378	0.378
1989	0.299	0.220	0.126	0.162	0.211	0.308	0.445	0.530	0.412	0.412	0.412	0.412	0.412	0.412	0.412
1990	0.299	0.296	0.166	0.200	0.238	0.331	0.450	0.588	0.611	0.611	0.611	0.611	0.611	0.611	0.611
1991	0.299	0.401	0.446	0.502	0.540	0.788	0.973	1.483	1.677	1.677	1.677	1.677	1.677	1.677	1.677
1992	0.299	0.787	1.214	1.348	1.438	2.197	2.621	3.547	2.782	2.782	2.782	2.782	2.782	2.782	2.782
1993	0.299	1.355	1.625	1.581	1.468	2.539	2.884	3.281	1.887	1.887	1.887	1.887	1.887	1.887	1.887
1994	0.299	2.395	1.993	2.012	1.278	1.946	2.031	1.843	0.973	0.973	0.973	0.973	0.973	0.973	0.973
1995	0.299	1.223	0.514	0.495	0.303	0.384	0.403	0.405	0.267	0.267	0.267	0.267	0.267	0.267	0.267
1996	0.299	0.798	0.492	0.576	0.330	0.376	0.345	0.335	0.257	0.257	0.257	0.257	0.257	0.257	0.257
1997	0.299	0.785	0.487	0.655	0.416	0.404	0.334	0.287	0.226	0.226	0.226	0.226	0.226	0.226	0.226
1998	0.299	0.650	0.359	0.497	0.388	0.463	0.343	0.229	0.169	0.169	0.169	0.169	0.169	0.169	0.169
1999	0.299	0.637	0.329	0.463	0.397	0.557	0.553	0.291	0.173	0.173	0.173	0.173	0.173	0.173	0.173
2000	0.299	0.706	0.545	0.831	0.681	0.847	0.841	0.516	0.261	0.261	0.261	0.261	0.261	0.261	0.261

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2001	0.299	0.821	0.736	1.127	1.002	1.089	1.041	0.592	0.347	0.347	0.347	0.347	0.347	0.347	0.347
2002	0.299	0.868	0.756	1.184	1.095	0.912	0.773	0.476	0.342	0.342	0.342	0.342	0.342	0.342	0.342
2003	0.299	0.730	0.524	0.842	0.955	0.944	0.829	0.463	0.372	0.372	0.372	0.372	0.372	0.372	0.372
2004	0.299	0.703	0.253	0.308	0.346	0.416	0.444	0.316	0.243	0.243	0.243	0.243	0.243	0.243	0.243
2005	0.299	0.582	0.195	0.202	0.215	0.311	0.427	0.320	0.263	0.263	0.263	0.263	0.263	0.263	0.263
2006	0.299	0.564	0.199	0.199	0.212	0.298	0.529	0.467	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2007	0.299	0.622	0.247	0.239	0.265	0.376	0.512	0.484	0.491	0.491	0.491	0.491	0.491	0.491	0.491
2008	0.299	0.833	0.405	0.382	0.440	0.613	0.846	0.565	0.620	0.620	0.620	0.620	0.620	0.620	0.620
2009	0.299	0.881	0.486	0.439	0.482	0.603	0.700	0.551	0.604	0.604	0.604	0.604	0.604	0.604	0.604
2010	0.299	0.778	0.530	0.477	0.531	0.682	0.656	0.504	0.541	0.541	0.541	0.541	0.541	0.541	0.541
2011	0.299	0.667	0.350	0.291	0.316	0.414	0.483	0.416	0.375	0.375	0.375	0.375	0.375	0.375	0.375
2012	0.299	0.476	0.228	0.183	0.191	0.265	0.330	0.338	0.294	0.294	0.294	0.294	0.294	0.294	0.294
2013	0.299	0.460	0.191	0.153	0.159	0.231	0.331	0.366	0.334	0.334	0.334	0.334	0.334	0.334	0.334
2014	0.299	0.581	0.260	0.200	0.195	0.270	0.399	0.512	0.444	0.444	0.444	0.444	0.444	0.444	0.444
2015	0.299	0.660	0.387	0.280	0.245	0.296	0.356	0.412	0.372	0.372	0.372	0.372	0.372	0.372	0.372
2016	0.299	0.559	0.411	0.304	0.263	0.279	0.333	0.366	0.372	0.372	0.372	0.372	0.372	0.372	0.372
2017	0.299	0.554	0.606	0.488	0.477	0.525	0.596	0.788	0.873	0.873	0.873	0.873	0.873	0.873	0.873
2018	0.299	0.534	0.361	0.280	0.273	0.314	0.341	0.379	0.385	0.385	0.385	0.385	0.385	0.385	0.385
2019	0.299	0.534	0.389	0.297	0.292	0.340	0.391	0.435	0.450	0.450	0.450	0.450	0.450	0.450	0.450
2020	0.299	0.815	0.541	0.400	0.376	0.411	0.466	0.531	0.618	0.618	0.618	0.618	0.618	0.618	0.618
2021	0.299	0.773	0.509	0.356	0.331	0.369	0.370	0.390	0.450	0.450	0.450	0.450	0.450	0.450	0.450
2022	0.299	0.781	0.534	0.394	0.363	0.404	0.463	0.473	0.544	0.544	0.544	0.544	0.544	0.544	0.544
2023	0.299	0.829	0.572	0.438	0.423	0.493	0.566	0.664	0.754	0.754	0.754	0.754	0.754	0.754	0.754

Table 24. Northern cod *F*-at-age estimates from xteNCAM. *F* = fishing mortality.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.000	0.000	0.000	0.017	0.113	0.226	0.310	0.329	0.335	0.336	0.422	0.426	0.272	0.305	0.283
1955	0.000	0.000	0.000	0.017	0.116	0.225	0.314	0.317	0.341	0.304	0.373	0.392	0.257	0.292	0.273
1956	0.000	0.000	0.000	0.017	0.121	0.232	0.328	0.304	0.334	0.292	0.350	0.345	0.234	0.281	0.260
1957	0.000	0.000	0.000	0.017	0.124	0.229	0.319	0.293	0.304	0.285	0.306	0.301	0.203	0.273	0.296
1958	0.000	0.000	0.000	0.017	0.122	0.208	0.272	0.239	0.213	0.189	0.169	0.179	0.121	0.154	0.172
1959	0.000	0.000	0.000	0.017	0.133	0.233	0.314	0.286	0.241	0.202	0.174	0.175	0.111	0.131	0.153
1960	0.000	0.000	0.000	0.018	0.141	0.253	0.363	0.360	0.301	0.255	0.223	0.213	0.143	0.158	0.178
1961	0.000	0.000	0.000	0.018	0.142	0.245	0.363	0.401	0.348	0.314	0.298	0.276	0.206	0.234	0.269
1962	0.000	0.000	0.000	0.018	0.143	0.231	0.341	0.413	0.386	0.387	0.414	0.395	0.334	0.394	0.458
1963	0.000	0.000	0.000	0.018	0.170	0.310	0.476	0.553	0.518	0.517	0.563	0.490	0.414	0.478	0.555
1964	0.000	0.000	0.000	0.018	0.172	0.365	0.687	0.790	0.710	0.652	0.630	0.540	0.485	0.517	0.537
1965	0.000	0.000	0.000	0.017	0.157	0.334	0.599	0.667	0.664	0.551	0.547	0.459	0.394	0.417	0.429
1966	0.000	0.000	0.000	0.017	0.157	0.344	0.623	0.717	0.669	0.671	0.630	0.532	0.498	0.497	0.515
1967	0.000	0.000	0.000	0.017	0.145	0.297	0.549	0.663	0.618	0.545	0.600	0.506	0.478	0.432	0.411
1968	0.000	0.000	0.000	0.016	0.161	0.355	0.635	0.799	0.680	0.578	0.580	0.505	0.528	0.474	0.467
1969	0.000	0.000	0.000	0.016	0.156	0.344	0.669	0.841	0.724	0.575	0.538	0.482	0.505	0.504	0.447
1970	0.000	0.000	0.000	0.017	0.146	0.301	0.550	0.740	0.615	0.483	0.392	0.332	0.303	0.292	0.254
1971	0.000	0.000	0.000	0.017	0.145	0.294	0.471	0.591	0.558	0.453	0.389	0.341	0.333	0.366	0.321
1972	0.000	0.000	0.000	0.017	0.150	0.308	0.443	0.546	0.582	0.525	0.492	0.451	0.449	0.501	0.425
1973	0.000	0.000	0.000	0.017	0.154	0.313	0.432	0.519	0.630	0.644	0.691	0.621	0.611	0.592	0.477
1974	0.000	0.000	0.000	0.018	0.156	0.324	0.497	0.633	0.781	0.838	0.975	0.905	0.788	0.690	0.586
1975	0.000	0.000	0.000	0.018	0.169	0.368	0.593	0.769	1.005	0.994	1.105	0.923	0.828	0.696	0.598
1976	0.000	0.000	0.000	0.019	0.181	0.400	0.621	0.800	0.964	1.063	1.014	0.794	0.675	0.566	0.507

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1977	0.000	0.000	0.000	0.019	0.187	0.401	0.573	0.705	0.804	0.768	0.785	0.595	0.521	0.434	0.384
1978	0.000	0.000	0.000	0.019	0.169	0.314	0.478	0.645	0.737	0.636	0.532	0.428	0.342	0.284	0.265
1979	0.000	0.000	0.000	0.021	0.168	0.273	0.372	0.496	0.546	0.480	0.411	0.317	0.270	0.222	0.219
1980	0.000	0.000	0.000	0.025	0.176	0.251	0.363	0.474	0.515	0.423	0.361	0.272	0.232	0.173	0.182
1981	0.000	0.000	0.000	0.026	0.185	0.237	0.335	0.408	0.454	0.445	0.368	0.302	0.273	0.195	0.172
1982	0.000	0.000	0.000	0.025	0.224	0.283	0.458	0.511	0.542	0.512	0.464	0.399	0.342	0.247	0.187
1983	0.000	0.000	0.000	0.023	0.208	0.249	0.367	0.477	0.519	0.461	0.446	0.417	0.360	0.243	0.163
1984	0.000	0.000	0.000	0.016	0.157	0.208	0.282	0.404	0.447	0.404	0.403	0.392	0.325	0.209	0.134
1985	0.000	0.000	0.000	0.013	0.128	0.233	0.309	0.462	0.492	0.427	0.507	0.485	0.430	0.248	0.173
1986	0.000	0.000	0.000	0.012	0.100	0.185	0.269	0.355	0.438	0.398	0.495	0.473	0.434	0.300	0.216
1987	0.000	0.000	0.000	0.011	0.080	0.149	0.247	0.343	0.404	0.400	0.409	0.358	0.351	0.290	0.200
1988	0.000	0.000	0.000	0.010	0.075	0.145	0.233	0.286	0.321	0.310	0.291	0.277	0.264	0.231	0.170
1989	0.000	0.000	0.000	0.009	0.071	0.139	0.218	0.287	0.332	0.308	0.310	0.308	0.332	0.290	0.231
1990	0.000	0.000	0.000	0.009	0.074	0.161	0.220	0.265	0.319	0.366	0.339	0.308	0.343	0.298	0.291
1991	0.000	0.000	0.000	0.009	0.075	0.174	0.279	0.371	0.506	0.619	0.568	0.533	0.512	0.575	0.691
1992	0.000	0.000	0.000	0.007	0.061	0.147	0.283	0.478	0.765	0.796	0.583	0.554	0.460	0.573	0.869
1993	0.000	0.000	0.000	0.006	0.053	0.129	0.243	0.423	0.728	0.480	0.194	0.185	0.218	0.367	0.759
1994	0.000	0.000	0.000	0.005	0.037	0.075	0.144	0.227	0.353	0.212	0.107	0.124	0.187	0.349	0.780
1995	0.000	0.000	0.000	0.004	0.023	0.033	0.061	0.089	0.113	0.088	0.060	0.076	0.135	0.259	0.570
1996	0.000	0.000	0.000	0.004	0.028	0.047	0.091	0.123	0.130	0.111	0.086	0.088	0.152	0.284	0.590
1997	0.000	0.000	0.000	0.003	0.020	0.030	0.055	0.075	0.076	0.072	0.061	0.064	0.111	0.202	0.429
1998	0.000	0.000	0.000	0.003	0.029	0.065	0.135	0.202	0.184	0.177	0.153	0.146	0.187	0.231	0.391
1999	0.000	0.000	0.000	0.003	0.032	0.089	0.239	0.347	0.292	0.243	0.198	0.192	0.173	0.156	0.242
2000	0.000	0.000	0.000	0.002	0.028	0.078	0.162	0.231	0.201	0.171	0.144	0.135	0.121	0.114	0.150

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2001	0.000	0.000	0.000	0.002	0.028	0.097	0.214	0.318	0.255	0.194	0.162	0.161	0.152	0.117	0.119
2002	0.000	0.000	0.000	0.002	0.020	0.079	0.215	0.345	0.300	0.232	0.168	0.146	0.119	0.092	0.088
2003	0.000	0.000	0.000	0.001	0.009	0.025	0.085	0.144	0.155	0.154	0.135	0.153	0.138	0.127	0.114
2004	0.000	0.000	0.000	0.001	0.006	0.016	0.056	0.097	0.090	0.068	0.050	0.042	0.033	0.030	0.026
2005	0.000	0.000	0.000	0.001	0.005	0.015	0.061	0.092	0.082	0.057	0.041	0.032	0.023	0.020	0.020
2006	0.000	0.000	0.000	0.001	0.004	0.017	0.076	0.122	0.125	0.098	0.082	0.063	0.044	0.044	0.046
2007	0.000	0.000	0.000	0.000	0.003	0.013	0.047	0.077	0.096	0.080	0.068	0.052	0.035	0.033	0.037
2008	0.000	0.000	0.000	0.000	0.003	0.010	0.031	0.051	0.076	0.085	0.082	0.065	0.040	0.038	0.039
2009	0.000	0.000	0.000	0.000	0.002	0.008	0.026	0.047	0.072	0.087	0.085	0.072	0.045	0.046	0.040
2010	0.000	0.000	0.000	0.000	0.002	0.007	0.024	0.045	0.065	0.067	0.069	0.061	0.039	0.042	0.035
2011	0.000	0.000	0.000	0.000	0.002	0.008	0.026	0.054	0.071	0.068	0.064	0.058	0.035	0.036	0.029
2012	0.000	0.000	0.000	0.000	0.001	0.006	0.021	0.049	0.068	0.061	0.056	0.053	0.038	0.035	0.028
2013	0.000	0.000	0.000	0.000	0.001	0.005	0.018	0.039	0.056	0.056	0.055	0.049	0.043	0.042	0.026
2014	0.000	0.000	0.000	0.000	0.001	0.004	0.014	0.030	0.047	0.050	0.050	0.046	0.042	0.039	0.022
2015	0.000	0.000	0.000	0.000	0.001	0.003	0.011	0.025	0.043	0.050	0.055	0.059	0.052	0.047	0.029
2016	0.000	0.000	0.000	0.000	0.001	0.003	0.014	0.035	0.063	0.067	0.077	0.076	0.066	0.063	0.049
2017	0.000	0.000	0.000	0.000	0.001	0.002	0.012	0.031	0.074	0.084	0.105	0.105	0.095	0.089	0.076
2018	0.000	0.000	0.000	0.000	0.000	0.002	0.011	0.028	0.065	0.077	0.101	0.101	0.089	0.068	0.068
2019	0.000	0.000	0.000	0.000	0.000	0.002	0.009	0.021	0.050	0.065	0.093	0.087	0.072	0.056	0.074
2020	0.000	0.000	0.000	0.000	0.000	0.002	0.008	0.018	0.044	0.054	0.068	0.073	0.059	0.050	0.076
2021	0.000	0.000	0.000	0.000	0.000	0.002	0.007	0.017	0.045	0.061	0.074	0.082	0.066	0.055	0.068
2022	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.019	0.048	0.067	0.076	0.080	0.071	0.066	0.079
2023	0.000	0.000	0.000	0.000	0.000	0.002	0.009	0.024	0.056	0.073	0.067	0.066	0.062	0.050	0.059

Table 25. Probability of SSB exceeding 2024 levels at various catch multipliers over a 3 year projection period. SSB = Spawning Stock Biomass.

Catch multiplier	Catch (t)	2025	2026	2027
0	0	32%	34%	38%
0.5	6758	30%	32%	36%
1	13517	28%	30%	33%
1.5	20275	26%	27%	31%
2	27033	24%	25%	29%

Table 26. Probability of SSB exceeding the LRP at various catch multipliers over a 3 year projection period. SSB = spawning stock biomass; LRP = lower reference point.

Catch multiplier	Catch (t)	2025	2026	2027
0	0	69%	60%	58%
0.5	6758	68%	58%	56%
1	13517	66%	55%	53%
1.5	20275	64%	53%	51%
2	27033	62%	51%	48%

Table 27. Estimates of SSB relative to the LRP, with 95% confidence intervals in parentheses, at various catch multipliers over a 3 year projection period. SSB = spawning stock biomass; LRP = lower reference point.

Catch multiplier	Catch (t)	2024	2025	2026	2027
0	0	1.24 (0.72, 2.12)	1.21 (0.57, 2.58)	1.14 (0.41, 3.16)	1.14 (0.33, 3.92)
0.5	6758	1.24 (0.72, 2.12)	1.19 (0.56, 2.55)	1.11 (0.40, 3.10)	1.10 (0.31, 3.86)
1	13517	1.24 (0.72, 2.12)	1.17 (0.55, 2.52)	1.07 (0.38, 3.05)	1.06 (0.30, 3.80)
1.5	20275	1.24 (0.72, 2.12)	1.15 (0.53, 2.49)	1.04 (0.36, 3.00)	1.02 (0.28, 3.74)
2	27033	1.24 (0.72, 2.12)	1.13 (0.52, 2.46)	1.01 (0.34, 2.95)	0.97 (0.26, 3.68)

FIGURES

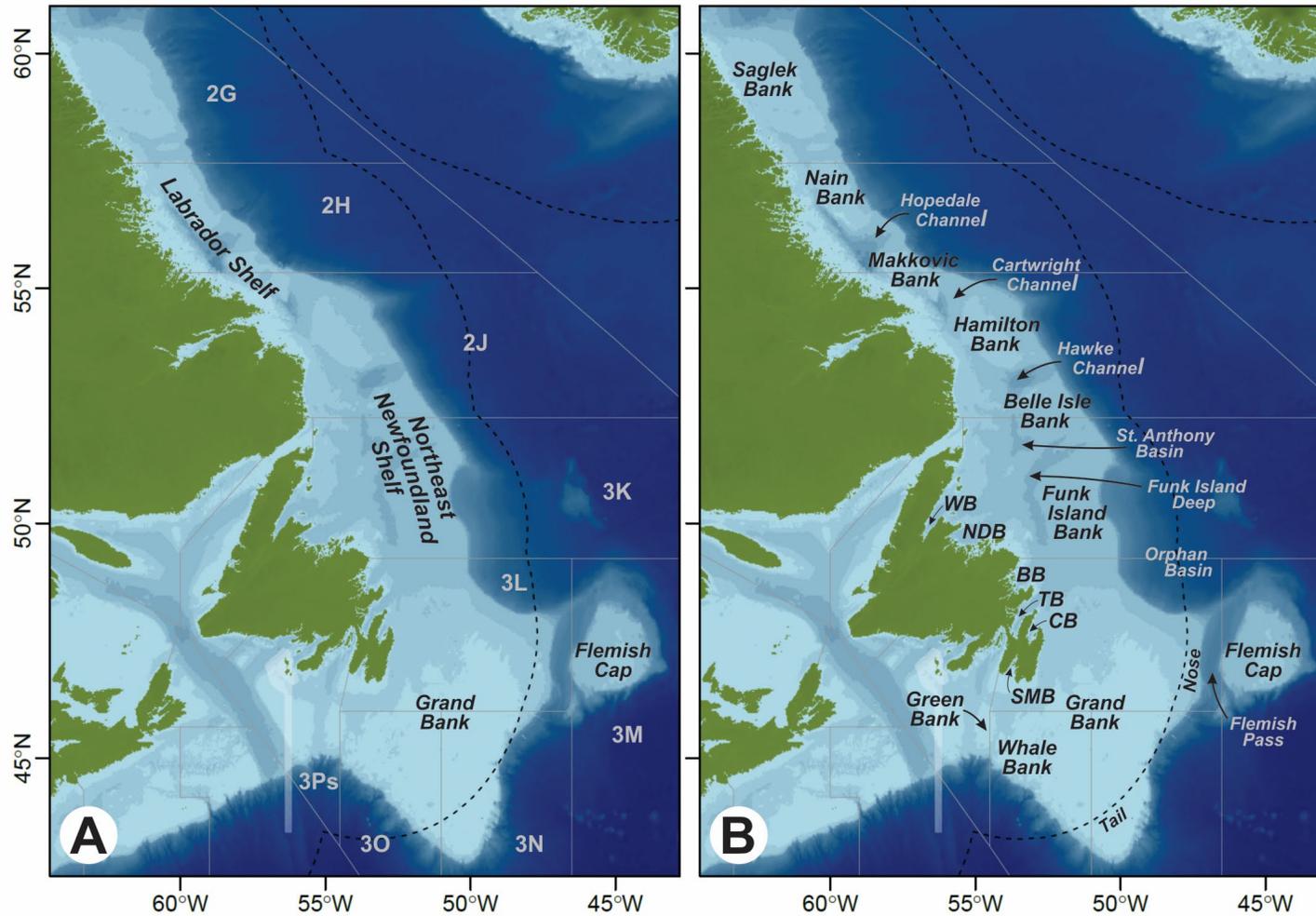


Figure 1. (A) Major geographic features and NAFO Division and Subdivision boundaries around Newfoundland and Labrador (NL) and adjacent areas of the northwest Atlantic. (B) Fishing banks and major bays around eastern Newfoundland and Labrador. The dashed line is Canada's 200 nautical mile limit. WB = White Bay; NDB = Notre Dame Bay; BB = Bonavista Bay; TB = Trinity Bay; CB = Conception Bay; and SMB = Saint Mary's Bay.

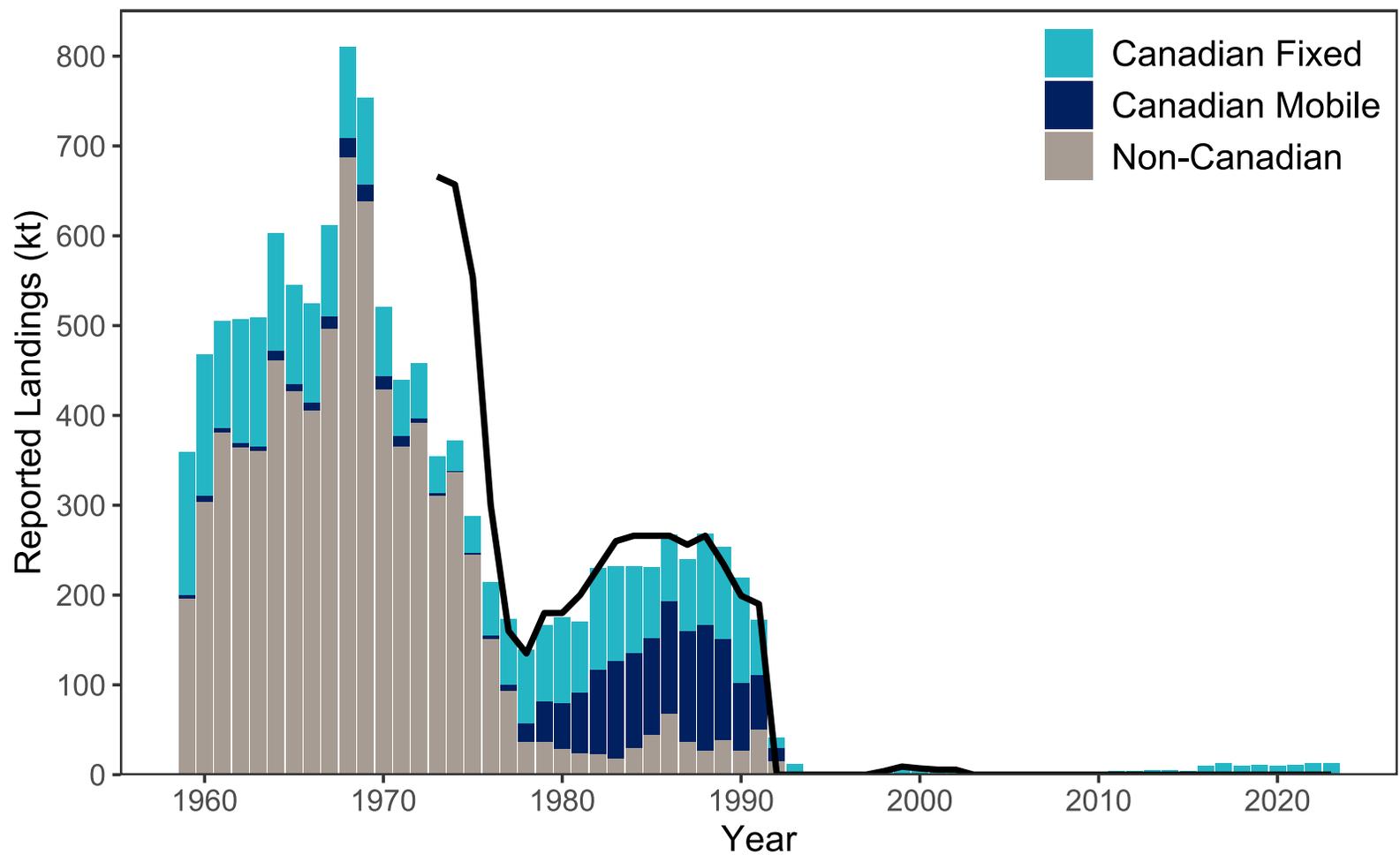


Figure 2. Total allowable catches (TACs, represented by black line) and reported landings (kt) of cod from NAFO Divisions 2J3KL by Canadian mobile fleets (offshore), Canadian fixed gear fleets (mostly inshore), and non-Canadian fleets.

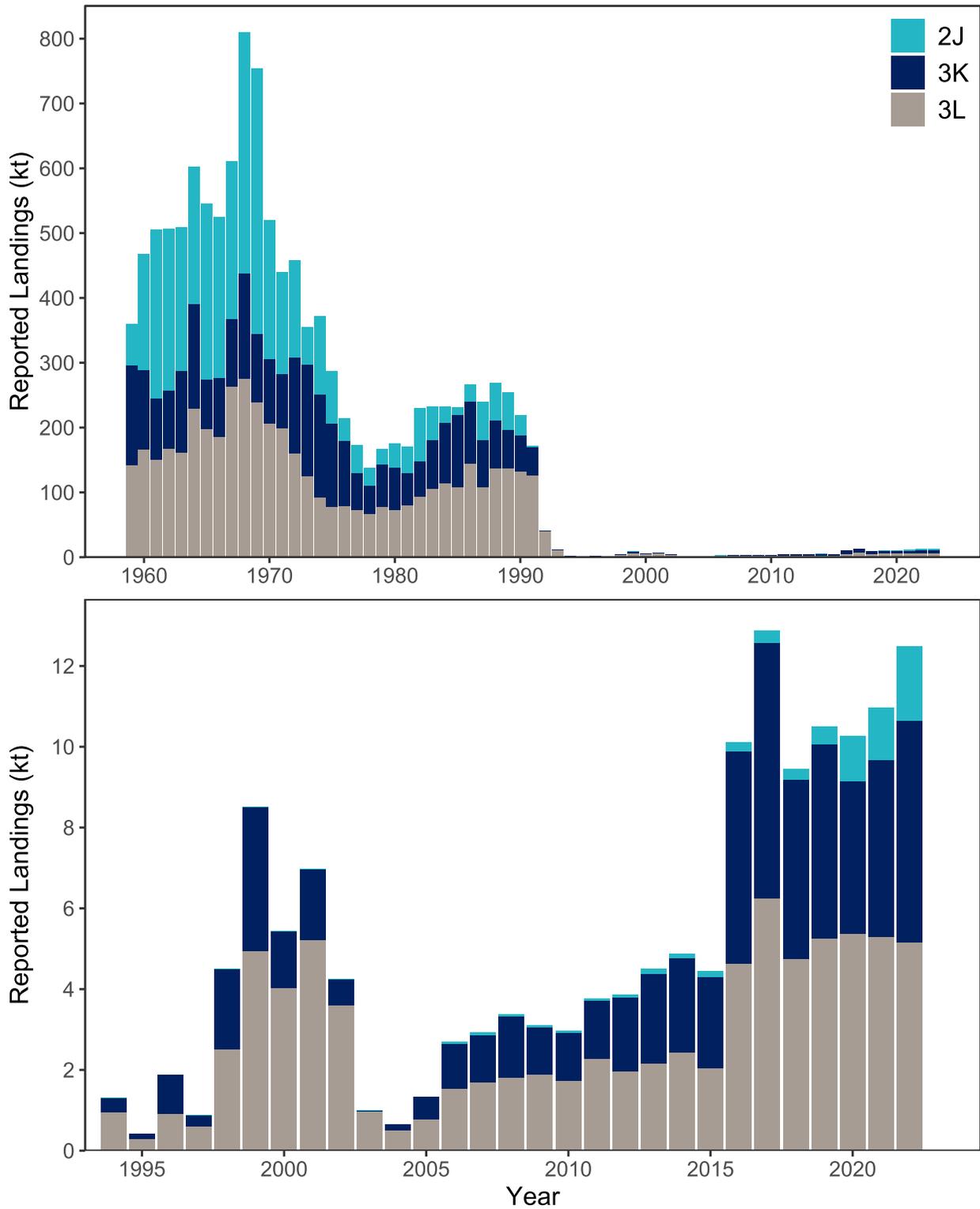


Figure 3. Reported landings (kt) of cod in NAFO Divisions 2J3KL by division. (Upper Panel) Trends since 1959; (Lower Panel) Trends since 1994 (on expanded scale). Note that the lower panel excludes recreational fishery landings except during 2008 and 2011–12.

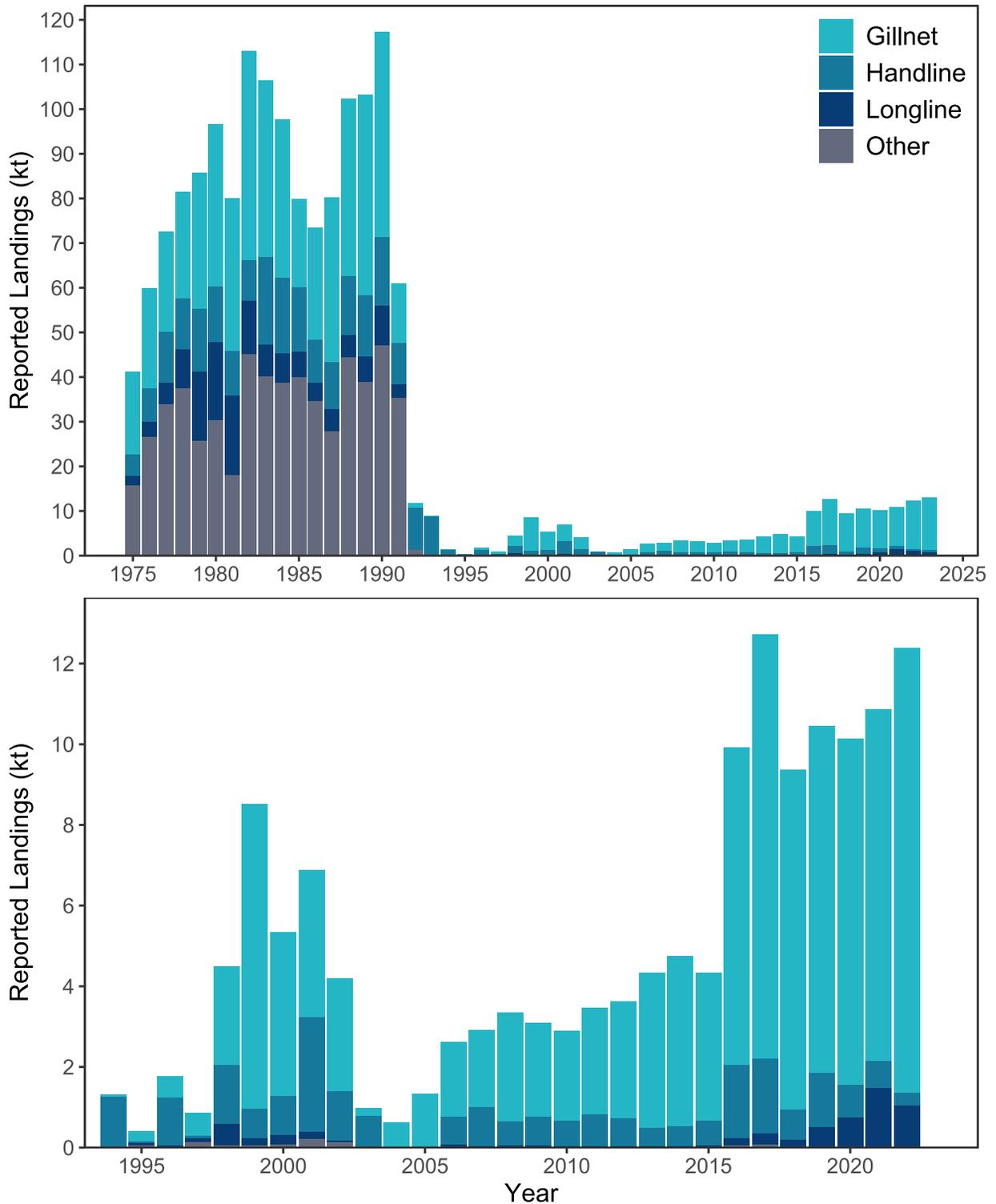


Figure 4. Reported fixed gear landings (kt) of cod from NAFO Divisions 2J3KL by gear type. (Upper Panel) Trends since 1975; (Lower Panel) Trends since 1994 (on expanded scale). Note that lower panel excludes recreational fishery landings except during 2008 and 2011–12.

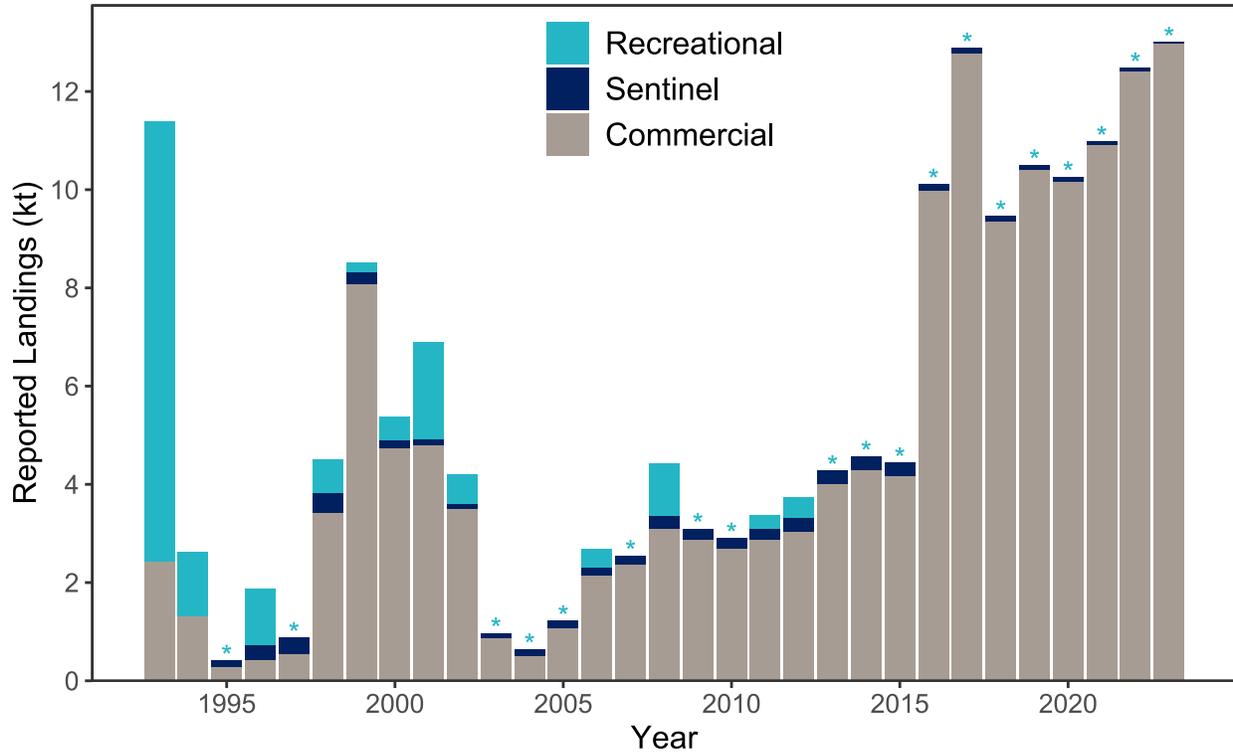


Figure 5. Reported landings (kt) of cod by fishery type from NAFO Divisions 2J3KL for the fisheries during 1993 onward. Asterisks (*) indicate years where recreational catches were taken but removals are not available.

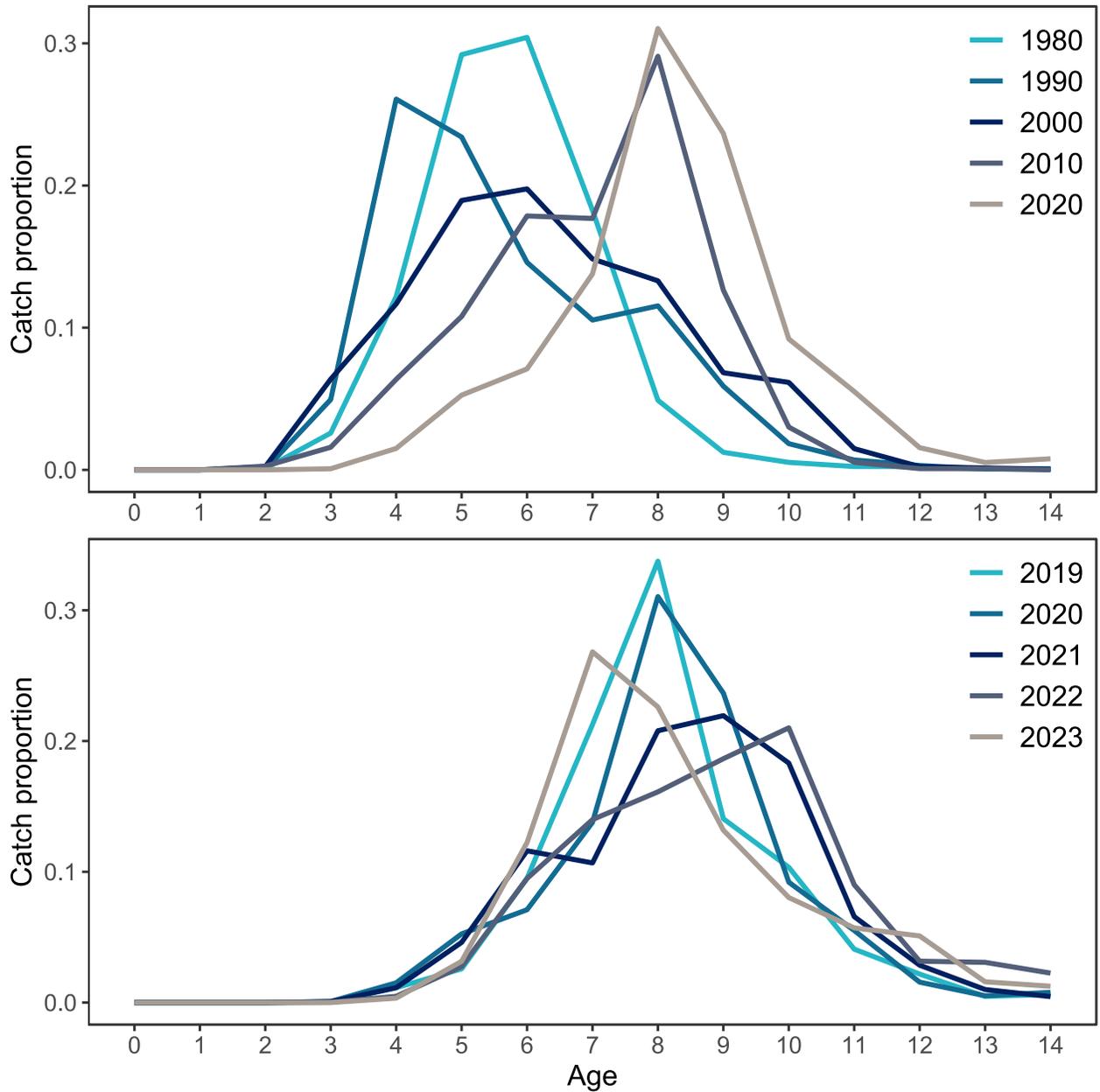


Figure 6. Comparison of the commercial catch proportions-at-age for Divisions 2J3KL cod from the beginning of the last five decades (Upper Panel) and for the last five years (Lower Panel).

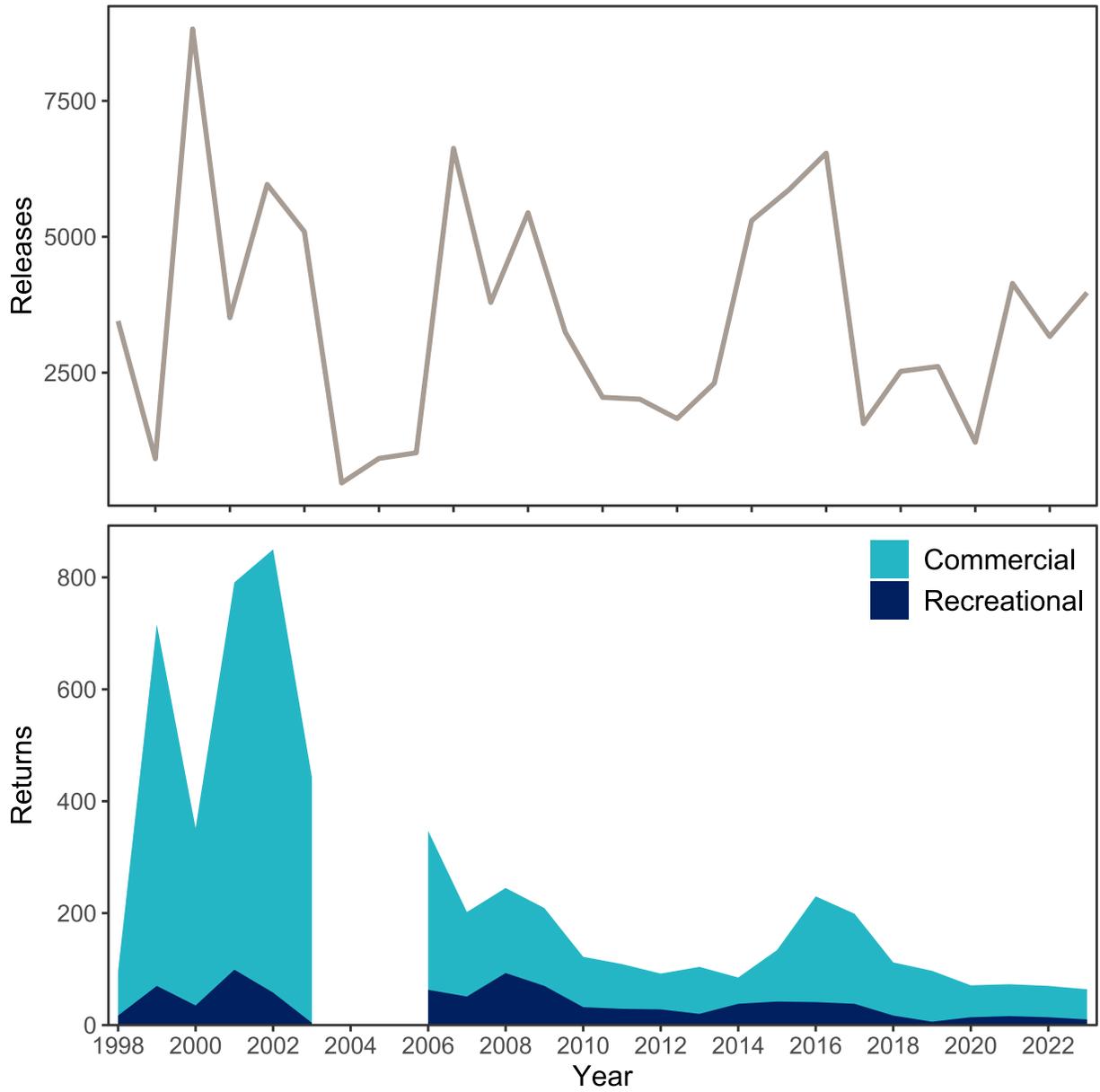


Figure 7. Annual tag releases and returns for Atlantic Cod in NAFO Divisions 2J3KL 1997–2023

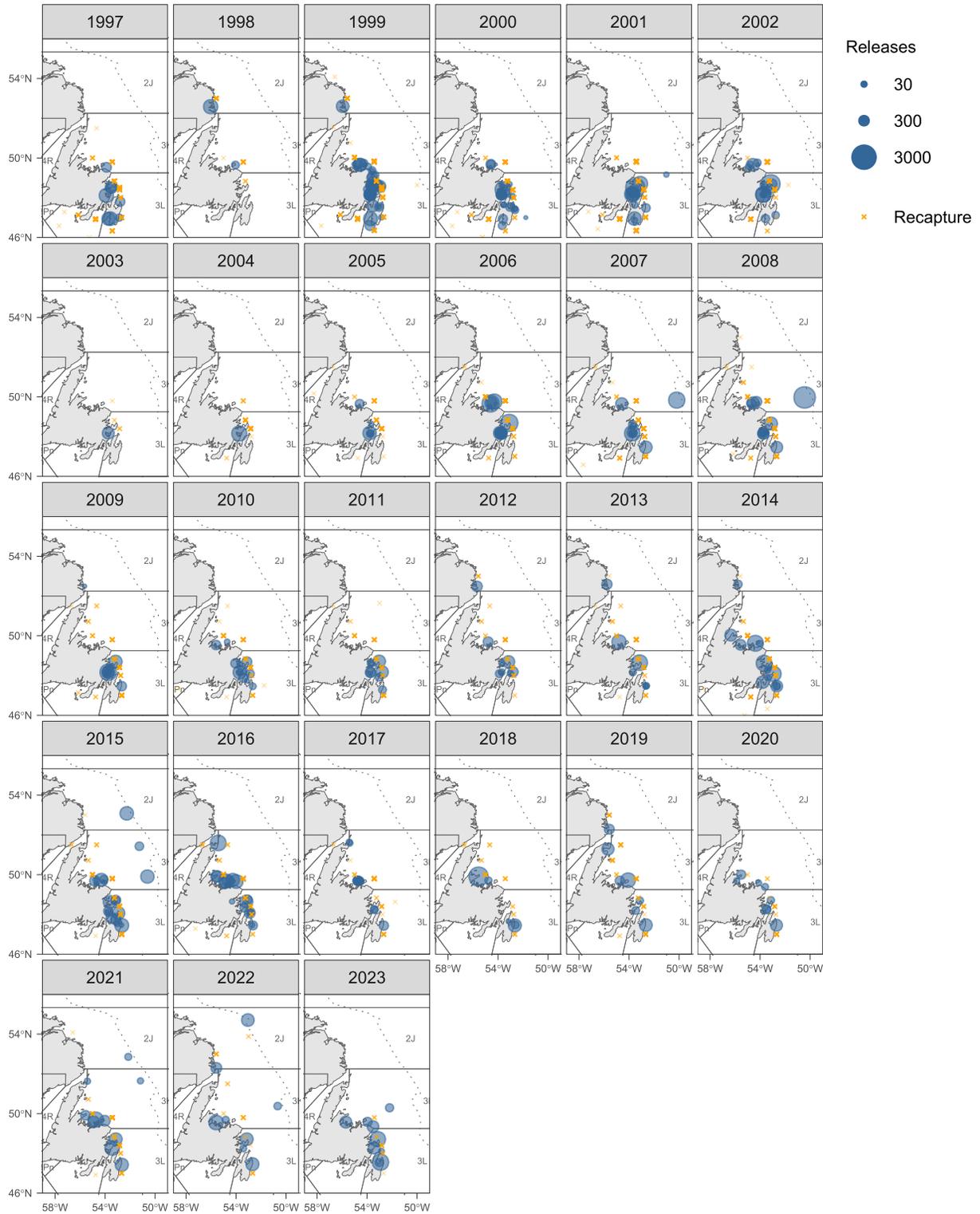


Figure 8. Distribution of tagged cod releases (blue circles) and recaptures (orange x) across NAFO Divisions 2J3KL 1997–2023. NAFO Divisions indicated using solid grey lines and the 1,000 m isobath is indicated using a dotted grey line.

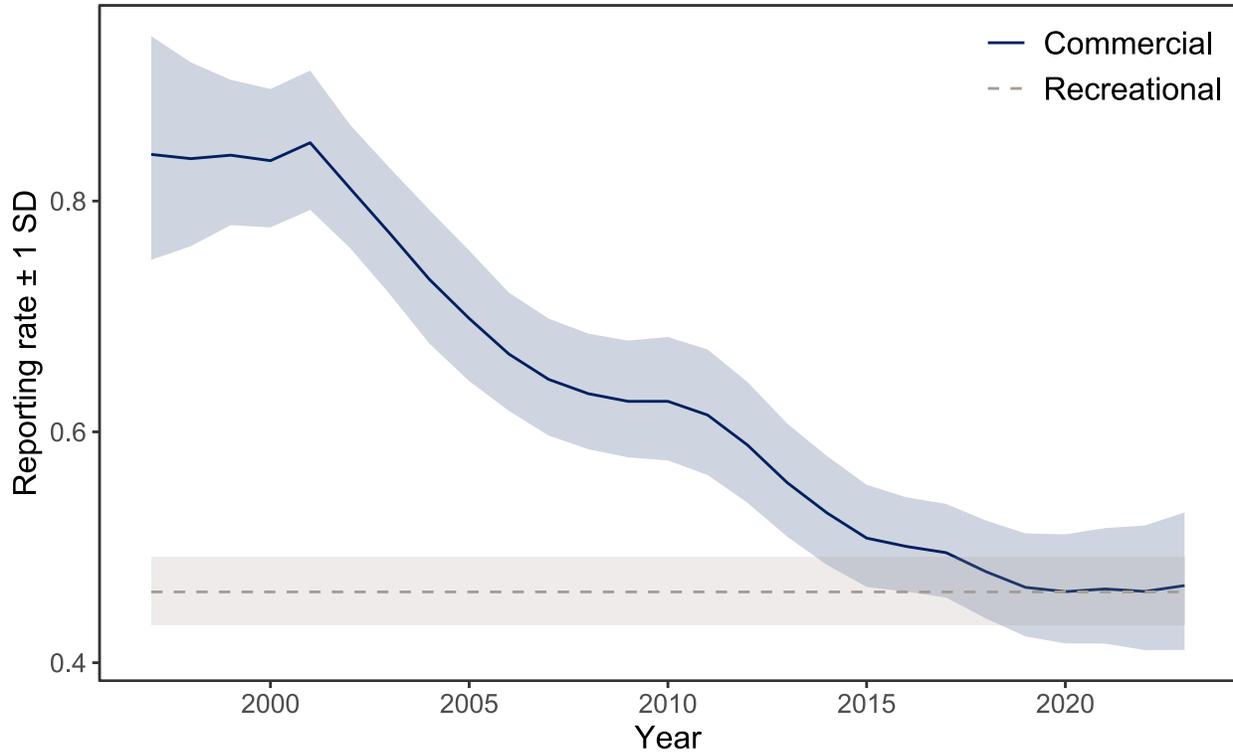


Figure 9. Estimated tag reporting rate for the NAFO Div 2J3KL commercial and recreational fisheries 1997–2023

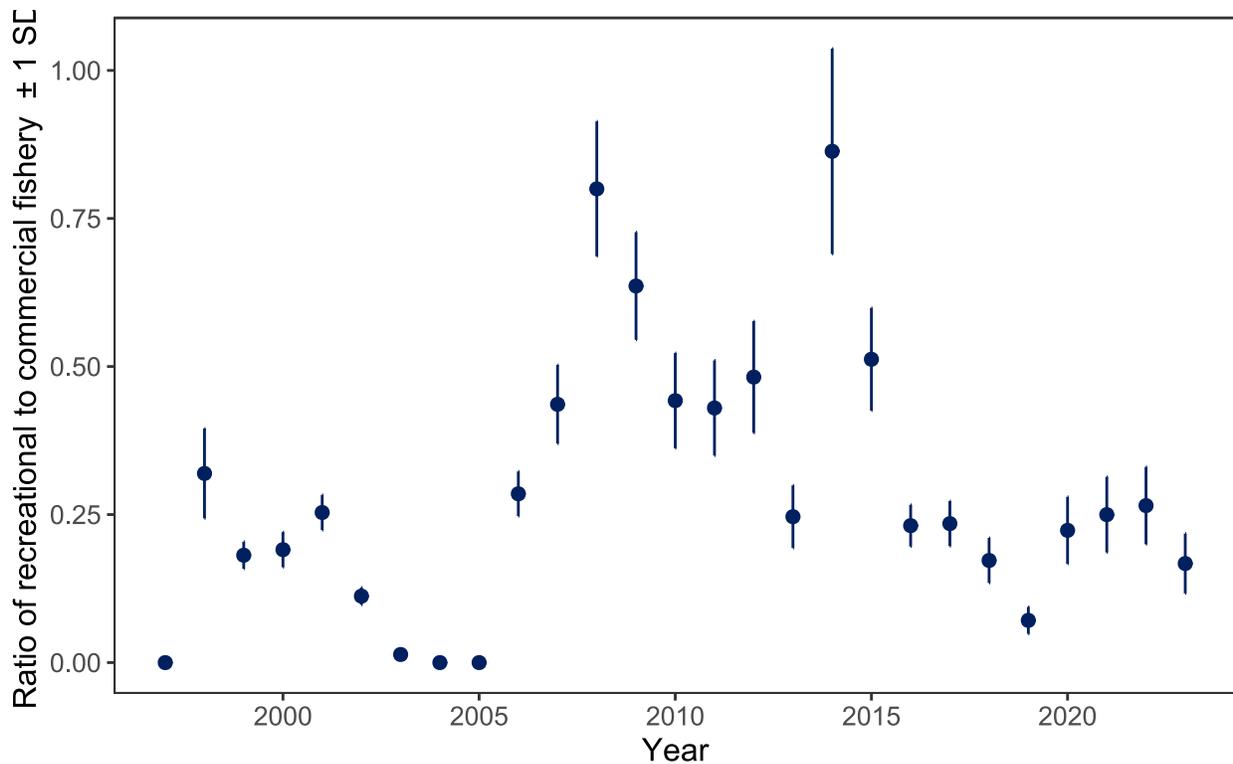


Figure 10. Proportion of returns from the recreational fishery in NAFO Divisions 2J3KL 1997–2023

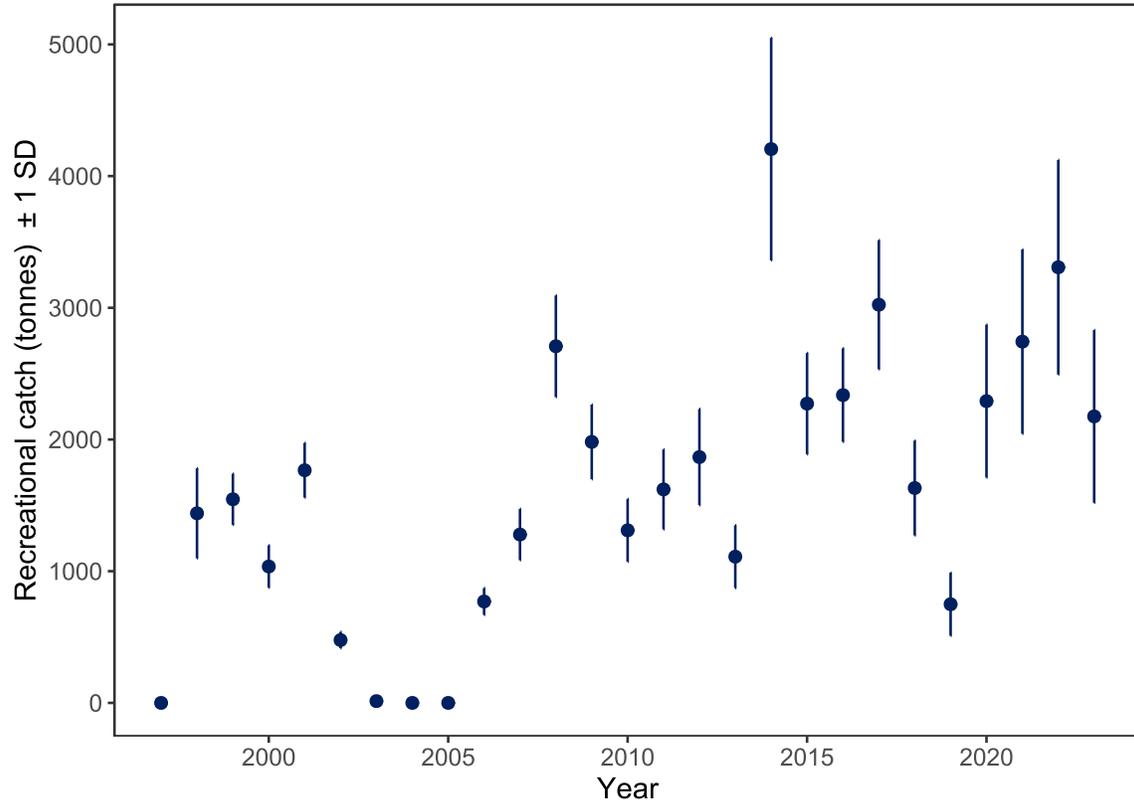


Figure 11. Estimated recreational catch (tonnes) in NAFO Divisions 2J3KL derived from tag returns 1997–2023

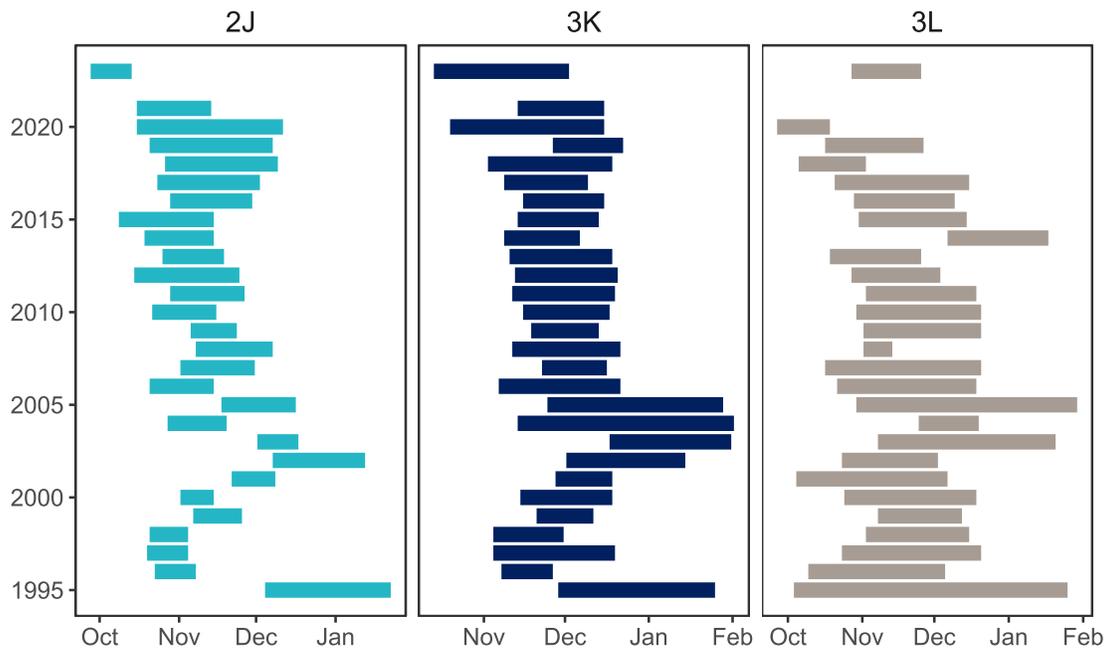


Figure 12. Annual timing of the fall DFO research vessel bottom trawl surveys in NAFO Divisions 2J3KL.

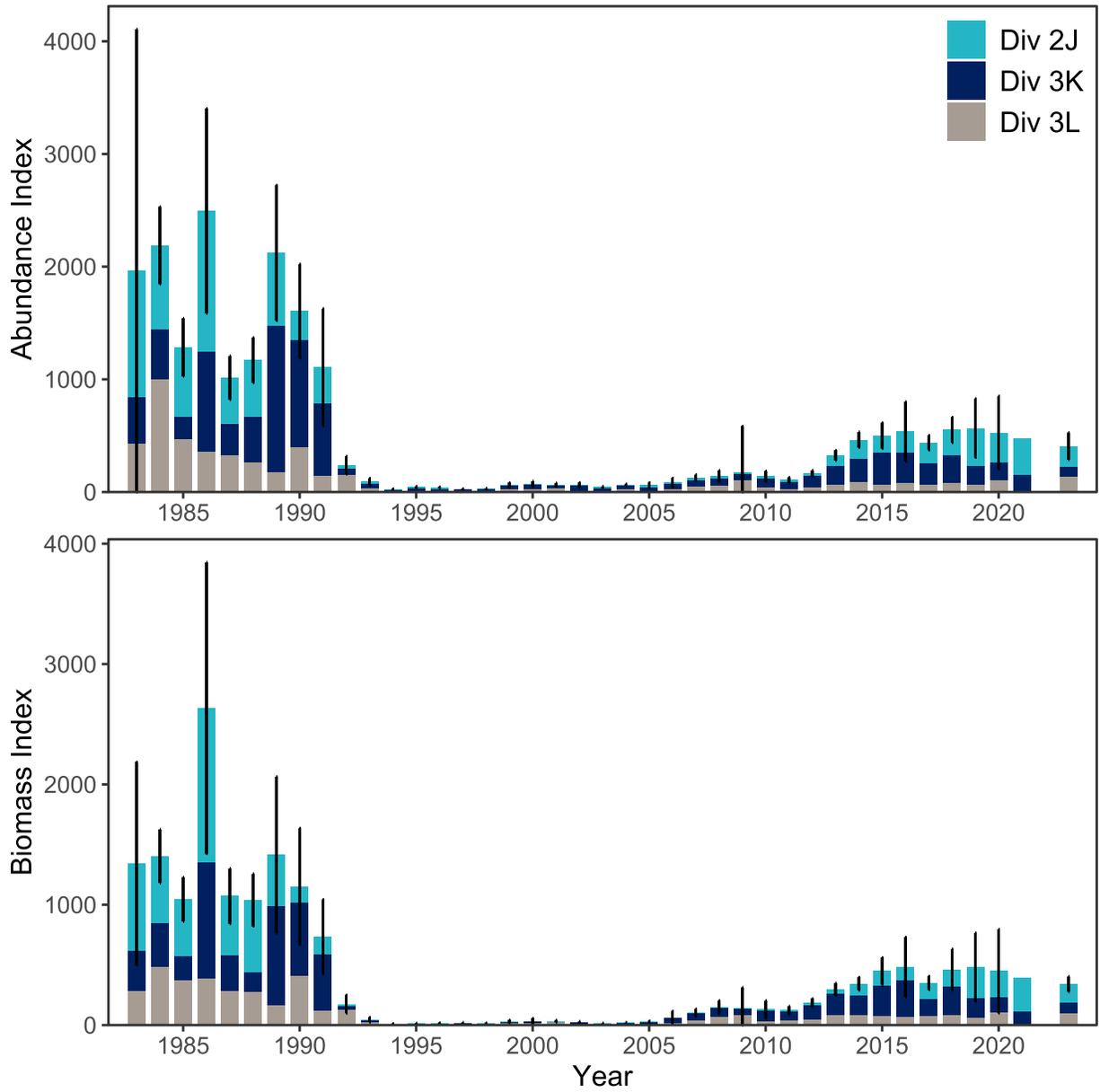


Figure 13. (Upper Panel) Trends in the offshore indices of cod abundance and (Lower Panel) total biomass from the fall DFO research vessel bottom trawl surveys of index strata in NAFO Divisions 2J3KL. Error bars are approximate 95% confidence intervals.

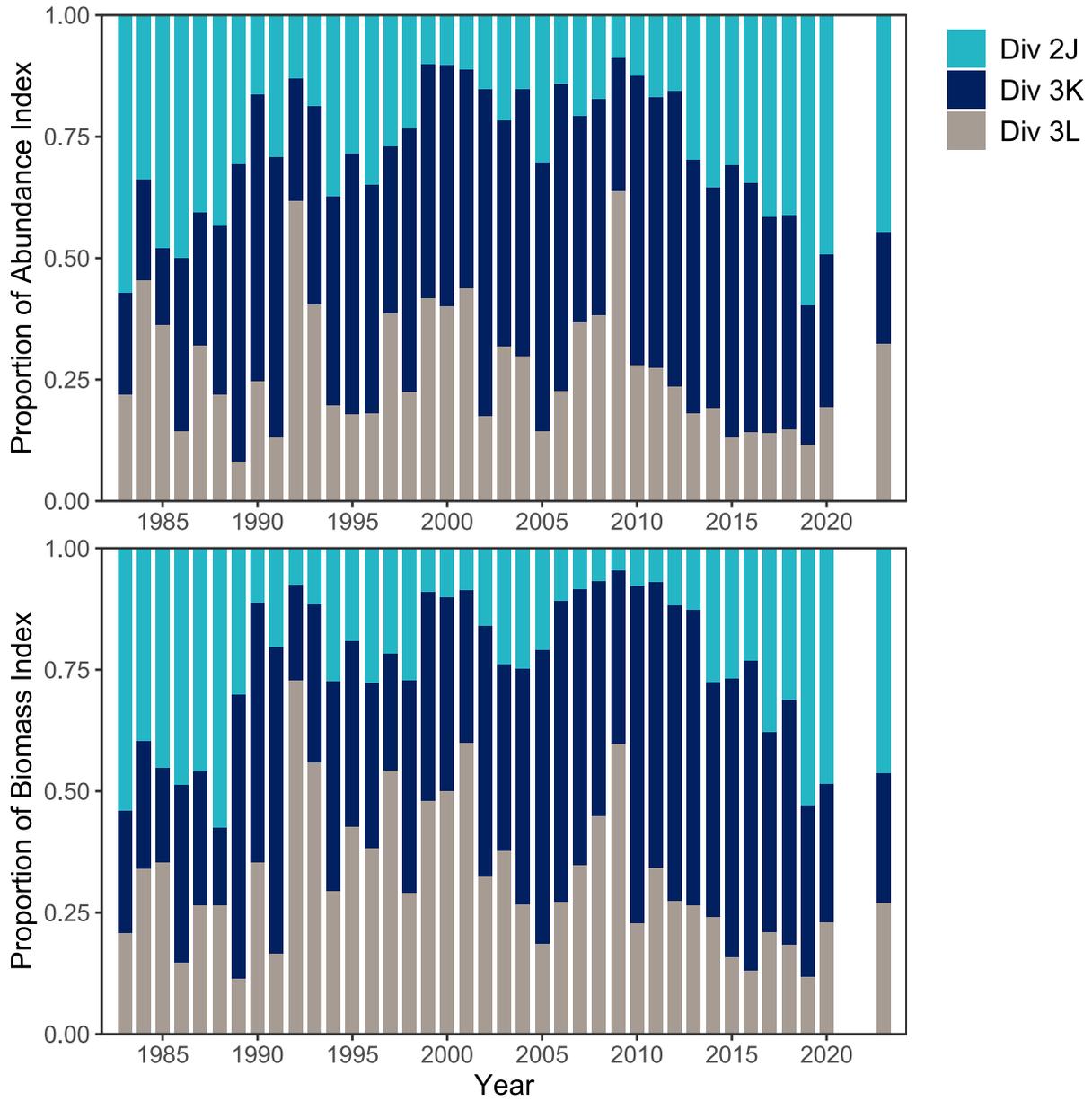


Figure 14. (Upper Panel) Proportion of cod abundance and (Lower Panel) total biomass in each division from the fall DFO research vessel bottom trawl surveys of index strata in NAFO Divisions 2J3KL.

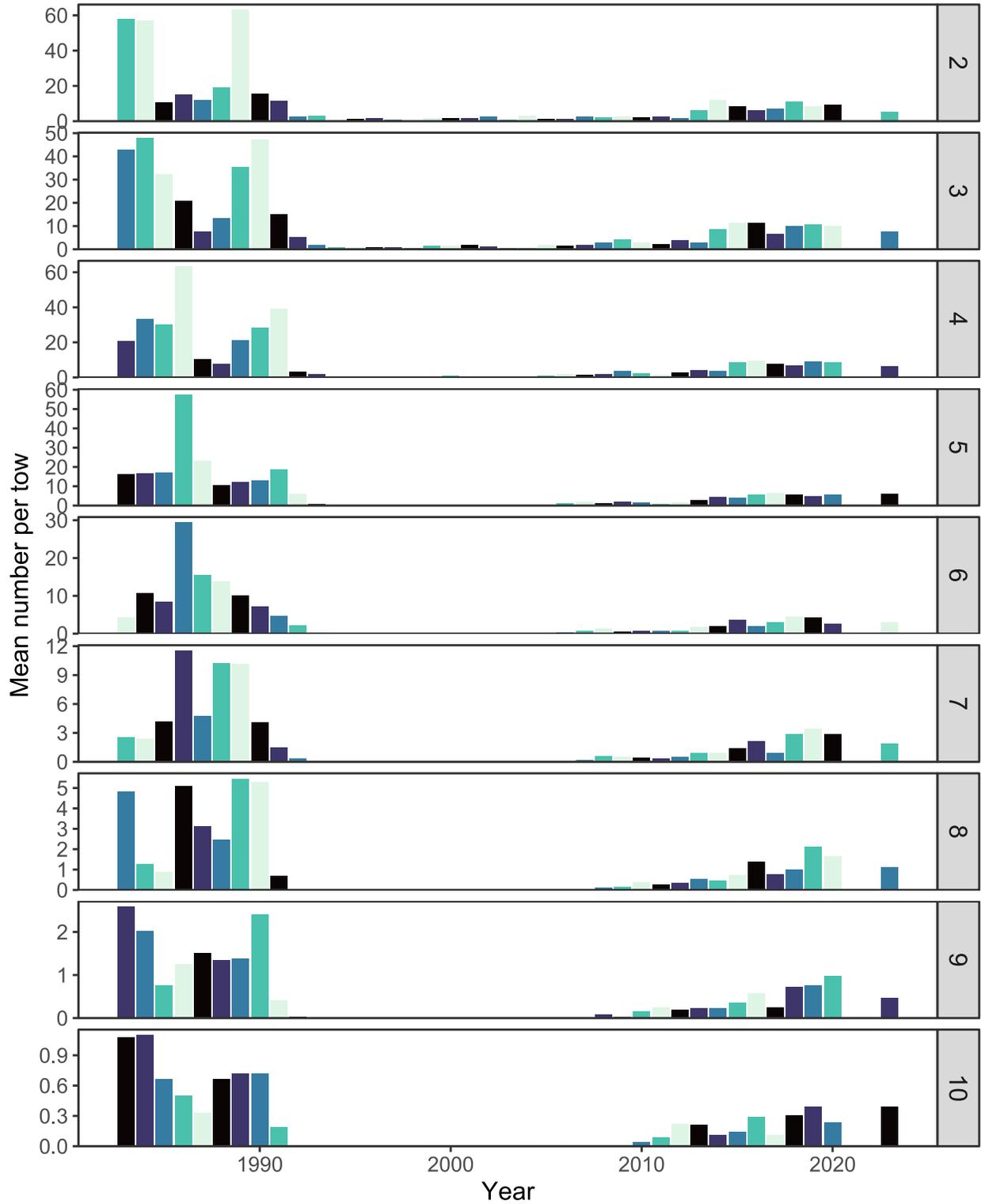


Figure 15. Mean number per tow at ages 2–10 of cod in NAFO Divisions 2J3KL from the fall research vessel bottom-trawl surveys. Cohorts are coloured in a repeating pattern to aid visual tracking.

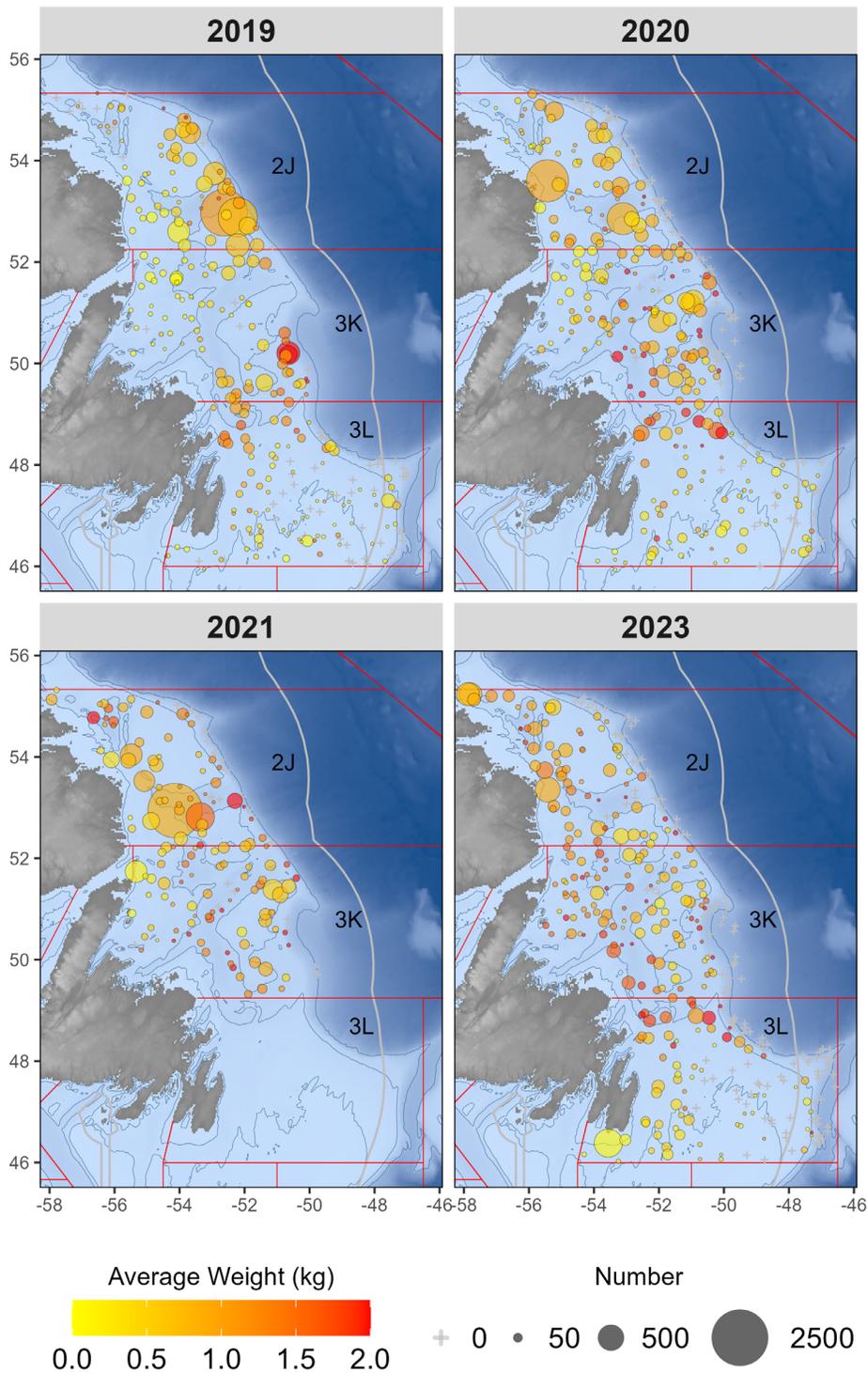


Figure 16. Age-aggregated distribution of cod catches (number per tow), from the fall DFO RV survey of all strata in NAFO Divisions 2J3KL during 2019–23. Symbol size (continuous scaling) is proportional to numbers caught. Symbol colour is scaled by the average weight (kg) of cod caught in each set.

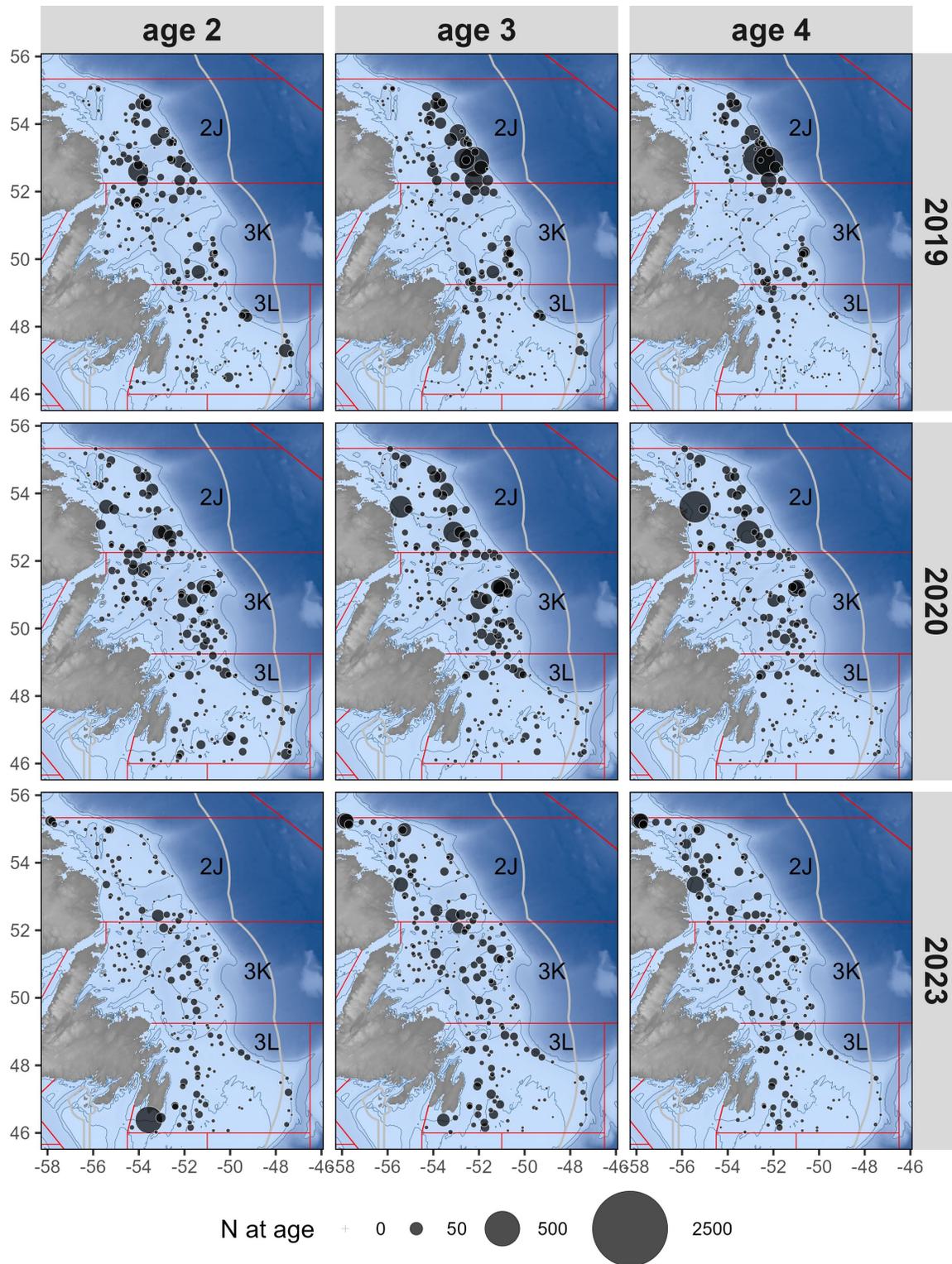


Figure 17. Age-disaggregated distribution of cod catches (number per tow for ages 2–4), from the fall DFO RV survey of all strata in NAFO Divisions 2J3KL during 2020–23. Symbol size (continuous scaling) is proportional to numbers caught at-age.

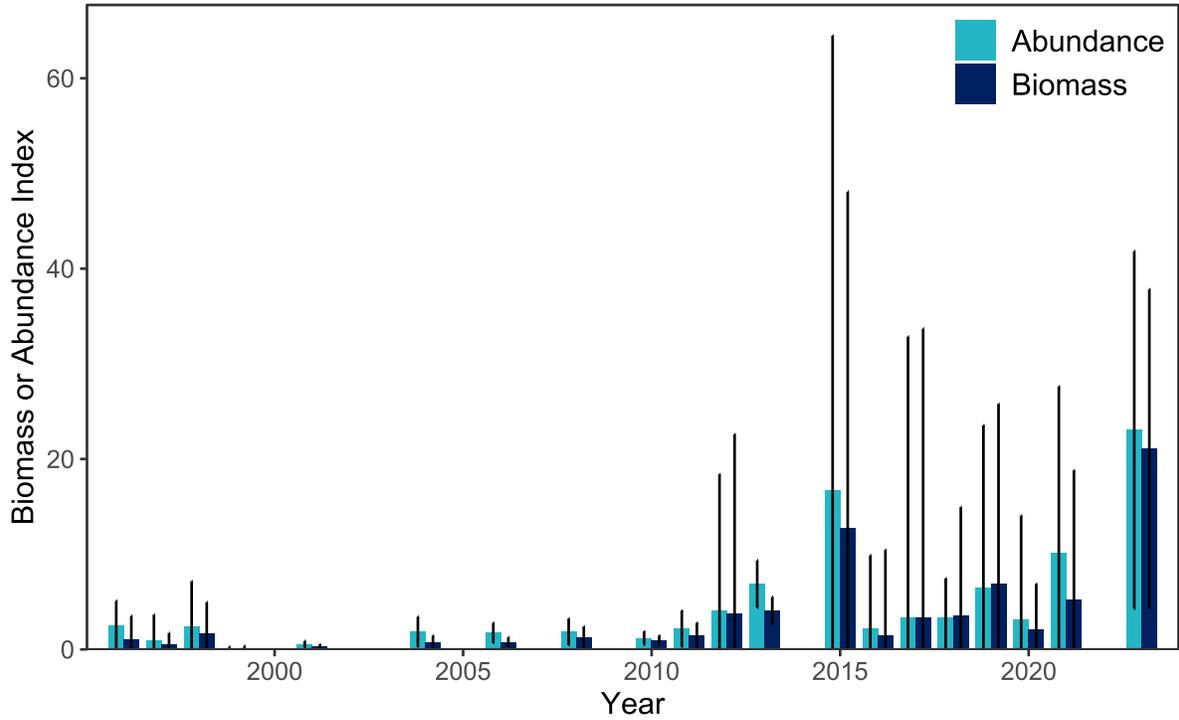


Figure 18. Trends in the offshore indices of cod abundance and total biomass from the fall DFO research vessel bottom trawl surveys in NAFO Div. 2H. Error bars are approximate 95% confidence intervals.

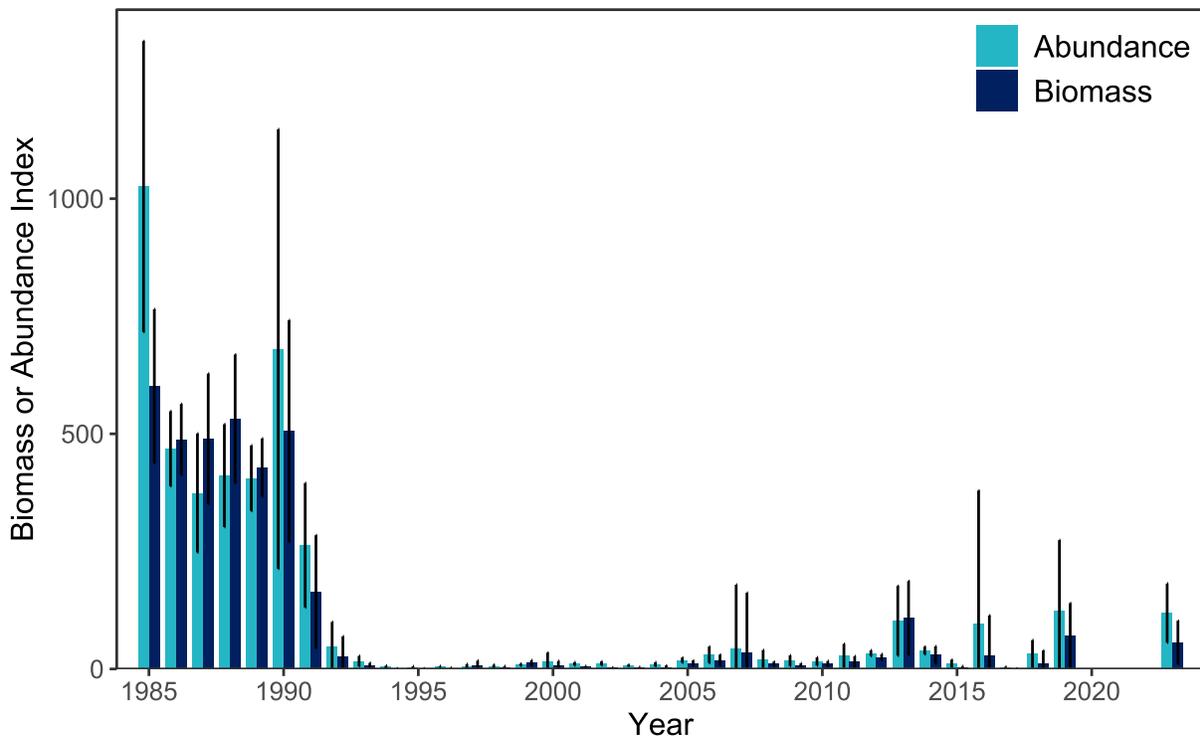


Figure 19. Trends in the offshore indices of cod abundance and total biomass from the spring DFO research vessel bottom trawl surveys in NAFO Div. 3L. Error bars are approximate 95% confidence intervals.

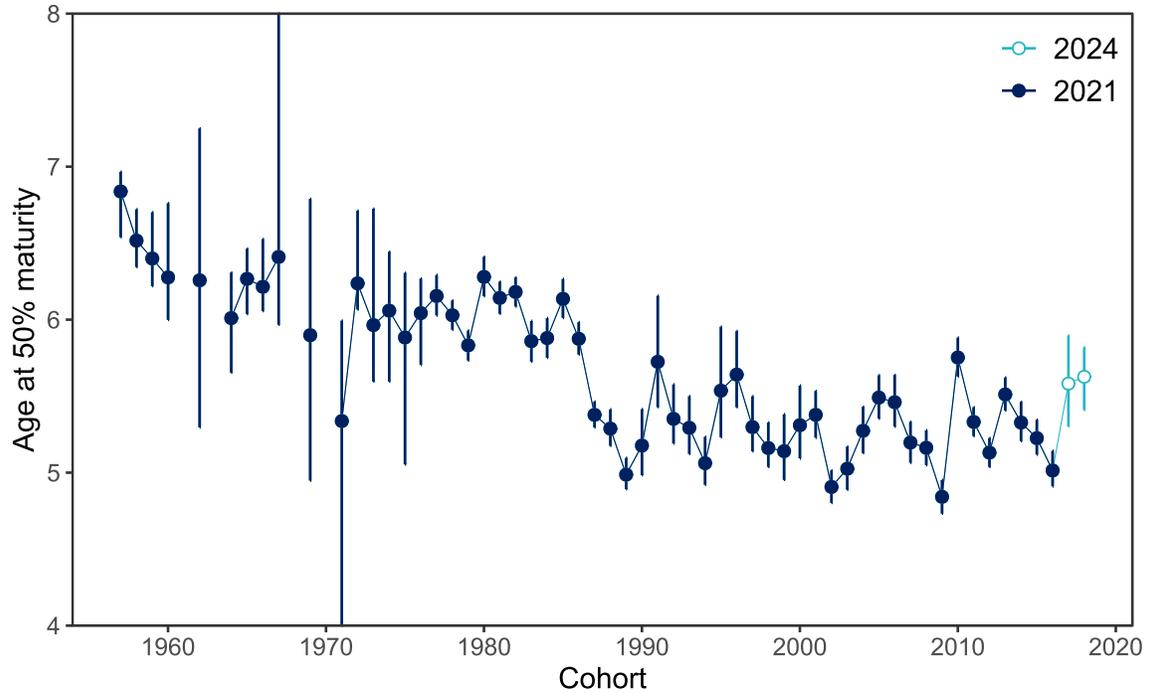


Figure 20. Age at 50% maturity (\pm 95% confidence interval) by cohort for female cod in Divisions 2J3KL combined based on sampling during fall research bottom-trawl surveys. The open circles show the results from the 2024 stock update back to the 1990 cohort. See text for details.

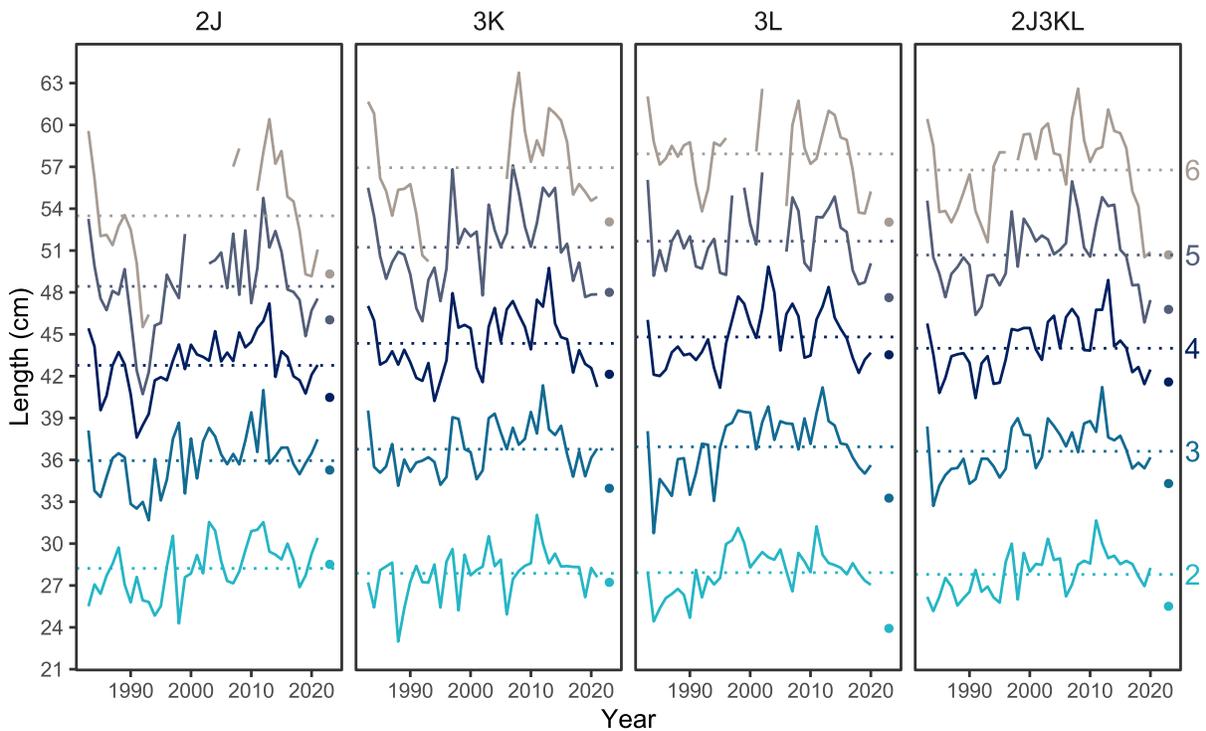


Figure 21. Mean lengths (cm) at ages 2-6 of cod in NAFO Divisions 2J3KL since 1983, as determined from sampling during fall research vessel bottom-trawl surveys. Time-series mean for each age indicated by a dashed line. Values calculated from fewer than 5 aged fish are not plotted.

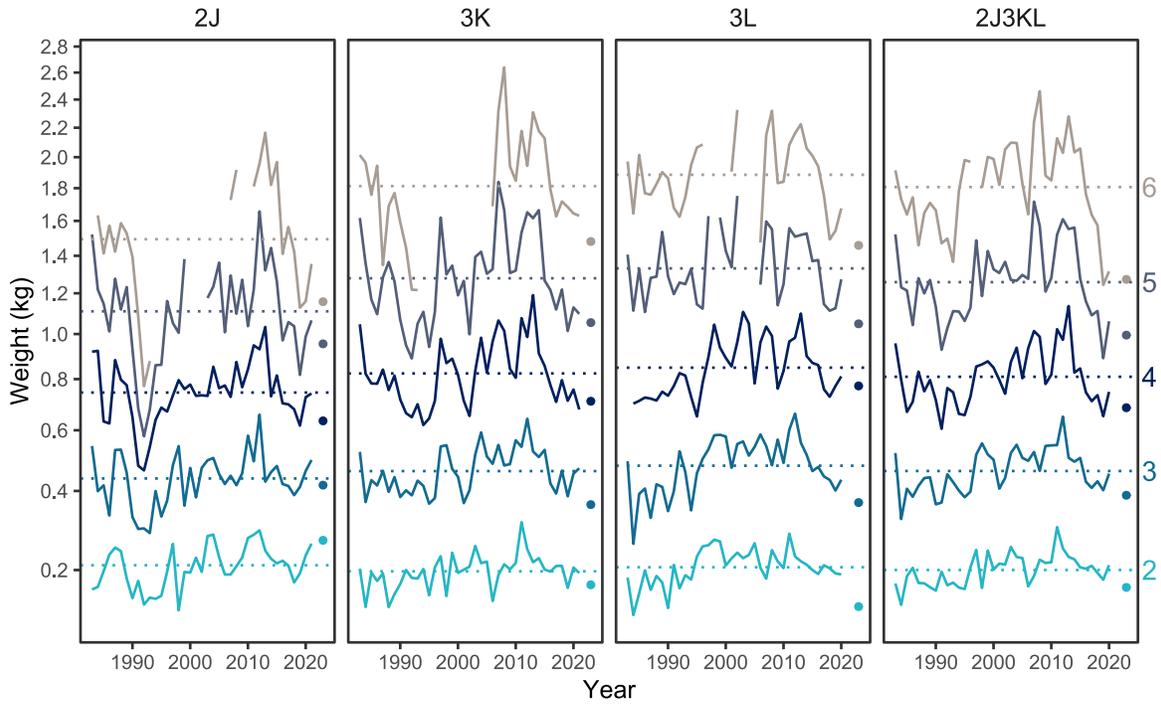


Figure 22. Mean weights (kg) at ages 2–6 of cod in NAFO Divisions 2J3KL since 1983, as determined from sampling during fall research vessel bottom-trawl surveys. Time-series mean for each age indicated by a dashed line. Values calculated from fewer than 5 aged fish are not plotted. Note the square root scale of the Y-axis to aid comparison of trends across ages.

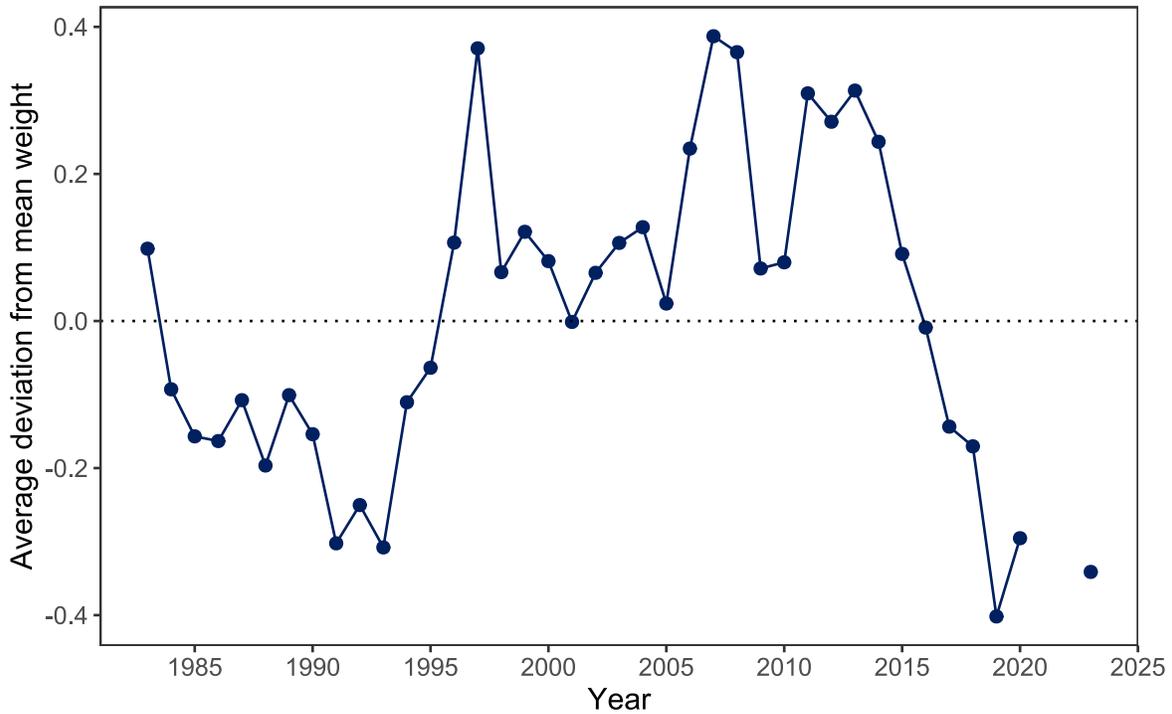


Figure 23. Average deviation from mean weight-at-age for ages 3–7 from fall RV bottom-trawl surveys since 1983 in NAFO Divisions 2J3KL combined.

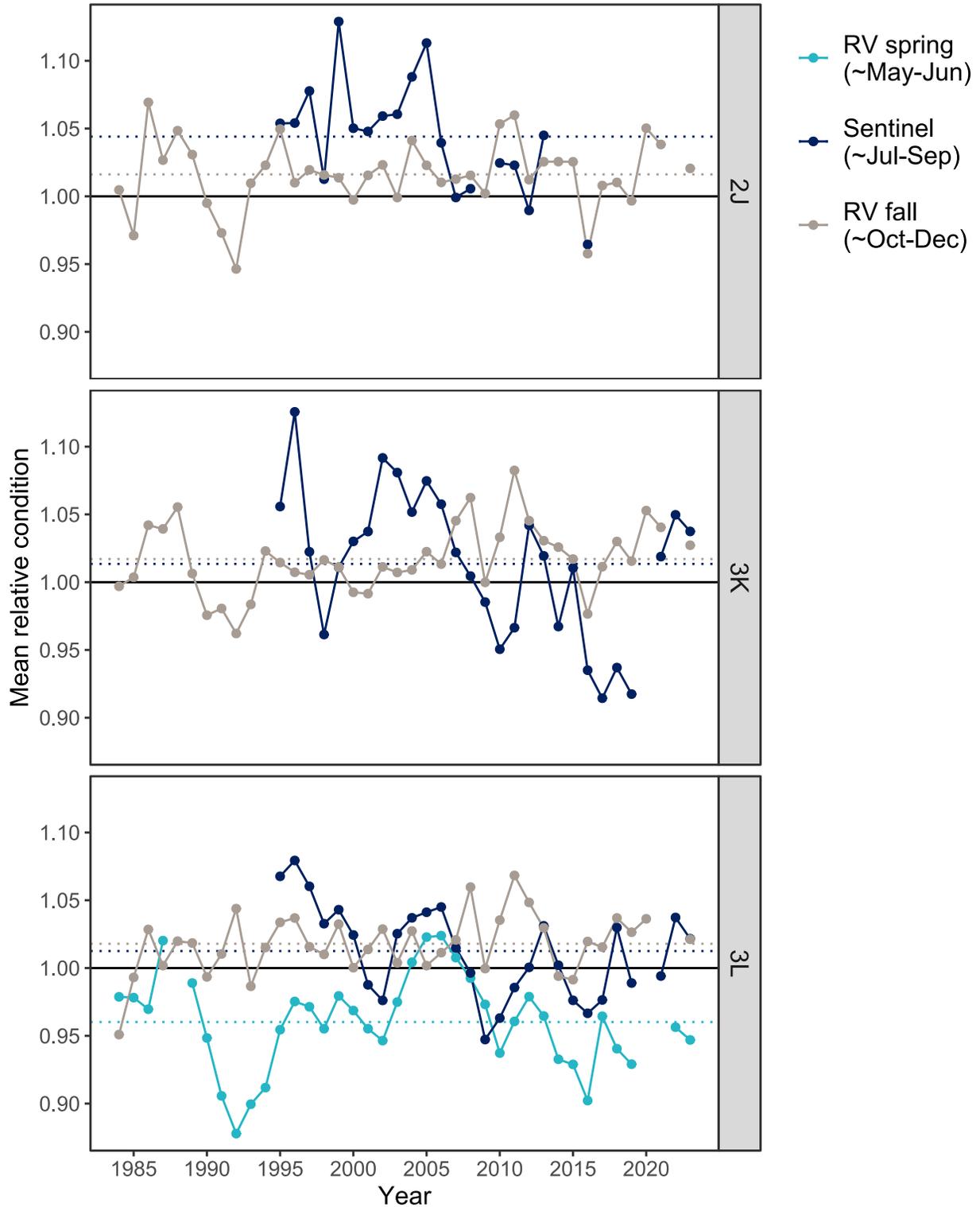


Figure 24. Relative gutted condition of cod in Divisions 2J3KL from 1983 onward, as determined from sampling during bottom-trawl surveys in spring and fall, and the Sentinel gillnet survey. Dotted line represents averages by survey and NAFO divisions and solid line represents overall average.

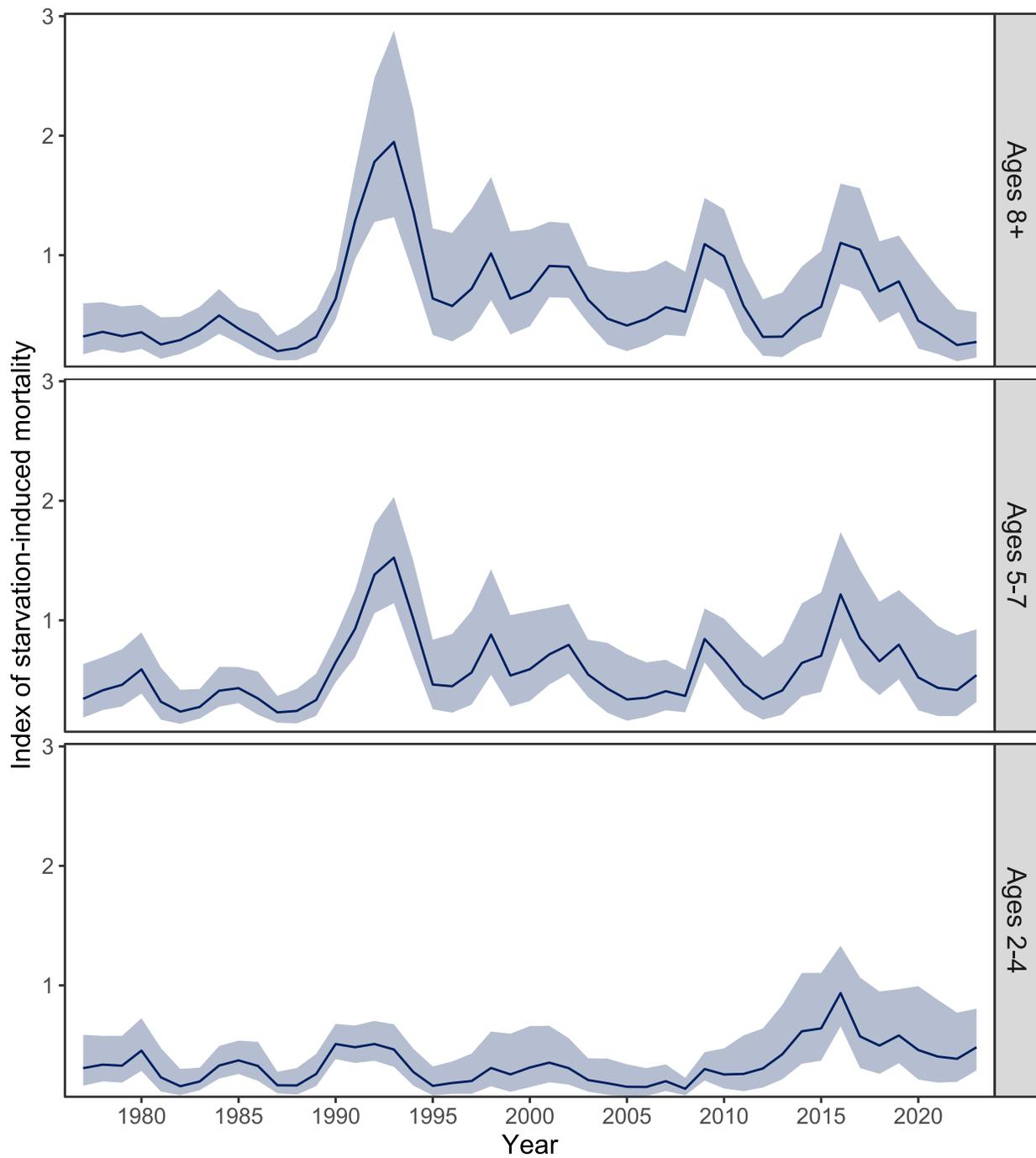


Figure 25. Index of starvation-induced natural mortality for cod in Divisions 2J3KL, analyzed from 1977 onwards through spring and fall bottom-trawl surveys, along with the Sentinel gillnet survey. This index is derived from a seasonal model of gutted condition where cod with residual levels below -0.18 are assumed to succumb to starvation. Methods followed are outlined in Regular et al. (2022).

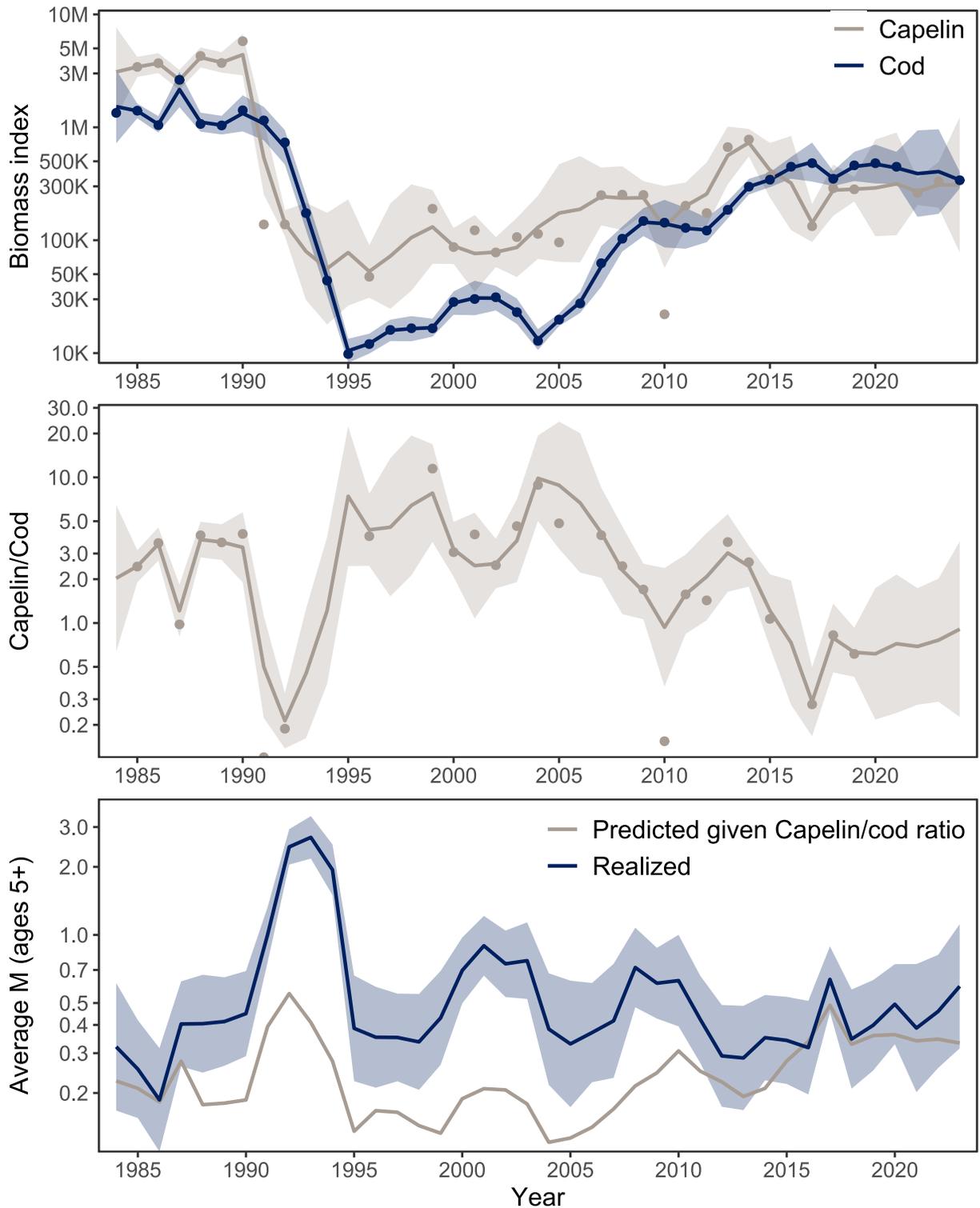


Figure 26. (Upper Panel) Observed (dots) and predicted (lines) biomass index of cod and Capelin, (Middle Panel) Capelin/cod biomass ratio, and (Lower Panel) predicted and realized levels of population weighted average natural mortality for cod ages 5+. Predicted levels of natural mortality are informed by changes in the Capelin/cod ratio. Y-axes are in log scale and shaded regions represent 95% confidence intervals.

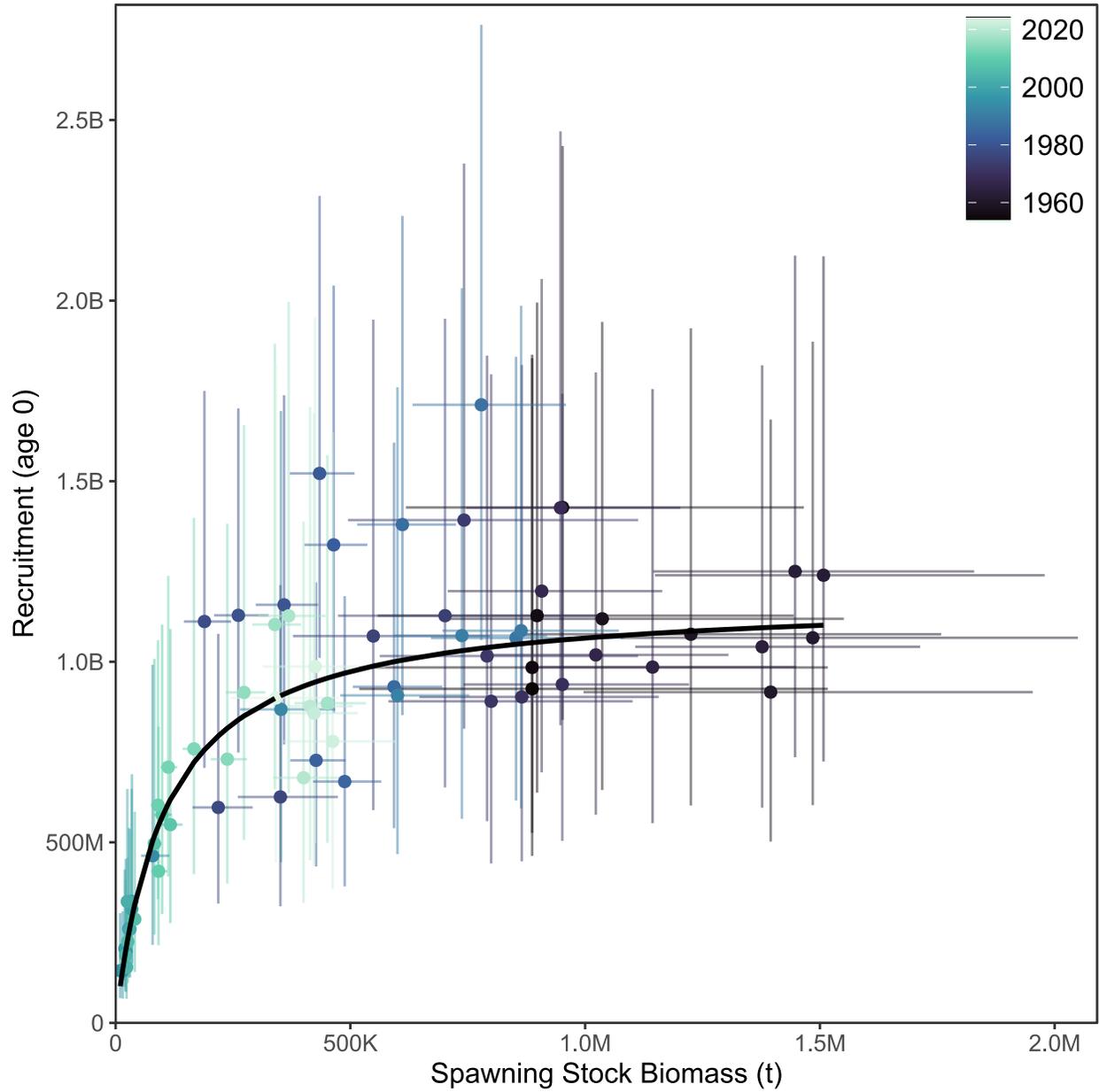


Figure 27. Beverton-Holt stock-recruitment relationship estimated by xteNCAM. Horizontal and vertical whiskers represent 95% confidence intervals around estimates of recruitment (dots), and black lines are predicted levels of recruitment.

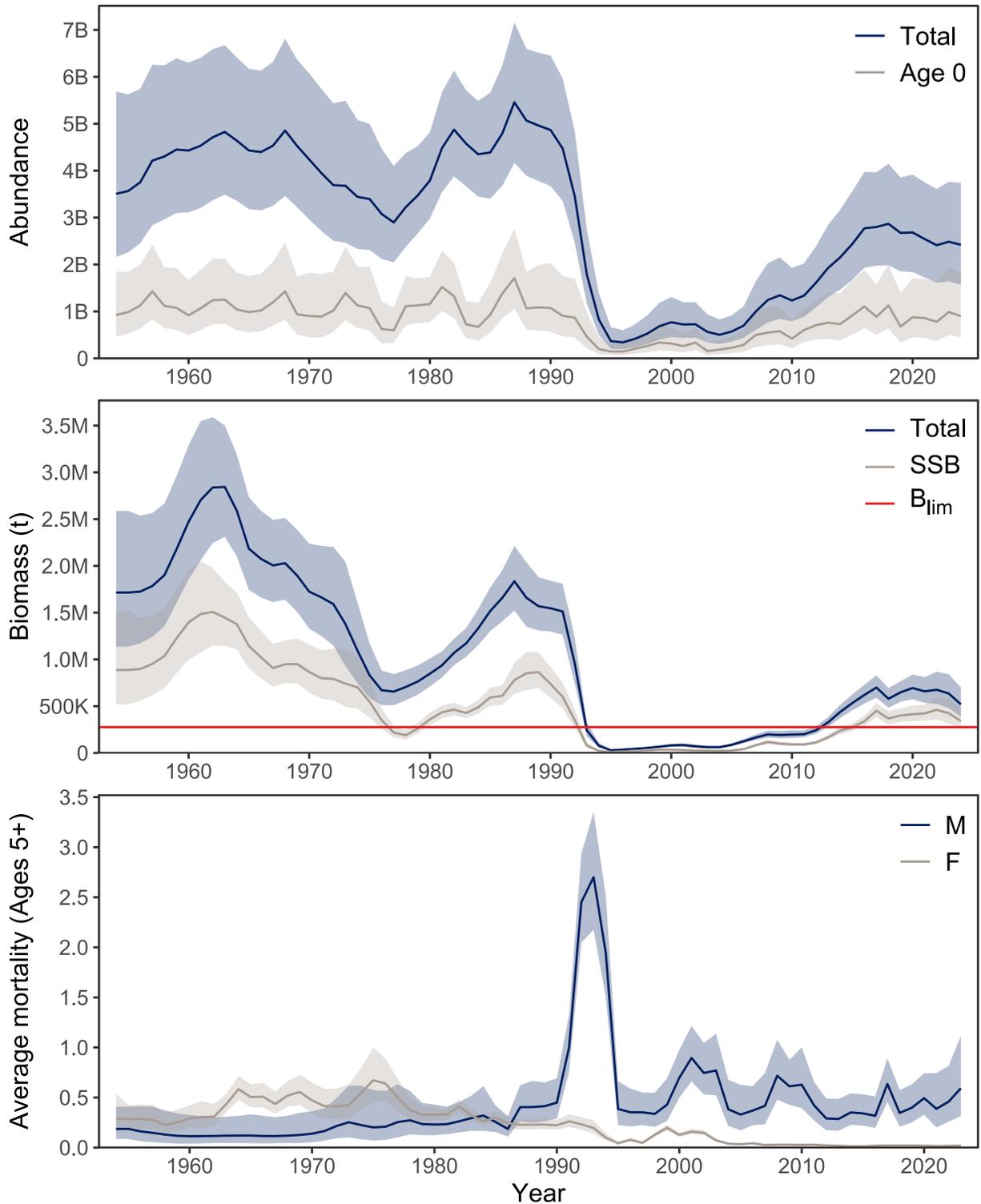


Figure 28. (Upper Panel) Stock abundance, (Middle Panel) biomass, and (Lower Panel) mortality rate estimates \pm 95% confidence intervals (shaded regions) for 2J3KL cod since 1954 from xteNCAM. Quantities are indicated in the legends in each panel. SSB = spawning stock biomass; M = natural mortality; F = fishing mortality.

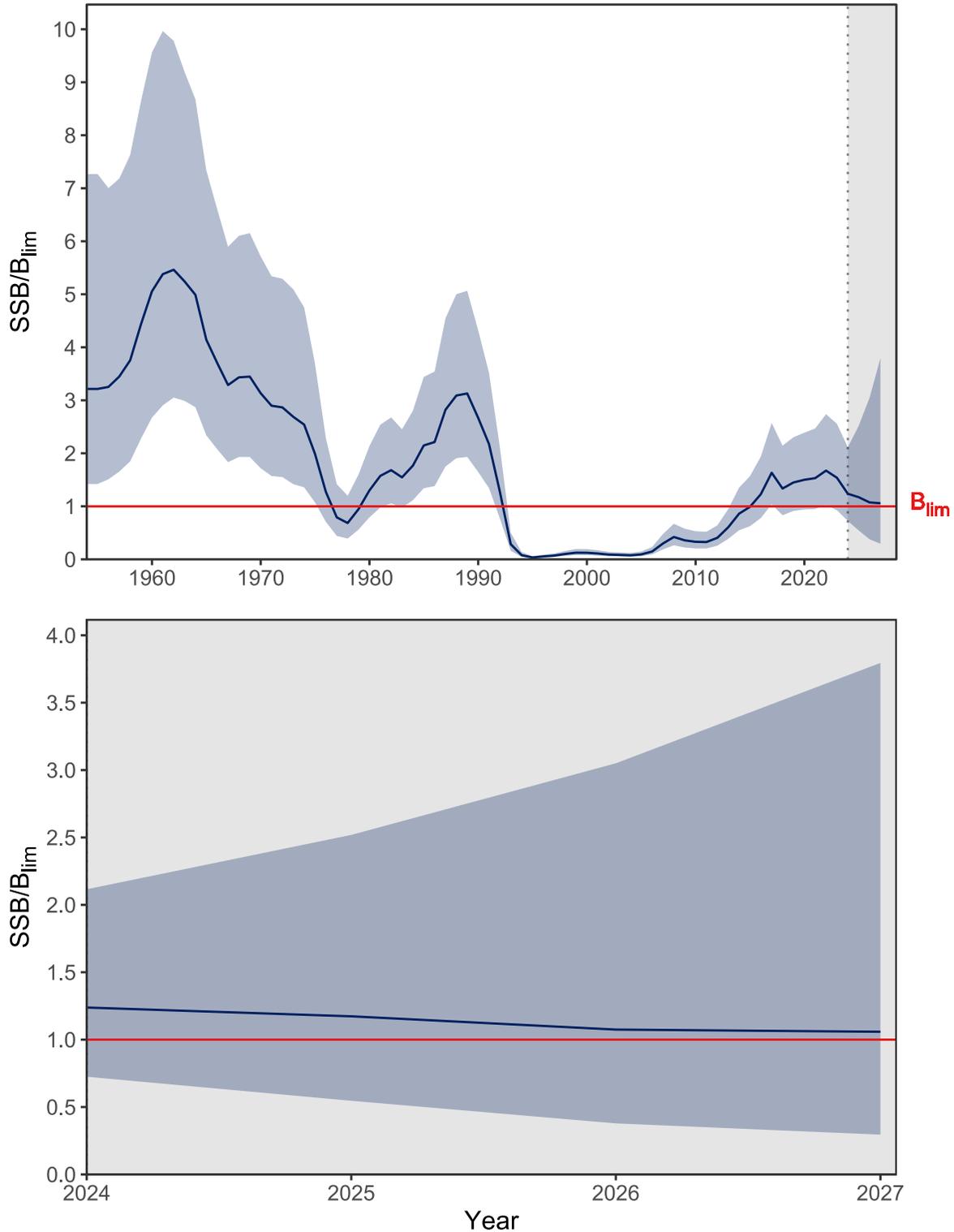


Figure 29. Projected relative SSB (SSB/B_{lim}) assuming status quo levels of Capelin and catch, where B_{lim} (horizontal solid red line) is defined as 40% of B_{MSY} . Solid blue line is the model estimate and the blue shaded region are 95% confidence intervals. Light grey region indicates projection period, which is the focal period of the lower panel. SSB = spawning stock biomass; B_{lim} is biomass at the limit reference point; B_{MSY} is biomass that produces the maximum sustainable yield.

APPENDIX A: ASSESSMENT MODEL DIAGNOSTICS

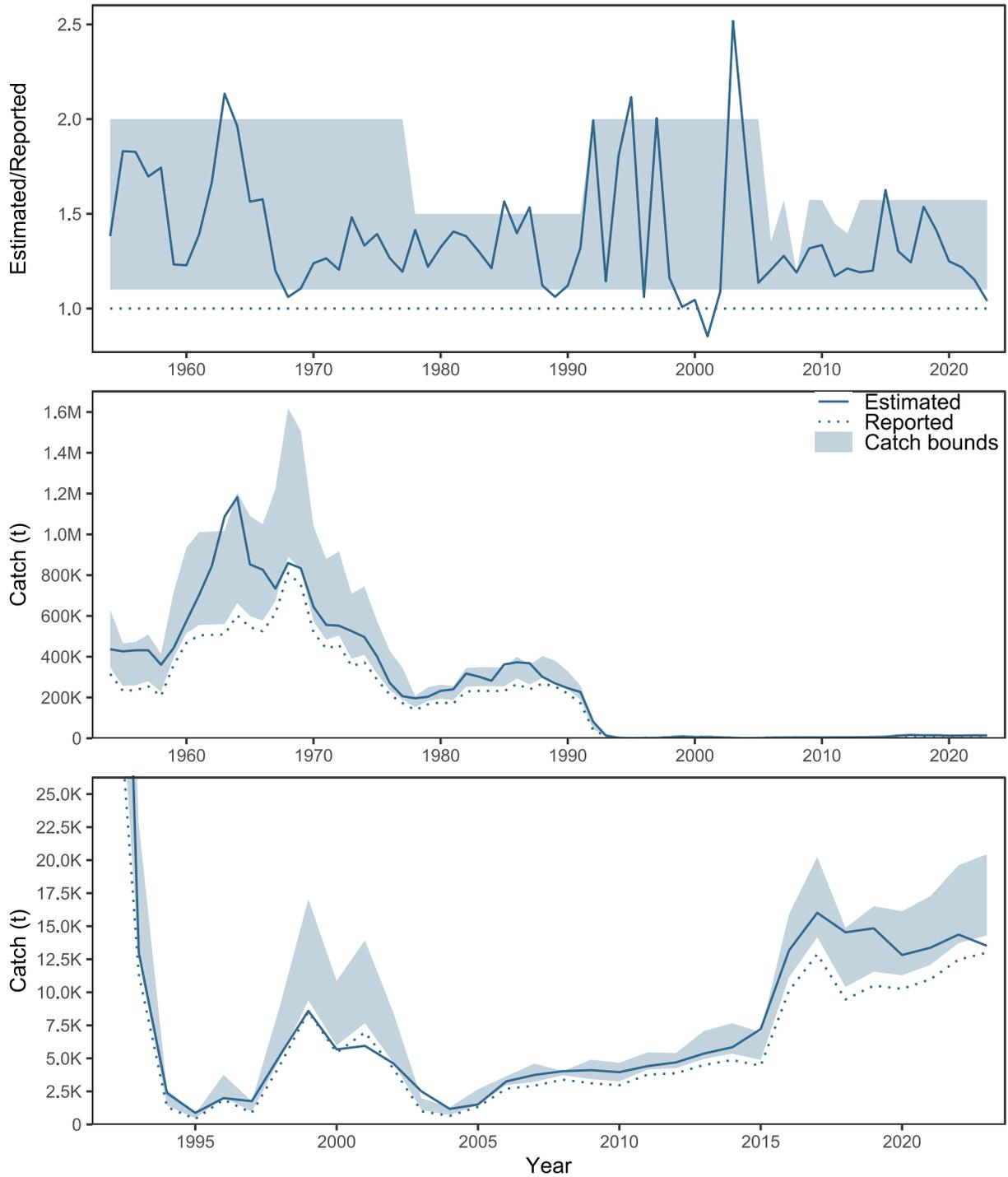


Figure A1. (Upper Panel) Estimated total catch weight relative to reported catches and (Middle Panel) estimated total catch weight since 1954 and (Lower Panel) since 1992. Shaded regions represent catch bounds.

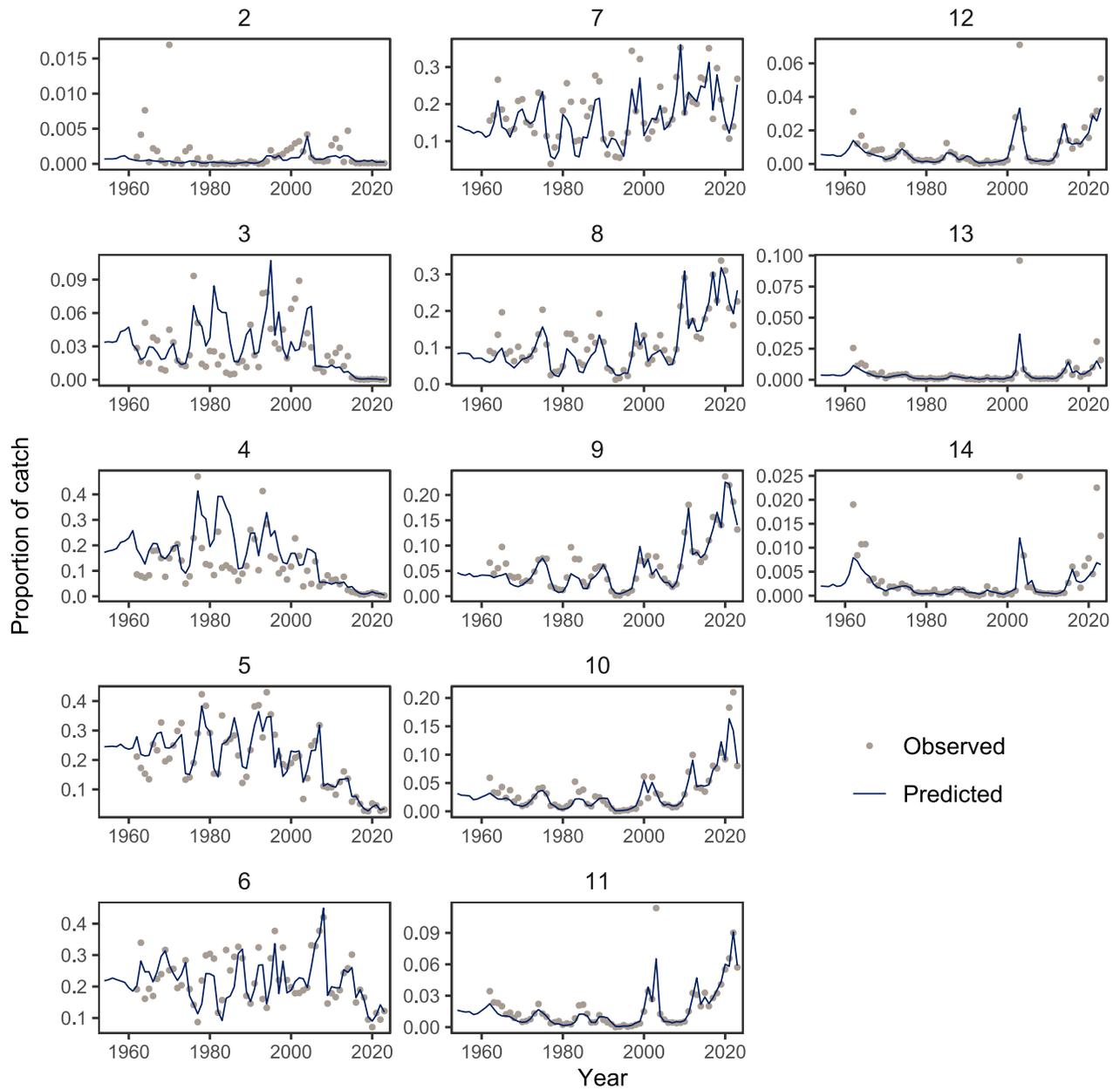


Figure A2. Observed (dots) and model predicted values (lines) for the proportions of each age in the catch.

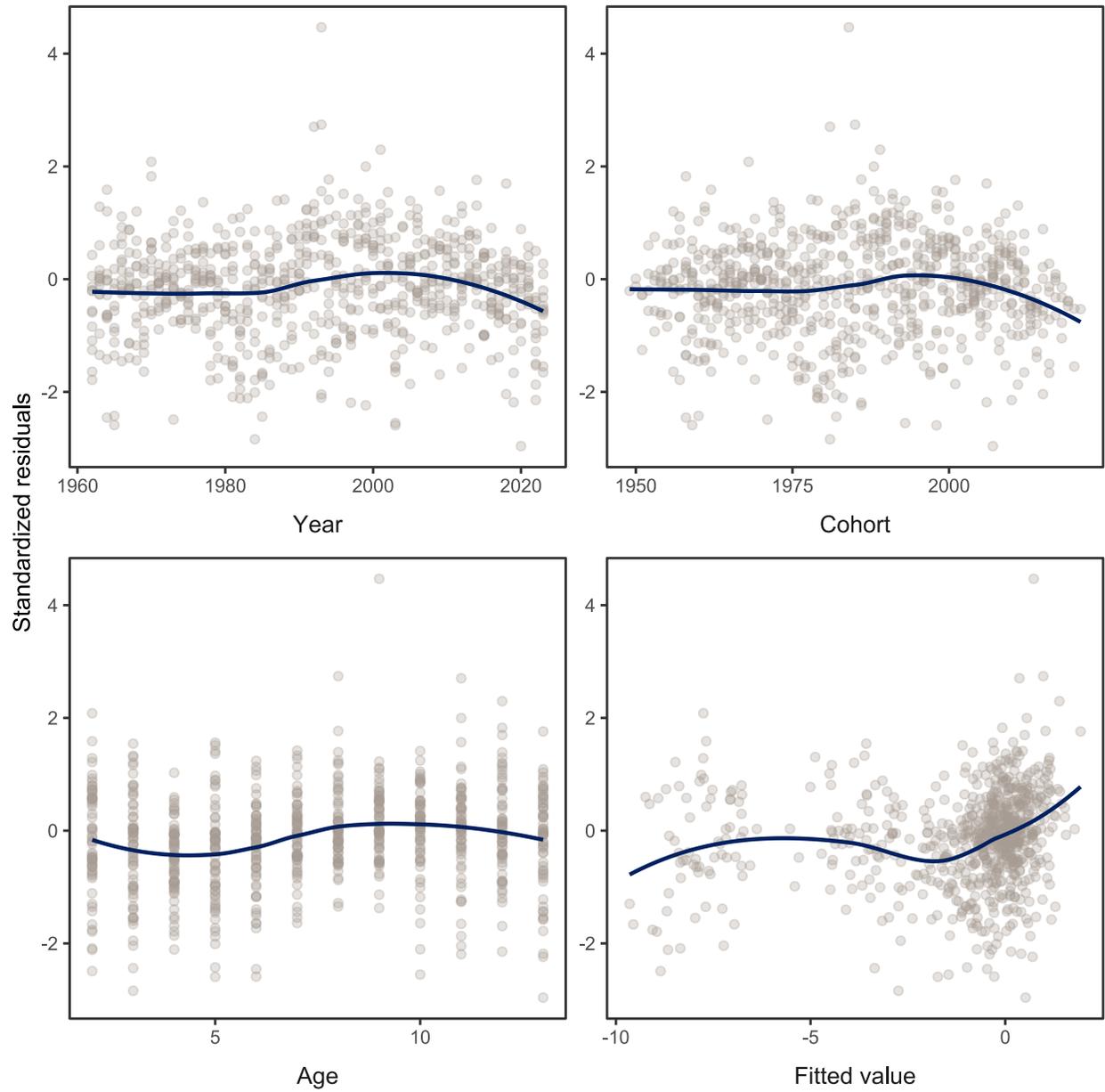


Figure A3. Standardized residuals from catch composition continuation ratio logits faceted by age, cohort, year, and fitted value from *xteNCAM*. Lines are loess curves.

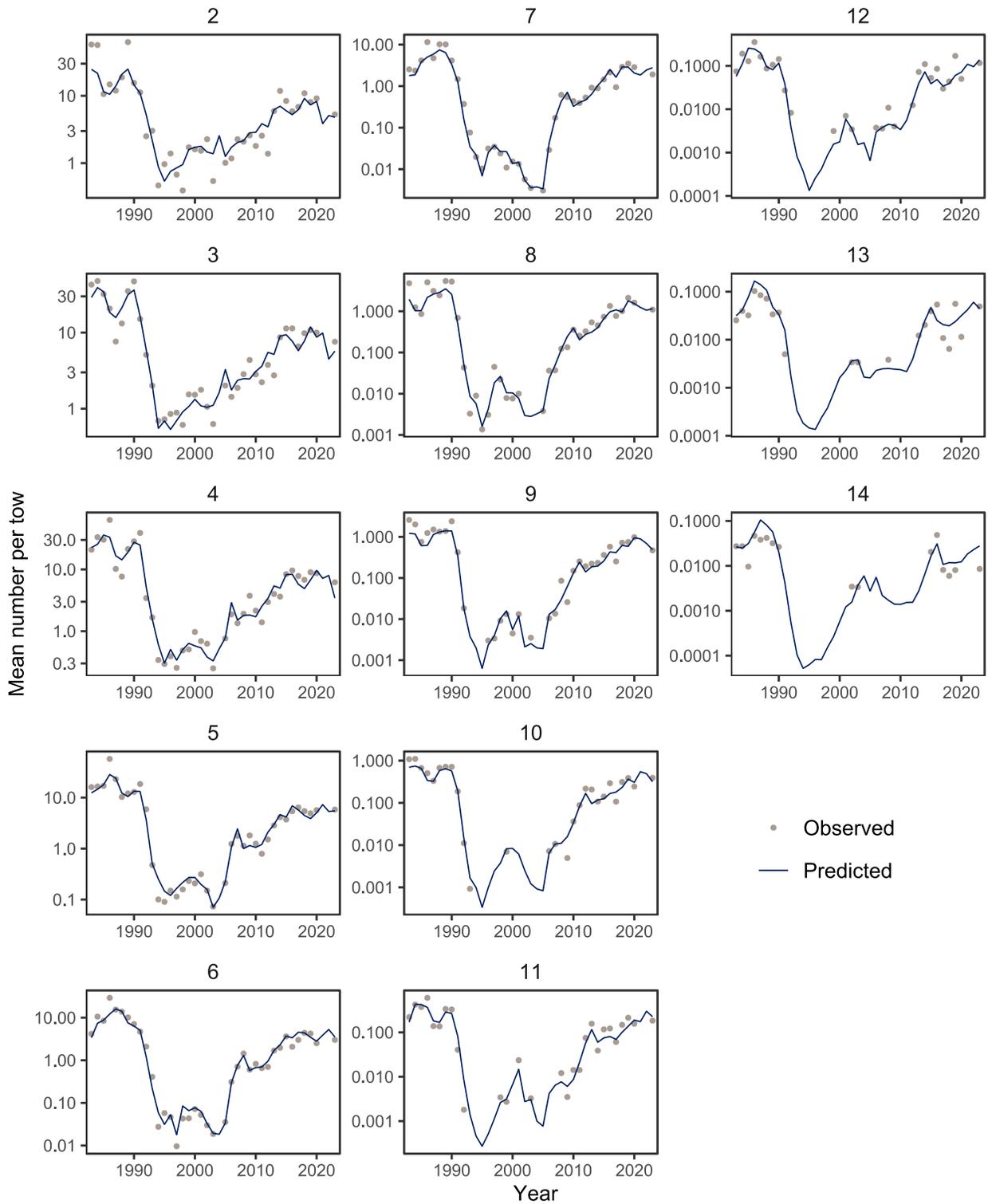


Figure A4. Observed (dots) and model predicted values (lines) for the age-disaggregated DFO RV survey index. Y-axis is in log scale.

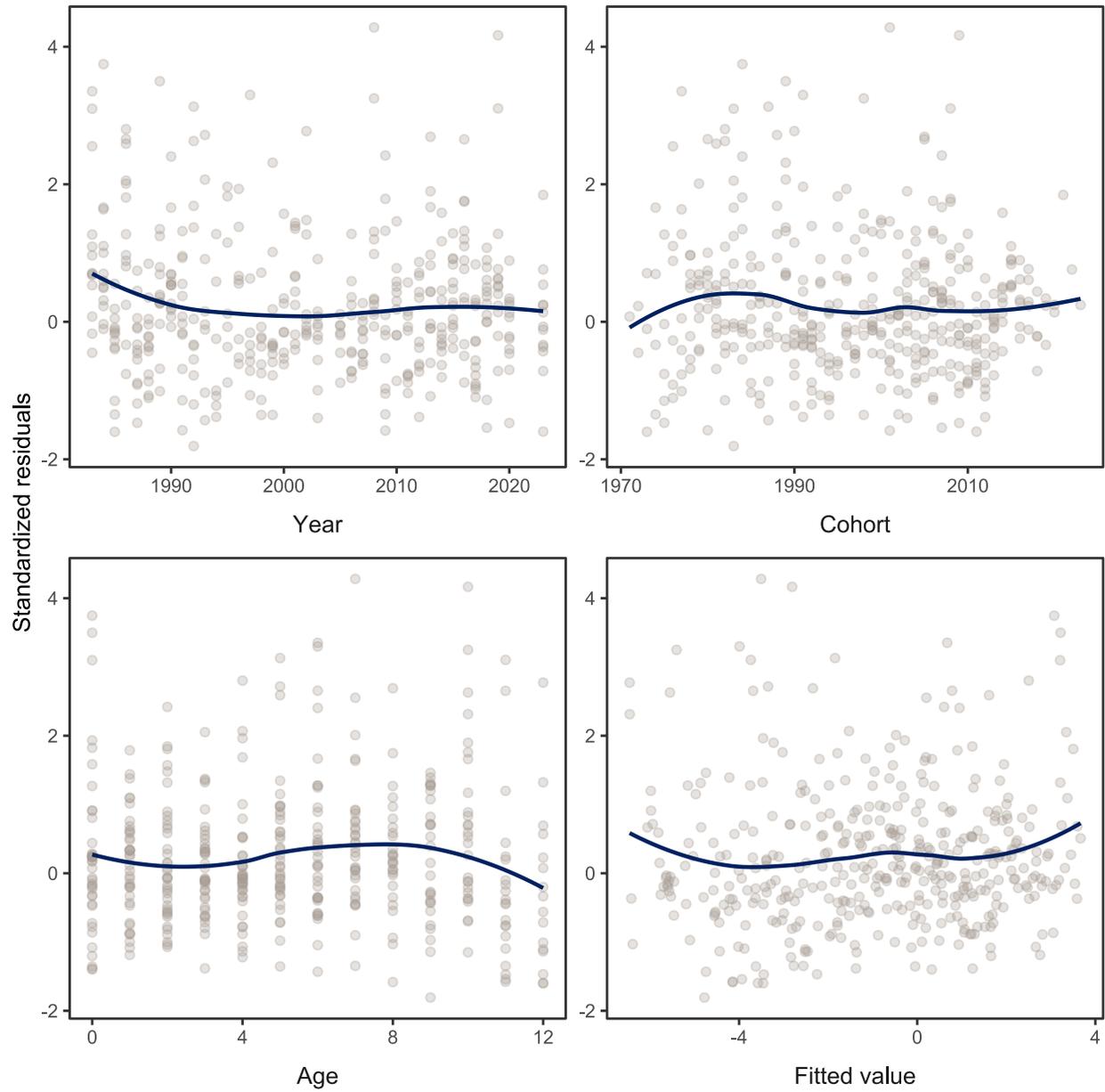


Figure A5. Standardized residuals from the RV survey faceted by age, cohort, year, and fitted value from xteNCAM. Lines are lowess curves.

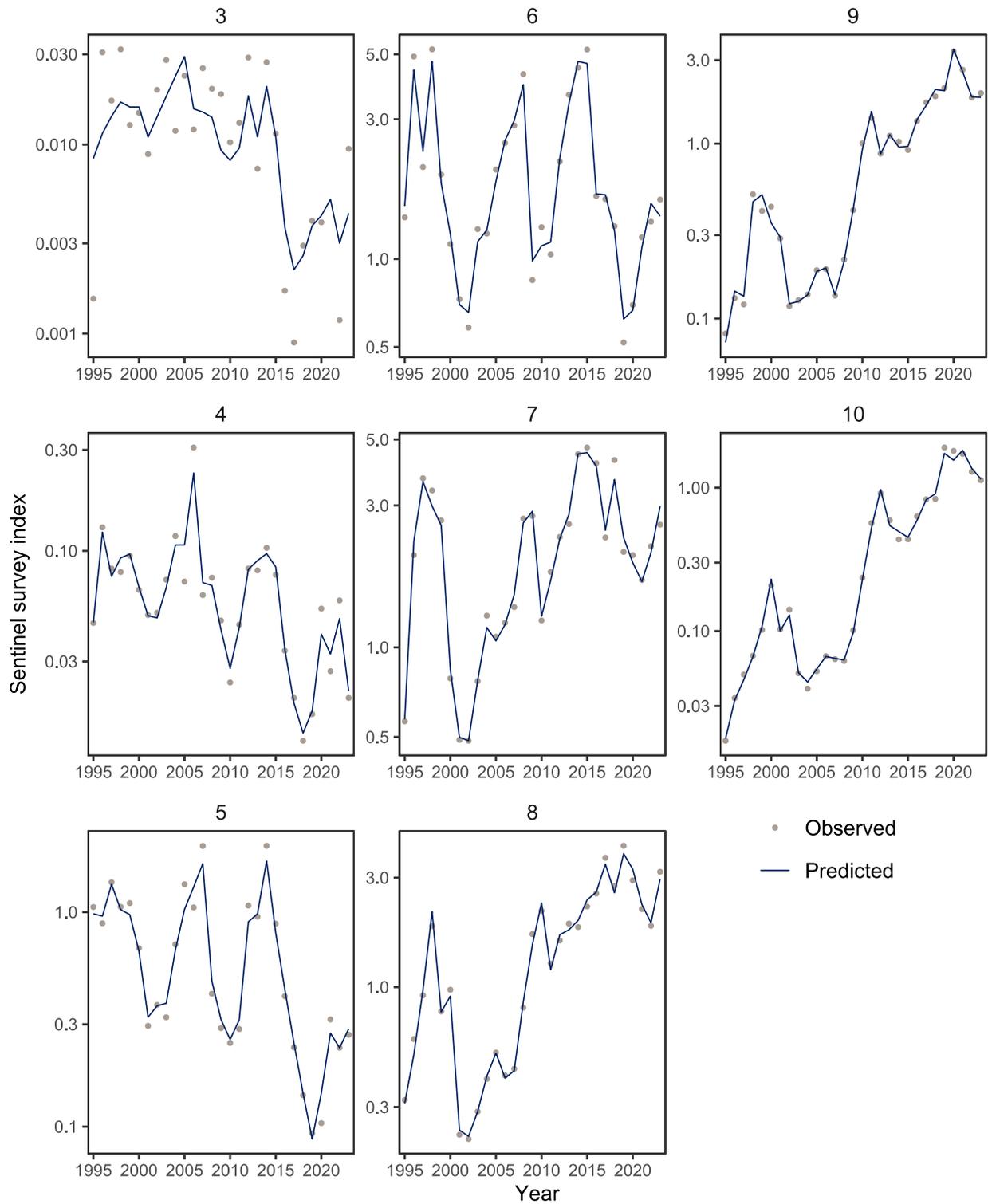


Figure A6. Observed (dots) and model predicted values (lines) for the age-disaggregated Sentinel survey index. Y-axis is in log scale.

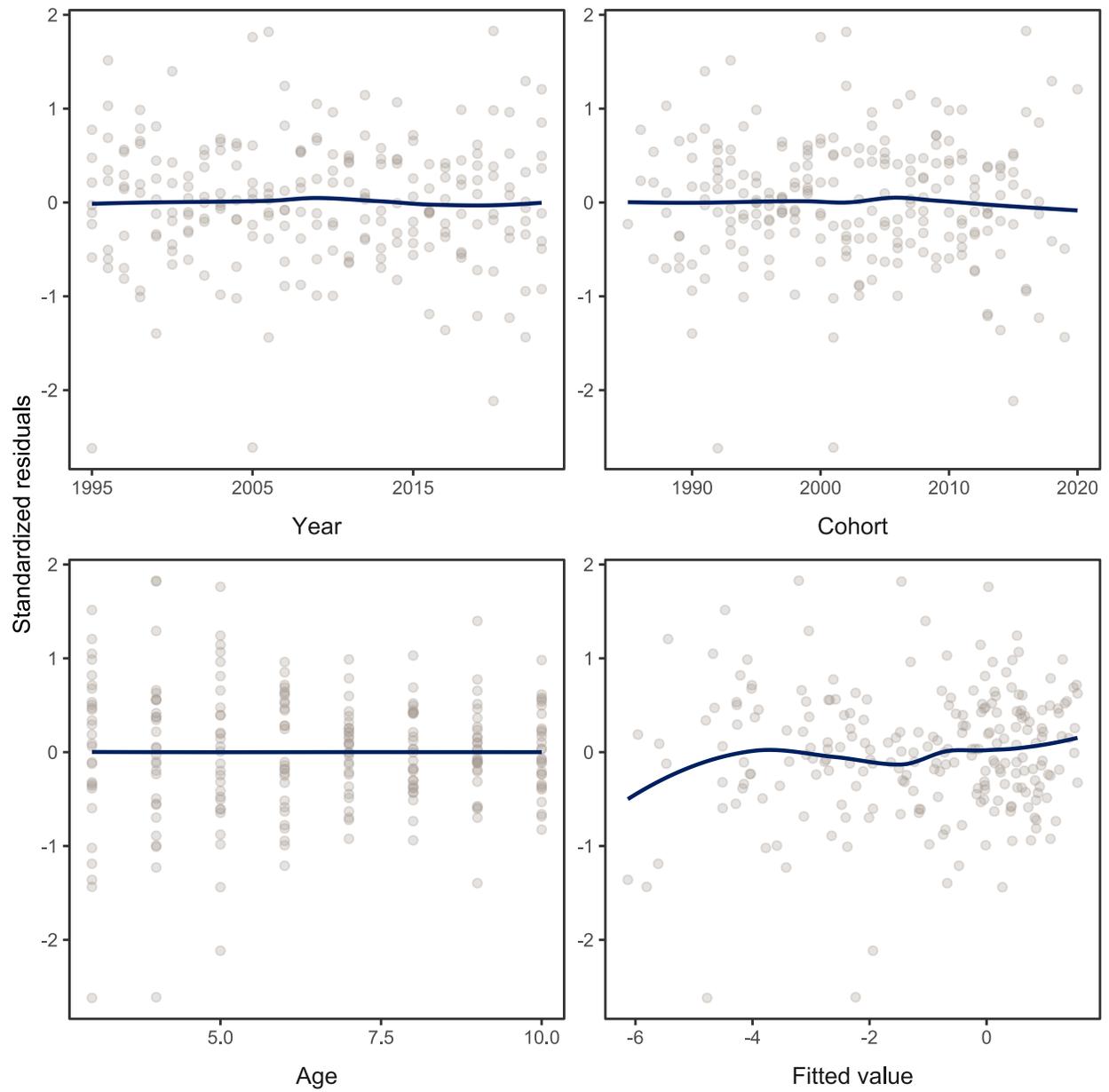


Figure A7. Standardized residuals from the Sentinel survey faceted by age, cohort, year, and fitted value from xteNCAM. Lines are lowess curves.

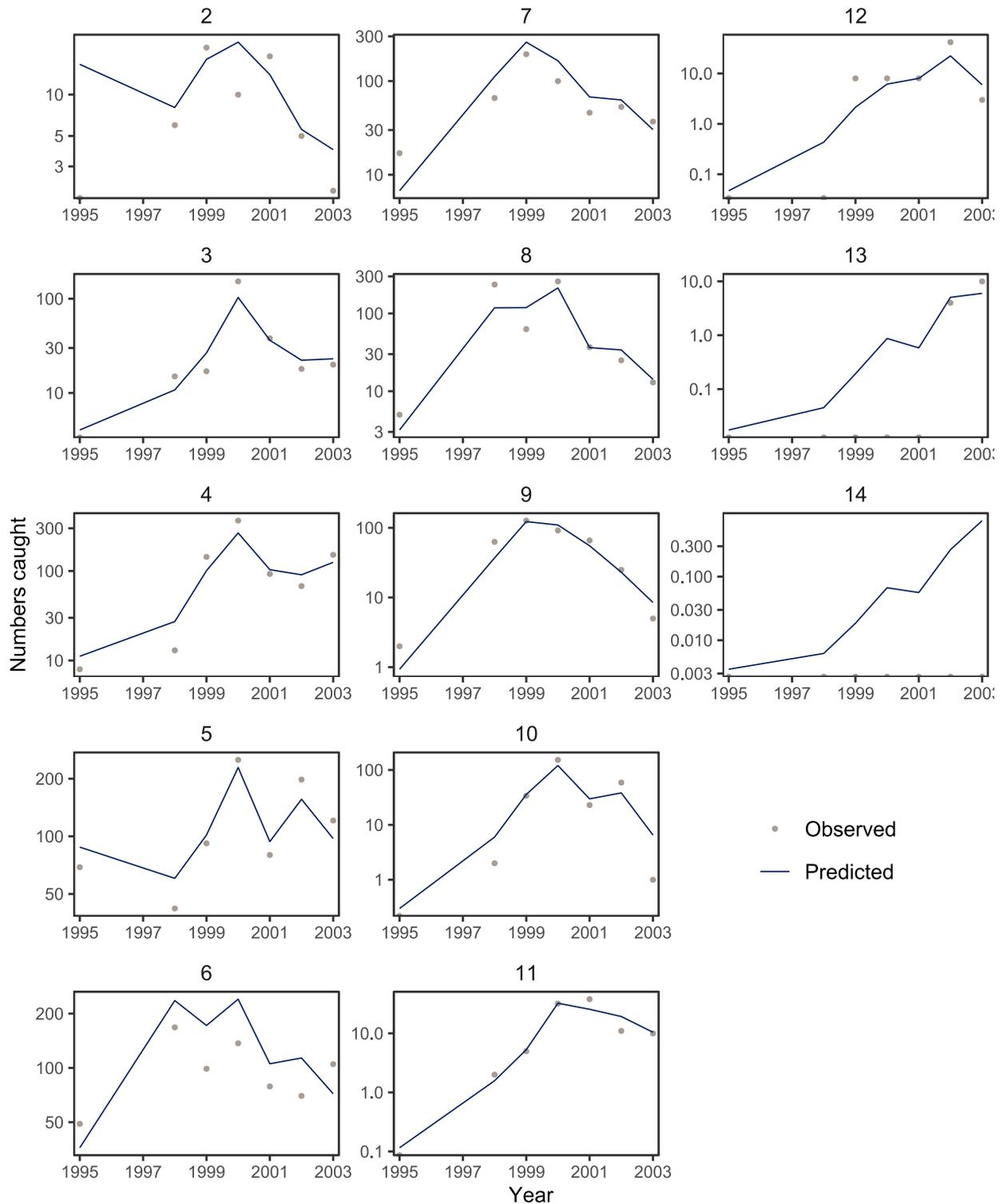


Figure A8. Observed (dots) and model predicted values (lines) for the age-disaggregated Smith Sound survey index. Y-axis is in log scale.

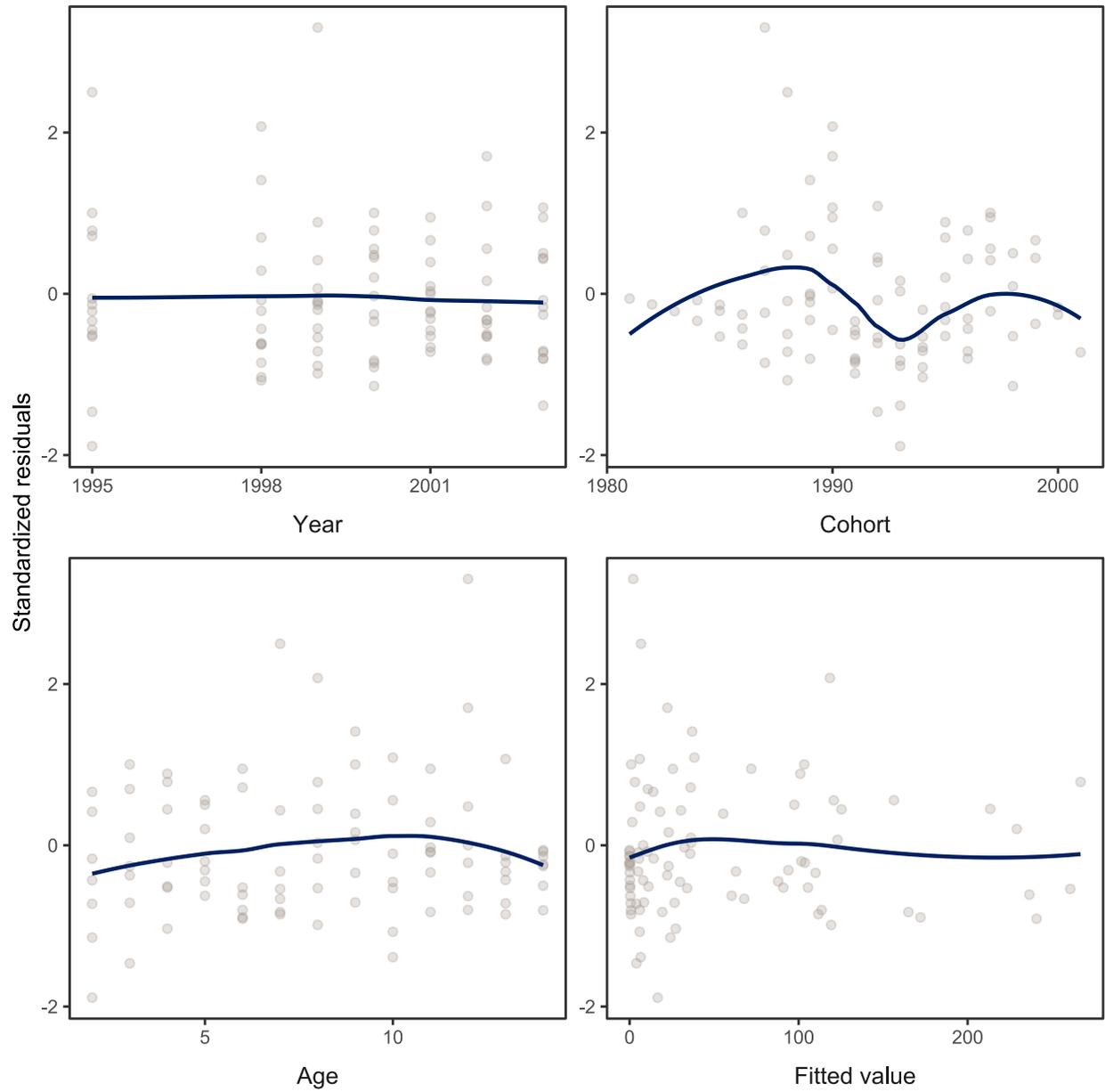


Figure A9. Standardized residuals from the Smith Sound survey faceted by age, cohort, year, and fitted value from xteNCAM. Lines are lowess curves.

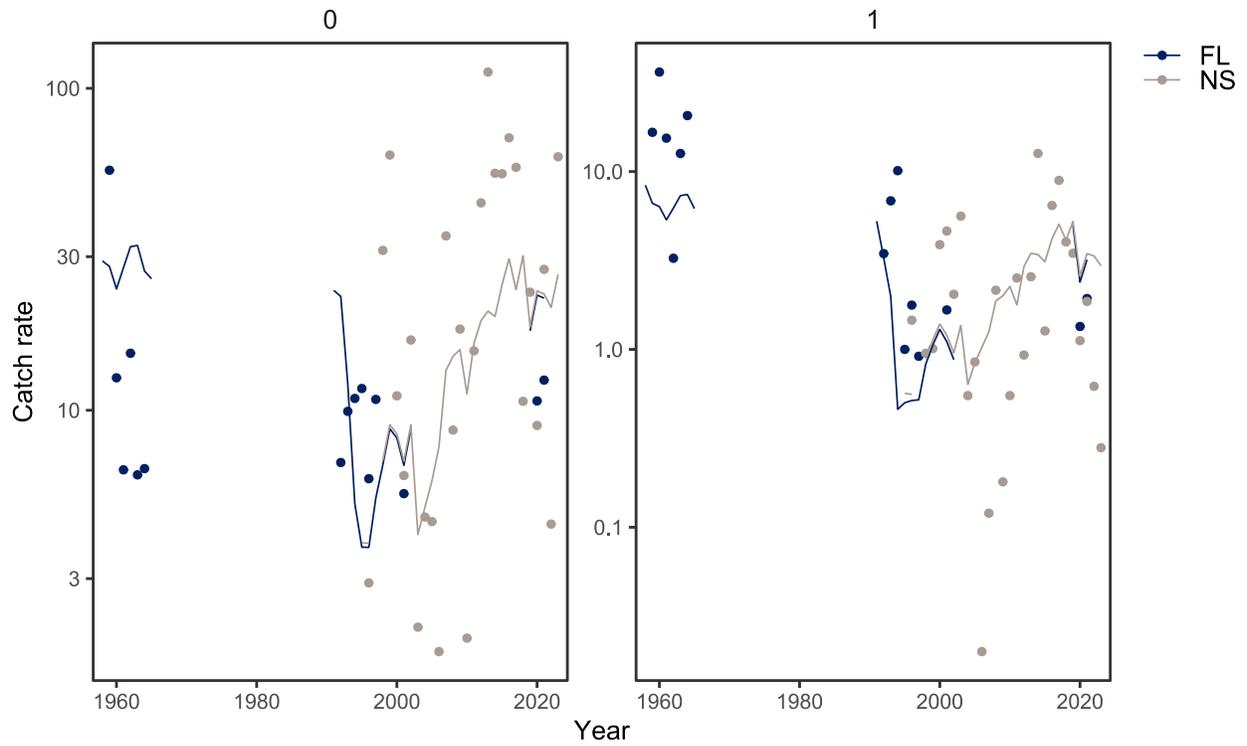


Figure A10. Observed (dots) and model predicted values (lines) for the juvenile survey indices. Y-axis is in log scale. FL = Fleming survey; NS = Newman Sound survey.

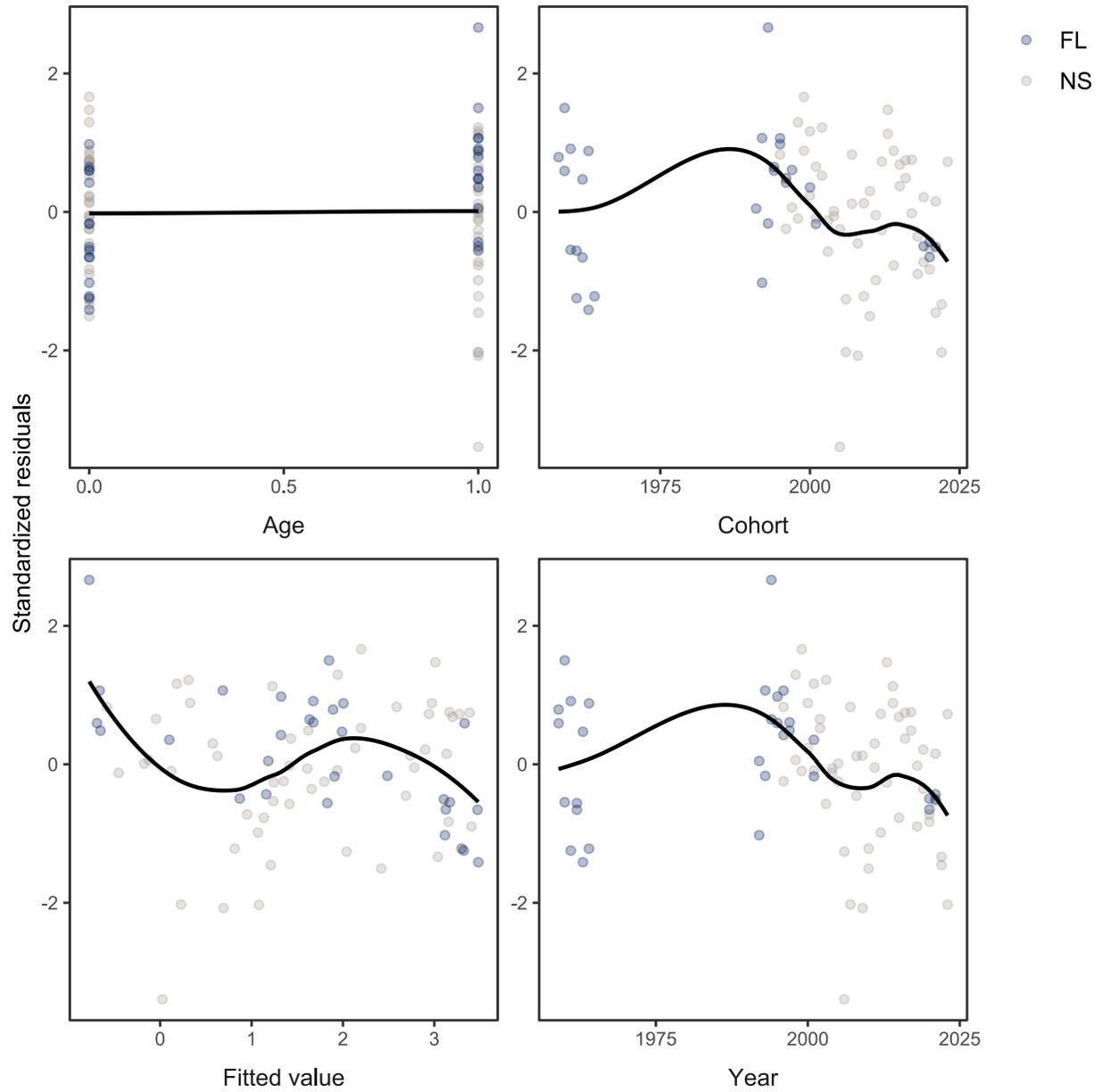


Figure A11. Standardized residuals from juvenile survey indices faceted by age, cohort, year, and fitted value from *xteNCAM*. Lines are lowess curves.

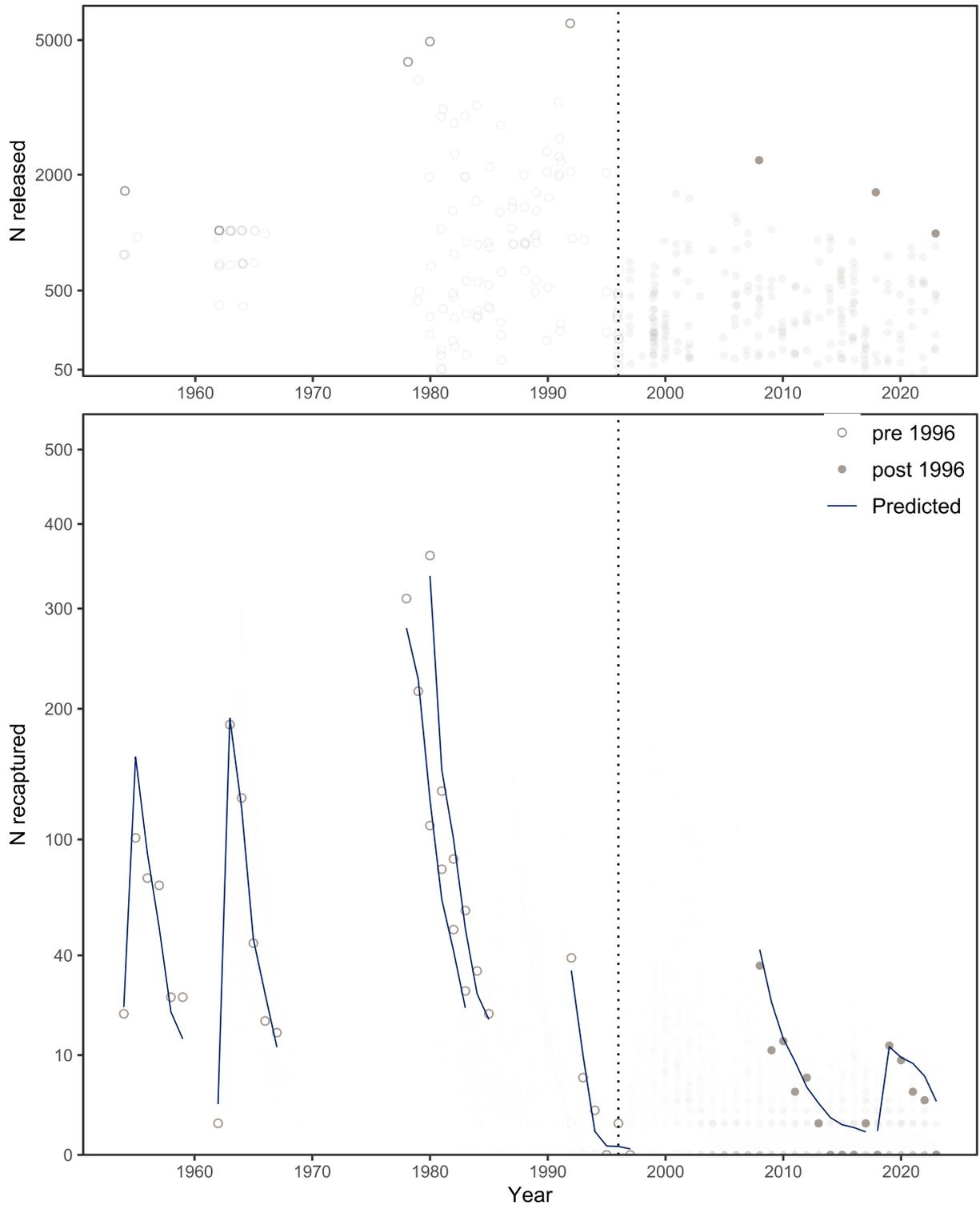


Figure A12. (Upper Panel) Number of tag releases and (Lower Panel) aggregate (all ages) observed (points) versus model predicted (lines) number of recaptures of tagged cod by experiment and recapture year. The largest experiments in each decade are emphasized. Y-axes are in square root scale.

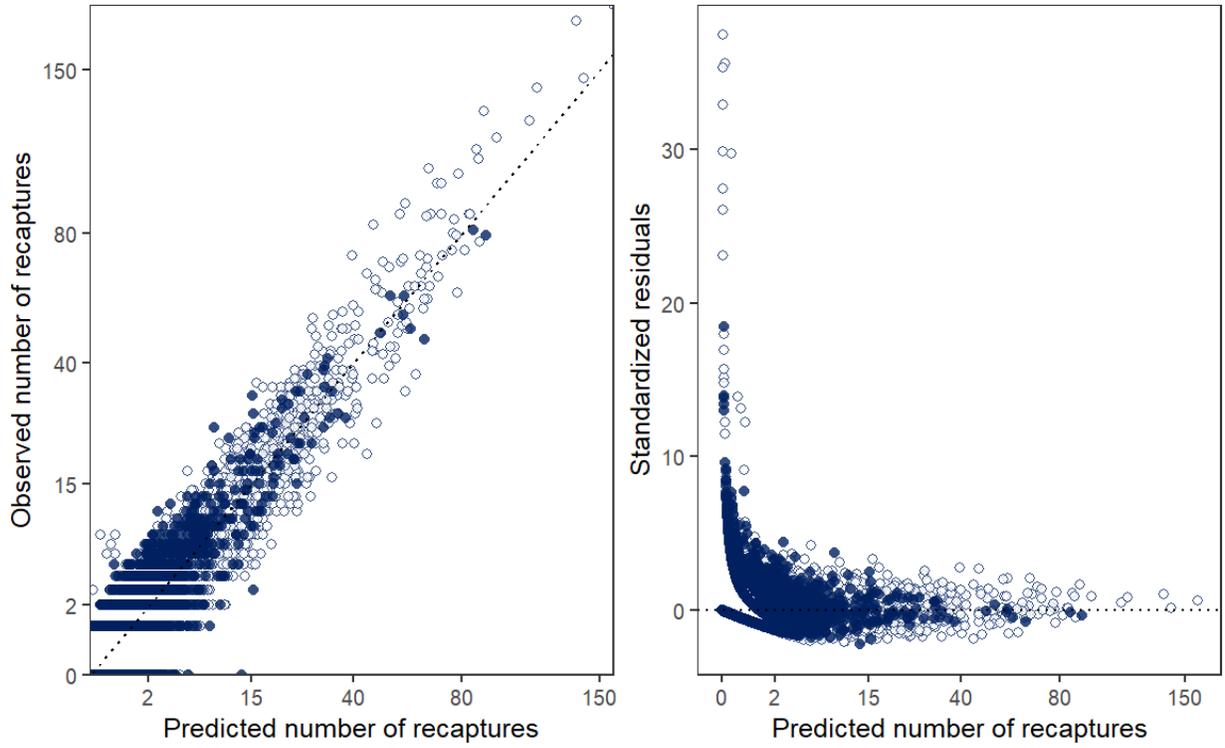


Figure A13. (Left Panel) Observed versus model predicted reported catches of tagged cod from tagging experiments and (Right Panel) conditional Poisson standardized residuals. Axes of predicted and observed number of recaptures are in square root scale.

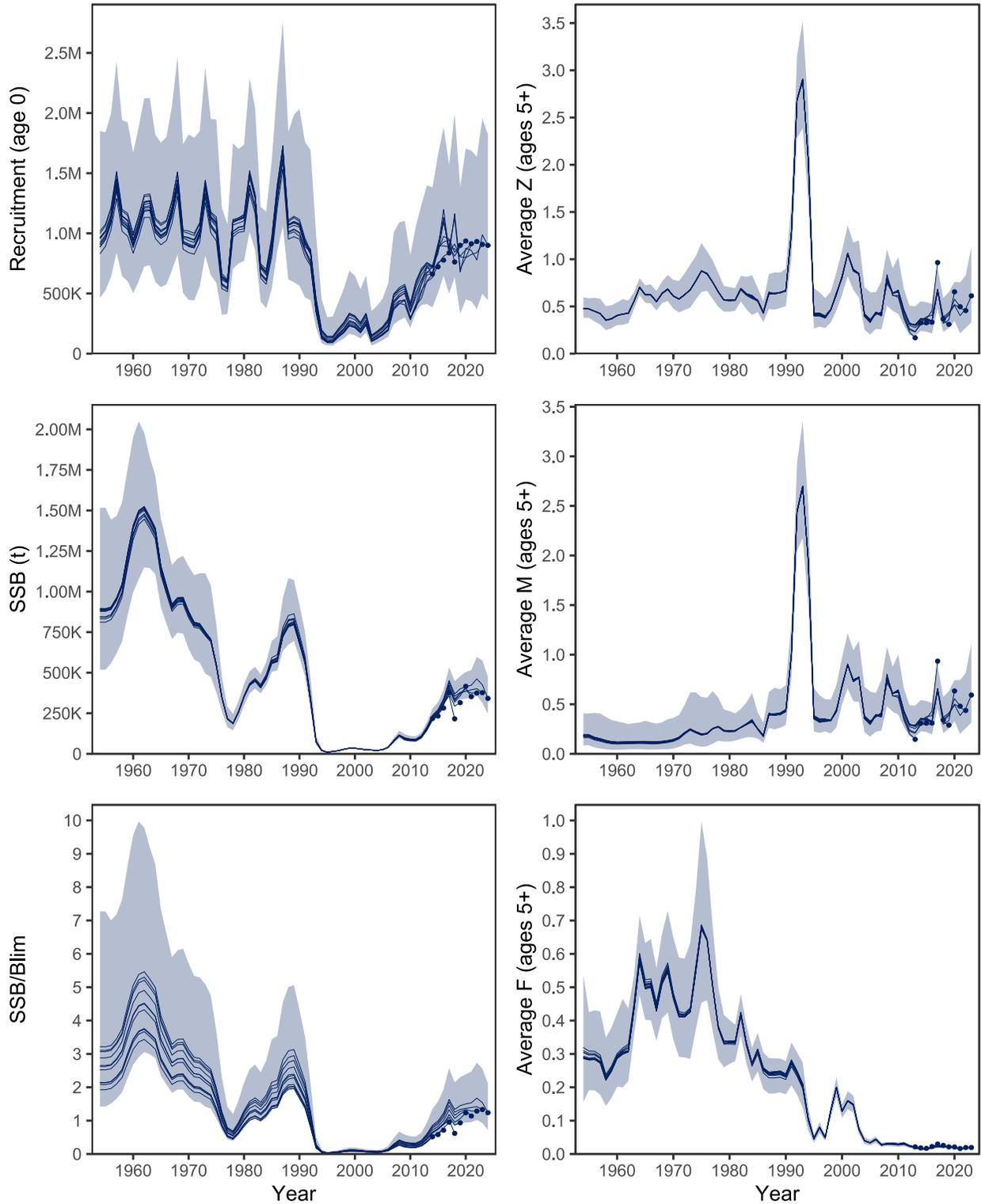


Figure A14. (Left Panels) Retrospective estimates of recruitment, stock size and stock size related to B_{lim} and (Right Panels) mortality rates (Z , M , F) from xteNCAM. Circles indicate the most recent estimate for each retrospective year. B_{lim} = biomass at the limit reference point; Z = total mortality; M = natural mortality; F = fishing mortality.