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Assessment of the Northern Cod (*Gadus morhua*) Stock in NAFO Divisions 2J3KL in 2025

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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.

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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 conducted March 24–27, 2025, 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, consider the effects of environmental conditions, and provide short- to medium-term projections of the stock.

This was the second assessment of this stock using the updated assessment model and Limit Reference Point (LRP) defined at the October 2023 framework process. The assessment model was extended back to 1954 (previously starting at 1983) through the inclusion of additional data, and the longer term perspective provided by this model informed a revision of the LRP. While estimates of stock size since 1983 were largely the same, the previous LRP was roughly 40% higher than the current LRP. Following this revision, it was determined that the stock had been out of the Critical Zone since 2016.

Under the current assessment, the 2025 Spawning Stock Biomass (SSB) is 2.0 (95% Confidence Interval [CI] = 1.2–3.3) times the LRP. There is less than a 1% chance that the stock is in the Critical Zone. An Upper Stock Reference Point has not been defined; therefore, it cannot be determined whether the stock is in the Cautious or Healthy Zone.

Following a period of growth from 2010–16, SSB has remained unchanged. The SSB in 2025 is estimated at 524 kt (95% CI = 404–678 kt). Estimated numbers of recruits (age 0) have remained unchanged since the mid-2010s, corresponding to about 90% of pre-collapse (1954–90) levels. Natural mortality (M, ages 5+) has varied between 0.28 and 0.89 since 1995 (mean = 0.47) and in 2023 was above average (0.32 [95% CI = 0.17–0.59]). Fishing mortality (F, ages 5+) has been below 0.05 since 2004 and in 2024 was 0.02 (95% CI = 0.02–0.03).

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 the collapse and continued low productivity of Capelin has impeded the 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 2028 with zero to two times authorized removals for 2024 of 21,317 t show the probability of the stock declining into the Critical Zone increases from 15% with zero removals to 27% if removals are doubled. With total removal levels examined here (0 to 42,634 t) the risk of stock decline from 2025–28 is moderately high, ranging from 56% to 71%. There is no level of removals that gives a high ($\geq 75\%$) probability of stock growth. Under current conditions, 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 M, increases in removals further add to the risk of stock decline.

INTRODUCTION

This document gives an account of the 2025 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 on March 24–27, 2025, in St. John's, Newfoundland and Labrador (NL) using available data up to the end of 2024. 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).

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, 2016a; DFO 2016a). In 2021, this model indicated that the Spawning Stock Biomass (SSB) at that time 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, 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 would reach the LRP by 2022 was 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 RVs 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 are 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 are 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.

In an effort to improve the assessment, a series of extensions to NCAM were reviewed and accepted at the framework meeting 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 (M) 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% of the SSB that produces the maximum sustainable yield (B_{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 previous LRP (average SSB from the 1980s).

The extended model and revised LRP was first applied in 2024, where it was determined that SSB was 1.2 times the LRP in 2024 (DFO 2024c). In the current assessment, xteNCAM was used to assess the status of the stock using data up to 2024. In addition to the assessment model results, several other sources of information were reviewed at the assessment (e.g., information on physical and biological oceanography, Capelin, predators, prey, inshore pre-recruit surveys, tagging, industry surveys).

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 2016–24 were added to the time series (Table 1; Figures 2–3). Fixed gear landings (from 1975) are also updated to 2024 (Table 2; Figure 4) and show that most of the catch throughout 2006–24 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.

FISHERIES

After the stock status was determined to be out of the Critical Zone, the 1992 moratorium on Northern cod fishing was lifted, reopening the commercial fishery in 2024 with a Total Allowable Catch (TAC) of 18,000 t, which was primarily allocated to inshore sectors. Prior to this, removals were limited to a directed inshore stewardship fishery, which was active between 2006–23. From 2016–23, the 2J3KL Northern cod stewardship fishery had 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 was 12,999 t from 2021–23. Provisional total reported landings in 2024 were 15,661 t. 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.

A recreational fishery has also been active since 2006. 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 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 1983–2024 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 and recreational fishery landings are not directly measured (see below). The amount of discarding in the recreational fishery is unknown.

There is a recreational fishery that takes place inshore in NL from June to October. For the past 18 years (2006–24) there are only direct estimates of recreation landings for 2006, 2008, 2011, and 2012. There have been a combination of methods used to obtain these estimates (e.g., phone surveys and surveillance).

Analyses of tag return information from commercial versus recreational fishing suggests that removals from the recreational fishery have been large and, in some years, higher than reported by Conservation and Protection officers (see Bratley et al. 2010), averaging about 30% of reported fishery removals from 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 and to what extent 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 2011–24. General sampling objectives for the fishery were to obtain a representative length frequency plus otoliths 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, handline, 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 1962–2024 (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 consisted 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

(2011–24), 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 (see Bratley and Healey 2007 and Bratley et al. 2018 for details). 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).

An update was provided on the current tagging program, including locations and numbers of tag releases and recaptures. In 2022, 3,164 tags were released, with a further 4,129 deployed in 2023 and 5,614 deployed in 2024 (Table 5). Twenty percent of these tags were high-reward (\$100 reward), with the remaining eighty percent as low-reward (\$10 reward between 1997–2022; \$25 reward since 2023). Tagging occurred in Divs. 2J3KL in 2021–22, and in 3KL in 2023 (Figure 7). Recaptured tags received in 2022–24 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 7).

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:

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

where C 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 . $C_{\text{comm},y}$ 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,

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

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 (sd) 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 t of catch to return 10 tags, then 1,000 t 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. Equally important is the assumption that the population of fish exposed to the commercial and recreational fishery is more or less the same. Both the recreational and commercial fisheries primarily target fish in the inshore from summer to early fall, so are most likely pursuing similar fish. The gears used are different; 5 in 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). Finally, cod less than 45 cm fork length (FL) are not tagged. If fish less than 45 cm make up a meaningful share of landings and their proportions differ between commercial and recreational catches, tagging-based estimates of recreational catch 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 8).

Estimated reporting rate from the commercial fishery has declined from a high of 0.85 in 2001 to an average of 0.52 in recent years (2020–24). The reporting rate from the recreational fishery is estimated as a constant for the time series, and 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 in 2023. These efforts may be contributing to a slight improvement in the reporting rate since 2023 (Figure 9).

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) the ratio was closer to one. The ratio of recreational to commercial tag returns was generally low and stable in the early years (1997–2006) with a mean of 0.19 (range = 0.01–0.32), high and variable between 2007–15 (mean = 0.54, range = 0.25–0.86), and has returned to a low and stable period since 2016 (mean = 0.2, range = 0.08–0.28; 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 0.01–4.18 kt, with no recreational catch in 1997, 2004, or 2005. Generally, recreational catch varied between 0.01–1.76 kt (mean = 1.01 kt) in the early period (1997–2006), and has increased since 2007, varying between 0.79–4.18 kt (mean = 2.2 kt). In 2024, the estimate of recreational catch was 2.7 kt (sd = 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

Bottom-trawl surveys have been conducted by DFO using dedicated RVs during the fall in Div. 2J, 3K, and 3L since 1977, 1978, and 1981, respectively, and the information from these surveys was updated to 2024. Spring surveys have been conducted by DFO in Div. 3L between 1971–82 and 1985–2024. 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 et al. 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.

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 in Div. 3L. The inshore strata fished intermittently from 1996 onwards are not included in this index, nor are deep-water strata (greater than 366 m 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 RV survey index values for Divs. 2J, 3K, and 3L began in 1983 and shows that the abundance and biomass indices have been low since the start of the moratorium in 1992 (Table 6; Figure 12). Both abundance and biomass indices increased since 2011, however there has been no clear trend in either direction. Most (greater than 75%) of the abundance and biomass is found in the northern portion of the stock area (Divs. 2J and 3K; Figure 13). The average abundance and biomass indices from the last three years are approximately 30% of the average during the 1980s. The 2024 survey abundance and biomass index values were 576 million fish and 585 kt, respectively.

Year-to-year fluctuations in the RV survey index can reflect changes in survey timing and availability or it may reflect an underlying trend. The decrease in older fish observed in the 2017 survey may be due to cod remaining inshore later than usual and not fully overlapping with the RV survey area, or to increased *M* among older individuals prior to the survey. Similarly, the decline in the index in 2023 may be attributed to the earlier-than-average timing of the 2J3KL survey, particularly in Div. 2J (Figure 14). The index increased in 2024, suggesting that a portion of the stock may not have been available to the 2023 survey. Alternatively, cod may have experienced higher-than-normal *M* in 2023. Instead of inferring a definitive cause for such year-over-year fluctuations, many of these changes likely reflect stochastic variability rather than a meaningful trend.

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 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. Age structure has broadened since 2012, reflecting survival of post-2000 cohorts into older ages (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 from the last three to four surveys. 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; Brattey et al. 2010).

Patterns of distribution in the most recent four years indicate that both number and weight per tow were generally spread widely throughout Div. 2J, 3K, and northern 3L (Figure 16). In some years, there were large tows of fish on the edge of the continental shelf. In 2020 and 2021, there were some large tows of cod (greater than 500 fish per tow) in Div. 2J, however there were fewer large tows of cod in 2023 and 2024 (Figure 16). There were no clear or consistent patterns in the distribution of cod across ages 2–4 over the last three surveys (Figure 17).

DIVISION 2H

Trends in the abundance and biomass indices and length frequencies were examined from bordering Divs. 2GH to the north. Div. 2G has not been surveyed since 1999, and Div. 2H has been covered intermittently from 1999–2010. After 2010, Div. 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 was 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 was an increasing trend in abundance since 2013 (Figure 19).

MATURITY

Annual estimates of age at 50% maturity (A50) and proportions mature at age for females from the 2J3KL cod stock, collected during annual fall RV 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 SSB. The A50 is used as a metric for monitoring changes in age at maturity. The A50 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 (2020) are often more uncertain because only younger ages (1–5 years) are available to estimate A50. The estimate of A50 for the 2010 cohort (5.8) is unusual and is the highest observed since 1991; 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 A50 for the 1990 cohort onwards from the previous stock assessment in 2024 are overlaid on the 2025 assessment results in Figure 20. This comparison shows that the addition of one more year of data resulted in very minor retrospective changes in A50 among the 2015–18 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 Div. 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 Divs.

Weight-at-age also showed a steep decline in Div. 2J and 3K during the same period that lengths were declining and as with length-at-age, there was less of a trend in Div. 3L. Mean weight-at-age was above average in 2011–14 in all Divs. 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 1981–2024 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. The means of these deviations across ages therefore provides a general sense of changes in mean weights of the population. These deviations indicate that mean weight-at-age generally 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 2016b). 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 Div. 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. 3KL; limited sampling in 2J), and fall RV survey (primarily October–December in Divs. 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 Divs., varying with little trend around a level slightly above one. In the fall, cod in Divs. 2J and 3K showed lower relative condition in the early 1990s and all Divs. showed a peak in condition around 2011. There were no clear trends in condition in the summer in 2J; however, these averages were 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 sentinel and spring RV series. The most pronounced decline in mean relative condition was observed during spring in 3L in the early 1990s. Focusing on the last two to three years, condition appears to be near seasonal averages.

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 5–7 and 8+ age groups from 1977–89. However, it showed a rapid increase in the early 1990s, increasing by approximately five times the 1989 levels for the 5–7 and 8+ age groups. Since the early 1990s, the index has shown variability for the 5–7 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

We assessed Northern cod using xteNCAM (DFO 2024b; Regular et al. 2025a, 2025b), an extended version of NCAM (Cadigan 2015, 2016a; DFO 2016a). Like the formulation adopted in 2016, xteNCAM integrates much of the existing information about the productivity of the stock and, as such, is capable of estimating annual rates of M and fishing mortality (F). 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.

To extend NCAM, a series of stepwise changes were implemented and reviewed at a framework meeting (DFO 2024b). Details of the extensions are outlined in Regular et al. (2025a, 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 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 RV survey (ages 2–14, 1983–2003, 2005–20, 2023–24),

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- inshore combined 2J3KL sentinel 5.5 in mesh gillnet index (ages 3–10, 1995–2024),
 - 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, 2024) and Newman Sound surveys (1996, 1998–2024),
 - fishery catch age composition information (ages 2–14, 1962–2024),
 - partial fishery landings information (1954–2024),
 - tagging information (release years: 1954–55, 1962–66, 1978–93, 1995–2024), and
 - indices to calculate Capelin/cod biomass ratio (acoustic estimates of Capelin biomass in 3L [1985–92, 1996, 1999–2005, 2007–15, 2017–19, 2022–24] and total biomass estimates of cod from the fall RV survey [1983–2003, 2005–20, 2023–24]).

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, 2016a) and Regular et al. (2025a, 2025b).

Fall Research Vessel Survey

The main source of information on trends in the status of Northern cod is the fall RV survey. This survey is based on a stratified random design, has a long time series (1983–2024), 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 scaled to the entire population provided the catchability coefficient (q) can be estimated for each age class. 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 RV survey index time series included the results of the latest (2024) survey and the age range 2–14 years. The q was constrained to be equal for ages 6 to 14. The 2004 and 2021 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 1983–2024, were used in xteNCAM (Table 7).

Inshore Acoustic Biomass Estimates and RV Survey Catchability Parameter

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 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 10,000–26,000 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. As Smith Sound biomass declined, fall RV surveys showed increasing offshore biomass, particularly among older cod. Acoustic telemetry and conventional tagging of cod released offshore in 2008 confirmed a seasonal shoreward migration, similar to pre-moratorium patterns. 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 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 handline) 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 2024. 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 diet.

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 (3.25 in and 5.5 in mesh) and line-trawls (Stansbury et al. 2000). The methodology for calculating the index and full details of the sentinel fishery are described in Kumar et al.¹. The standardized age-disaggregated catch rate index (fish/net, ages 3–10) from 5.5 in mesh gillnets (fixed) from Divs. 2J3KL combined was updated, and results from 1995–2024 were used in xteNCAM (Table 13). Sentinel survey q was assumed to follow a two-dimensional 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).

Juvenile Surveys

There are two long-term surveys designed to monitor the abundance of juvenile cod: the Fleming survey (see Lewis et al. 2022 for details), and the Newman Sound survey (see Gregory et al. 2019 for details). The Fleming survey was conducted along the Northeast Coast of Newfoundland from 1959–64. The survey ceased in 1964, but was reinstated from 1992–97, and again in 2020–21 and 2024. 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.

¹ Kumar, R., Maddock-Parsons, D., Varkey, D., and Regular, P. In prep. Standardized Indices and Biological Information from Sentinel Survey: Exploring Trends and Patterns in Northern Cod from 1995 to 2024. DFO Can. Sci. Advis. Sec. Res. Doc.

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 2024 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 were 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 1954–2024 (second last column of Table 1), and catch-at-age from 1962–2024 (Table 4) converted to proportions with zeros replaced (see Cadigan 2015), were used as inputs for 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 has not been quantified for Northern cod.

For the current assessment model, an interval was required for the likely range of catch. 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 (2006–24) 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 upper catch bounds (CU) were set to different levels across periods. The catch bounds were as follows:

1. 1954–77 [CL, CU] = [1.1, 2] where a wide bound accounts for a broad range of possible catches through this period;
2. 1978–91 [CL, CU] = [1.1, 1.5] with the upper bound to account mainly for discards and non-Canadian misreporting;
3. 1992–2005 [CL, CU] = [1.1, 2] with the higher upper bound to account for the period of no DMP and more variable catch;
4. 2006–24, 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 2006–24 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 from 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 weights 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 1954–2024, 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–October (Bratney 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 the 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 2016a). 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 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 indices of Capelin and cod biomass. For Capelin, the spring acoustic survey index of Capelin biomass was used as it is the best available data 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 2024 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 of cod in 2J3KL 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 a 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-recruitment relationship. Several stock-recruitment relationships were tested for the framework; however, the standard formulation of the Beverton-Holt curve was most parsimonious and 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 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 DFO's PA guidelines (DFO 2009, 2023b). Refined with data up to 2024, these internal calculations yield the current LRP estimate of 260 Kt (95% CI = 168–401 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 649 million (95% CI = 387–1,088 million) in 2005 to 3 billion (95% CI = 2–4 billion) in 2017. Growth in abundance has since stalled and levels at the beginning of 2025 were 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 90 Kt (95% CI = 74–110 Kt) in 2005 to 730 Kt (95% CI = 616–864 Kt) in 2017 (Figure 28; middle panel). Likewise, SSB increased from 26 Kt (95% CI = 22–31 Kt) in 2005 to 469 Kt (95% CI = 397–553 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 the 2025 assessment, the stock is 2.0 (95% CI = 1.2–3.3) times the LRP and, accounting for statistical uncertainties, there is less than a 1% chance 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 2024 is estimated to be 0.02 (95% CI = 0.02–0.03). Average M increased rapidly from levels below 0.4 to a peak of 2.5 around 1992–94, then declined 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 2024, average M is estimated to be 0.32 (95% CI = 0.17–0.59).

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). Although the model can attribute the sudden RV survey decline to either F or M, it assigns most of the mortality to M to remain consistent with the integrated tagging data. 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 some systematic patterns in estimates of stock size or rates. For example, F has a tendency to be overestimated and SSB underestimated in the terminal year. There are also occasional years where M may be overestimated and SSB underestimated. This is due, in part, to uncertainty in F and M in the terminal year because of the incomplete tagging data from that year (all tags have yet to be returned). The largest retrospective revisions are present in 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 for the 2025 Northern cod assessment, which specified the following objectives:

- One, two, and 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 2024 authorized removals.
- The level of removals that enable growth from the current SSB with a high probability (>75%) over the short-term (3 years) and, if possible, medium- to long-term (5 years).

Projections assume average levels of Capelin (DFO 2025) over 2023–25 (specifically, a mean of observed values from 2023, 2024, and forecast levels from 2025 assuming average ice timing over 2023–24), terminal year selectivity, and average mean weight and proportion mature at age over 2022–24.

These projections indicated moderate probabilities (29–44%) of growth over the next three years (Table 25). Probabilities of exceeding the LRP are moderately high to high across all catch multiplier scenarios (73–98%; Table 26). Under current catch levels (approximately 21,317 t), SSB relative to B_{lim} is projected to be 1.62 (95% CI = 0.52–5.03) by 2028 (Table 27; Figure 29).

Even without directed fishing (catch multiplier = 0.0), the stock is not expected to grow with a high probability (>75%; Table 25).

Conclusions

Although the status of the stock has improved and there is a low probability that the stock is in the Critical Zone, growth in the stock has stalled since 2017. Following DFO's PA framework, management actions must encourage stock growth in the short term and minimize risk of preventable decline (DFO 2009).

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TABLES

Table 1. Reported landings (kt) of cod from NAFO Divs. 2J3KL from 1954 onward. Proportion of Canadian catch (%) indicated in parentheses. Provisional catches for terminal year. A dash (-) 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 Total (%) Can)	2J3KL MAH/ TAC
1954	-	-	-	-	-	-	-	-	-	315.8 (-) ^a	-
1955	-	-	-	-	-	-	-	-	-	232.9 (-) ^a	-
1956	-	-	-	-	-	-	-	-	-	236.2 (-) ^a	-
1957	-	-	-	-	-	-	-	-	-	254.5 (-) ^a	-
1958	-	-	-	-	-	-	-	-	-	206.7 (-) ^a	-
1959	46.4	17.5	63.9 (27%)	97.7	56.3	153.9 (37%)	56.0	85.7	141.7 (64%)	359.6 (46%)	-
1960	164.1	15.4	179.5 (9%)	75.1	47.7	122.7 (39%)	71.3	94.2	165.5 (61%)	467.8 (35%)	-
1961	243.1	17.5	260.7 (7%)	64.0	31.2	95.2 (33%)	78.6	70.7	149.2 (50%)	505.1 (25%)	-
1962	226.8	23.4	250.3 (9%)	47.0	42.8	89.8 (48%)	94.7	72.3	166.9 (46%)	507.0 (28%)	-
1963	197.9	23.8	221.6 (11%)	79.3	47.5	126.8 (37%)	87.5	73.3	160.8 (48%)	509.2 (29%)	-
1964	197.4	14.8	212.2 (7%)	121.4	40.7	162.2 (25%)	152.5	75.8	228.3 (38%)	602.7 (23%)	-
1965	246.7	25.1	271.8 (9%)	50.1	26.5	76.6 (35%)	137.7	58.9	196.7 (34%)	545.0 (22%)	-
1966	226.3	22.6	248.9 (9%)	58.9	32.2	91.1 (35%)	128.5	56.0	184.4 (35%)	524.5 (23%)	-
1967	217.3	27.7	245.0 (11%)	78.8	24.9	103.7 (24%)	213.8	49.2	263.1 (24%)	611.8 (19%)	-
1968	359.8	12.9	372.7 (5%)	121.6	40.8	162.4 (26%)	227.6	47.3	274.9 (23%)	810.0 (15%)	-
1969	405.3	4.3	409.6 (1%)	81.0	24.9	105.9 (24%)	170.2	68.0	238.2 (36%)	753.7 (15%)	-
1970	213.0	2.0	214.9 (1%)	78.4	21.5	99.9 (22%)	152.3	53.1	205.4 (33%)	520.2 (18%)	-
1971	154.7	3.3	158.0 (2%)	61.5	21.1	82.6 (26%)	160.7	38.1	198.9 (25%)	439.5 (17%)	-
1972	149.4	1.7	151.2 (1%)	133.4	14.1	147.4 (10%)	113.4	46.3	159.7 (32%)	458.3 (14%)	-
1973	54.1	3.6	57.7 (8%)	159.8	13.2	173.0 (8%)	99.0	24.8	123.8 (21%)	354.5 (12%)	666.0
1974	119.5	1.8	121.3 (1%)	149.2	10.7	160.0 (7%)	68.8	22.6	91.4 (26%)	372.6 (10%)	657.0
1975	79.0	3.0	82.0 (4%)	112.9	15.5	128.4 (12%)	54.4	22.7	77.1 (30%)	287.5 (15%)	554.0
1976	30.8	3.9	34.6 (11%)	80.3	20.9	101.2 (21%)	43.2	35.2	78.4 (48%)	214.2 (29%)	300.0
1977	40.1	3.5	43.6 (9%)	27.8	28.8	56.6 (53%)	32.2	40.3	72.4 (63%)	172.7 (46%)	160.0
1978	22.2	6.6	28.9 (39%)	13.4	29.6	43.0 (85%)	21.5	45.2	66.7 (82%)	138.6 (74%)	135.0
1979	15.7	8.4	24.2 (73%)	38.5	27.0	65.5 (74%)	26.9	50.4	77.2 (84%)	166.9 (78%)	180.0
1980	21.0	17.2	38.2 (81%)	28.8	37.0	65.8 (90%)	29.5	42.3	71.8 (81%)	175.8 (84%)	180.0
1981	26.9	14.3	41.1 (88%)	27.0	23.0	50.0 (92%)	36.8	42.8	79.7 (81%)	170.7 (86%)	200.0
1982	67.3	14.4	81.7 (89%)	13.0	42.1	55.1 (93%)	36.5	56.5	92.9 (90%)	229.8 (90%)	230.0
1983	41.4	10.7	52.2 (92%)	34.4	40.7	75.1 (96%)	50.0	55.0	105.0 (90%)	232.3 (92%)	260.0
1984	12.0	13.2	25.2 (89%)	59.2	35.1	94.3 (88%)	63.6	49.4	113.0 (86%)	232.5 (87%)	266.0
1985	1.5	10.2	11.8 (99%)	81.8	30.4	112.2 (88%)	68.0	39.3	107.3 (71%)	231.3 (81%)	266.0
1986	13.6	12.9	26.5 (70%)	67.9	28.4	96.3 (94%)	111.8	32.2	144.0 (63%)	266.7 (75%)	266.0
1987	43.3	16.0	59.4 (93%)	45.8	27.4	73.3 (92%)	70.5	36.7	107.3 (76%)	239.9 (85%)	256.0
1988	41.5	17.1	58.6 (100%)	40.3	33.8	74.1 (100%)	84.6	51.4	136.0 (80%)	268.7 (90%)	266.0
1989	34.6	23.3	57.9 (98%)	38.5	20.7	59.2 (98%)	77.6	59.2	136.8 (73%)	254.0 (85%)	235.0
1990	18.1	14.5	32.6 (99%)	27.4	27.5	54.9 (99%)	56.7	75.3	131.9 (81%)	219.5 (88%)	199.3
1991	0.7	2.2	2.9 (97%)	30.4	13.3	43.8 (99%)	79.9	45.4	125.3 (60%) ^b	172.0 (71%)	190.0
1992	0.0	0.0	0.0 (100%)	0.9	0.9	1.7 (84%)	28.2	11.0	39.2 (63%) ^c	41.0 (64%)	0.0
1993	0.0	0.0	0.0 (100%)	0.0	0.5	0.5 (100%)	2.4	8.4	10.8 (78%) ^d	11.4 (79%)	0.0
1994	0.0	0.0	0.0 (100%)	0.0	0.4	0.4 (100%)	0.0	0.9	0.9 (100%)	1.3 (100%) ^e	0.0
1995	0.0	0.0	0.0 (100%)	0.0	0.1	0.1 (100%)	0.0	0.3	0.3 (100%)	0.4 (100%) ^f	0.0
1996	0.0	0.0	0.0 (100%)	0.0	1.0	1.0 (100%)	0.0	0.9	0.9 (100%)	1.9 (100%) ^g	0.0
1997	0.0	0.0	0.0 (100%)	0.0	0.3	0.3 (100%)	0.0	0.6	0.6 (100%)	0.9 (100%)	0.0
1998	0.0	0.0	0.0 (100%)	0.0	2.0	2.0 (100%)	0.0	2.5	2.5 (100%)	4.5 (100%)	4.0
1999	0.0	0.0	0.0 (100%)	0.0	3.6	3.6 (100%)	0.0	4.9	4.9 (100%)	8.5 (100%)	9.0
2000	0.0	0.0	0.0 (100%)	0.0	1.4	1.4 (100%)	0.1	3.9	4.0 (99%)	5.4 (99%)	7.0
2001	0.0	0.0	0.0 (100%)	0.0	1.7	1.7 (100%)	0.1	5.1	5.2 (98%)	7.0 (99%)	5.6
2002	0.0	0.0	0.0 (100%)	0.0	0.6	0.6 (100%)	0.1	3.5	3.6 (99%)	4.2 (99%)	5.6
2003	0.0	0.0	0.0 (100%)	0.0	0.0	0.0 (100%)	0.0	0.9	1.0 (98%) ^h	1.0 (98%)	0.0

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 Total (% Can)	2J3KL MAH/ TAC
2004	0.0	0.0	0.0 (100%)	0.0	0.2	0.2 (100%)	0.0	0.5	0.5 (99%)	0.6 (99%)	0.0
2005	0.0	0.0	0.0 (100%)	0.0	0.6	0.6 (100%)	0.0	0.8	0.8 (100%)	1.3 (100%)	0.0
2006	0.0	0.1	0.1 (100%)	0.0	1.1	1.1 (100%)	0.0	1.5	1.5 (99%)	2.7 (99%)	0.0 ^j
2007	0.0	0.1	0.1 (100%)	0.0	1.2	1.2 (100%)	0.0	1.7	1.7 (99%)	2.9 (100%)	0.0 ^j
2008	0.0	0.1	0.1 (100%)	0.0	1.5	1.5 (100%)	0.0	1.8	1.8 (98%)	3.4 (99%)	0.0 ^j
2009	0.0	0.1	0.1 (100%)	0.0	1.2	1.2 (100%)	0.0	1.9	1.9 (99%)	3.1 (99%)	0.0 ^j
2010	0.0	0.1	0.1 (100%)	0.0	1.2	1.2 (100%)	0.1	1.7	1.7 (97%)	3.0 (98%)	0.0 ^j
2011	0.0	0.1	0.1 (100%)	0.0	1.5	1.5 (100%)	0.3	2.0	2.3 (87%)	3.8 (92%)	0.0 ^j
2012	0.0	0.1	0.1 (100%)	0.0	1.8	1.8 (100%)	0.1	1.8	1.9 (93%)	3.9 (97%)	0.0 ^j
2013	0.0	0.1	0.1 (100%)	0.0	2.2	2.2 (100%)	0.1	2.0	2.2 (94%)	4.5 (97%)	0.0 ^j
2014	0.0	0.1	0.1 (100%)	0.0	2.3	2.3 (100%)	0.1	2.3	2.4 (95%)	4.9 (98%)	0.0 ^j
2015	0.0	0.1	0.1 (100%)	0.0	2.3	2.3 (100%)	0.1	2.0	2.0 (97%)	4.4 (98%)	0.0 ^j
2016	0.0	0.2	0.2 (100%)	0.0	5.3	5.3 (100%)	0.2	4.4	4.6 (96%)	10.1 (98%)	0.0 ^j
2017	0.0	0.3	0.3 (100%)	0.0	6.3	6.3 (100%)	0.2	6.1	6.2 (98%)	12.9 (99%)	0.0 ^j
2018	0.0	0.3	0.3 (100%)	0.0	4.4	4.4 (100%)	0.1	4.7	4.7 (99%)	9.5 (99%)	9.5
2019	0.0	0.4	0.4 (100%)	0.0	4.8	4.8 (100%)	0.0	5.2	5.2 (99%)	10.5 (100%)	12.3
2020	0.0	1.1	1.1 (100%)	0.0	3.8	3.8 (100%)	0.1	5.3	5.4 (98%)	10.3 (99%)	12.3
2021	0.0	1.3	1.3 (100%)	0.0	4.4	4.4 (100%)	0.1	5.2	5.3 (98%)	11.0 (99%)	13.0
2022	0.0	1.8	1.8 (100%)	0.0	5.5	5.5 (100%)	0.1	5.1	5.1 (99%)	12.5 (99%)	13.0
2023	0.0	2.5	2.5 (100%)	0.0	5.6	5.6 (100%)	0.1	4.9	5.0 (99%)	13.0 (100%)	13.0
2024	0.0	3.0	3.0 (100%)	0.0	6.2	6.2 (100%)	0.0	6.4	6.4 (100%)	15.7 (100%)	21.3

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

^b Figure is 4 kt 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 kt catch from the recreational fishery after the moratorium was declared.

^d Canadian surveillance estimate of foreign catch. Includes 5.053 kt estimated for the recreational fishery additional to that recorded by Canadian statistics.

^e 1.3 kt is from the food fishery; the remainder is bycatch.

^f Includes 0.275 kt caught in the sentinel survey and 0.138 kt caught as bycatch.

^g Comprised of a sentinel survey catch of 0.296 kt, a food fishery catch of 1.155 kt and bycatch of 0.422 kt.

^h 0.780 kt of this catch was the result of a mass mortality in Smith Sound.

ⁱ Excludes recreational fishery.

^j There was no MAH or 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 terminal 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
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

Year	Gillnet	Longline	Handline	Other	Total
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
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
2024	13,898	1,268	365	118	15,650 ^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 Divs. 2J3KL combined since 1954. Provisional catches for terminal 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
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
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

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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
2024	2	0	1	0	1	2	1,764	9,539	3,406	795	33	0

^a Average portions between 1962–64 were used to re-construct monthly landings across these years.

Table 4. Catch numbers-at-age (000s) for the commercial cod fishery in NAFO Divs. 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
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
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

Year	0 ^a	1 ^a	2	3	4	5	6	7	8	9	10	11	12	13	14
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
2024	0	0	0	0	1	63	520	998	1,483	1,240	662	391	251	73	75

^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
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

Year	Disc tag experiments	Disc tags released	Disc tags recaptured	T-bar tag experiments	T-bar tags released	T-bar tags recaptured
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
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	125
2020	0	0	0	8	1,219	76
2021	0	0	0	11	4,148	85
2022	0	0	0	8	3,164	81
2023	0	0	0	11	4,129	75
2024	0	0	0	13	5,614	126

Table 6. Cod abundance (000s) index (AI) and biomass (t) index (BI) for Northern cod from index strata in the fall RV survey. A dash (-) 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
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	320,456	155,521	-	-	285,102	111,350	-	-
2022	-	-	-	-	-	-	-	-
2023	181,873	93,768	131,156	406,798	157,250	90,656	91,750	339,656
2024	246,364	187,803	141,889	576,056	296,499	157,710	130,504	584,713

Table 7. Mean number of cod per tow at age in the index strata for the fall RV survey of NAFO Divs. 2J3KL. A dash (-) 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
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	5.34	7.63	6.24	5.83	2.98	1.91	1.08	0.47	0.40	0.18	0.12	0.04	0.02
2024	3.82	8.21	8.93	7.88	6.74	4.04	1.88	0.82	0.44	0.29	0.16	0.07	0.04

Table 8. Estimated proportions mature for female cod from NAFO Divs. 2J3KL from the fall RV survey 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
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
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

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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	0.000	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	0.000	0.001	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	0.000	0.000	0.009	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	0.000	0.000	0.000	0.052	0.300	0.957	0.986	0.994	0.999	1.000	1.000	1.000	1.000	1.000
2023	0.000	0.000	0.000	0.001	0.010	0.250	0.671	0.998	0.999	0.999	1.000	1.000	1.000	1.000	1.000
2024	0.000	0.000	0.000	0.003	0.023	0.224	0.673	0.907	1.000	1.000	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 growth model described in Cadigan (2016b) fitted by cohort to average weight-at-age data for cod from the fall RV survey in NAFO Divs. 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	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1955	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1956	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1957	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1958	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1959	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1960	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1961	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1962	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1963	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1964	0.000	0.014	0.079	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1965	0.000	0.013	0.078	0.245	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1966	0.000	0.013	0.074	0.241	0.562	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1967	0.000	0.013	0.071	0.226	0.550	1.069	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1968	0.000	0.013	0.069	0.213	0.509	1.046	1.796	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1969	0.000	0.013	0.069	0.206	0.475	0.959	1.755	2.751	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1970	0.000	0.013	0.069	0.204	0.455	0.886	1.598	2.688	3.923	5.285	6.795	8.400	10.048	11.687	13.272
1971	0.000	0.013	0.070	0.204	0.451	0.844	1.467	2.437	3.834	5.285	6.795	8.400	10.048	11.687	13.272
1972	0.000	0.012	0.072	0.212	0.452	0.838	1.391	2.227	3.469	5.167	6.795	8.400	10.048	11.687	13.272
1973	0.000	0.012	0.067	0.220	0.474	0.840	1.383	2.106	3.161	4.674	6.647	8.400	10.048	11.687	13.272
1974	0.000	0.012	0.062	0.200	0.498	0.890	1.388	2.093	2.984	4.255	6.022	8.226	10.048	11.687	13.272
1975	0.000	0.012	0.062	0.178	0.443	0.943	1.480	2.103	2.967	4.013	5.485	7.474	9.853	11.687	13.272
1976	0.000	0.012	0.064	0.178	0.384	0.824	1.579	2.256	2.985	3.993	5.174	6.819	8.987	11.475	13.272
1977	0.000	0.013	0.065	0.183	0.381	0.699	1.362	2.416	3.212	4.019	5.150	6.437	8.223	10.519	13.050
1978	0.000	0.013	0.068	0.185	0.394	0.690	1.133	2.066	3.451	4.334	5.186	6.410	7.774	9.660	12.029
1979	0.000	0.013	0.068	0.194	0.397	0.715	1.115	1.694	2.934	4.664	5.597	6.457	7.743	9.150	11.096
1980	0.000	0.014	0.068	0.191	0.414	0.716	1.158	1.662	2.380	3.955	6.022	6.966	7.802	9.118	10.535
1981	0.000	0.014	0.071	0.188	0.402	0.746	1.154	1.727	2.330	3.184	5.108	7.488	8.405	9.187	10.501
1982	0.000	0.014	0.073	0.194	0.390	0.714	1.201	1.716	2.423	3.112	4.096	6.366	9.017	9.875	10.580
1983	0.000	0.014	0.070	0.200	0.402	0.684	1.134	1.780	2.398	3.237	3.997	5.099	7.700	10.565	11.339
1984	0.000	0.014	0.071	0.191	0.415	0.701	1.074	1.664	2.483	3.194	4.157	4.971	6.175	9.075	12.090
1985	0.000	0.014	0.073	0.196	0.395	0.724	1.097	1.559	2.299	3.300	4.093	5.167	6.016	7.304	10.462
1986	0.000	0.013	0.071	0.204	0.405	0.690	1.133	1.587	2.135	3.031	4.219	5.077	6.249	7.114	8.466
1987	0.000	0.013	0.070	0.198	0.428	0.710	1.078	1.640	2.167	2.795	3.851	5.223	6.131	7.383	8.246
1988	0.000	0.013	0.067	0.195	0.416	0.757	1.114	1.559	2.238	2.828	3.528	4.745	6.295	7.235	8.548
1989	0.000	0.013	0.067	0.189	0.411	0.737	1.198	1.616	2.127	2.919	3.560	4.324	5.698	7.414	8.371
1990	0.000	0.013	0.070	0.191	0.397	0.729	1.169	1.750	2.211	2.775	3.673	4.352	5.171	6.696	8.561
1991	0.000	0.014	0.075	0.203	0.407	0.706	1.157	1.711	2.409	2.890	3.493	4.489	5.193	6.058	7.723
1992	0.000	0.014	0.076	0.223	0.442	0.734	1.122	1.695	2.359	3.165	3.644	4.270	5.353	6.070	6.972
1993	0.000	0.014	0.074	0.226	0.497	0.811	1.181	1.648	2.339	3.105	4.008	4.461	5.095	6.253	6.973
1994	0.000	0.015	0.076	0.217	0.503	0.927	1.322	1.751	2.279	3.081	3.938	4.922	5.328	5.957	7.178
1995	0.000	0.015	0.078	0.222	0.475	0.938	1.533	1.983	2.444	3.009	3.911	4.843	5.892	6.234	6.845
1996	0.000	0.016	0.079	0.222	0.482	0.871	1.549	2.323	2.790	3.249	3.826	4.814	5.806	6.903	7.166
1997	0.000	0.016	0.084	0.223	0.475	0.877	1.422	2.346	3.292	3.734	4.156	4.718	5.775	6.811	7.940
1998	0.000	0.016	0.086	0.239	0.469	0.853	1.422	2.132	3.321	4.422	4.796	5.149	5.670	6.780	7.844
1999	0.000	0.017	0.089	0.247	0.507	0.832	1.367	2.121	2.998	4.458	5.688	5.954	6.208	6.668	7.814
2000	0.000	0.017	0.091	0.255	0.526	0.904	1.318	2.018	2.967	4.006	5.730	7.055	7.184	7.317	7.696
2001	0.000	0.017	0.091	0.260	0.544	0.942	1.439	1.926	2.801	3.949	5.136	7.103	8.488	8.458	8.454
2002	0.000	0.018	0.091	0.255	0.555	0.974	1.502	2.111	2.651	3.704	5.046	6.362	8.540	9.948	9.751
2003	0.000	0.019	0.096	0.253	0.534	0.993	1.556	2.206	2.912	3.482	4.709	6.235	7.656	10.003	11.399
2004	0.000	0.019	0.099	0.264	0.522	0.942	1.584	2.287	3.046	3.829	4.402	5.797	7.489	8.987	11.456
2005	0.000	0.019	0.099	0.274	0.542	0.907	1.482	2.326	3.159	4.006	4.844	5.397	6.947	8.780	10.328
2006	0.000	0.019	0.098	0.274	0.564	0.938	1.411	2.151	3.209	4.155	5.068	5.936	6.448	8.136	10.082
2007	0.000	0.019	0.097	0.271	0.561	0.977	1.452	2.027	2.940	4.216	5.254	6.209	7.084	7.536	9.342
2008	0.000	0.020	0.100	0.266	0.555	0.970	1.512	2.077	2.746	3.833	5.326	6.433	7.404	8.265	8.644

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2009	0.000	0.019	0.103	0.275	0.543	0.957	1.498	2.164	2.801	3.555	4.815	6.514	7.664	8.631	9.460
2010	0.000	0.019	0.101	0.280	0.560	0.935	1.478	2.140	2.919	3.612	4.439	5.864	7.754	8.924	9.865
2011	0.000	0.018	0.101	0.275	0.569	0.961	1.442	2.110	2.882	3.764	4.493	5.382	6.963	9.020	10.188
2012	0.000	0.017	0.094	0.274	0.556	0.974	1.476	2.054	2.840	3.710	4.681	5.429	6.367	8.090	10.287
2013	0.000	0.016	0.089	0.256	0.554	0.950	1.491	2.096	2.761	3.655	4.608	5.653	6.404	7.379	9.227
2014	0.000	0.016	0.084	0.242	0.518	0.944	1.453	2.112	2.810	3.550	4.539	5.560	6.664	7.402	8.404
2015	0.000	0.016	0.079	0.227	0.489	0.883	1.441	2.054	2.824	3.602	4.405	5.476	6.548	7.696	8.410
2016	0.000	0.015	0.078	0.215	0.458	0.835	1.350	2.035	2.743	3.612	4.458	5.310	6.449	7.558	8.736
2017	0.000	0.015	0.078	0.212	0.435	0.783	1.277	1.909	2.715	3.505	4.460	5.362	6.252	7.444	8.576
2018	0.000	0.015	0.078	0.211	0.429	0.744	1.200	1.808	2.550	3.465	4.325	5.354	6.300	7.216	8.448
2019	0.000	0.016	0.078	0.211	0.427	0.734	1.140	1.702	2.418	3.261	4.273	5.189	6.279	7.256	8.189
2020	0.000	0.016	0.078	0.211	0.426	0.731	1.125	1.620	2.281	3.096	4.027	5.123	6.082	7.222	8.220
2021	0.000	0.016	0.079	0.212	0.427	0.729	1.121	1.599	2.173	2.925	3.830	4.836	6.002	6.994	8.170
2022	0.000	0.015	0.079	0.214	0.429	0.730	1.119	1.592	2.146	2.792	3.625	4.606	5.676	6.898	7.912
2023	0.000	0.015	0.076	0.212	0.434	0.734	1.120	1.590	2.137	2.757	3.465	4.368	5.414	6.535	7.800
2024	0.000	0.014	0.074	0.207	0.430	0.742	1.125	1.591	2.133	2.746	3.422	4.181	5.144	6.244	7.403

Table 10. Mid-year weight-at-age estimates (kg) from a generalized Von Bertalanffy growth model described in Cadigan (2016b) fitted by cohort to average weight-at-age data for cod from the fall RV survey in NAFO Divs. 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	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1955	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1956	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1957	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1958	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1959	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1960	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1961	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1962	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1963	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1964	0.003	0.037	0.147	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1965	0.003	0.035	0.144	0.382	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1966	0.003	0.034	0.136	0.374	0.789	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1967	0.003	0.033	0.129	0.349	0.772	1.404	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1968	0.003	0.033	0.125	0.327	0.711	1.373	2.245	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1969	0.003	0.033	0.124	0.314	0.660	1.254	2.194	3.311	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1970	0.003	0.033	0.124	0.312	0.630	1.155	1.993	3.235	4.583	6.025	7.589	9.222	10.872	12.489	14.031
1971	0.003	0.034	0.128	0.312	0.626	1.097	1.825	2.930	4.479	6.025	7.589	9.222	10.872	12.489	14.031
1972	0.003	0.032	0.132	0.326	0.627	1.090	1.728	2.673	4.052	5.892	7.589	9.222	10.872	12.489	14.031
1973	0.003	0.030	0.122	0.340	0.661	1.093	1.717	2.525	3.689	5.333	7.428	9.222	10.872	12.489	14.031
1974	0.003	0.030	0.110	0.306	0.698	1.162	1.725	2.510	3.481	4.855	6.738	9.037	10.872	12.489	14.031
1975	0.003	0.031	0.110	0.269	0.615	1.236	1.845	2.524	3.463	4.579	6.141	8.226	10.667	12.489	14.031
1976	0.003	0.032	0.113	0.267	0.527	1.073	1.972	2.712	3.484	4.557	5.794	7.515	9.753	12.271	14.031
1977	0.003	0.033	0.115	0.276	0.521	0.900	1.693	2.910	3.754	4.588	5.769	7.098	8.940	11.279	13.807
1978	0.003	0.034	0.120	0.278	0.540	0.887	1.398	2.480	4.037	4.950	5.810	7.069	8.459	10.380	12.764
1979	0.003	0.034	0.120	0.291	0.542	0.921	1.373	2.022	3.427	5.327	6.270	7.122	8.427	9.843	11.803
1980	0.004	0.035	0.119	0.285	0.565	0.920	1.427	1.981	2.768	4.517	6.745	7.679	8.491	9.810	11.222
1981	0.003	0.036	0.123	0.278	0.545	0.958	1.420	2.060	2.707	3.628	5.726	8.247	9.138	9.884	11.188
1982	0.003	0.035	0.127	0.287	0.525	0.911	1.475	2.042	2.815	3.543	4.587	7.026	9.791	10.610	11.271
1983	0.003	0.035	0.121	0.296	0.540	0.867	1.385	2.117	2.783	3.684	4.474	5.629	8.384	11.332	12.059
1984	0.003	0.036	0.123	0.282	0.557	0.887	1.305	1.968	2.878	3.632	4.652	5.486	6.734	9.769	12.833
1985	0.003	0.035	0.128	0.289	0.531	0.916	1.331	1.837	2.653	3.748	4.575	5.700	6.559	7.882	11.150
1986	0.003	0.034	0.124	0.303	0.546	0.872	1.375	1.866	2.455	3.431	4.712	5.597	6.811	7.677	9.054
1987	0.003	0.033	0.122	0.295	0.579	0.900	1.307	1.928	2.488	3.153	4.290	5.752	6.678	7.963	8.818
1988	0.003	0.033	0.118	0.291	0.563	0.963	1.353	1.832	2.569	3.185	3.919	5.215	6.849	7.800	9.137
1989	0.003	0.034	0.118	0.281	0.556	0.939	1.460	1.902	2.442	3.288	3.949	4.742	6.192	7.985	8.944
1990	0.003	0.036	0.125	0.286	0.538	0.929	1.426	2.067	2.540	3.126	4.074	4.767	5.610	7.206	9.139
1991	0.003	0.036	0.136	0.308	0.556	0.900	1.412	2.022	2.776	3.258	3.875	4.915	5.628	6.512	8.242
1992	0.003	0.036	0.137	0.343	0.609	0.942	1.372	2.004	2.721	3.577	4.045	4.677	5.799	6.519	7.435
1993	0.004	0.037	0.133	0.347	0.691	1.048	1.451	1.951	2.699	3.511	4.457	4.889	5.522	6.713	7.431
1994	0.004	0.038	0.137	0.330	0.699	1.208	1.634	2.083	2.632	3.486	4.382	5.401	5.777	6.399	7.646
1995	0.004	0.039	0.138	0.336	0.654	1.220	1.905	2.369	2.833	3.407	4.354	5.318	6.394	6.698	7.295
1996	0.004	0.041	0.139	0.334	0.661	1.127	1.924	2.786	3.246	3.691	4.264	5.288	6.304	7.420	7.638
1997	0.004	0.042	0.149	0.332	0.647	1.131	1.757	2.812	3.838	4.251	4.643	5.188	6.274	7.325	8.464
1998	0.004	0.043	0.154	0.358	0.635	1.093	1.752	2.547	3.871	5.040	5.364	5.671	6.164	7.294	8.367
1999	0.004	0.044	0.158	0.371	0.689	1.059	1.676	2.526	3.486	5.079	6.361	6.562	6.758	7.179	8.336
2000	0.004	0.044	0.161	0.382	0.716	1.155	1.607	2.394	3.442	4.558	6.406	7.766	7.817	7.883	8.216
2001	0.004	0.045	0.160	0.390	0.740	1.203	1.759	2.275	3.238	4.485	5.739	7.816	9.217	9.104	9.028
2002	0.004	0.047	0.160	0.379	0.755	1.246	1.836	2.496	3.054	4.195	5.631	7.002	9.270	10.676	10.397
2003	0.004	0.049	0.167	0.373	0.722	1.269	1.903	2.610	3.357	3.932	5.244	6.855	8.318	10.732	12.112
2004	0.004	0.049	0.173	0.389	0.699	1.195	1.936	2.706	3.512	4.325	4.892	6.366	8.131	9.658	12.168
2005	0.004	0.049	0.173	0.404	0.726	1.144	1.801	2.751	3.642	4.526	5.382	5.916	7.538	9.431	10.993
2006	0.005	0.048	0.171	0.403	0.755	1.181	1.705	2.531	3.698	4.693	5.630	6.504	6.988	8.738	10.730
2007	0.005	0.050	0.169	0.398	0.750	1.229	1.751	2.375	3.374	4.760	5.835	6.801	7.672	8.088	9.945
2008	0.005	0.051	0.175	0.390	0.741	1.219	1.824	2.427	3.141	4.314	5.912	7.043	8.015	8.862	9.200

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2009	0.005	0.050	0.178	0.403	0.725	1.204	1.806	2.530	3.197	3.989	5.332	7.129	8.292	9.248	10.056
2010	0.004	0.050	0.175	0.410	0.746	1.175	1.781	2.499	3.332	4.045	4.904	6.409	8.385	9.557	10.479
2011	0.004	0.047	0.175	0.402	0.757	1.205	1.735	2.463	3.286	4.214	4.955	5.870	7.524	9.655	10.814
2012	0.004	0.045	0.163	0.400	0.739	1.219	1.774	2.397	3.238	4.151	5.161	5.913	6.870	8.658	10.915
2013	0.004	0.042	0.154	0.374	0.735	1.188	1.790	2.442	3.146	4.090	5.078	6.155	6.901	7.891	9.794
2014	0.004	0.040	0.145	0.353	0.688	1.180	1.742	2.458	3.197	3.970	5.002	6.050	7.178	7.905	8.917
2015	0.004	0.039	0.137	0.331	0.649	1.104	1.727	2.389	3.209	4.023	4.852	5.959	7.051	8.216	8.913
2016	0.004	0.039	0.135	0.314	0.609	1.044	1.619	2.365	3.116	4.029	4.905	5.778	6.945	8.067	9.255
2017	0.004	0.039	0.135	0.309	0.578	0.981	1.532	2.220	3.082	3.908	4.902	5.828	6.732	7.946	9.084
2018	0.004	0.039	0.134	0.308	0.570	0.931	1.441	2.104	2.898	3.863	4.752	5.814	6.776	7.702	8.949
2019	0.004	0.039	0.135	0.308	0.568	0.919	1.370	1.983	2.750	3.638	4.693	5.633	6.749	7.738	8.675
2020	0.004	0.040	0.135	0.308	0.567	0.915	1.352	1.888	2.596	3.457	4.427	5.559	6.537	7.696	8.701
2021	0.004	0.039	0.137	0.309	0.568	0.914	1.347	1.864	2.475	3.269	4.213	5.253	6.449	7.453	8.643
2022	0.004	0.038	0.136	0.313	0.570	0.915	1.344	1.856	2.444	3.122	3.992	5.007	6.104	7.349	8.370
2023	0.004	0.037	0.132	0.310	0.577	0.919	1.346	1.853	2.434	3.083	3.818	4.752	5.827	6.969	8.251
2024	0.004	0.036	0.127	0.302	0.572	0.929	1.352	1.855	2.430	3.071	3.772	4.552	5.541	6.663	7.838

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 gillnet (5.5 inch mesh) catch rates (fish/net) of cod in NAFO Divs. 2J3KL from 1995 onward. A dash (-) indicates no data.

Year	3	4	5	6	7	8	9	10
1995	0.002	0.046	1.066	1.399	0.570	0.325	0.083	0.017
1996	0.031	0.130	0.893	4.950	2.059	0.598	0.132	0.034
1997	0.017	0.083	1.388	2.075	3.732	0.928	0.121	0.050
1998	0.032	0.080	1.066	5.240	3.396	1.862	0.518	0.068
1999	0.013	0.096	1.110	1.957	2.692	0.790	0.415	0.103
2000	0.015	0.066	0.685	1.133	0.793	0.982	0.439	0.210
2001	0.009	0.050	0.297	0.735	0.493	0.229	0.289	0.104
2002	0.020	0.051	0.372	0.587	0.489	0.219	0.119	0.142
2003	0.028	0.074	0.326	1.273	0.776	0.289	0.128	0.051
2004	0.012	0.118	0.714	1.231	1.289	0.401	0.138	0.040
2005	0.023	0.072	1.360	2.037	1.095	0.523	0.191	0.053
2006	0.012	0.311	1.060	2.510	1.221	0.415	0.193	0.067
2007	0.025	0.062	2.045	2.872	1.374	0.443	0.136	0.064
2008	0.020	0.075	0.419	4.303	2.726	0.818	0.219	0.062
2009	0.019	0.047	0.290	0.852	2.785	1.714	0.419	0.102
2010	0.010	0.024	0.247	1.292	1.239	2.164	1.009	0.237
2011	0.013	0.045	0.287	1.043	1.806	1.276	1.409	0.570
2012	0.029	0.083	1.079	2.161	2.366	1.606	0.881	0.919
2013	0.007	0.081	0.956	3.656	2.610	1.901	1.115	0.596
2014	0.027	0.104	2.044	4.513	4.479	1.834	1.028	0.437
2015	0.011	0.077	0.886	5.201	4.708	2.252	0.921	0.437
2016	0.002	0.034	0.406	1.643	4.169	2.563	1.350	0.632
2017	0.001	0.020	0.237	1.619	2.367	3.705	1.739	0.839
2018	0.003	0.013	0.141	1.301	4.287	2.777	1.872	0.840
2019	0.004	0.017	0.093	0.520	2.102	4.149	2.087	1.914
2020	0.004	0.053	0.103	0.691	2.028	2.897	3.334	1.792
2021	-	0.027	0.314	1.176	1.672	2.171	2.621	1.707
2022	0.001	0.058	0.231	1.325	2.162	1.828	1.809	1.279
2023	0.010	0.020	0.269	1.602	2.598	3.199	1.952	1.134
2024	0.004	0.034	0.338	1.420	2.797	3.564	2.560	0.888

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 dash (-) 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
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
2024	1.79	0.26	21.67	0.24

Table 15. Blocks of lower (CL) and upper (CU) catch bounds. Upper catch bounds were lowered when recreational catch estimates were available. A dash (-) 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
2013–24	-	1.1	1.573

Table 16. Population and variance parameter estimates, with coefficients of variation (CV), from xteNCAM (RV = DFO research vessel survey; SN = sentinel survey; SS = Smith Sound; D = proportion of stock in Smith Sound; NB = negative binomial). A dash (-) indicates not applicable.

Quantity	Symbol	Estimate	CV
Number of parameters	k	203	-
Negative log-likelihood	$\ln(L)$	18,740	-
Akaike information criterion	AIC	37,886	-
RV survey observation error	σ_{RV}	0.429	0.047
SN survey observation error (age 3)	σ_{SN_a}	0.665	0.156
SN survey observation error (ages 4-14)	σ_{SN_a}	0.159	0.106
Age correlation in SN q	$\varphi_{SN_q,age}$	0.873	0.295
Year correlation in SN q	$\varphi_{SN_q,year}$	0.891	0.333
SN q variance parameter	σ_{SN_q}	0.798	0.135
Age composition error (ages 0-2)	σ_{P_a}	1.745	0.107
Age composition error (ages 3-4)	σ_{P_a}	0.861	0.092
Age composition error (ages 5-14)	σ_{P_a}	0.309	0.047
Age correlation in process errors	$\varphi_{\delta,age}$	0.811	0.385
Year correlation in process errors	$\varphi_{\delta,year}$	0.864	0.413
Process error variance	σ_{δ}	0.234	0.130
Age correlation in F	$\varphi_{F,age}$	0.895	0.333
Year correlation in F	$\varphi_{F,year}$	0.998	0.438
F variance parameter	σ_F	0.206	0.053
D variance parameter	σ_D	0.664	0.190
Age correlation in D	$\varphi_{D,age}$	0.868	0.473
Year correlation in D	$\varphi_{D,year}$	0.897	0.506
S-R relationship parameter	α_{SSB}	13.568	0.445
S-R relationship parameter	$\log(\beta_{SSB})$	-11.378	0.465
Variance of log-recruitment	σ_r	0.256	0.187
Baseline level of natural mortality	m	0.312	0.287
Effect of the capelin/cod ratio on M	β_{cap}	-0.421	0.109
Variance of tagging F deviations (pre 1997)	$\sigma_{f_{x,1}}$	0.951	0.079
Variance of tagging F deviations (post 1997)	$\sigma_{f_{x,2}}$	1.018	0.073
NB overdispersion parameter for pre 1997 tag experiments	κ_1	16.444	0.093
NB overdispersion parameter for post 1997 tag experiments	κ_2	8.504	0.153
Juvenile survey observation error	σ_{juv}	1.208	0.083
Limit reference point (kt)	B_{lim}	259.642	0.222
2025 relative spawning stock biomass	SSB_{2025}/B_{lim}	2.017	0.253
2024 average natural mortality	$\bar{M}_{5+,2024}$	0.315	0.319
2024 average fishing mortality	$\bar{F}_{5+,2024}$	0.020	0.128

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

Year	Abundance (millions)	Recruits (age 0; millions)	Biomass (kt)	SSB (kt)	SSB/Blim
1954	3,492 (2,143, 5,688)	960 (480, 1,920)	1,760 (1,148, 2,700)	914 (529, 1,578)	3.52 (1.53, 8.10)
1955	3,547 (2,240, 5,616)	1,015 (541, 1,902)	1,760 (1,148, 2,700)	914 (529, 1,578)	3.52 (1.53, 8.10)
1956	3,726 (2,430, 5,715)	1,156 (654, 2,043)	1,762 (1,176, 2,641)	917 (560, 1,502)	3.53 (1.60, 7.79)
1957	4,163 (2,799, 6,191)	1,447 (852, 2,459)	1,822 (1,246, 2,662)	972 (620, 1,523)	3.74 (1.75, 7.99)
1958	4,231 (2,910, 6,151)	1,140 (654, 1,987)	1,937 (1,362, 2,754)	1,058 (698, 1,606)	4.08 (1.96, 8.46)
1959	4,367 (3,030, 6,293)	1,104 (611, 1,996)	2,213 (1,614, 3,035)	1,249 (862, 1,809)	4.81 (2.42, 9.54)
1960	4,341 (3,033, 6,214)	949 (512, 1,758)	2,510 (1,875, 3,361)	1,423 (1,011, 2,003)	5.48 (2.85, 10.52)
1961	4,430 (3,112, 6,306)	1,093 (610, 1,957)	2,743 (2,086, 3,608)	1,513 (1,095, 2,092)	5.83 (3.11, 10.93)
1962	4,584 (3,257, 6,452)	1,257 (728, 2,172)	2,866 (2,264, 3,628)	1,527 (1,164, 2,004)	5.88 (3.25, 10.66)
1963	4,682 (3,366, 6,513)	1,268 (739, 2,174)	2,857 (2,313, 3,527)	1,451 (1,145, 1,839)	5.59 (3.15, 9.93)
1964	4,496 (3,234, 6,250)	1,063 (602, 1,880)	2,587 (2,094, 3,196)	1,372 (1,099, 1,713)	5.29 (3.00, 9.31)
1965	4,302 (3,070, 6,030)	1,013 (562, 1,826)	2,184 (1,742, 2,739)	1,144 (901, 1,453)	4.41 (2.46, 7.90)
1966	4,272 (3,046, 5,992)	1,042 (585, 1,857)	2,072 (1,658, 2,588)	1,021 (798, 1,307)	3.93 (2.18, 7.11)
1967	4,409 (3,151, 6,169)	1,213 (703, 2,094)	2,001 (1,608, 2,489)	907 (706, 1,167)	3.49 (1.92, 6.35)
1968	4,731 (3,369, 6,643)	1,441 (834, 2,488)	2,031 (1,639, 2,517)	954 (750, 1,213)	3.67 (2.04, 6.62)
1969	4,416 (3,138, 6,215)	961 (515, 1,794)	1,899 (1,507, 2,393)	962 (748, 1,237)	3.70 (2.05, 6.70)
1970	4,155 (2,895, 5,961)	939 (463, 1,905)	1,724 (1,326, 2,241)	878 (656, 1,176)	3.38 (1.83, 6.24)
1971	3,880 (2,659, 5,662)	926 (457, 1,873)	1,653 (1,241, 2,201)	810 (589, 1,114)	3.12 (1.67, 5.81)
1972	3,620 (2,455, 5,338)	1,039 (571, 1,891)	1,571 (1,136, 2,172)	797 (569, 1,117)	3.07 (1.65, 5.72)
1973	3,625 (2,439, 5,388)	1,414 (830, 2,407)	1,356 (924, 1,992)	743 (500, 1,105)	2.86 (1.50, 5.45)
1974	3,435 (2,340, 5,040)	1,168 (676, 2,016)	1,082 (747, 1,567)	700 (479, 1,022)	2.69 (1.44, 5.04)
1975	3,429 (2,338, 5,030)	1,117 (610, 2,044)	826 (589, 1,159)	549 (380, 793)	2.11 (1.13, 3.94)
1976	3,127 (2,149, 4,551)	663 (334, 1,316)	671 (512, 879)	353 (261, 477)	1.36 (0.75, 2.47)
1977	2,961 (2,078, 4,219)	635 (342, 1,178)	658 (514, 841)	221 (165, 295)	0.85 (0.47, 1.54)
1978	3,312 (2,421, 4,532)	1,160 (727, 1,850)	713 (569, 892)	192 (147, 249)	0.74 (0.42, 1.30)
1979	3,570 (2,727, 4,674)	1,174 (774, 1,783)	777 (635, 951)	266 (213, 331)	1.02 (0.60, 1.74)
1980	3,889 (3,050, 4,958)	1,209 (802, 1,821)	861 (722, 1,027)	364 (303, 437)	1.40 (0.85, 2.32)
1981	4,603 (3,631, 5,835)	1,594 (1,058, 2,401)	948 (817, 1,099)	439 (375, 514)	1.69 (1.04, 2.75)
1982	5,017 (3,985, 6,315)	1,391 (900, 2,149)	1,086 (952, 1,238)	470 (408, 543)	1.81 (1.13, 2.90)
1983	4,719 (3,774, 5,901)	766 (453, 1,297)	1,196 (1,050, 1,362)	436 (380, 501)	1.68 (1.05, 2.68)
1984	4,497 (3,556, 5,687)	700 (390, 1,256)	1,369 (1,185, 1,581)	501 (432, 582)	1.93 (1.21, 3.08)
1985	4,559 (3,520, 5,905)	972 (559, 1,692)	1,576 (1,352, 1,838)	615 (523, 724)	2.37 (1.47, 3.82)
1986	4,973 (3,809, 6,492)	1,427 (881, 2,312)	1,734 (1,470, 2,044)	641 (539, 762)	2.47 (1.53, 3.97)
1987	5,632 (4,300, 7,377)	1,752 (1,087, 2,823)	1,928 (1,599, 2,323)	823 (668, 1,013)	3.17 (1.96, 5.13)
1988	5,201 (4,002, 6,758)	1,099 (635, 1,903)	1,732 (1,413, 2,122)	895 (708, 1,132)	3.45 (2.12, 5.60)
1989	5,101 (3,890, 6,689)	1,133 (621, 2,069)	1,634 (1,366, 1,954)	908 (733, 1,124)	3.50 (2.15, 5.68)
1990	4,999 (3,772, 6,625)	1,110 (586, 2,101)	1,603 (1,349, 1,905)	774 (623, 961)	2.98 (1.83, 4.85)
1991	4,616 (3,457, 6,164)	954 (491, 1,854)	1,566 (1,310, 1,873)	630 (503, 790)	2.43 (1.49, 3.95)
1992	3,600 (2,561, 5,059)	925 (473, 1,810)	994 (773, 1,279)	368 (278, 488)	1.42 (0.85, 2.36)
1993	1,922 (1,243, 2,972)	528 (244, 1,143)	254 (187, 344)	82 (57, 120)	0.32 (0.18, 0.56)
1994	929 (544, 1,585)	240 (101, 575)	82 (58, 115)	23 (16, 33)	0.09 (0.05, 0.15)
1995	426 (224, 808)	171 (78, 378)	29 (23, 38)	10 (8, 13)	0.04 (0.02, 0.07)
1996	394 (214, 728)	173 (76, 395)	37 (30, 47)	16 (13, 19)	0.06 (0.04, 0.10)
1997	480 (262, 880)	243 (112, 528)	46 (38, 56)	20 (17, 23)	0.08 (0.05, 0.12)
1998	598 (328, 1,092)	304 (140, 657)	56 (48, 65)	28 (25, 32)	0.11 (0.07, 0.17)
1999	771 (430, 1,382)	388 (183, 819)	69 (59, 80)	35 (32, 39)	0.13 (0.09, 0.21)
2000	863 (493, 1,512)	363 (170, 774)	84 (69, 103)	35 (31, 39)	0.13 (0.09, 0.21)
2001	807 (470, 1,388)	302 (140, 652)	86 (69, 108)	31 (27, 35)	0.12 (0.08, 0.19)
2002	814 (478, 1,389)	386 (193, 769)	73 (58, 94)	25 (22, 29)	0.10 (0.06, 0.15)
2003	638 (367, 1,110)	188 (76, 465)	64 (51, 79)	24 (21, 27)	0.09 (0.06, 0.14)

Year	Abundance (millions)	Recruits (age 0; millions)	Biomass (kt)	SSB (kt)	SSB/Blim
2004	573 (329, 998)	224 (99, 506)	64 (52, 79)	21 (18, 25)	0.08 (0.05, 0.13)
2005	649 (387, 1,088)	267 (125, 570)	90 (74, 110)	26 (22, 31)	0.10 (0.06, 0.16)
2006	794 (480, 1,312)	342 (162, 721)	130 (108, 156)	42 (35, 49)	0.16 (0.10, 0.25)
2007	1,123 (668, 1,889)	569 (276, 1,174)	173 (144, 208)	86 (72, 101)	0.33 (0.21, 0.53)
2008	1,385 (838, 2,289)	624 (311, 1,252)	207 (171, 250)	120 (97, 147)	0.46 (0.29, 0.74)
2009	1,493 (922, 2,417)	654 (336, 1,273)	202 (165, 248)	103 (84, 125)	0.40 (0.24, 0.64)
2010	1,371 (860, 2,185)	483 (238, 979)	207 (168, 255)	95 (79, 114)	0.37 (0.23, 0.59)
2011	1,466 (948, 2,265)	670 (372, 1,207)	209 (174, 250)	93 (78, 111)	0.36 (0.22, 0.58)
2012	1,755 (1,170, 2,633)	786 (444, 1,392)	253 (215, 298)	116 (99, 136)	0.45 (0.28, 0.71)
2013	2,072 (1,393, 3,083)	829 (446, 1,540)	339 (289, 397)	172 (147, 201)	0.66 (0.42, 1.04)
2014	2,286 (1,545, 3,381)	783 (409, 1,498)	453 (386, 532)	244 (208, 286)	0.94 (0.60, 1.49)
2015	2,587 (1,762, 3,799)	988 (544, 1,793)	553 (472, 649)	282 (242, 328)	1.09 (0.68, 1.73)
2016	2,908 (2,027, 4,172)	1,150 (675, 1,958)	643 (548, 756)	350 (301, 407)	1.35 (0.85, 2.14)
2017	2,961 (2,091, 4,193)	959 (540, 1,701)	730 (616, 864)	469 (397, 553)	1.81 (1.14, 2.86)
2018	2,946 (2,045, 4,244)	1,102 (621, 1,953)	605 (507, 722)	385 (318, 466)	1.48 (0.92, 2.39)
2019	2,869 (1,999, 4,116)	816 (425, 1,566)	680 (578, 800)	419 (352, 499)	1.61 (1.01, 2.57)
2020	2,893 (1,997, 4,190)	922 (482, 1,764)	735 (614, 881)	436 (360, 527)	1.68 (1.05, 2.69)
2021	2,877 (1,974, 4,194)	971 (504, 1,871)	740 (612, 895)	467 (388, 561)	1.80 (1.12, 2.89)
2022	2,802 (1,907, 4,116)	872 (422, 1,802)	810 (651, 1,007)	541 (433, 677)	2.08 (1.29, 3.38)
2023	2,607 (1,741, 3,904)	880 (426, 1,819)	766 (600, 979)	496 (380, 648)	1.91 (1.16, 3.16)
2024	2,415 (1,591, 3,667)	891 (436, 1,821)	668 (545, 820)	444 (356, 553)	1.71 (1.05, 2.78)
2025	2,487 (1,605, 3,855)	1,016 (505, 2,043)	692 (541, 886)	524 (404, 678)	2.02 (1.23, 3.31)

Table 18. Northern cod mortality rate (total [Z], natural [M], fishing [F]) estimates with lower and upper 95% confidence intervals indicated in parentheses.

Year	Average Z (ages 5+)	Average M (ages 5+)	Average F (ages 5+)
1954	0.474 (0.379, 0.593)	0.198 (0.093, 0.421)	0.276 (0.146, 0.521)
1955	0.476 (0.382, 0.593)	0.198 (0.093, 0.421)	0.278 (0.183, 0.424)
1956	0.448 (0.338, 0.594)	0.172 (0.069, 0.429)	0.276 (0.180, 0.423)
1957	0.422 (0.306, 0.582)	0.156 (0.058, 0.421)	0.266 (0.169, 0.419)
1958	0.354 (0.248, 0.505)	0.137 (0.049, 0.383)	0.217 (0.138, 0.342)
1959	0.368 (0.266, 0.510)	0.124 (0.044, 0.351)	0.245 (0.162, 0.370)
1960	0.403 (0.301, 0.540)	0.119 (0.042, 0.335)	0.284 (0.195, 0.414)
1961	0.419 (0.304, 0.580)	0.119 (0.044, 0.320)	0.300 (0.195, 0.463)
1962	0.426 (0.325, 0.558)	0.120 (0.048, 0.300)	0.306 (0.218, 0.429)
1963	0.557 (0.478, 0.650)	0.122 (0.048, 0.308)	0.435 (0.354, 0.536)
1964	0.703 (0.620, 0.798)	0.123 (0.047, 0.317)	0.581 (0.473, 0.713)
1965	0.625 (0.540, 0.722)	0.121 (0.045, 0.326)	0.504 (0.401, 0.633)
1966	0.623 (0.531, 0.731)	0.117 (0.044, 0.312)	0.506 (0.399, 0.643)
1967	0.542 (0.451, 0.652)	0.116 (0.045, 0.299)	0.426 (0.332, 0.546)
1968	0.631 (0.528, 0.755)	0.120 (0.046, 0.313)	0.511 (0.400, 0.653)
1969	0.674 (0.552, 0.823)	0.127 (0.047, 0.342)	0.547 (0.416, 0.718)
1970	0.606 (0.474, 0.775)	0.139 (0.054, 0.359)	0.467 (0.338, 0.646)
1971	0.577 (0.436, 0.762)	0.164 (0.069, 0.388)	0.412 (0.290, 0.587)
1972	0.623 (0.464, 0.835)	0.210 (0.091, 0.484)	0.412 (0.290, 0.586)
1973	0.667 (0.482, 0.923)	0.242 (0.098, 0.599)	0.425 (0.285, 0.634)
1974	0.757 (0.568, 1.009)	0.216 (0.078, 0.593)	0.541 (0.374, 0.784)
1975	0.863 (0.648, 1.151)	0.195 (0.069, 0.551)	0.668 (0.452, 0.989)
1976	0.841 (0.659, 1.074)	0.204 (0.076, 0.548)	0.637 (0.457, 0.889)
1977	0.747 (0.573, 0.974)	0.251 (0.102, 0.616)	0.496 (0.364, 0.676)
1978	0.642 (0.489, 0.842)	0.272 (0.133, 0.559)	0.370 (0.278, 0.491)
1979	0.565 (0.446, 0.717)	0.240 (0.129, 0.447)	0.325 (0.257, 0.413)
1980	0.567 (0.451, 0.712)	0.239 (0.131, 0.436)	0.328 (0.269, 0.400)
1981	0.559 (0.454, 0.690)	0.237 (0.138, 0.409)	0.322 (0.272, 0.381)
1982	0.663 (0.542, 0.811)	0.259 (0.150, 0.448)	0.404 (0.346, 0.471)
1983	0.605 (0.460, 0.795)	0.290 (0.166, 0.506)	0.315 (0.263, 0.377)
1984	0.565 (0.394, 0.810)	0.309 (0.159, 0.600)	0.256 (0.210, 0.311)
1985	0.543 (0.431, 0.684)	0.255 (0.157, 0.416)	0.287 (0.237, 0.349)
1986	0.420 (0.325, 0.543)	0.189 (0.113, 0.314)	0.232 (0.185, 0.290)
1987	0.633 (0.477, 0.842)	0.416 (0.274, 0.634)	0.217 (0.172, 0.273)
1988	0.628 (0.463, 0.850)	0.410 (0.254, 0.663)	0.217 (0.173, 0.273)
1989	0.642 (0.484, 0.852)	0.423 (0.274, 0.652)	0.219 (0.177, 0.273)
1990	0.666 (0.499, 0.890)	0.451 (0.296, 0.689)	0.215 (0.172, 0.268)
1991	1.259 (1.000, 1.584)	1.006 (0.763, 1.327)	0.253 (0.198, 0.321)
1992	2.678 (2.278, 3.148)	2.453 (2.051, 2.933)	0.225 (0.172, 0.294)
1993	2.897 (2.385, 3.519)	2.708 (2.185, 3.357)	0.189 (0.135, 0.265)
1994	2.049 (1.615, 2.599)	1.953 (1.512, 2.522)	0.096 (0.067, 0.137)
1995	0.431 (0.268, 0.693)	0.388 (0.228, 0.663)	0.043 (0.033, 0.056)
1996	0.441 (0.295, 0.661)	0.365 (0.222, 0.602)	0.076 (0.062, 0.094)
1997	0.411 (0.281, 0.602)	0.364 (0.236, 0.562)	0.047 (0.039, 0.056)
1998	0.470 (0.333, 0.663)	0.343 (0.211, 0.557)	0.127 (0.108, 0.150)
1999	0.619 (0.451, 0.850)	0.422 (0.262, 0.681)	0.197 (0.170, 0.229)
2000	0.835 (0.632, 1.105)	0.709 (0.509, 0.988)	0.126 (0.108, 0.148)
2001	1.053 (0.818, 1.356)	0.894 (0.660, 1.212)	0.159 (0.134, 0.188)
2002	0.899 (0.683, 1.184)	0.752 (0.536, 1.053)	0.148 (0.125, 0.176)
2003	0.841 (0.590, 1.199)	0.770 (0.520, 1.139)	0.071 (0.059, 0.086)

Year	Average Z (ages 5+)	Average M (ages 5+)	Average F (ages 5+)
2004	0.432 (0.258, 0.721)	0.394 (0.223, 0.694)	0.038 (0.029, 0.050)
2005	0.370 (0.206, 0.662)	0.337 (0.177, 0.640)	0.033 (0.026, 0.041)
2006	0.407 (0.258, 0.641)	0.366 (0.221, 0.605)	0.041 (0.033, 0.051)
2007	0.459 (0.264, 0.800)	0.433 (0.241, 0.779)	0.026 (0.021, 0.033)
2008	0.740 (0.496, 1.102)	0.711 (0.470, 1.077)	0.028 (0.024, 0.034)
2009	0.645 (0.457, 0.910)	0.616 (0.429, 0.885)	0.028 (0.023, 0.036)
2010	0.669 (0.432, 1.035)	0.643 (0.407, 1.015)	0.026 (0.021, 0.034)
2011	0.451 (0.299, 0.680)	0.422 (0.272, 0.656)	0.029 (0.023, 0.036)
2012	0.319 (0.198, 0.513)	0.297 (0.178, 0.495)	0.022 (0.018, 0.027)
2013	0.302 (0.185, 0.492)	0.284 (0.169, 0.477)	0.018 (0.014, 0.023)
2014	0.358 (0.237, 0.543)	0.345 (0.224, 0.531)	0.014 (0.011, 0.017)
2015	0.354 (0.233, 0.537)	0.340 (0.220, 0.526)	0.013 (0.011, 0.016)
2016	0.329 (0.210, 0.513)	0.311 (0.194, 0.498)	0.018 (0.014, 0.022)
2017	0.656 (0.474, 0.907)	0.635 (0.454, 0.888)	0.021 (0.017, 0.026)
2018	0.363 (0.228, 0.576)	0.342 (0.210, 0.560)	0.020 (0.016, 0.025)
2019	0.413 (0.270, 0.632)	0.393 (0.251, 0.613)	0.020 (0.016, 0.026)
2020	0.468 (0.315, 0.693)	0.451 (0.300, 0.677)	0.017 (0.013, 0.022)
2021	0.346 (0.193, 0.619)	0.333 (0.182, 0.609)	0.013 (0.010, 0.018)
2022	0.480 (0.279, 0.825)	0.465 (0.266, 0.813)	0.014 (0.011, 0.019)
2023	0.534 (0.314, 0.907)	0.518 (0.299, 0.896)	0.016 (0.012, 0.020)
2024	0.335 (0.186, 0.605)	0.315 (0.169, 0.589)	0.020 (0.016, 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	960	702	530	404	312	220	148	93	55	31	17	9	5	3	2
1955	1,015	702	530	404	312	220	148	93	55	31	17	9	5	3	2
1956	1,156	742	530	404	312	220	148	92	56	31	18	9	5	3	2
1957	1,447	845	565	403	312	220	148	92	58	33	19	11	6	3	2
1958	1,140	1,059	666	441	316	222	150	94	60	37	22	12	7	4	2
1959	1,104	834	870	544	358	230	156	101	65	43	27	16	9	5	3
1960	949	808	694	724	451	263	160	102	68	46	32	21	12	7	4
1961	1,093	694	665	572	600	331	180	99	64	46	33	23	15	10	6
1962	1,257	799	560	535	466	440	228	111	60	41	31	22	16	11	7
1963	1,268	920	645	448	432	341	309	144	66	37	25	18	14	10	7
1964	1,063	927	755	525	364	307	220	168	74	36	20	13	10	8	6
1965	1,013	778	769	622	431	260	188	96	68	33	17	10	7	6	5
1966	1,042	741	645	639	518	316	164	90	44	32	17	9	6	4	3
1967	1,213	762	609	534	535	384	199	79	39	20	15	8	5	3	2
1968	1,441	888	617	498	444	402	255	104	36	19	11	7	5	3	2
1969	961	1,054	712	499	411	326	250	121	42	17	10	5	4	2	1
1970	939	703	830	569	409	301	203	114	47	18	8	5	3	2	1
1971	926	687	511	624	449	296	191	102	48	23	10	5	3	2	1
1972	1,039	677	427	331	451	309	182	102	50	25	13	6	3	2	1
1973	1,414	760	359	230	208	282	175	95	51	25	13	7	4	2	1
1974	1,168	1,034	435	199	140	123	151	90	48	24	11	6	3	2	1
1975	1,117	854	721	295	138	87	66	73	41	20	9	4	2	1	1
1976	663	817	652	550	225	90	46	29	29	13	7	3	1	1	1
1977	635	485	640	518	438	150	46	20	11	10	4	2	1	1	0
1978	1,160	465	371	502	410	288	75	21	8	5	4	2	1	1	0
1979	1,174	849	363	294	400	276	157	37	9	4	2	2	1	1	0
1980	1,209	859	716	307	244	277	159	87	20	5	2	1	2	1	1
1981	1,594	884	755	629	259	167	160	88	48	11	3	1	1	1	1
1982	1,391	1,166	793	677	540	175	94	89	52	29	6	2	1	1	1
1983	766	1,018	1,053	717	585	348	89	44	48	28	16	4	1	1	1
1984	700	561	926	965	633	396	190	46	24	27	17	10	2	1	0
1985	972	512	495	850	861	463	229	100	26	14	17	10	6	2	1
1986	1,427	711	445	454	762	667	290	121	53	14	9	9	6	4	1
1987	1,752	1,044	618	412	411	622	472	174	71	31	9	5	5	3	2
1988	1,099	1,282	892	536	339	305	388	216	79	36	16	4	3	3	2
1989	1,133	804	1,071	804	459	263	202	193	101	39	18	8	2	1	1
1990	1,110	829	645	949	678	348	169	104	86	48	19	9	4	1	1
1991	954	812	618	551	771	500	215	87	45	34	18	7	3	2	0
1992	925	698	545	400	329	422	193	62	14	5	3	2	1	0	0
1993	528	677	323	165	101	75	41	11	1	0	0	0	0	0	0
1994	240	386	175	64	33	22	5	2	0	0	0	0	0	0	0
1995	171	176	34	24	8	9	3	1	0	0	0	0	0	0	0
1996	173	125	47	20	14	6	6	2	0	0	0	0	0	0	0
1997	243	127	52	28	11	10	4	4	1	0	0	0	0	0	0
1998	304	178	52	31	14	7	6	3	3	1	0	0	0	0	0
1999	388	222	85	36	18	9	4	4	2	2	1	0	0	0	0
2000	363	284	110	61	22	12	5	2	2	1	1	0	0	0	0
2001	302	266	131	62	25	11	5	2	1	1	1	1	0	0	0
2002	386	221	110	62	20	9	3	1	1	0	1	0	0	0	0
2003	188	282	86	51	18	6	3	1	1	0	0	0	0	0	0
2004	224	137	128	51	21	7	2	1	1	0	0	0	0	0	0

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2005	267	164	61	98	37	15	5	1	1	0	0	0	0	0	0
2006	342	195	83	49	79	29	11	3	1	1	0	0	0	0	0
2007	569	250	102	67	40	64	21	6	2	1	0	0	0	0	0
2008	624	417	124	79	52	30	42	12	3	1	0	0	0	0	0
2009	654	457	170	82	54	33	16	18	7	2	0	0	0	0	0
2010	483	479	180	104	53	33	18	8	10	3	1	0	0	0	0
2011	670	353	208	104	64	30	16	9	4	5	2	0	0	0	0
2012	786	490	169	145	77	46	19	10	6	3	3	1	0	0	0
2013	829	575	288	133	119	63	35	14	7	4	2	2	1	0	0
2014	783	606	349	237	114	101	50	25	9	4	3	1	2	1	0
2015	988	573	330	271	195	94	77	33	14	6	3	2	1	1	0
2016	1,150	723	290	226	205	152	69	54	22	10	4	2	1	1	1
2017	959	841	412	196	169	158	115	50	37	14	6	2	1	1	0
2018	1,102	701	487	229	121	105	93	62	22	14	5	2	1	0	0
2019	816	806	416	348	176	94	77	66	41	14	9	3	1	1	0
2020	922	597	479	292	266	135	68	52	41	25	9	5	2	1	0
2021	971	675	301	309	212	196	95	44	30	22	13	4	3	1	0
2022	872	711	327	202	235	165	146	68	30	19	14	8	3	2	1
2023	880	638	300	195	141	170	112	89	39	17	10	7	4	1	1
2024	891	644	212	168	133	101	112	68	47	20	8	5	4	2	1
2025	1,016	652	190	135	126	105	78	82	46	31	13	5	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	0.23	9.69	42.07	99.10	175.36	235.42	266.63	255.14	217.07	166.03	118.19	75.90	46.89	31.67	21.09
1955	0.24	9.69	42.07	99.10	175.36	235.42	266.63	255.14	217.07	166.03	118.19	75.90	46.89	31.67	21.09
1956	0.28	10.25	42.07	99.10	175.34	234.83	265.11	253.17	218.89	163.26	120.66	78.58	47.69	31.85	21.15
1957	0.35	11.67	44.79	98.84	175.02	235.26	265.42	253.14	227.86	176.27	129.43	88.63	55.95	35.88	23.21
1958	0.27	14.62	52.86	108.31	177.25	236.95	269.15	257.58	234.00	196.00	146.74	102.18	68.29	45.21	27.26
1959	0.27	11.52	69.03	133.53	201.05	246.41	280.78	276.81	255.75	225.89	184.99	135.63	90.67	61.61	39.16
1960	0.23	11.15	55.07	177.75	253.11	281.42	287.90	279.32	266.22	245.31	215.54	173.51	123.35	84.70	55.85
1961	0.26	9.58	52.72	140.47	336.90	353.70	323.73	272.49	250.65	242.66	224.42	194.00	153.43	112.92	75.48
1962	0.30	11.03	44.40	131.39	261.84	469.97	410.35	305.18	233.54	216.90	209.17	186.04	160.71	132.16	93.41
1963	0.31	12.70	51.15	109.94	242.54	364.49	554.07	395.81	258.50	193.08	172.74	151.56	135.66	121.53	92.53
1964	0.26	12.66	59.87	128.76	204.34	328.68	395.20	461.80	289.85	189.29	136.51	108.58	98.64	94.73	77.69
1965	0.24	10.34	60.02	152.76	241.84	277.85	338.22	264.41	266.28	174.96	117.44	83.26	69.93	67.05	59.90
1966	0.25	9.61	48.04	153.96	291.04	337.74	294.89	247.86	172.90	169.81	117.58	75.50	57.00	50.00	45.59
1967	0.29	9.72	43.42	120.73	294.28	410.69	356.55	216.04	154.90	108.26	99.80	70.20	48.24	36.44	31.11
1968	0.35	11.24	42.80	106.10	226.29	420.22	457.79	285.36	143.16	102.40	73.11	61.74	45.53	31.11	23.90
1969	0.23	13.28	48.99	102.67	194.97	312.72	438.22	334.11	165.71	87.60	66.59	46.10	40.09	28.17	19.67
1970	0.23	8.94	56.99	116.10	185.86	266.45	324.89	306.21	185.17	97.48	57.57	43.85	30.93	25.63	17.41
1971	0.22	8.82	35.90	127.19	202.73	249.93	280.91	249.71	184.96	121.24	69.68	43.59	34.04	24.04	19.60
1972	0.25	8.38	30.78	70.13	203.68	259.04	253.55	226.57	173.22	127.82	88.95	52.53	33.37	25.52	16.94
1973	0.34	9.04	24.13	50.53	98.47	237.17	241.54	200.86	160.32	115.30	86.08	59.61	35.49	21.94	15.46
1974	0.28	12.34	27.02	39.80	69.66	109.44	209.40	187.58	144.32	101.04	68.57	46.92	33.70	19.67	12.08
1975	0.27	10.41	44.80	52.69	61.13	82.34	97.45	153.16	121.08	78.92	49.94	28.40	20.12	15.80	9.93
1976	0.16	10.17	41.63	97.67	86.53	74.49	72.52	65.87	87.15	53.35	33.71	18.36	12.17	9.17	8.00
1977	0.15	6.28	41.57	94.78	166.70	104.72	63.21	47.89	36.46	40.26	21.27	13.65	9.03	6.53	5.32
1978	0.28	6.14	25.21	92.99	161.54	198.55	84.79	42.81	29.26	19.94	21.82	10.92	8.26	5.69	4.35
1979	0.28	11.36	24.78	57.04	158.81	197.06	174.57	62.08	27.84	17.31	12.45	14.60	7.90	6.31	4.48
1980	0.29	11.90	48.80	58.68	100.93	198.20	184.39	144.91	46.92	19.93	12.69	9.46	11.86	6.55	5.35
1981	0.38	12.56	53.27	118.46	104.26	124.70	184.70	152.14	112.39	34.66	15.61	10.23	8.09	10.32	5.89
1982	0.33	15.97	57.59	131.68	210.70	124.78	112.82	153.00	126.53	88.85	26.54	12.49	8.50	6.77	9.14
1983	0.18	14.08	73.28	143.77	235.13	238.15	100.78	79.09	114.18	91.66	64.10	19.46	9.50	6.68	5.74
1984	0.17	7.88	65.48	184.75	262.38	277.93	203.89	76.13	60.07	85.22	69.49	47.82	14.59	7.37	5.59
1985	0.23	7.00	36.06	166.32	340.14	335.68	251.73	156.44	59.65	47.47	67.57	53.76	36.26	11.56	6.34
1986	0.34	9.59	31.49	92.59	309.04	459.75	328.53	191.41	112.57	43.87	36.23	46.62	36.48	25.54	9.49
1987	0.42	13.61	43.09	81.70	175.70	442.04	508.31	284.77	154.58	86.75	34.16	25.08	31.78	25.72	19.92
1988	0.26	16.38	59.96	104.69	141.17	231.26	432.60	336.57	177.47	101.98	55.45	21.25	15.95	20.05	16.80
1989	0.27	10.45	71.61	151.70	188.61	193.61	241.42	312.63	214.05	114.99	64.33	34.76	13.17	9.85	12.54
1990	0.27	11.18	44.92	180.94	268.99	253.52	197.28	182.71	189.31	132.64	70.29	38.12	20.15	7.35	5.61
1991	0.23	11.08	46.07	111.83	314.10	352.65	248.09	149.42	108.15	97.93	63.00	33.28	18.13	9.09	3.41
1992	0.22	9.55	41.19	89.36	145.52	309.47	216.56	105.44	32.70	15.97	12.37	8.13	4.32	2.35	1.09
1993	0.13	9.59	23.95	37.21	50.26	60.87	48.33	17.70	2.60	1.24	0.56	0.52	0.34	0.19	0.09
1994	0.06	5.65	13.39	13.97	16.57	20.70	6.85	3.19	0.60	0.25	0.15	0.08	0.08	0.05	0.02
1995	0.04	2.65	2.61	5.28	3.91	8.33	4.50	1.16	0.55	0.21	0.10	0.06	0.03	0.03	0.01
1996	0.04	1.98	3.74	4.48	6.86	5.18	9.05	4.30	1.00	0.50	0.18	0.08	0.05	0.03	0.02
1997	0.06	2.04	4.39	6.32	5.12	8.60	5.45	8.82	3.81	0.90	0.44	0.16	0.07	0.04	0.02
1998	0.07	2.92	4.52	7.46	6.53	5.83	8.89	5.52	8.62	3.76	0.85	0.41	0.14	0.06	0.03
1999	0.09	3.73	7.58	8.86	9.29	7.52	5.43	8.22	5.02	8.13	3.42	0.77	0.36	0.12	0.05
2000	0.09	4.85	9.94	15.54	11.64	10.77	6.28	3.72	6.07	4.23	6.94	2.96	0.65	0.30	0.10
2001	0.07	4.64	11.87	16.13	13.73	10.05	6.67	3.38	2.40	5.09	3.51	5.74	2.40	0.52	0.24
2002	0.09	4.05	10.01	15.74	10.82	8.78	4.88	2.84	1.84	1.74	3.79	2.62	4.16	1.71	0.38
2003	0.05	5.32	8.27	12.80	9.86	6.37	5.16	2.68	1.68	1.27	1.25	2.81	1.94	3.08	1.27
2004	0.05	2.60	12.66	13.37	11.19	6.66	3.85	3.07	2.00	1.32	0.96	0.93	2.01	1.38	2.16
2005	0.06	3.07	6.01	26.86	19.88	13.55	6.71	3.42	2.78	1.89	1.22	0.88	0.84	1.79	1.21
2006	0.08	3.63	8.13	13.50	44.70	27.39	15.04	5.99	3.10	2.60	1.74	1.11	0.78	0.74	1.56
2007	0.14	4.82	9.92	18.24	22.56	62.09	30.80	12.04	4.57	2.45	2.02	1.34	0.85	0.59	0.55
2008	0.15	8.21	12.42	20.99	29.05	29.37	63.87	25.11	9.18	3.31	1.74	1.41	0.92	0.58	0.40
2009	0.16	8.88	17.46	22.52	29.09	31.88	24.03	38.79	18.33	6.01	2.09	1.07	0.86	0.56	0.35
2010	0.12	9.32	18.15	29.24	29.45	30.43	26.27	16.76	28.72	12.16	3.81	1.29	0.66	0.53	0.34

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2011	0.16	6.48	20.93	28.58	36.24	28.82	22.82	19.06	12.95	20.20	8.24	2.51	0.84	0.43	0.34
2012	0.19	8.54	15.93	39.57	42.87	44.58	28.66	19.91	16.20	10.76	16.27	6.46	1.94	0.65	0.33
2013	0.20	9.46	25.69	34.06	66.13	59.79	51.47	28.76	18.24	14.53	9.38	13.87	5.40	1.62	0.54
2014	0.19	9.52	29.24	57.38	58.96	95.75	71.94	51.90	25.89	15.96	12.28	7.71	11.20	4.30	1.27
2015	0.24	8.88	26.21	61.29	95.15	82.66	111.26	68.36	40.94	20.41	12.13	9.08	5.59	7.99	3.03
2016	0.28	11.17	22.75	48.58	93.89	126.88	93.67	109.69	59.08	34.33	16.45	9.48	6.90	4.19	5.92
2017	0.23	12.98	32.13	41.59	73.28	123.89	147.02	94.83	99.18	49.06	27.40	12.66	7.15	5.15	3.09
2018	0.27	10.84	37.92	48.24	52.02	77.95	111.99	112.60	56.70	49.50	23.46	12.48	5.64	3.16	2.25
2019	0.20	12.50	32.47	73.29	75.05	68.62	88.27	111.86	99.38	46.66	38.87	17.52	9.09	4.09	2.30
2020	0.22	9.36	37.53	61.52	113.20	98.32	76.55	84.72	93.56	77.30	34.55	27.31	12.06	6.23	2.80
2021	0.23	10.49	23.85	65.57	90.50	143.05	106.46	70.49	66.07	63.67	50.20	21.55	16.54	7.27	3.73
2022	0.21	10.78	25.72	43.24	100.83	120.39	163.26	108.04	64.15	53.97	49.27	37.29	15.56	11.89	5.19
2023	0.21	9.36	22.93	41.50	61.29	124.93	125.95	141.69	84.18	45.56	36.32	31.85	23.50	9.73	7.33
2024	0.21	9.31	15.62	34.75	57.04	74.83	125.75	107.57	99.61	55.18	28.33	21.99	18.85	13.68	5.63
2025	0.24	9.43	13.79	26.98	52.85	77.21	88.21	130.49	99.16	85.13	44.50	22.26	17.03	14.46	10.48

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	0.12	2.64	42.02	194.77	214.35	165.93	118.18	75.90	46.89	31.67	21.09
1955	0.00	0.00	0.00	0.00	0.12	2.64	42.02	194.77	214.35	165.93	118.18	75.90	46.89	31.67	21.09
1956	0.00	0.00	0.00	0.00	0.12	2.64	41.78	193.27	216.14	163.16	120.66	78.58	47.69	31.85	21.15
1957	0.00	0.00	0.00	0.00	0.12	2.64	41.83	193.25	225.00	176.16	129.43	88.63	55.95	35.88	23.21
1958	0.00	0.00	0.00	0.00	0.12	2.66	42.42	196.64	231.06	195.88	146.74	102.18	68.29	45.21	27.26
1959	0.00	0.00	0.00	0.01	0.13	2.77	44.25	211.31	252.55	225.75	184.99	135.63	90.67	61.61	39.16
1960	0.00	0.00	0.00	0.00	0.17	3.16	45.37	213.23	262.89	245.16	215.54	173.51	123.35	84.70	55.85
1961	0.00	0.00	0.00	0.01	0.01	3.97	51.02	208.02	247.51	242.52	224.42	194.00	153.43	112.92	75.48
1962	0.00	0.00	0.00	0.01	0.20	0.43	64.67	232.98	230.61	216.77	209.16	186.04	160.71	132.16	93.41
1963	0.00	0.00	0.01	0.03	0.30	4.76	21.95	302.16	255.26	192.96	172.74	151.56	135.66	121.53	92.53
1964	0.00	0.00	0.03	0.19	0.71	6.48	73.62	299.87	286.22	189.18	136.51	108.58	98.64	94.73	77.69
1965	0.00	0.00	0.06	0.40	2.36	11.18	83.50	211.15	263.12	174.85	117.43	83.26	69.93	67.05	59.90
1966	0.00	0.00	0.08	0.83	4.66	22.27	98.71	208.76	170.42	169.77	117.58	75.50	57.00	50.00	45.59
1967	0.00	0.00	0.01	0.98	8.08	37.64	128.26	185.34	153.14	108.17	99.80	70.20	48.24	36.44	31.11
1968	0.00	0.00	0.00	0.11	8.80	54.21	176.14	235.83	141.21	102.33	73.11	61.74	45.53	31.11	23.90
1969	0.00	0.00	0.00	0.03	1.67	52.02	192.97	265.60	161.27	87.50	66.58	46.10	40.09	28.17	19.67
1970	0.00	0.00	0.04	0.00	0.70	17.49	161.12	248.64	177.77	97.10	57.56	43.85	30.93	25.63	17.41
1971	0.00	0.08	0.04	0.44	0.06	11.16	102.18	207.02	177.55	120.44	69.64	43.59	34.04	24.04	19.60
1972	0.00	0.14	0.67	0.48	3.81	2.20	93.24	186.48	166.26	126.86	88.86	52.53	33.37	25.52	16.94
1973	0.00	0.00	1.02	2.72	3.66	21.92	48.40	176.49	156.19	114.33	85.96	59.60	35.49	21.94	15.46
1974	0.00	0.00	0.00	4.01	9.04	19.30	77.86	165.08	142.74	100.71	68.45	46.91	33.70	19.67	12.08
1975	0.00	0.00	0.01	0.02	13.59	24.62	52.94	133.90	120.52	78.85	49.92	28.39	20.12	15.80	9.93
1976	0.00	0.00	0.04	0.18	0.31	31.41	43.28	57.21	85.79	53.34	33.71	18.36	12.17	9.17	8.00
1977	0.00	0.00	0.03	0.50	2.50	4.50	41.10	40.57	35.49	40.16	21.27	13.65	9.03	6.53	5.32
1978	0.00	0.00	0.01	0.47	4.60	22.56	30.14	35.35	27.75	19.84	21.81	10.92	8.26	5.69	4.35
1979	0.00	0.00	0.00	0.14	4.90	27.58	90.56	54.09	25.71	17.00	12.44	14.60	7.90	6.31	4.48
1980	0.00	0.00	0.00	0.01	1.75	32.81	87.54	130.52	46.36	19.31	12.61	9.46	11.86	6.55	5.35
1981	0.00	0.00	0.01	0.03	0.33	14.08	102.13	126.87	110.94	34.63	15.41	10.20	8.09	10.32	5.89
1982	0.00	0.00	0.06	0.29	0.88	5.44	54.03	135.44	122.15	88.71	26.54	12.43	8.49	6.77	9.14
1983	0.00	0.00	0.00	0.70	4.37	13.99	40.10	68.73	111.85	91.07	64.09	19.46	9.48	6.67	5.74
1984	0.00	0.00	0.00	0.07	6.33	39.37	97.97	68.93	58.84	84.94	69.41	47.82	14.59	7.36	5.58
1985	0.00	0.00	0.01	0.03	1.54	37.39	148.45	145.80	59.22	47.34	67.54	53.74	36.26	11.56	6.34
1986	0.00	0.00	0.00	0.13	0.85	24.52	127.62	177.25	112.02	43.85	36.21	46.62	36.48	25.54	9.49
1987	0.00	0.00	0.01	0.10	2.44	17.43	209.12	217.28	153.17	86.72	34.16	25.08	31.78	25.72	19.92
1988	0.00	0.00	0.01	0.23	1.79	28.29	164.37	301.77	167.22	101.87	55.45	21.25	15.94	20.05	16.80
1989	0.00	0.00	0.00	0.30	2.84	22.29	139.97	281.81	212.08	113.61	64.32	34.76	13.17	9.85	12.54
1990	0.00	0.00	0.00	0.18	4.52	24.75	112.28	170.25	187.94	132.54	70.12	38.12	20.15	7.35	5.61
1991	0.00	0.00	0.00	0.05	5.62	45.91	107.63	139.05	107.36	97.88	63.00	33.26	18.13	9.09	3.41
1992	0.00	0.02	0.04	0.12	1.90	77.36	122.89	89.04	32.46	15.96	12.37	8.13	4.32	2.35	1.09
1993	0.00	0.00	0.20	0.32	1.84	16.77	41.52	16.29	2.54	1.23	0.56	0.52	0.34	0.19	0.09
1994	0.00	0.00	0.00	0.41	1.18	10.57	6.27	3.16	0.59	0.25	0.15	0.08	0.08	0.05	0.02
1995	0.00	0.00	0.00	0.02	0.38	3.37	4.34	1.16	0.55	0.21	0.10	0.06	0.03	0.03	0.01
1996	0.00	0.00	0.00	0.01	0.23	1.46	7.76	4.29	1.00	0.50	0.18	0.08	0.05	0.03	0.02
1997	0.00	0.00	0.03	0.05	0.15	2.53	3.20	8.66	3.81	0.90	0.44	0.16	0.07	0.04	0.02
1998	0.00	0.00	0.01	0.23	0.50	1.81	7.41	4.62	8.60	3.76	0.85	0.41	0.14	0.06	0.03
1999	0.00	0.00	0.00	0.13	1.01	3.49	4.73	8.09	4.76	8.12	3.42	0.77	0.36	0.12	0.05
2000	0.00	0.00	0.00	0.05	0.78	3.50	5.66	3.68	6.06	4.16	6.94	2.96	0.65	0.30	0.10
2001	0.00	0.01	0.01	0.02	0.54	2.64	4.36	3.34	2.40	5.09	3.49	5.74	2.40	0.52	0.24
2002	0.00	0.00	0.05	0.16	0.31	2.85	3.12	2.50	1.84	1.74	3.79	2.62	4.16	1.71	0.38
2003	0.00	0.00	0.01	0.33	0.79	2.42	4.38	2.41	1.63	1.27	1.25	2.81	1.94	3.08	1.27
2004	0.00	0.00	0.01	0.10	1.26	2.83	3.57	3.03	1.95	1.31	0.96	0.93	2.01	1.38	2.16

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2005	0.00	0.00	0.02	0.20	1.11	5.15	5.79	3.40	2.78	1.88	1.22	0.88	0.84	1.79	1.21
2006	0.00	0.00	0.04	0.25	3.96	8.63	11.24	5.88	3.10	2.60	1.74	1.11	0.78	0.74	1.56
2007	0.00	0.00	0.01	0.42	2.67	34.74	24.08	11.26	4.56	2.45	2.02	1.34	0.85	0.59	0.55
2008	0.00	0.00	0.03	0.13	3.16	14.31	60.24	24.24	9.05	3.31	1.74	1.41	0.92	0.58	0.40
2009	0.00	0.00	0.03	0.34	1.31	12.40	20.92	38.61	18.25	6.00	2.09	1.07	0.86	0.56	0.35
2010	0.00	0.02	0.05	0.38	2.28	8.16	20.18	16.42	28.71	12.15	3.80	1.29	0.66	0.53	0.34
2011	0.00	0.00	0.19	0.49	3.13	9.05	16.87	18.02	12.91	20.20	8.23	2.51	0.84	0.43	0.34
2012	0.00	0.00	0.01	1.79	4.38	18.02	20.46	19.05	16.02	10.76	16.27	6.46	1.94	0.65	0.33
2013	0.00	0.00	0.01	0.12	13.15	25.38	42.71	26.79	18.14	14.50	9.38	13.87	5.40	1.62	0.54
2014	0.00	0.00	0.03	0.29	1.58	54.09	59.49	50.45	25.55	15.95	12.27	7.71	11.20	4.30	1.27
2015	0.00	0.00	0.03	0.60	4.45	14.55	96.98	66.22	40.78	20.36	12.13	9.08	5.59	7.99	3.03
2016	0.00	0.00	0.04	0.36	7.45	40.67	58.47	106.69	58.78	34.31	16.44	9.48	6.90	4.19	5.92
2017	0.00	0.00	0.01	0.46	3.66	53.21	120.48	88.01	98.65	49.03	27.40	12.66	7.15	5.15	3.09
2018	0.00	0.01	0.00	0.22	3.71	21.01	97.21	110.08	56.14	49.45	23.45	12.48	5.64	3.16	2.25
2019	0.00	0.00	0.13	0.13	3.71	23.80	63.70	109.95	99.15	46.60	38.86	17.52	9.09	4.09	2.30
2020	0.00	0.00	0.05	1.14	4.46	36.11	60.15	80.31	93.37	77.28	34.54	27.30	12.06	6.23	2.80
2021	0.00	0.00	0.00	0.57	7.47	69.94	92.23	67.82	65.56	63.65	50.20	21.55	16.54	7.27	3.73
2022	0.00	0.00	0.00	0.02	5.20	36.13	156.25	106.57	63.78	53.91	49.27	37.29	15.56	11.89	5.19
2023	0.00	0.00	0.01	0.03	0.63	31.29	84.57	141.42	84.08	45.53	36.31	31.85	23.50	9.73	7.33
2024	0.00	0.00	0.01	0.12	1.31	16.77	84.60	97.55	99.60	55.17	28.33	21.99	18.85	13.68	5.63
2025	0.00	0.00	0.01	0.09	1.49	31.84	78.40	120.93	97.07	85.13	44.50	22.26	17.03	14.46	10.48

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

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.312	0.281	0.273	0.257	0.349	0.394	0.470	0.517	0.566	0.591	0.655	0.661	0.543	0.534	0.527
1955	0.312	0.281	0.273	0.257	0.352	0.400	0.478	0.508	0.583	0.570	0.620	0.644	0.538	0.531	0.526
1956	0.312	0.274	0.275	0.259	0.350	0.396	0.473	0.460	0.515	0.483	0.521	0.519	0.436	0.444	0.438
1957	0.312	0.238	0.247	0.243	0.341	0.384	0.456	0.434	0.449	0.434	0.449	0.440	0.364	0.402	0.437
1958	0.312	0.196	0.203	0.209	0.315	0.349	0.398	0.362	0.333	0.309	0.291	0.299	0.254	0.271	0.294
1959	0.312	0.184	0.184	0.188	0.308	0.363	0.432	0.394	0.340	0.298	0.276	0.274	0.219	0.225	0.251
1960	0.312	0.195	0.193	0.188	0.309	0.379	0.481	0.463	0.391	0.340	0.317	0.302	0.239	0.242	0.265
1961	0.312	0.215	0.217	0.205	0.311	0.370	0.485	0.509	0.443	0.400	0.400	0.367	0.300	0.317	0.355
1962	0.312	0.215	0.223	0.214	0.313	0.354	0.462	0.521	0.488	0.479	0.534	0.495	0.431	0.484	0.550
1963	0.312	0.198	0.206	0.208	0.340	0.438	0.609	0.667	0.610	0.598	0.676	0.609	0.510	0.574	0.652
1964	0.312	0.188	0.193	0.197	0.337	0.490	0.828	0.906	0.803	0.729	0.707	0.619	0.537	0.586	0.607
1965	0.312	0.187	0.185	0.183	0.310	0.459	0.737	0.780	0.748	0.649	0.654	0.558	0.487	0.513	0.513
1966	0.312	0.197	0.188	0.178	0.300	0.464	0.738	0.825	0.766	0.783	0.728	0.627	0.599	0.601	0.595
1967	0.312	0.211	0.202	0.184	0.286	0.410	0.649	0.767	0.712	0.644	0.692	0.612	0.590	0.549	0.503
1968	0.312	0.221	0.212	0.192	0.309	0.476	0.741	0.899	0.789	0.682	0.673	0.611	0.631	0.585	0.567
1969	0.312	0.238	0.224	0.200	0.311	0.473	0.785	0.945	0.829	0.671	0.630	0.578	0.599	0.608	0.546
1970	0.312	0.320	0.286	0.237	0.322	0.451	0.685	0.859	0.721	0.587	0.490	0.432	0.403	0.395	0.358
1971	0.312	0.475	0.433	0.325	0.374	0.486	0.632	0.719	0.668	0.561	0.495	0.446	0.439	0.477	0.435
1972	0.312	0.636	0.620	0.468	0.468	0.571	0.647	0.696	0.705	0.647	0.612	0.571	0.571	0.628	0.554
1973	0.312	0.559	0.588	0.497	0.524	0.627	0.668	0.679	0.759	0.773	0.820	0.749	0.741	0.724	0.609
1974	0.312	0.361	0.387	0.367	0.471	0.625	0.729	0.787	0.900	0.959	1.097	1.027	0.909	0.811	0.709
1975	0.312	0.270	0.271	0.272	0.423	0.643	0.813	0.914	1.117	1.104	1.218	1.032	0.938	0.807	0.711
1976	0.312	0.244	0.231	0.229	0.407	0.667	0.841	0.945	1.070	1.174	1.122	0.897	0.780	0.673	0.616
1977	0.312	0.267	0.243	0.233	0.419	0.695	0.806	0.849	0.903	0.867	0.885	0.692	0.623	0.539	0.490
1978	0.312	0.246	0.232	0.226	0.397	0.609	0.714	0.781	0.826	0.726	0.621	0.513	0.432	0.379	0.363
1979	0.312	0.170	0.169	0.189	0.369	0.548	0.585	0.620	0.632	0.566	0.493	0.397	0.351	0.305	0.305
1980	0.312	0.129	0.129	0.169	0.377	0.548	0.592	0.592	0.594	0.501	0.434	0.345	0.303	0.247	0.258
1981	0.312	0.109	0.109	0.153	0.395	0.576	0.585	0.523	0.524	0.519	0.443	0.371	0.339	0.263	0.244
1982	0.312	0.102	0.100	0.146	0.439	0.676	0.749	0.628	0.612	0.577	0.530	0.464	0.399	0.304	0.251
1983	0.312	0.094	0.087	0.125	0.390	0.606	0.663	0.608	0.579	0.527	0.511	0.479	0.419	0.313	0.233
1984	0.312	0.125	0.085	0.114	0.312	0.546	0.638	0.567	0.520	0.480	0.474	0.468	0.401	0.292	0.216
1985	0.312	0.140	0.087	0.110	0.256	0.469	0.643	0.643	0.584	0.516	0.587	0.578	0.518	0.345	0.274
1986	0.312	0.140	0.077	0.100	0.203	0.346	0.512	0.525	0.530	0.490	0.581	0.572	0.516	0.396	0.318
1987	0.312	0.157	0.144	0.195	0.296	0.472	0.781	0.784	0.682	0.680	0.684	0.640	0.626	0.573	0.487
1988	0.312	0.179	0.104	0.154	0.256	0.416	0.697	0.763	0.700	0.691	0.670	0.661	0.645	0.615	0.558
1989	0.312	0.221	0.121	0.172	0.278	0.442	0.658	0.815	0.744	0.722	0.724	0.724	0.745	0.706	0.650
1990	0.312	0.295	0.158	0.208	0.305	0.483	0.659	0.844	0.927	0.975	0.948	0.920	0.954	0.909	0.905
1991	0.312	0.398	0.434	0.515	0.604	0.951	1.238	1.841	2.186	2.301	2.249	2.219	2.199	2.259	2.375
1992	0.312	0.770	1.198	1.376	1.477	2.332	2.888	4.024	3.550	3.581	3.373	3.353	3.261	3.371	3.659
1993	0.312	1.351	1.615	1.609	1.510	2.674	3.112	3.715	2.620	2.377	2.103	2.097	2.131	2.279	2.669
1994	0.312	2.441	1.997	2.054	1.310	2.030	2.178	2.089	1.337	1.198	1.099	1.118	1.181	1.343	1.781
1995	0.312	1.313	0.513	0.512	0.327	0.419	0.460	0.497	0.381	0.355	0.329	0.346	0.406	0.532	0.854
1996	0.312	0.876	0.512	0.623	0.374	0.439	0.440	0.469	0.394	0.374	0.350	0.353	0.416	0.549	0.860
1997	0.312	0.885	0.515	0.713	0.458	0.450	0.392	0.371	0.309	0.305	0.293	0.296	0.344	0.437	0.673
1998	0.312	0.732	0.377	0.533	0.431	0.542	0.478	0.437	0.353	0.346	0.321	0.316	0.356	0.399	0.560
1999	0.312	0.707	0.336	0.483	0.430	0.640	0.768	0.639	0.461	0.409	0.360	0.357	0.337	0.319	0.405
2000	0.312	0.774	0.569	0.882	0.729	0.944	1.001	0.766	0.462	0.434	0.404	0.397	0.382	0.374	0.410
2001	0.312	0.884	0.752	1.157	1.031	1.189	1.236	0.926	0.600	0.540	0.505	0.507	0.496	0.459	0.462
2002	0.312	0.940	0.774	1.207	1.112	1.000	0.985	0.844	0.641	0.574	0.510	0.487	0.459	0.430	0.426
2003	0.312	0.792	0.535	0.859	0.959	0.972	0.903	0.615	0.519	0.522	0.503	0.519	0.504	0.490	0.476
2004	0.312	0.818	0.265	0.323	0.362	0.445	0.503	0.424	0.331	0.309	0.292	0.283	0.274	0.270	0.267

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2005	0.312	0.681	0.205	0.212	0.228	0.337	0.487	0.419	0.343	0.317	0.301	0.292	0.283	0.280	0.279
2006	0.312	0.645	0.206	0.205	0.221	0.319	0.585	0.582	0.509	0.484	0.468	0.448	0.431	0.429	0.431
2007	0.312	0.704	0.260	0.252	0.283	0.409	0.562	0.575	0.588	0.572	0.560	0.545	0.528	0.525	0.529
2008	0.312	0.896	0.412	0.388	0.453	0.636	0.857	0.614	0.682	0.691	0.687	0.671	0.645	0.644	0.645
2009	0.312	0.931	0.489	0.443	0.499	0.628	0.716	0.600	0.665	0.679	0.677	0.665	0.636	0.637	0.632
2010	0.312	0.835	0.548	0.493	0.562	0.720	0.676	0.556	0.606	0.608	0.610	0.602	0.579	0.583	0.576
2011	0.312	0.739	0.363	0.300	0.330	0.435	0.490	0.460	0.438	0.434	0.431	0.425	0.402	0.403	0.396
2012	0.312	0.531	0.238	0.190	0.203	0.282	0.347	0.384	0.361	0.354	0.349	0.345	0.331	0.328	0.321
2013	0.312	0.498	0.194	0.155	0.164	0.239	0.340	0.398	0.385	0.385	0.384	0.378	0.372	0.371	0.356
2014	0.312	0.608	0.256	0.199	0.196	0.273	0.398	0.527	0.486	0.490	0.490	0.486	0.482	0.479	0.462
2015	0.312	0.679	0.378	0.278	0.247	0.299	0.360	0.435	0.422	0.429	0.433	0.438	0.431	0.426	0.408
2016	0.312	0.563	0.391	0.294	0.259	0.278	0.334	0.389	0.431	0.437	0.446	0.445	0.435	0.432	0.418
2017	0.312	0.547	0.588	0.481	0.475	0.527	0.615	0.804	0.939	0.948	0.969	0.969	0.962	0.954	0.941
2018	0.312	0.522	0.336	0.263	0.260	0.303	0.351	0.416	0.441	0.451	0.474	0.476	0.464	0.443	0.444
2019	0.312	0.521	0.356	0.270	0.267	0.319	0.392	0.471	0.498	0.512	0.535	0.533	0.518	0.501	0.522
2020	0.312	0.685	0.437	0.319	0.303	0.348	0.433	0.543	0.634	0.644	0.655	0.659	0.646	0.637	0.665
2021	0.312	0.723	0.400	0.274	0.252	0.296	0.336	0.389	0.453	0.471	0.482	0.486	0.469	0.460	0.478
2022	0.312	0.862	0.516	0.356	0.323	0.383	0.493	0.544	0.593	0.612	0.623	0.623	0.611	0.607	0.633
2023	0.312	1.102	0.579	0.387	0.337	0.421	0.509	0.647	0.673	0.691	0.690	0.688	0.683	0.672	0.690
2024	0.312	1.220	0.448	0.286	0.234	0.263	0.314	0.376	0.408	0.431	0.430	0.420	0.409	0.393	0.427

Table 23. Northern cod natural mortality (M)-at-age estimates from xteNCAM.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1954	0.312	0.281	0.273	0.240	0.200	0.173	0.179	0.202	0.262	0.262	0.262	0.262	0.262	0.262	0.262
1955	0.312	0.281	0.273	0.240	0.200	0.173	0.179	0.202	0.262	0.262	0.262	0.262	0.262	0.262	0.262
1956	0.312	0.274	0.275	0.242	0.197	0.166	0.164	0.168	0.197	0.197	0.197	0.197	0.197	0.197	0.197
1957	0.312	0.238	0.246	0.227	0.187	0.157	0.155	0.151	0.159	0.159	0.159	0.159	0.159	0.159	0.159
1958	0.312	0.196	0.203	0.192	0.165	0.142	0.140	0.132	0.129	0.129	0.129	0.129	0.129	0.129	0.129
1959	0.312	0.184	0.184	0.171	0.149	0.131	0.131	0.119	0.109	0.109	0.109	0.109	0.109	0.109	0.109
1960	0.312	0.195	0.193	0.171	0.144	0.128	0.130	0.115	0.098	0.098	0.098	0.098	0.098	0.098	0.098
1961	0.312	0.215	0.216	0.187	0.149	0.129	0.132	0.115	0.094	0.094	0.094	0.094	0.094	0.094	0.094
1962	0.312	0.215	0.223	0.197	0.155	0.128	0.131	0.114	0.091	0.091	0.091	0.091	0.091	0.091	0.091
1963	0.312	0.198	0.206	0.190	0.153	0.131	0.134	0.114	0.089	0.089	0.089	0.089	0.089	0.089	0.089
1964	0.312	0.188	0.193	0.179	0.151	0.133	0.140	0.114	0.089	0.089	0.089	0.089	0.089	0.089	0.089
1965	0.312	0.187	0.184	0.166	0.140	0.126	0.138	0.119	0.092	0.092	0.092	0.092	0.092	0.092	0.092
1966	0.312	0.197	0.188	0.161	0.131	0.118	0.127	0.118	0.098	0.098	0.098	0.098	0.098	0.098	0.098
1967	0.312	0.211	0.202	0.168	0.133	0.117	0.122	0.114	0.100	0.100	0.100	0.100	0.100	0.100	0.100
1968	0.312	0.221	0.211	0.176	0.140	0.124	0.123	0.113	0.101	0.101	0.101	0.101	0.101	0.101	0.101
1969	0.312	0.238	0.224	0.184	0.149	0.135	0.130	0.115	0.102	0.102	0.102	0.102	0.102	0.102	0.102
1970	0.312	0.320	0.286	0.220	0.171	0.153	0.142	0.122	0.105	0.105	0.105	0.105	0.105	0.105	0.105
1971	0.312	0.475	0.432	0.308	0.223	0.193	0.164	0.131	0.111	0.111	0.111	0.111	0.111	0.111	0.111
1972	0.312	0.636	0.619	0.450	0.312	0.261	0.205	0.151	0.122	0.122	0.122	0.122	0.122	0.122	0.122
1973	0.312	0.559	0.588	0.480	0.364	0.313	0.237	0.163	0.129	0.129	0.129	0.129	0.129	0.129	0.129
1974	0.312	0.361	0.387	0.349	0.309	0.303	0.235	0.160	0.125	0.125	0.125	0.125	0.125	0.125	0.125
1975	0.312	0.270	0.271	0.254	0.249	0.277	0.223	0.152	0.119	0.119	0.119	0.119	0.119	0.119	0.119
1976	0.312	0.244	0.231	0.210	0.219	0.269	0.220	0.147	0.113	0.113	0.113	0.113	0.113	0.113	0.113
1977	0.312	0.267	0.243	0.214	0.226	0.296	0.236	0.151	0.112	0.112	0.112	0.112	0.112	0.112	0.112
1978	0.312	0.246	0.232	0.206	0.223	0.301	0.242	0.148	0.107	0.107	0.107	0.107	0.107	0.107	0.107
1979	0.312	0.170	0.169	0.167	0.197	0.279	0.215	0.129	0.091	0.091	0.091	0.091	0.091	0.091	0.091
1980	0.312	0.129	0.129	0.143	0.196	0.299	0.228	0.122	0.082	0.082	0.082	0.082	0.082	0.082	0.082
1981	0.312	0.109	0.109	0.127	0.204	0.343	0.255	0.126	0.077	0.077	0.077	0.077	0.077	0.077	0.077
1982	0.312	0.102	0.100	0.119	0.207	0.397	0.302	0.136	0.073	0.073	0.073	0.073	0.073	0.073	0.073
1983	0.312	0.094	0.087	0.100	0.177	0.365	0.306	0.143	0.075	0.075	0.075	0.075	0.075	0.075	0.075
1984	0.312	0.125	0.085	0.097	0.153	0.345	0.362	0.172	0.087	0.087	0.087	0.087	0.087	0.087	0.087
1985	0.312	0.140	0.087	0.096	0.129	0.246	0.346	0.203	0.107	0.107	0.107	0.107	0.107	0.107	0.107
1986	0.312	0.140	0.077	0.088	0.105	0.170	0.257	0.188	0.112	0.112	0.112	0.112	0.112	0.112	0.112
1987	0.312	0.157	0.144	0.183	0.217	0.330	0.546	0.458	0.298	0.298	0.298	0.298	0.298	0.298	0.298
1988	0.312	0.179	0.104	0.144	0.184	0.277	0.476	0.491	0.395	0.395	0.395	0.395	0.395	0.395	0.395
1989	0.312	0.221	0.121	0.162	0.208	0.307	0.453	0.543	0.429	0.429	0.429	0.429	0.429	0.429	0.429
1990	0.312	0.295	0.158	0.198	0.232	0.327	0.448	0.592	0.625	0.625	0.625	0.625	0.625	0.625	0.625
1991	0.312	0.398	0.434	0.506	0.531	0.783	0.970	1.487	1.709	1.709	1.709	1.709	1.709	1.709	1.709
1992	0.312	0.770	1.198	1.369	1.417	2.191	2.617	3.567	2.823	2.823	2.823	2.823	2.823	2.823	2.823
1993	0.312	1.351	1.615	1.603	1.458	2.549	2.879	3.313	1.925	1.925	1.925	1.925	1.925	1.925	1.925
1994	0.312	2.441	1.997	2.049	1.274	1.957	2.040	1.873	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1995	0.312	1.313	0.513	0.508	0.304	0.387	0.402	0.411	0.272	0.272	0.272	0.272	0.272	0.272	0.272
1996	0.312	0.876	0.512	0.620	0.346	0.393	0.352	0.349	0.269	0.269	0.269	0.269	0.269	0.269	0.269
1997	0.312	0.885	0.515	0.710	0.437	0.421	0.338	0.297	0.234	0.234	0.234	0.234	0.234	0.234	0.234
1998	0.312	0.732	0.377	0.530	0.402	0.477	0.342	0.235	0.173	0.173	0.173	0.173	0.173	0.173	0.173
1999	0.312	0.707	0.336	0.480	0.398	0.552	0.529	0.290	0.170	0.170	0.170	0.170	0.170	0.170	0.170
2000	0.312	0.774	0.569	0.880	0.700	0.867	0.840	0.535	0.262	0.262	0.262	0.262	0.262	0.262	0.262
2001	0.312	0.884	0.752	1.155	1.002	1.092	1.024	0.606	0.345	0.345	0.345	0.345	0.345	0.345	0.345
2002	0.312	0.940	0.774	1.205	1.091	0.921	0.771	0.494	0.341	0.341	0.341	0.341	0.341	0.341	0.341
2003	0.312	0.792	0.535	0.858	0.951	0.947	0.819	0.472	0.366	0.366	0.366	0.366	0.366	0.366	0.366
2004	0.312	0.818	0.265	0.322	0.357	0.430	0.448	0.328	0.241	0.241	0.241	0.241	0.241	0.241	0.241

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2005	0.312	0.681	0.205	0.211	0.223	0.322	0.427	0.328	0.260	0.260	0.260	0.260	0.260	0.260	0.260
2006	0.312	0.645	0.206	0.204	0.217	0.302	0.510	0.463	0.387	0.387	0.387	0.387	0.387	0.387	0.387
2007	0.312	0.704	0.260	0.251	0.280	0.397	0.516	0.499	0.493	0.493	0.493	0.493	0.493	0.493	0.493
2008	0.312	0.896	0.412	0.388	0.451	0.626	0.827	0.564	0.607	0.607	0.607	0.607	0.607	0.607	0.607
2009	0.312	0.931	0.489	0.443	0.496	0.620	0.691	0.555	0.593	0.593	0.593	0.593	0.593	0.593	0.593
2010	0.312	0.835	0.548	0.493	0.560	0.713	0.653	0.512	0.542	0.542	0.542	0.542	0.542	0.542	0.542
2011	0.312	0.739	0.363	0.300	0.329	0.427	0.464	0.407	0.368	0.368	0.368	0.368	0.368	0.368	0.368
2012	0.312	0.531	0.238	0.190	0.201	0.276	0.326	0.336	0.294	0.294	0.294	0.294	0.294	0.294	0.294
2013	0.312	0.498	0.194	0.155	0.163	0.234	0.322	0.361	0.330	0.330	0.330	0.330	0.330	0.330	0.330
2014	0.312	0.608	0.256	0.198	0.196	0.269	0.384	0.498	0.441	0.441	0.441	0.441	0.441	0.441	0.441
2015	0.312	0.679	0.378	0.278	0.247	0.296	0.349	0.411	0.380	0.380	0.380	0.380	0.380	0.380	0.380
2016	0.312	0.563	0.391	0.294	0.258	0.275	0.321	0.355	0.371	0.371	0.371	0.371	0.371	0.371	0.371
2017	0.312	0.547	0.588	0.481	0.475	0.525	0.603	0.774	0.868	0.868	0.868	0.868	0.868	0.868	0.868
2018	0.312	0.522	0.336	0.263	0.260	0.301	0.340	0.388	0.378	0.378	0.378	0.378	0.378	0.378	0.378
2019	0.312	0.521	0.356	0.270	0.267	0.317	0.384	0.450	0.450	0.450	0.450	0.450	0.450	0.450	0.450
2020	0.312	0.685	0.437	0.319	0.303	0.347	0.426	0.525	0.592	0.592	0.592	0.592	0.592	0.592	0.592
2021	0.312	0.723	0.400	0.274	0.252	0.294	0.330	0.373	0.412	0.412	0.412	0.412	0.412	0.412	0.412
2022	0.312	0.862	0.516	0.356	0.323	0.382	0.487	0.527	0.551	0.551	0.551	0.551	0.551	0.551	0.551
2023	0.312	1.102	0.579	0.387	0.337	0.420	0.502	0.627	0.626	0.626	0.626	0.626	0.626	0.626	0.626
2024	0.312	1.220	0.448	0.286	0.234	0.262	0.308	0.355	0.356	0.356	0.356	0.356	0.356	0.356	0.356

Table 24. Northern cod fishing mortality (F)-at-age estimates from xteNCAM.

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	0.149	0.221	0.291	0.314	0.304	0.329	0.393	0.399	0.282	0.272	0.266
1955	0.000	0.000	0.000	0.017	0.152	0.227	0.299	0.306	0.321	0.308	0.358	0.382	0.276	0.269	0.264
1956	0.000	0.000	0.000	0.017	0.153	0.230	0.308	0.293	0.317	0.286	0.324	0.322	0.239	0.247	0.241
1957	0.000	0.000	0.000	0.017	0.154	0.227	0.301	0.283	0.289	0.275	0.289	0.281	0.205	0.243	0.278
1958	0.000	0.000	0.000	0.017	0.149	0.207	0.258	0.230	0.204	0.180	0.162	0.169	0.125	0.141	0.164
1959	0.000	0.000	0.000	0.017	0.159	0.232	0.301	0.275	0.231	0.189	0.168	0.166	0.111	0.117	0.142
1960	0.000	0.000	0.000	0.017	0.165	0.251	0.351	0.348	0.292	0.242	0.219	0.204	0.141	0.144	0.167
1961	0.000	0.000	0.000	0.017	0.162	0.242	0.354	0.394	0.349	0.306	0.306	0.273	0.206	0.223	0.261
1962	0.000	0.000	0.000	0.018	0.159	0.226	0.332	0.407	0.397	0.388	0.443	0.404	0.339	0.392	0.459
1963	0.000	0.000	0.000	0.018	0.187	0.307	0.474	0.553	0.520	0.509	0.587	0.519	0.421	0.485	0.563
1964	0.000	0.000	0.000	0.018	0.186	0.357	0.688	0.791	0.714	0.640	0.618	0.531	0.448	0.497	0.518
1965	0.000	0.000	0.000	0.017	0.170	0.333	0.599	0.661	0.656	0.557	0.562	0.466	0.395	0.421	0.421
1966	0.000	0.000	0.000	0.017	0.168	0.347	0.610	0.707	0.668	0.685	0.630	0.529	0.501	0.503	0.497
1967	0.000	0.000	0.000	0.017	0.153	0.293	0.527	0.653	0.612	0.544	0.592	0.512	0.490	0.449	0.403
1968	0.000	0.000	0.000	0.016	0.169	0.352	0.618	0.785	0.688	0.581	0.573	0.510	0.530	0.485	0.466
1969	0.000	0.000	0.000	0.016	0.163	0.338	0.654	0.830	0.726	0.569	0.528	0.476	0.496	0.506	0.444
1970	0.000	0.000	0.000	0.017	0.151	0.298	0.543	0.738	0.617	0.482	0.385	0.328	0.299	0.291	0.254
1971	0.000	0.000	0.000	0.017	0.151	0.293	0.468	0.588	0.557	0.450	0.384	0.336	0.329	0.366	0.324
1972	0.000	0.000	0.000	0.017	0.156	0.309	0.442	0.545	0.583	0.525	0.490	0.449	0.448	0.506	0.432
1973	0.000	0.000	0.000	0.017	0.160	0.314	0.431	0.516	0.630	0.644	0.691	0.620	0.612	0.595	0.479
1974	0.000	0.000	0.000	0.018	0.162	0.322	0.494	0.627	0.776	0.834	0.973	0.903	0.784	0.687	0.585
1975	0.000	0.000	0.000	0.018	0.174	0.365	0.590	0.762	0.998	0.986	1.100	0.913	0.820	0.688	0.592
1976	0.000	0.000	0.000	0.019	0.187	0.398	0.621	0.797	0.956	1.061	1.009	0.784	0.667	0.559	0.502
1977	0.000	0.000	0.000	0.019	0.193	0.399	0.570	0.698	0.791	0.755	0.773	0.579	0.510	0.427	0.378
1978	0.000	0.000	0.000	0.020	0.174	0.308	0.472	0.634	0.719	0.620	0.515	0.406	0.326	0.272	0.256
1979	0.000	0.000	0.000	0.022	0.172	0.269	0.370	0.491	0.542	0.475	0.403	0.306	0.261	0.215	0.214
1980	0.000	0.000	0.000	0.026	0.181	0.249	0.364	0.469	0.512	0.418	0.352	0.263	0.221	0.165	0.176
1981	0.000	0.000	0.000	0.027	0.191	0.233	0.330	0.396	0.448	0.442	0.366	0.294	0.262	0.186	0.167
1982	0.000	0.000	0.000	0.026	0.232	0.279	0.447	0.491	0.539	0.504	0.457	0.391	0.327	0.231	0.178
1983	0.000	0.000	0.000	0.025	0.213	0.241	0.358	0.464	0.504	0.452	0.436	0.404	0.344	0.238	0.158
1984	0.000	0.000	0.000	0.017	0.158	0.201	0.276	0.396	0.433	0.393	0.388	0.381	0.315	0.205	0.129
1985	0.000	0.000	0.000	0.013	0.127	0.223	0.297	0.440	0.477	0.409	0.479	0.471	0.411	0.238	0.167
1986	0.000	0.000	0.000	0.012	0.098	0.176	0.255	0.336	0.418	0.378	0.469	0.460	0.405	0.285	0.207
1987	0.000	0.000	0.000	0.011	0.079	0.141	0.235	0.326	0.384	0.382	0.385	0.341	0.328	0.274	0.189
1988	0.000	0.000	0.000	0.010	0.073	0.139	0.221	0.272	0.305	0.296	0.275	0.266	0.250	0.220	0.162
1989	0.000	0.000	0.000	0.009	0.070	0.135	0.205	0.272	0.315	0.293	0.295	0.295	0.316	0.277	0.221
1990	0.000	0.000	0.000	0.009	0.072	0.156	0.210	0.252	0.302	0.349	0.323	0.294	0.329	0.284	0.280
1991	0.000	0.000	0.000	0.009	0.073	0.168	0.267	0.353	0.477	0.592	0.540	0.510	0.490	0.551	0.666
1992	0.000	0.000	0.000	0.007	0.060	0.142	0.272	0.457	0.727	0.758	0.550	0.529	0.438	0.548	0.836
1993	0.000	0.000	0.000	0.006	0.052	0.125	0.233	0.403	0.695	0.452	0.178	0.173	0.206	0.354	0.744
1994	0.000	0.000	0.000	0.005	0.036	0.073	0.138	0.216	0.336	0.198	0.099	0.118	0.181	0.342	0.780
1995	0.000	0.000	0.000	0.004	0.023	0.032	0.059	0.086	0.109	0.083	0.057	0.074	0.134	0.260	0.582
1996	0.000	0.000	0.000	0.003	0.028	0.046	0.089	0.120	0.126	0.106	0.081	0.084	0.148	0.281	0.592
1997	0.000	0.000	0.000	0.003	0.020	0.029	0.054	0.074	0.075	0.070	0.059	0.062	0.110	0.202	0.439
1998	0.000	0.000	0.000	0.003	0.029	0.065	0.135	0.201	0.181	0.173	0.148	0.143	0.183	0.227	0.388
1999	0.000	0.000	0.000	0.002	0.032	0.089	0.238	0.349	0.291	0.240	0.191	0.188	0.168	0.150	0.235
2000	0.000	0.000	0.000	0.002	0.029	0.077	0.161	0.232	0.199	0.172	0.141	0.134	0.120	0.112	0.148
2001	0.000	0.000	0.000	0.002	0.029	0.097	0.212	0.320	0.255	0.195	0.160	0.162	0.152	0.115	0.117
2002	0.000	0.000	0.000	0.001	0.020	0.079	0.215	0.350	0.299	0.233	0.169	0.146	0.118	0.089	0.085
2003	0.000	0.000	0.000	0.001	0.009	0.025	0.083	0.143	0.153	0.156	0.137	0.153	0.138	0.124	0.111
2004	0.000	0.000	0.000	0.001	0.006	0.015	0.055	0.096	0.089	0.068	0.050	0.041	0.033	0.029	0.025

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2005	0.000	0.000	0.000	0.001	0.005	0.015	0.060	0.091	0.083	0.057	0.041	0.032	0.023	0.020	0.019
2006	0.000	0.000	0.000	0.001	0.004	0.017	0.074	0.119	0.122	0.097	0.081	0.062	0.044	0.042	0.044
2007	0.000	0.000	0.000	0.000	0.003	0.013	0.046	0.076	0.094	0.079	0.067	0.052	0.034	0.032	0.036
2008	0.000	0.000	0.000	0.000	0.003	0.010	0.030	0.050	0.075	0.084	0.081	0.064	0.039	0.037	0.038
2009	0.000	0.000	0.000	0.000	0.002	0.008	0.025	0.046	0.071	0.086	0.083	0.072	0.043	0.044	0.038
2010	0.000	0.000	0.000	0.000	0.002	0.007	0.023	0.044	0.064	0.066	0.068	0.060	0.037	0.041	0.034
2011	0.000	0.000	0.000	0.000	0.002	0.007	0.026	0.053	0.070	0.066	0.063	0.056	0.034	0.035	0.028
2012	0.000	0.000	0.000	0.000	0.001	0.006	0.021	0.047	0.066	0.060	0.054	0.051	0.037	0.034	0.026
2013	0.000	0.000	0.000	0.000	0.001	0.005	0.018	0.037	0.055	0.055	0.053	0.048	0.041	0.040	0.025
2014	0.000	0.000	0.000	0.000	0.001	0.004	0.014	0.029	0.045	0.049	0.048	0.045	0.041	0.038	0.021
2015	0.000	0.000	0.000	0.000	0.001	0.003	0.011	0.024	0.042	0.049	0.053	0.057	0.051	0.046	0.028
2016	0.000	0.000	0.000	0.000	0.000	0.003	0.014	0.033	0.060	0.066	0.076	0.075	0.065	0.061	0.048
2017	0.000	0.000	0.000	0.000	0.000	0.002	0.012	0.030	0.071	0.081	0.102	0.102	0.094	0.087	0.074
2018	0.000	0.000	0.000	0.000	0.000	0.002	0.010	0.027	0.062	0.073	0.095	0.098	0.086	0.064	0.066
2019	0.000	0.000	0.000	0.000	0.000	0.002	0.008	0.021	0.049	0.062	0.085	0.083	0.068	0.052	0.072
2020	0.000	0.000	0.000	0.000	0.000	0.002	0.007	0.017	0.042	0.052	0.063	0.068	0.054	0.045	0.074
2021	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.015	0.040	0.058	0.070	0.073	0.057	0.047	0.066
2022	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.017	0.042	0.061	0.072	0.072	0.060	0.056	0.082
2023	0.000	0.000	0.000	0.000	0.000	0.001	0.007	0.020	0.047	0.065	0.064	0.062	0.058	0.046	0.064
2024	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.021	0.052	0.075	0.073	0.064	0.053	0.037	0.071

Table 25. Probability of spawning stock biomass (SSB) exceeding 2025 levels at various catch multipliers over a 3 year projection period.

Catch multiplier	Catch (t)	2026	2027	2028
0	0	44%	43%	41%
0.5	10658	41%	39%	38%
1	21317	37%	36%	35%
1.5	31976	34%	32%	32%
2	42634	30%	29%	29%

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

Catch multiplier	Catch (t)	2026	2027	2028
0	0	98%	92%	85%
0.5	10658	97%	91%	83%
1	21317	97%	89%	80%
1.5	31976	96%	87%	77%
2	42634	96%	85%	73%

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

Catch multiplier	Catch (t)	2025	2026	2027	2028
0	0	2.02 (1.23, 3.31)	1.93 (1.02, 3.65)	1.86 (0.78, 4.40)	1.78 (0.60, 5.29)
0.5	10658	2.02 (1.23, 3.31)	1.89 (0.99, 3.60)	1.80 (0.75, 4.30)	1.70 (0.56, 5.16)
1	21317	2.02 (1.23, 3.31)	1.85 (0.97, 3.54)	1.73 (0.72, 4.21)	1.62 (0.52, 5.03)
1.5	31976	2.02 (1.23, 3.31)	1.82 (0.95, 3.49)	1.67 (0.68, 4.11)	1.54 (0.48, 4.91)
2	42634	2.02 (1.23, 3.31)	1.78 (0.93, 3.44)	1.61 (0.65, 4.02)	1.46 (0.44, 4.79)

FIGURES

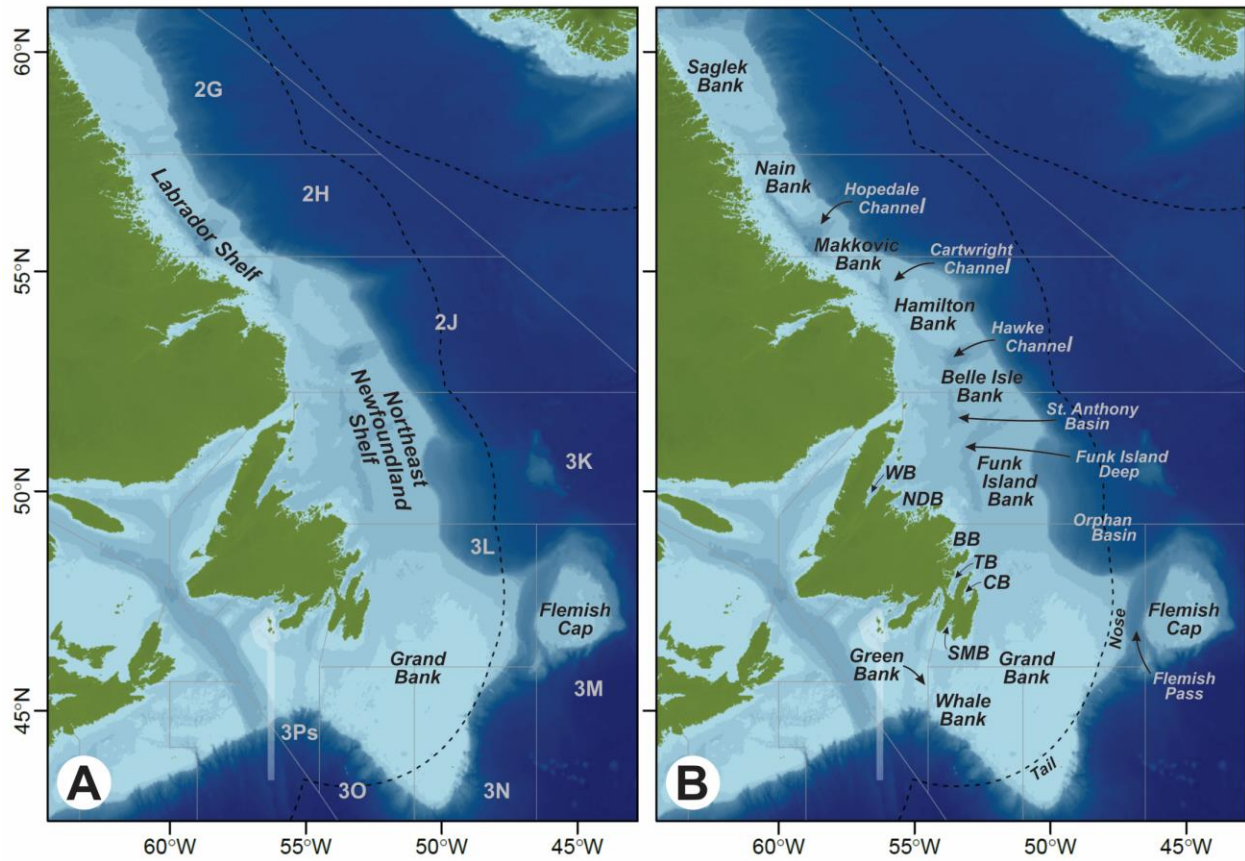


Figure 1. (A) Major geographic features and NAFO Division and Subdivision boundaries around Newfoundland and Labrador (NL) and adjacent areas of the northwest Atlantic. (B) Fishing banks and major bays around eastern NL. The dashed line is Canada's 200 nautical mile limit. WB = White Bay; NDB = Notre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

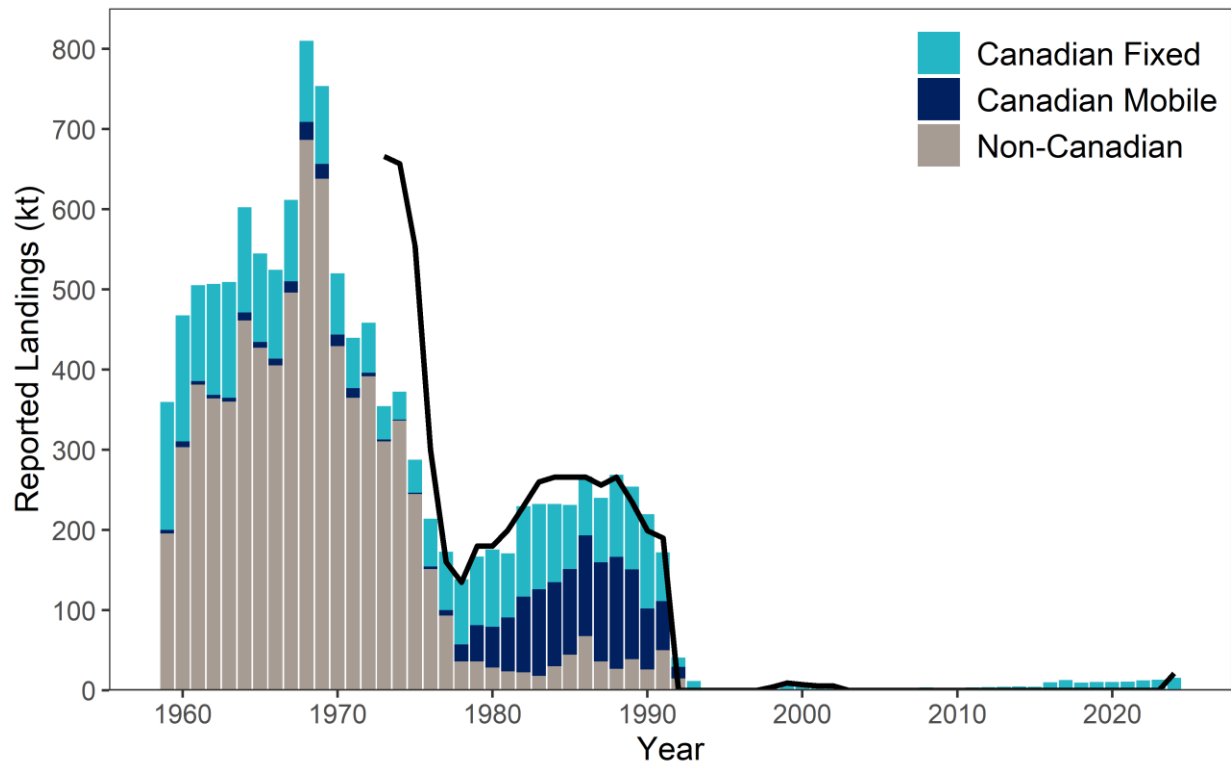


Figure 2. Total allowable catches (TACs, represented by black line) and reported landings (kt) of cod from NAFO Divs. 2J3KL by Canadian mobile fleets (offshore), Canadian fixed gear fleets (mostly inshore), and non-Canadian fleets.

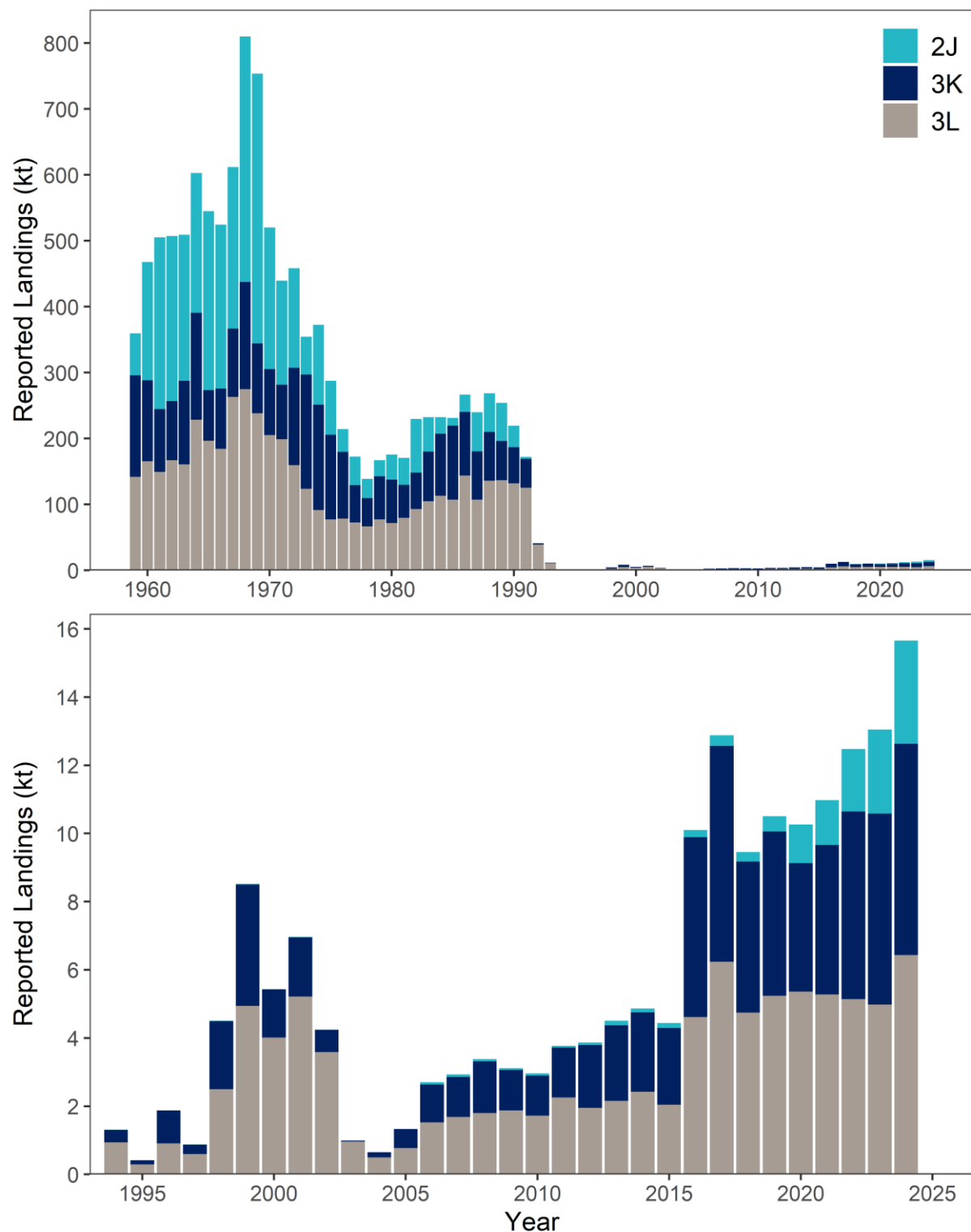


Figure 3. Reported landings (kt) of cod in NAFO Divs. 2J3KL by division. (Upper Panel) Trends since 1959; (Lower Panel) Trends since 1994 (on expanded scale). Note that the lower panel excludes recreational fishery landings except during 2008 and 2011–12.

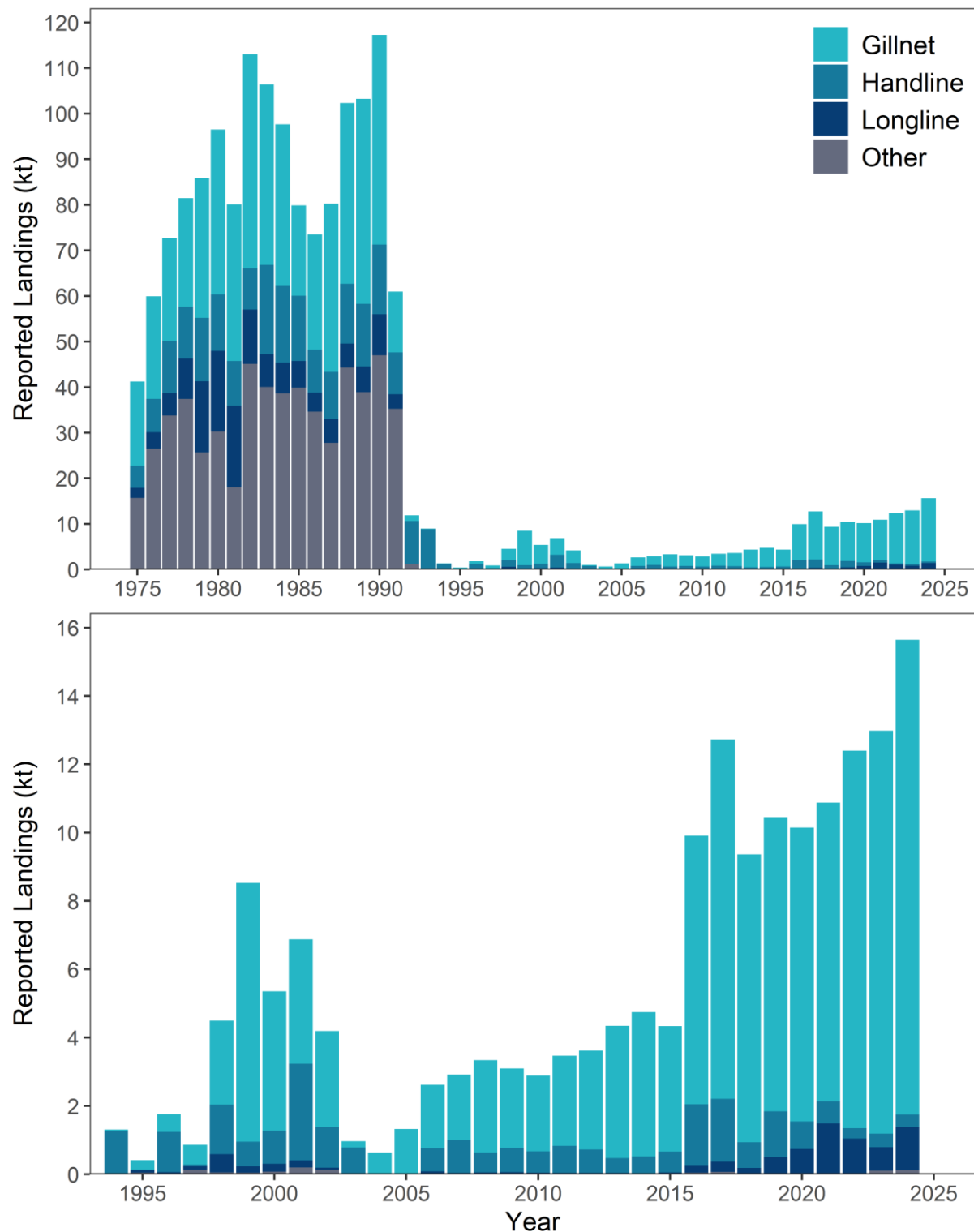


Figure 4. Reported fixed gear landings (kt) of cod from NAFO Divs. 2J3KL by gear type. (Upper Panel) Trends since 1975; (Lower Panel) Trends since 1994 (on expanded scale). Note that lower panel excludes recreational fishery landings except during 2008 and 2011–12.

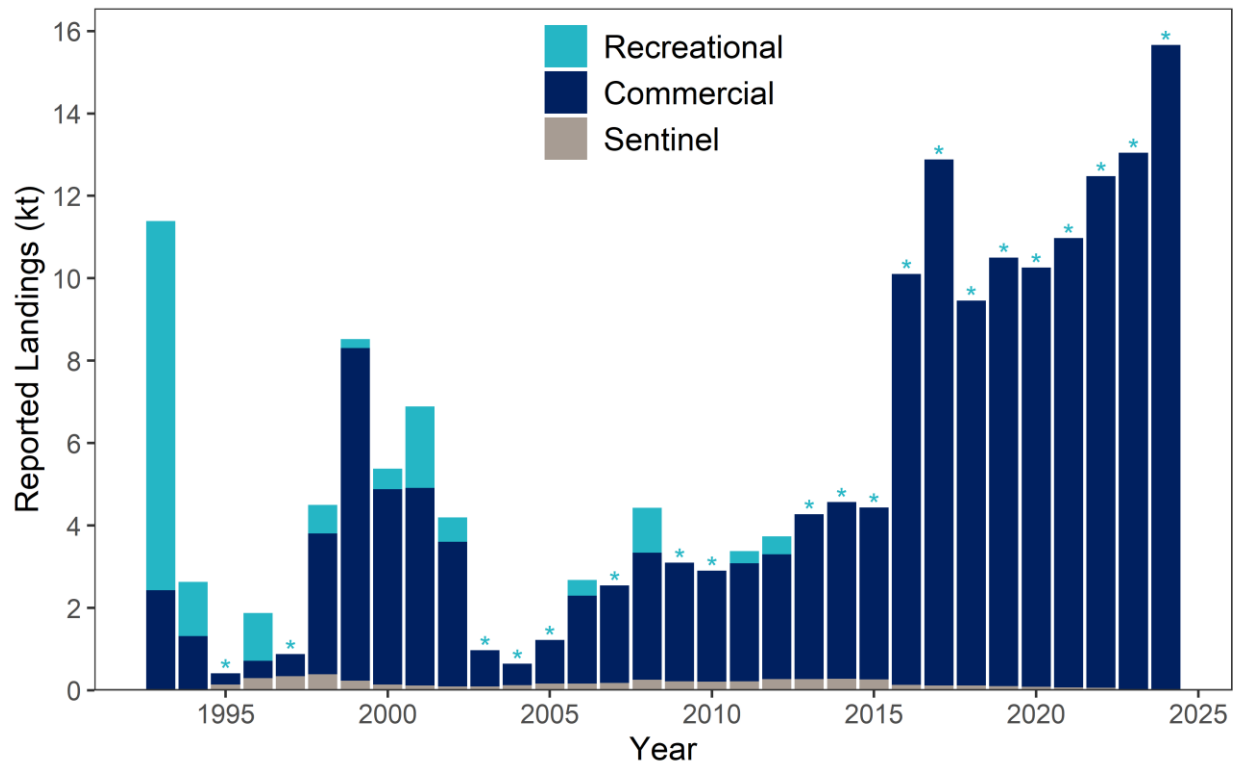


Figure 5. Reported landings (kt) of cod by fishery type from NAFO Divs. 2J3KL for the fisheries during 1993 onward. Asterisks (*) indicate years where recreational catches were taken but removals are not available.

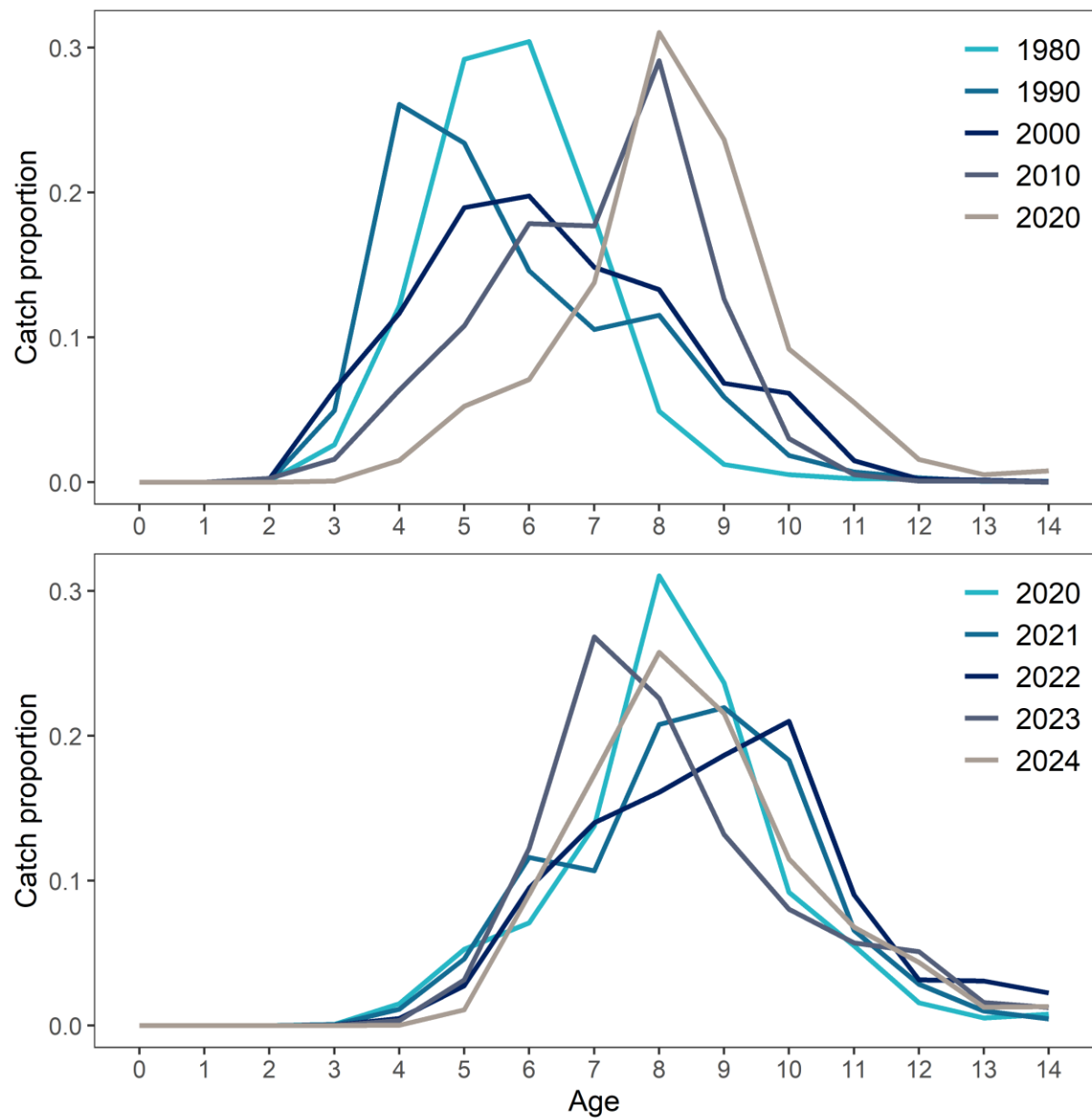


Figure 6. Comparison of the commercial catch proportions-at-age for NAFO Divs. 2J3KL cod from the beginning of the last five decades (Upper Panel) and for the last five years (Lower Panel).

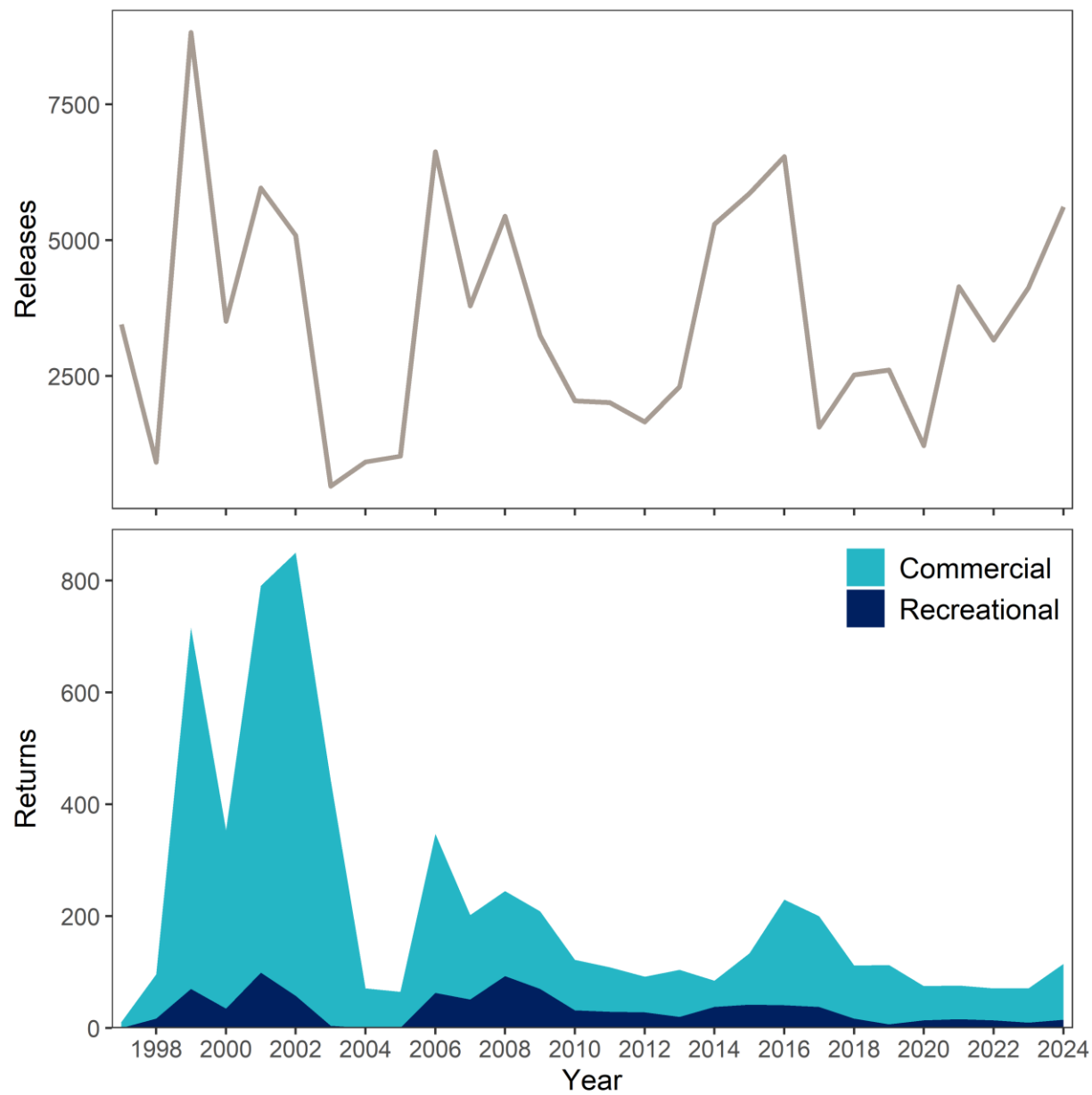


Figure 8. Annual tag releases and returns for Atlantic Cod in NAFO Divs. 2J3KL from 1997–2024.

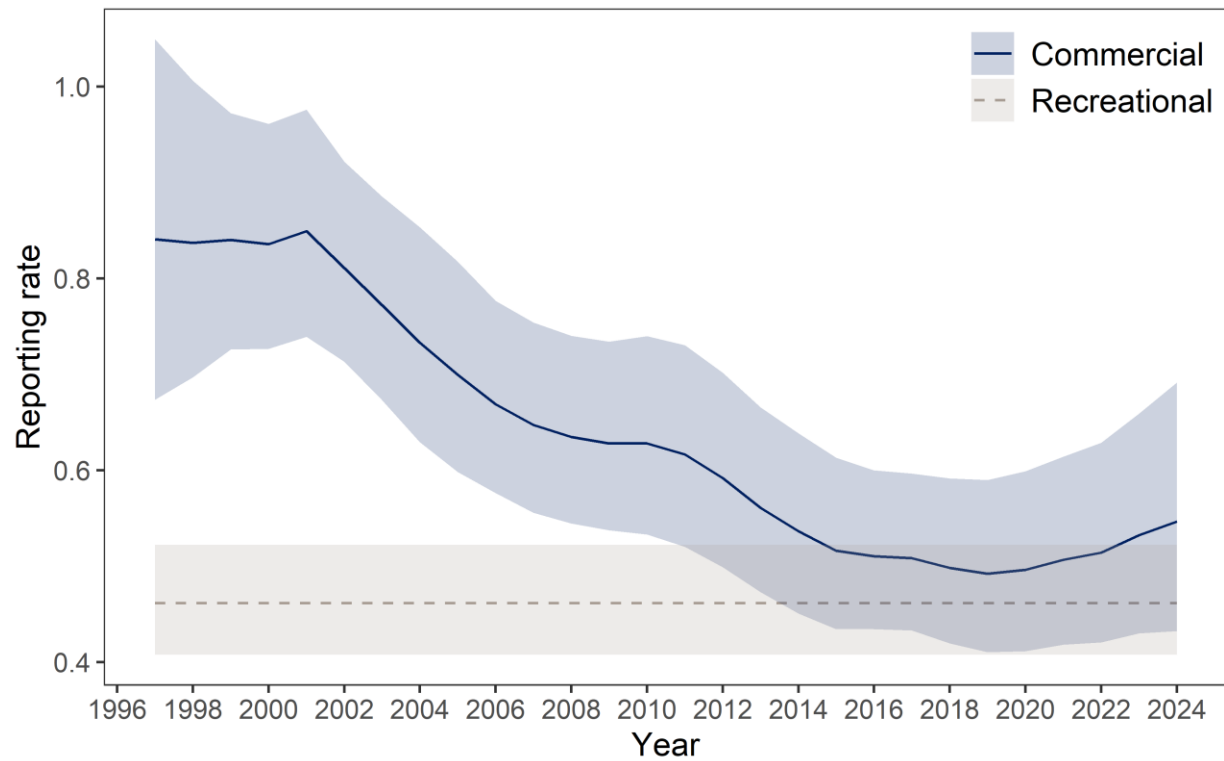


Figure 9. Estimated tag reporting rate for the NAFO Divs. 2J3KL commercial and recreational fisheries from 1997–2024. Shaded region represents 95% confidence intervals.

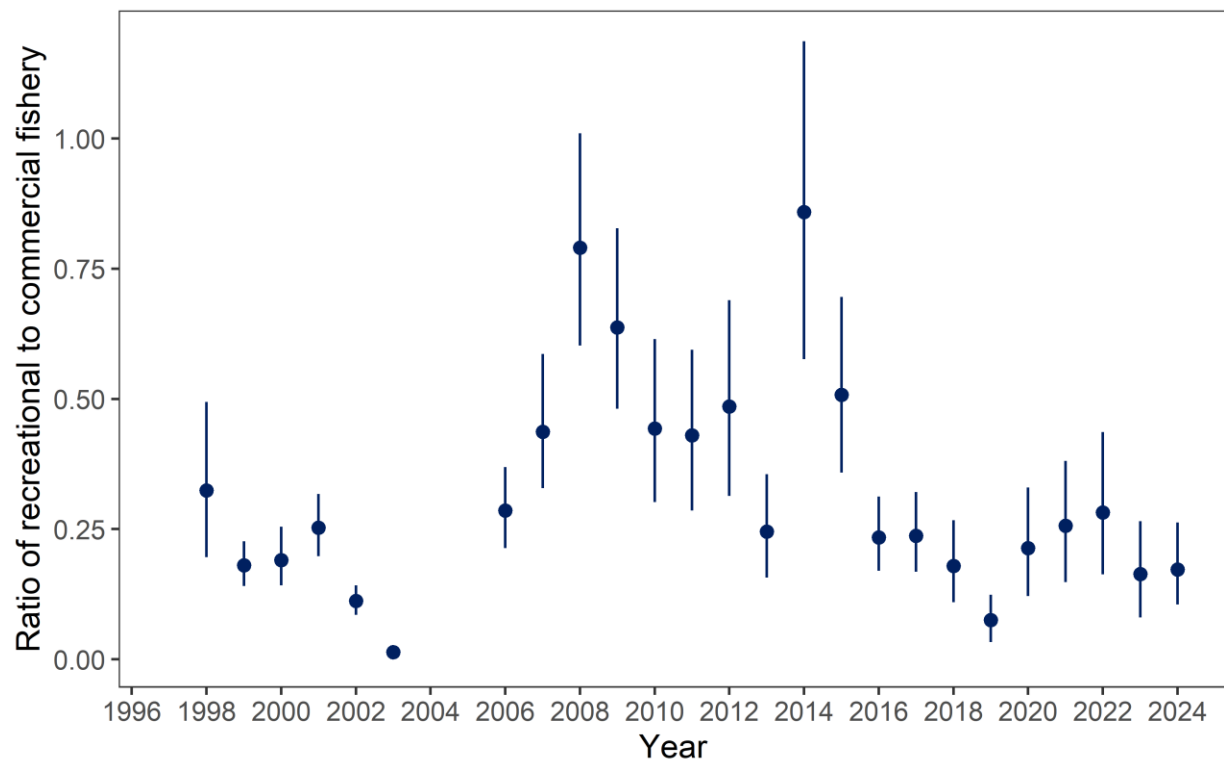


Figure 10. Ratio of returns from the recreational fishery in NAFO Divs. 2J3KL from 1997–2024 based on tagging data, with 95% confidence intervals.

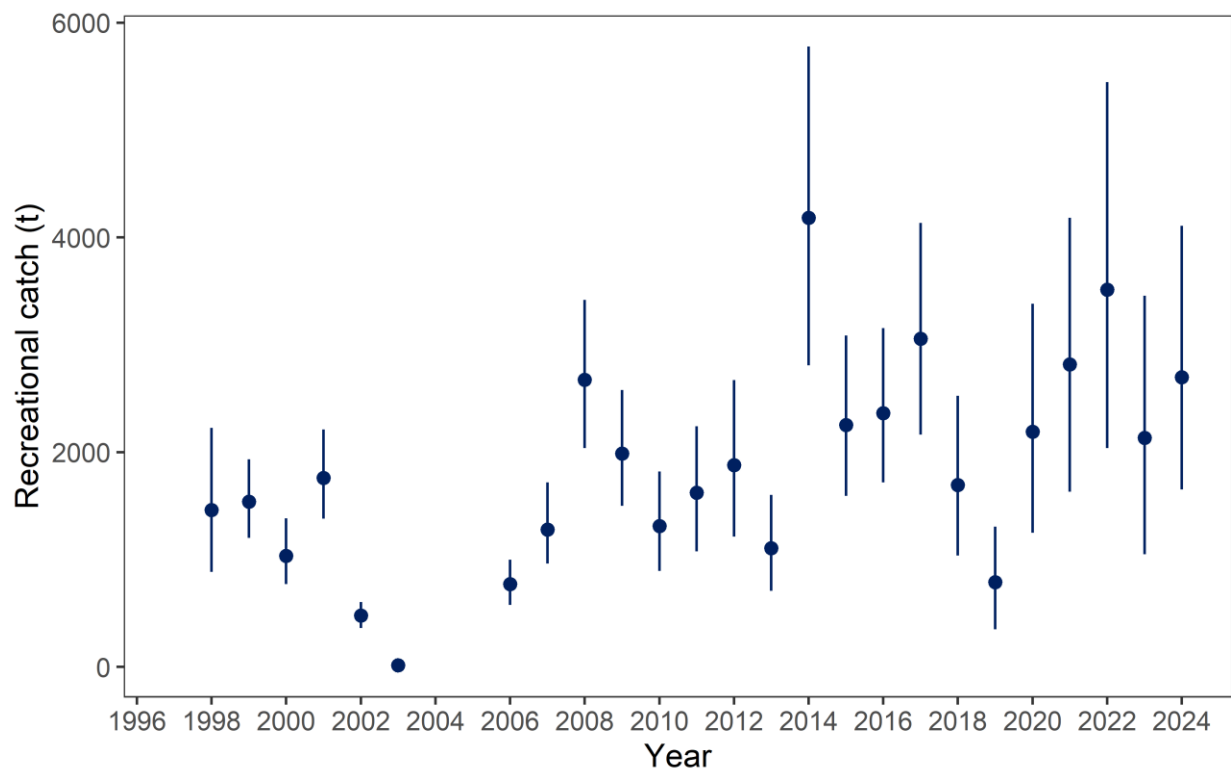


Figure 11. Estimated recreational catch (t) in NAFO Divs. 2J3KL derived from tag returns between 1997–2024, with 95% confidence intervals.

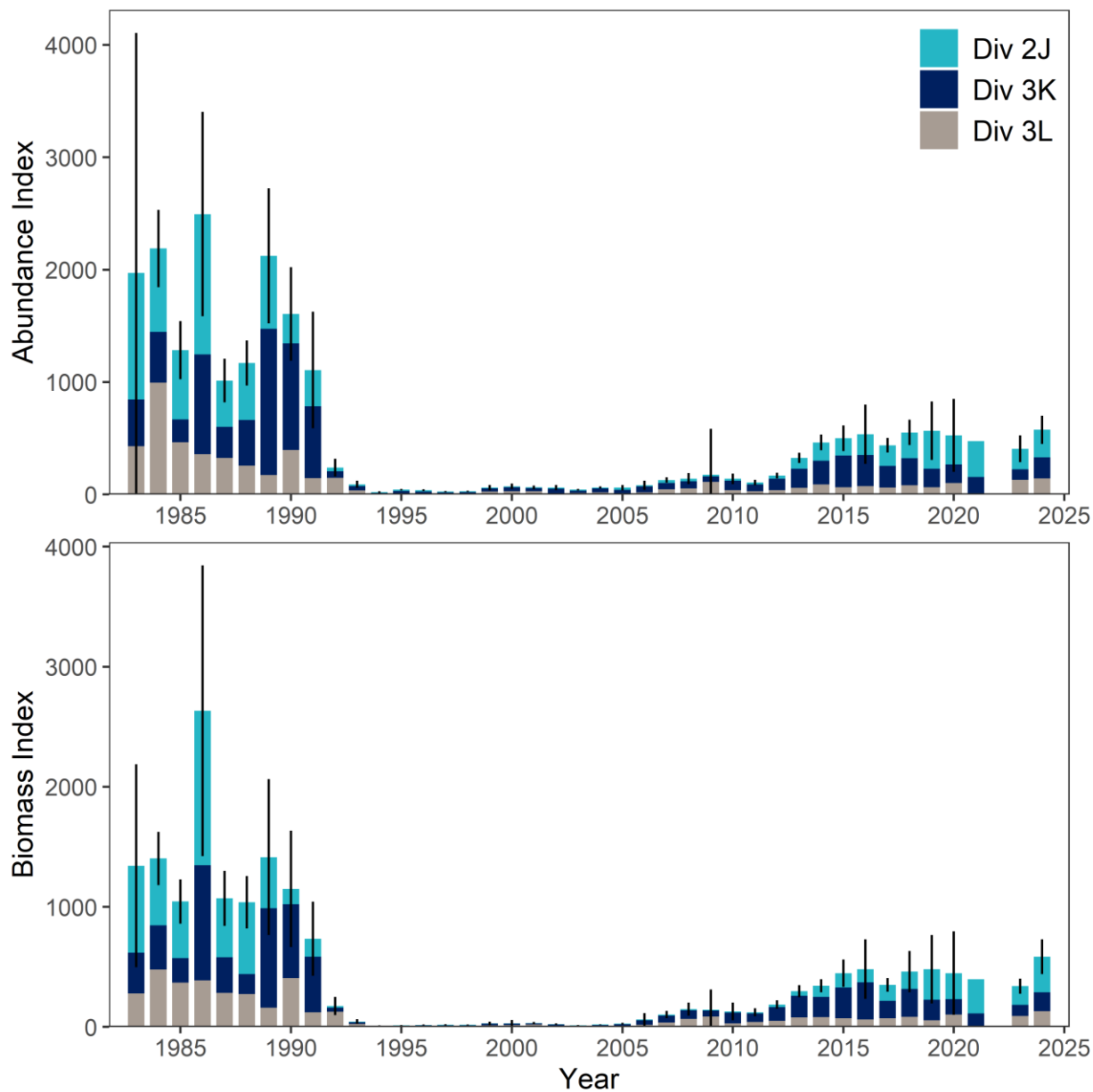


Figure 12. (Upper Panel) Trends in the offshore indices of cod abundance and (Lower Panel) total biomass from the fall research vessel survey of index strata in NAFO Divs. 2J3KL. Error bars are approximate 95% confidence intervals.

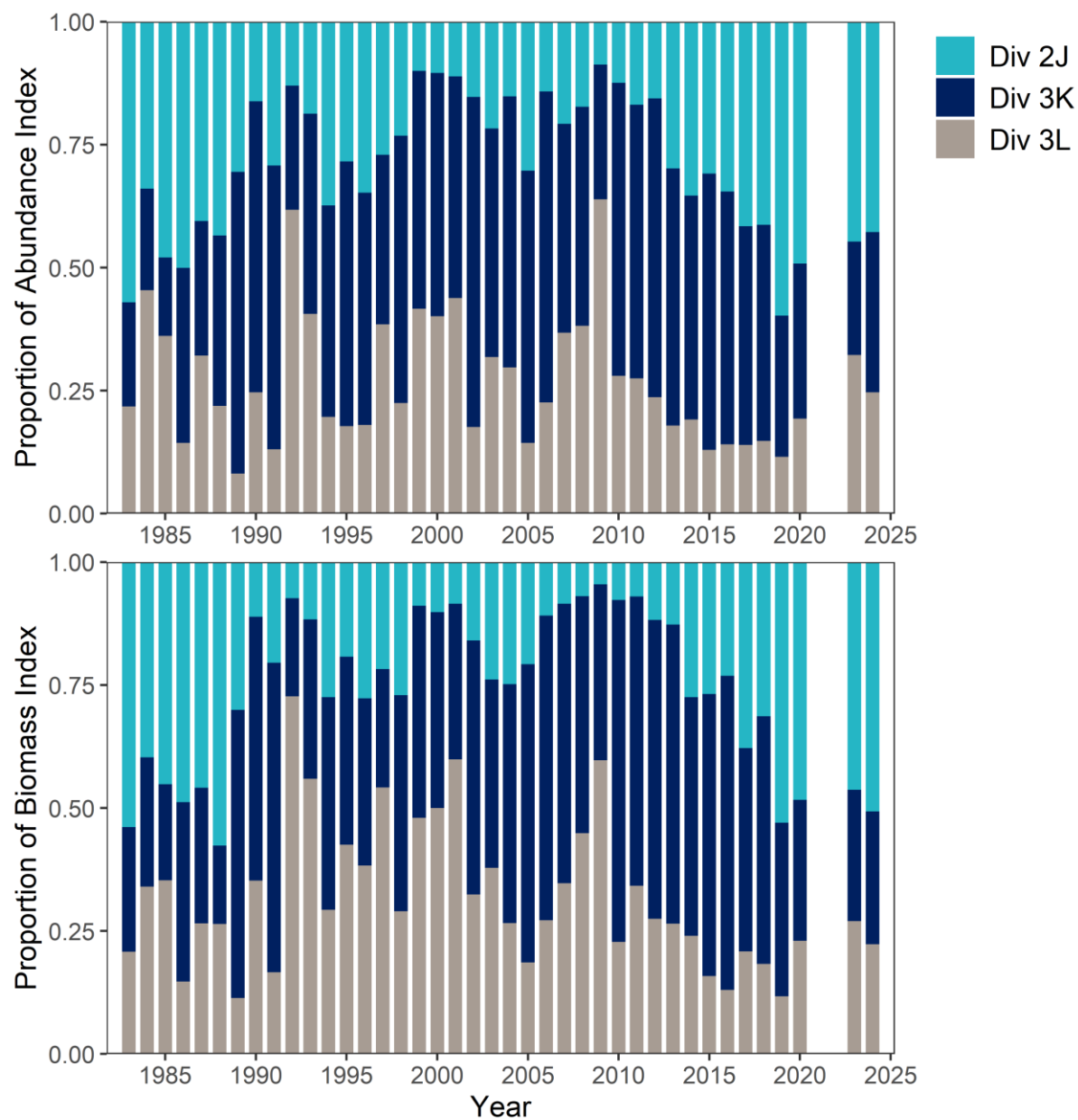


Figure 13. (Upper Panel) Proportion of cod abundance and (Lower Panel) total biomass in each division from the fall research vessel survey of index strata in NAFO Divs. 2J3KL.

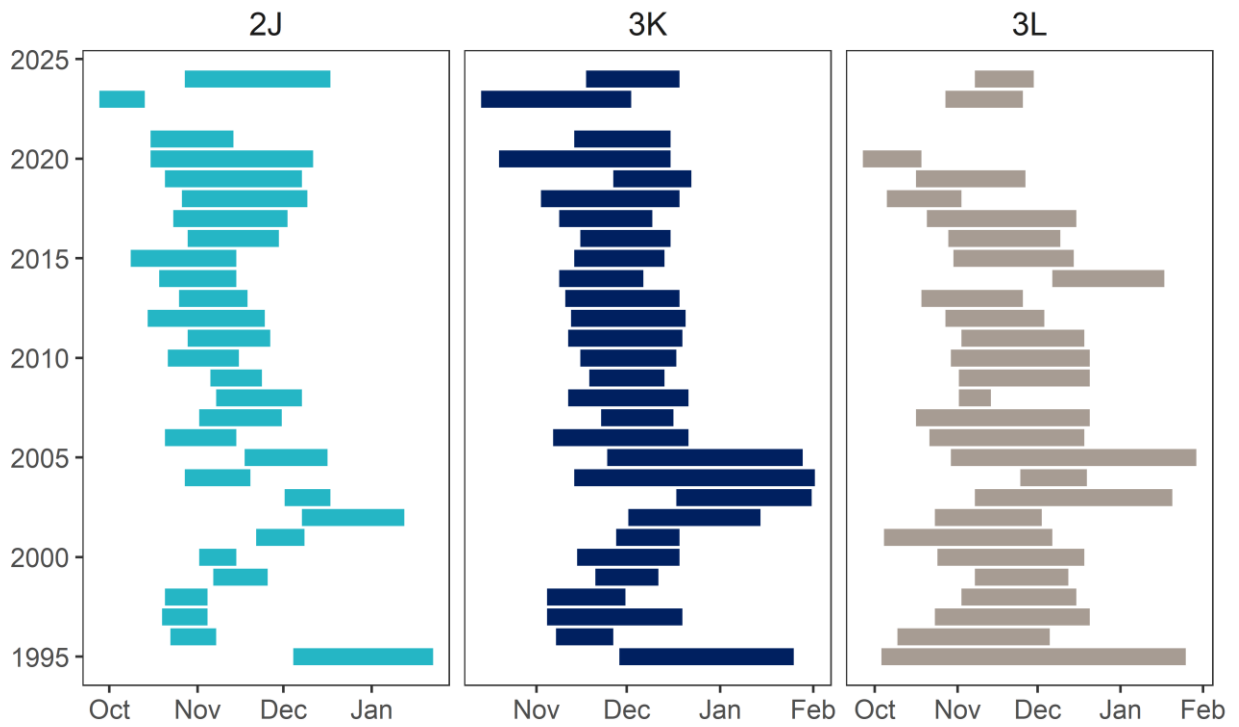


Figure 14. Annual timing of the fall research vessel survey in NAFO Divs. 2J3KL.

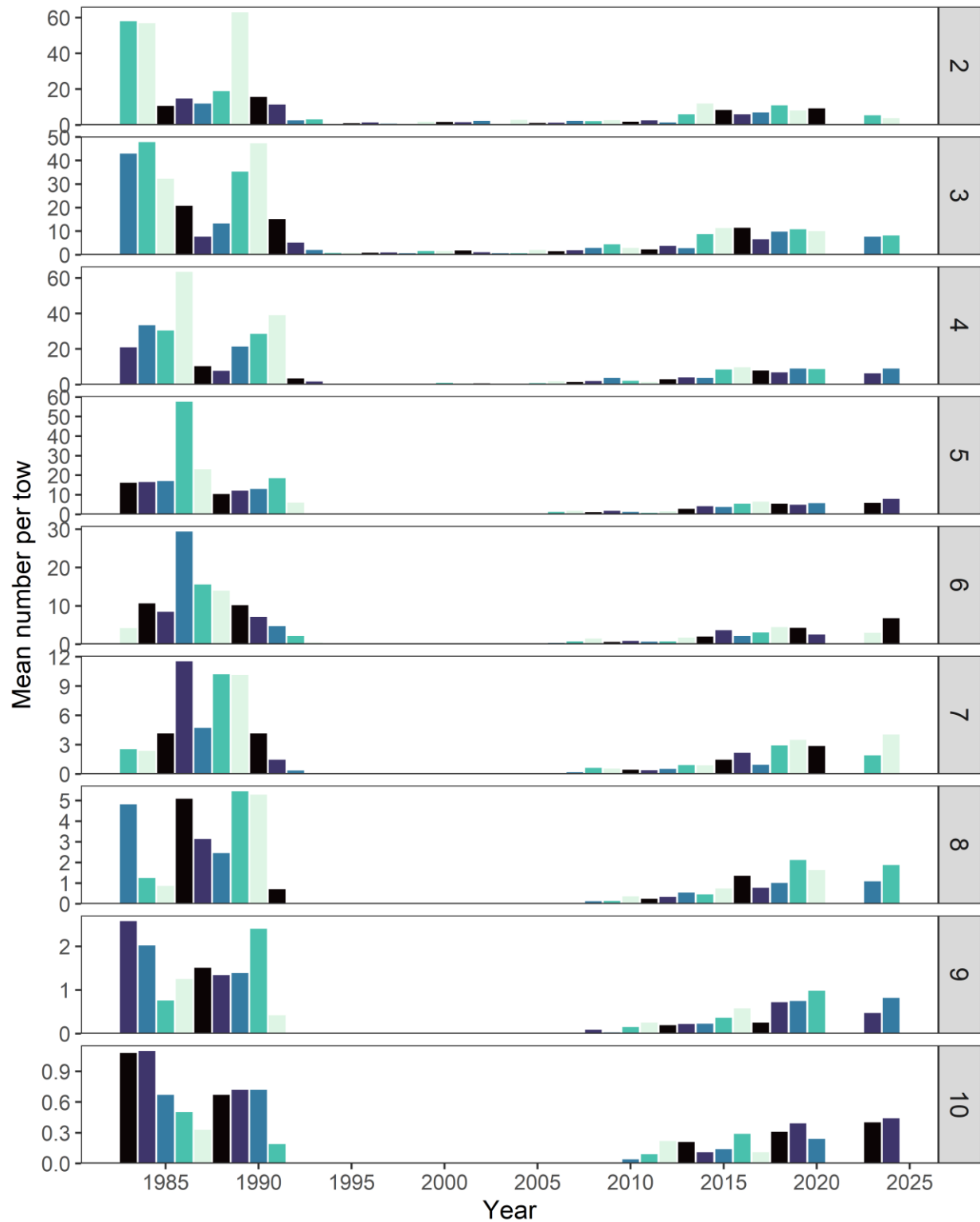


Figure 15. Mean number per tow at ages 2–10 of cod in NAFO Divs. 2J3KL from the fall research vessel survey. Cohorts are coloured in a repeating pattern to aid visual tracking.

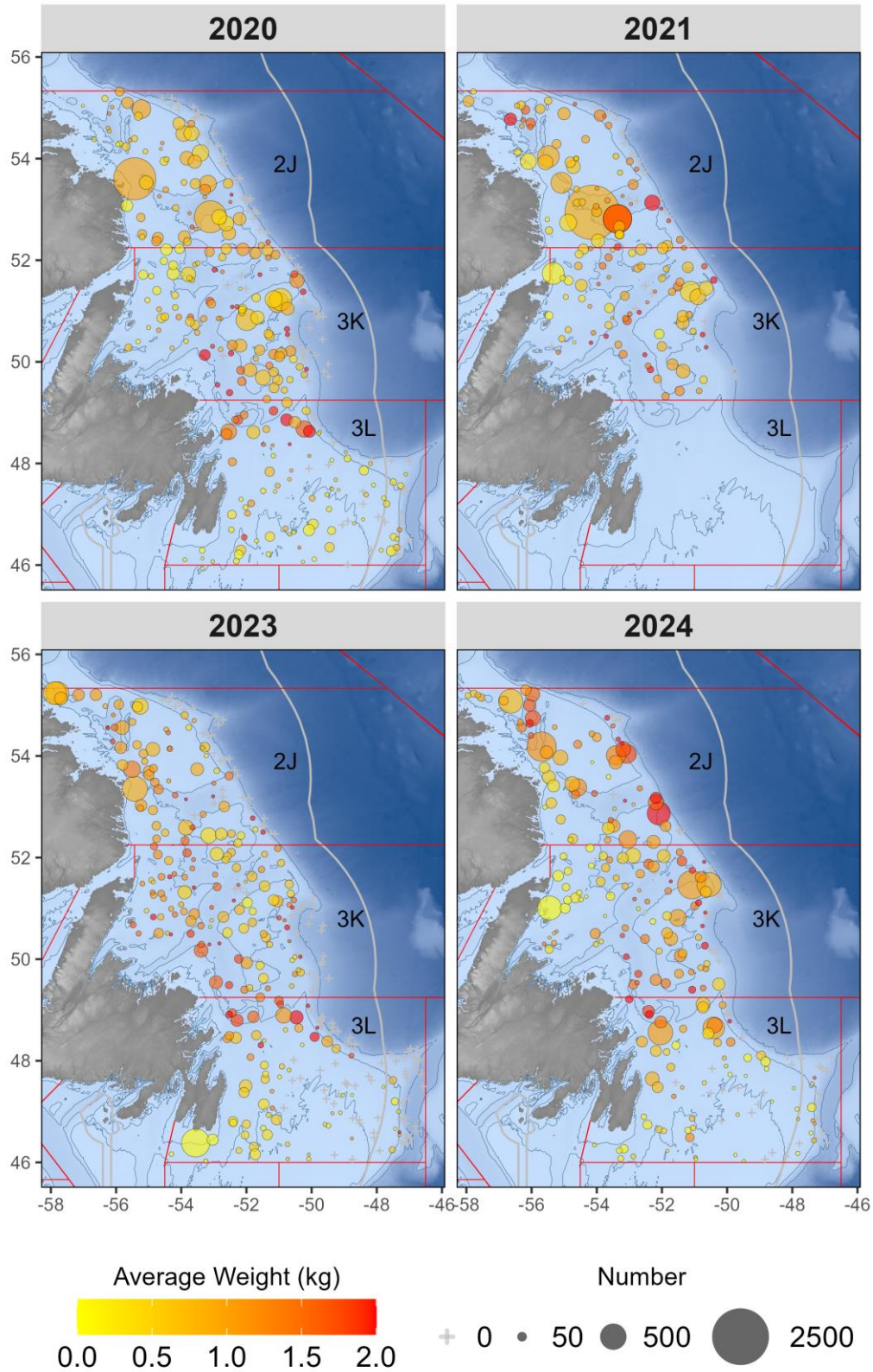


Figure 16. Age-aggregated distribution of cod catches (number per tow), from the fall research vessel survey of all strata in NAFO Divs. 2J3KL during 2019–23. Symbol size (continuous scaling) is proportional to numbers caught. Symbol colour is scaled by the average weight (kg) of cod caught in each set.

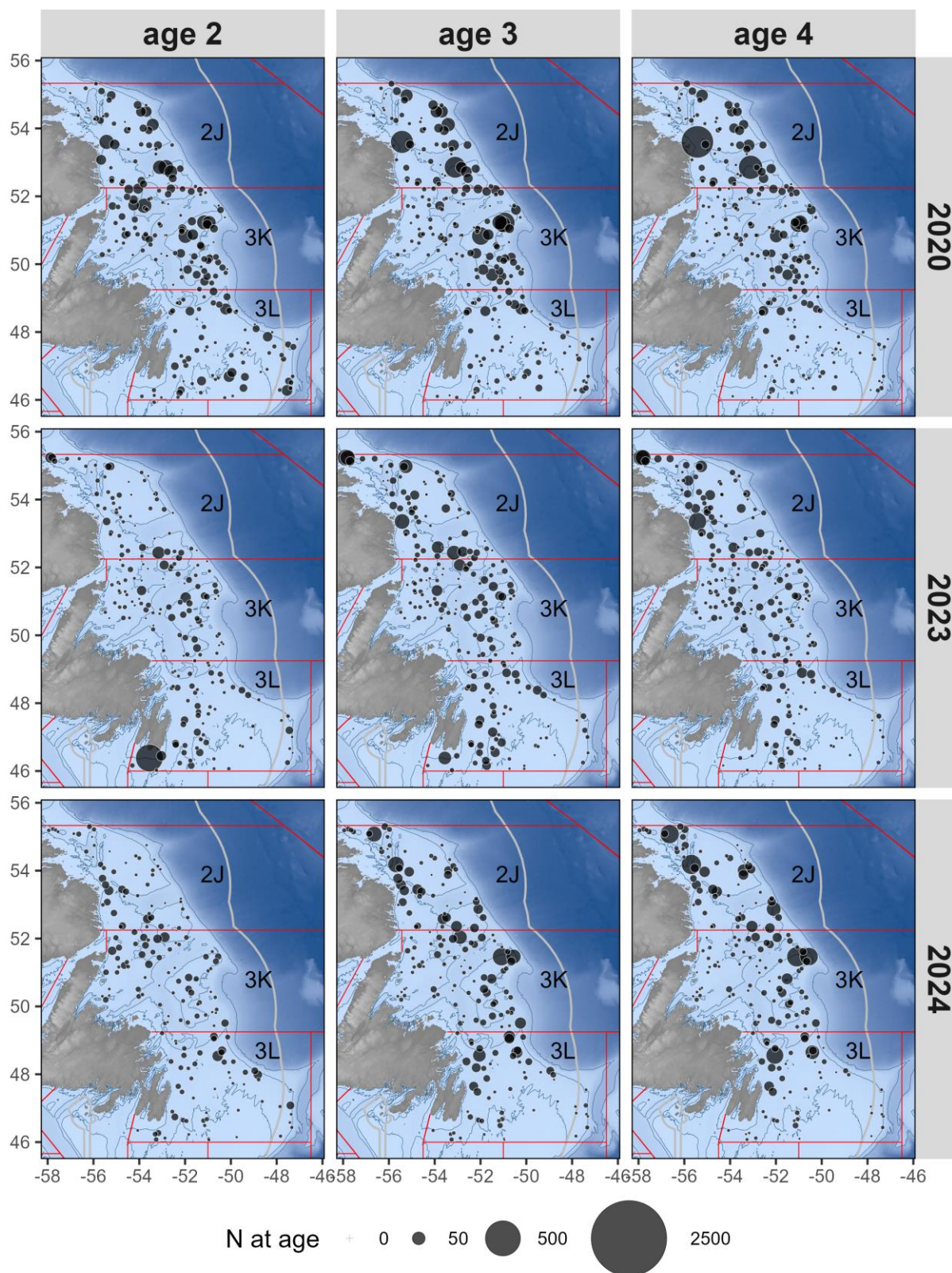


Figure 17. Age-disaggregated distribution of cod catches (number per tow for ages 2–4), from the fall research vessel survey of all strata in NAFO Divs. 2J3KL during 2020–23. Symbol size (continuous scaling) is proportional to numbers caught at age.

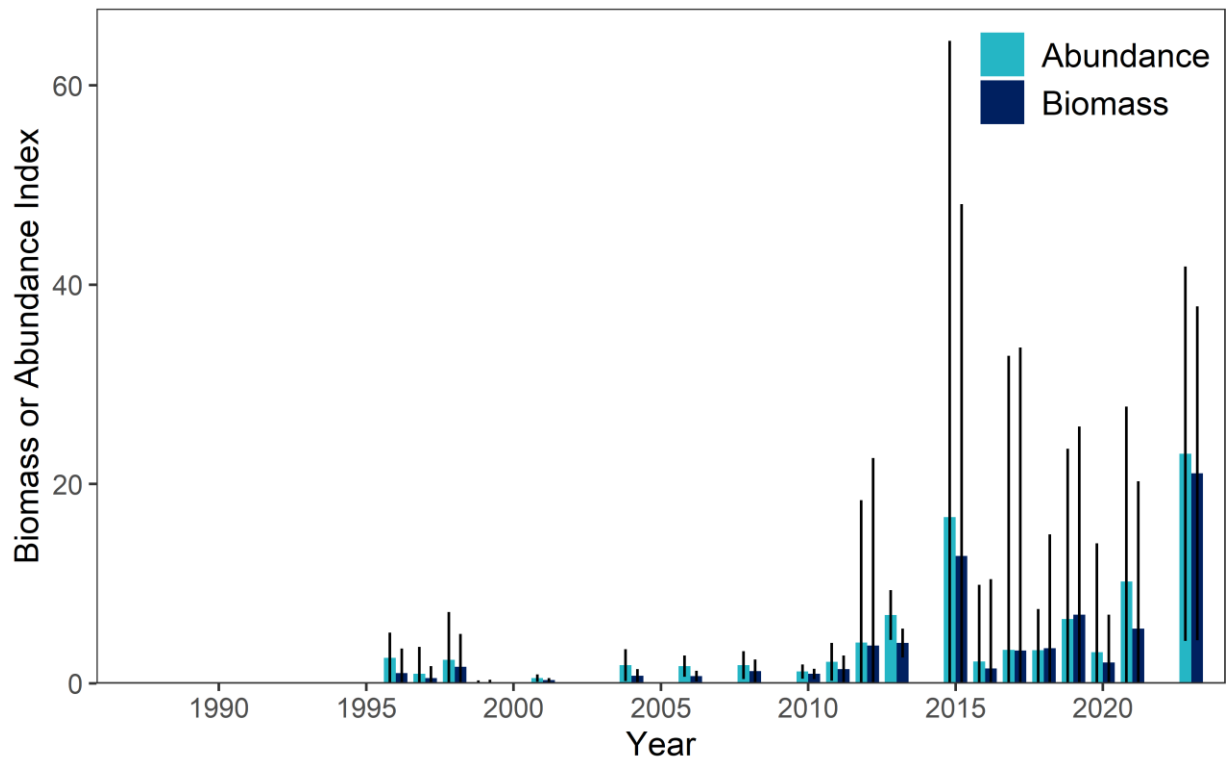


Figure 18. Trends in the offshore indices of cod abundance and total biomass from the fall research vessel survey in NAFO Div. 2H. Error bars are approximate 95% confidence intervals.

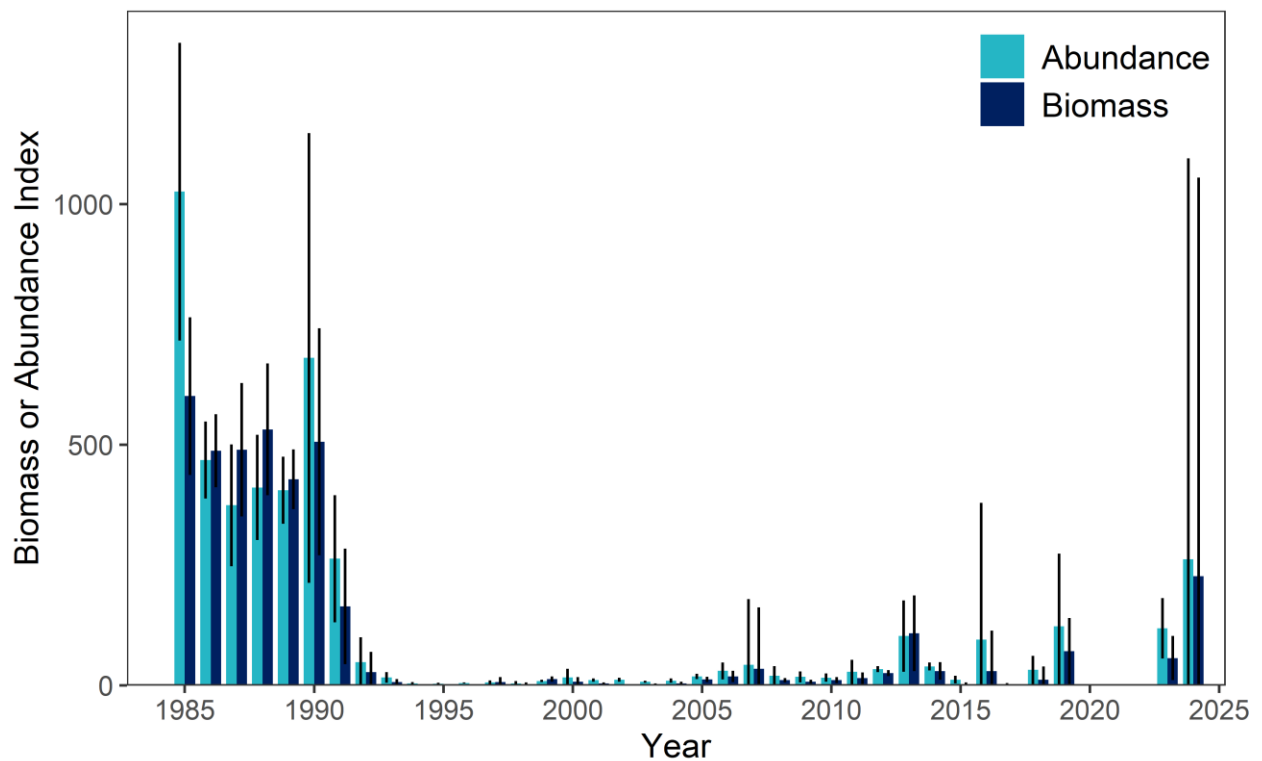


Figure 19. Trends in the offshore indices of cod abundance and total biomass from the spring research vessel survey in NAFO Div. 3L. Error bars are approximate 95% confidence intervals.

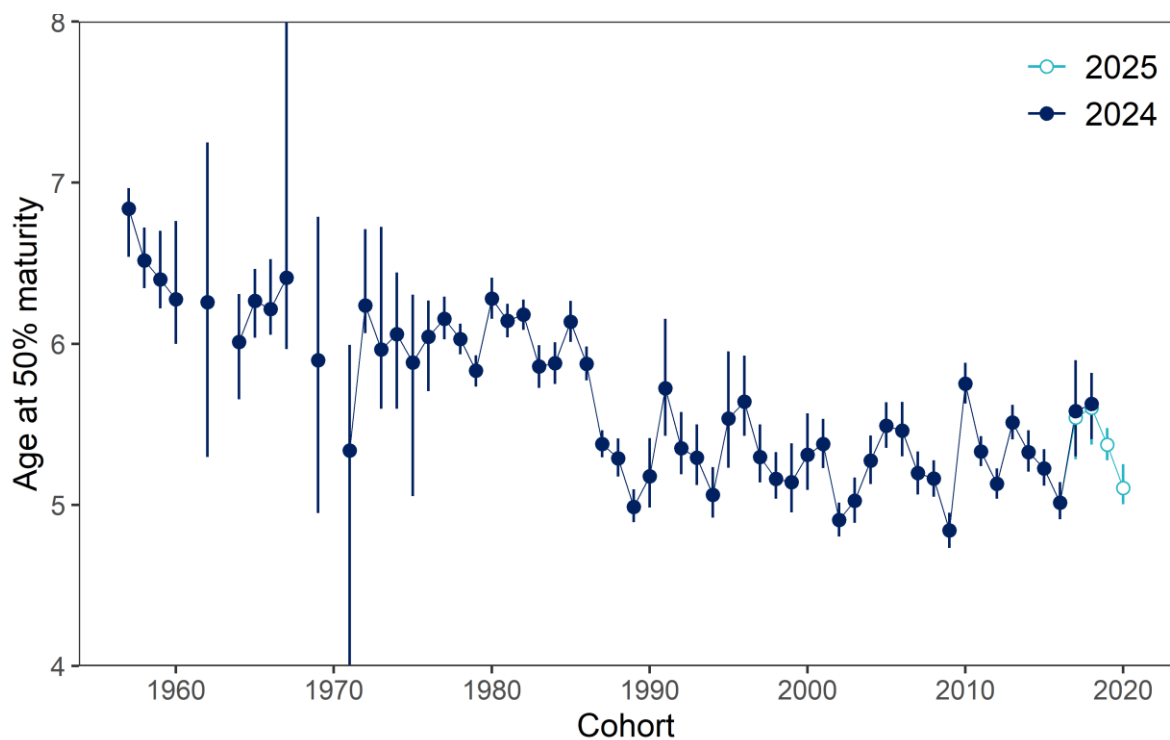


Figure 20. Age at 50% maturity ($\pm$ 95% confidence interval) by cohort for female cod in NAFO Divs. 2J3KL combined based on sampling during the fall research vessel survey. The open circles show the results from the 2025 stock update back to the 1990 cohort. See text for details.

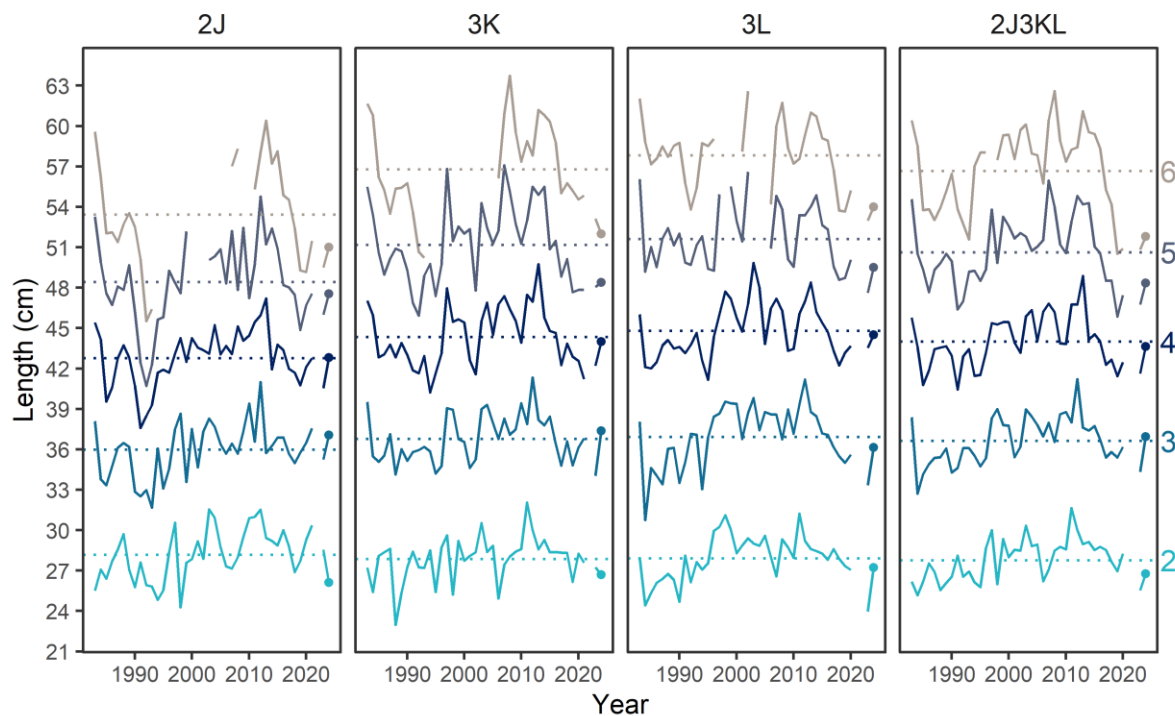


Figure 21. Mean lengths (cm) of cod at ages 2–6 in NAFO Divs. 2J3KL since 1983, as determined from sampling during the fall research vessel survey. Time-series mean for each age indicated by a dashed line. Values calculated from fewer than 5 aged fish are not plotted.

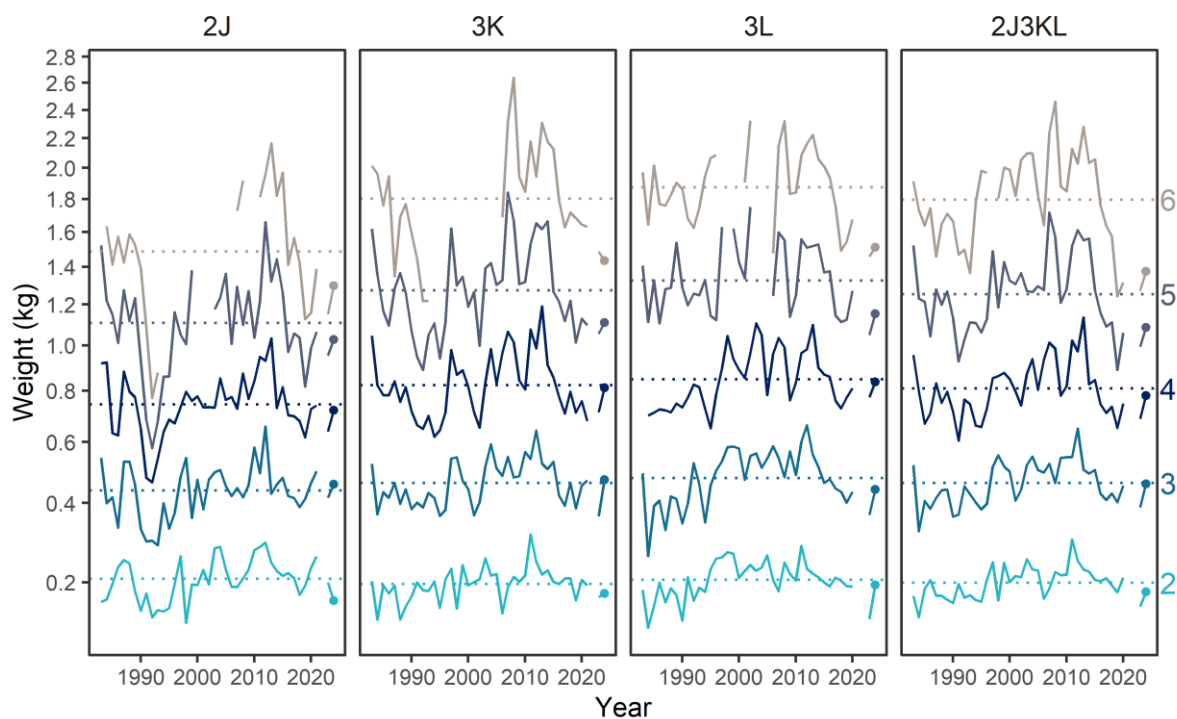


Figure 22. Mean weights (kg) of cod at ages 2–6 in NAFO Divs. 2J3KL since 1983, as determined from sampling during the fall research vessel survey. Time-series mean for each age indicated by a dashed line. Values calculated from fewer than 5 aged fish are not plotted. Note the square root scale of the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

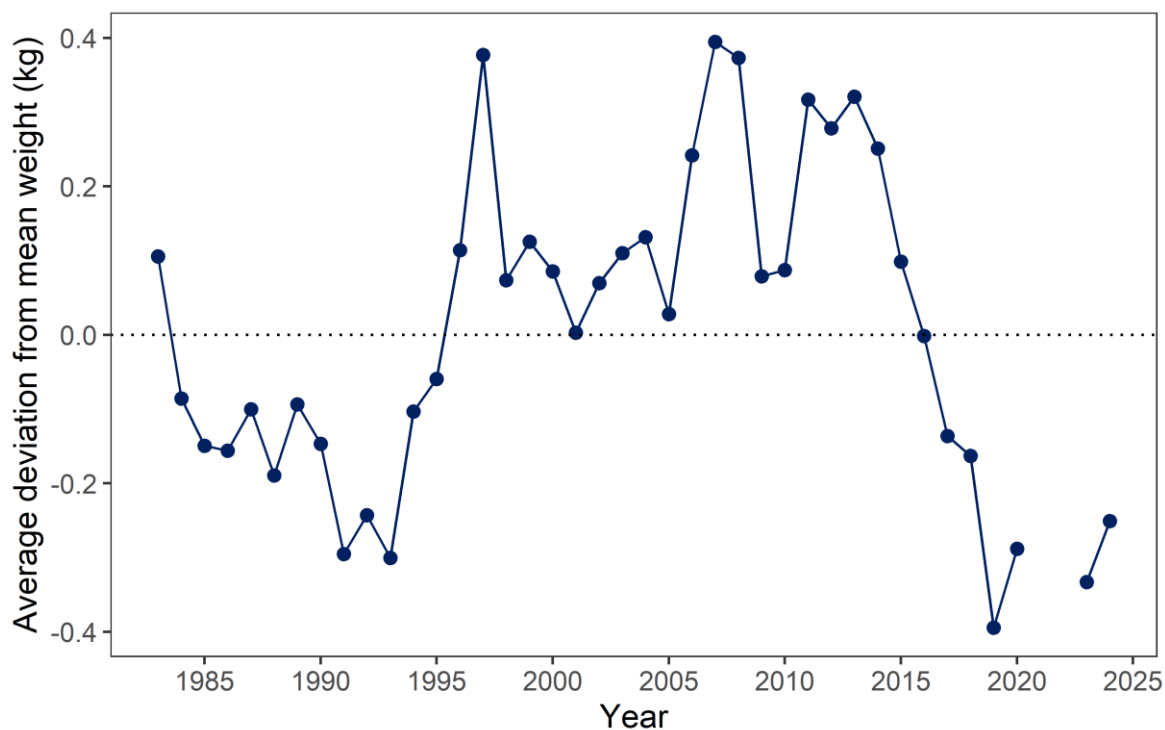


Figure 23. Average deviation from mean weight-at-age for ages 3–7 from the fall research vessel survey since 1983 in NAFO Divs. 2J3KL combined.

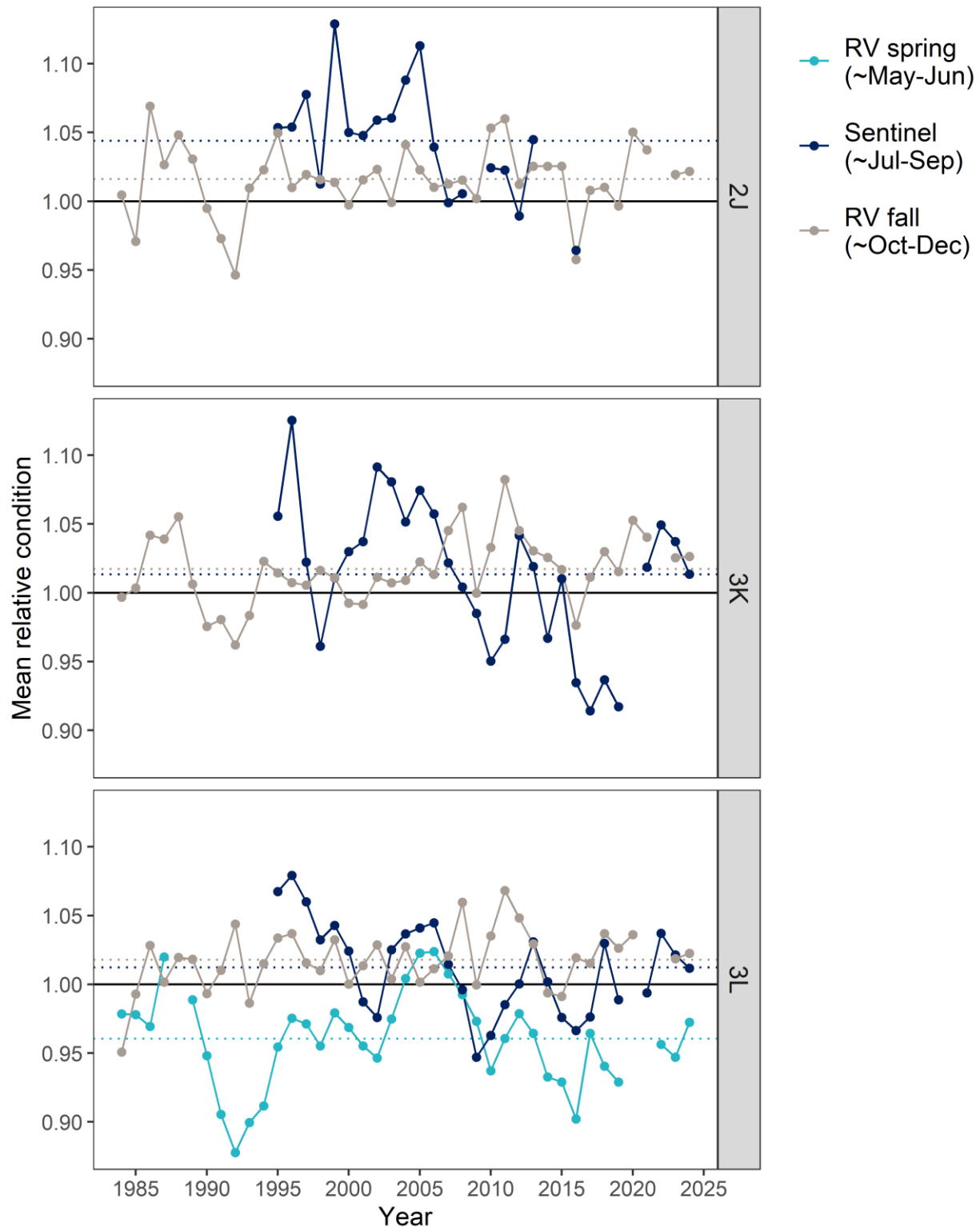


Figure 24. Relative gutted condition of cod in NAFO Divs. 2J3KL from 1983 onward, as determined from sampling during the spring and fall research vessel surveys and the sentinel gillnet survey. Dotted line represents averages by survey and NAFO Divs. and solid line represents overall average.

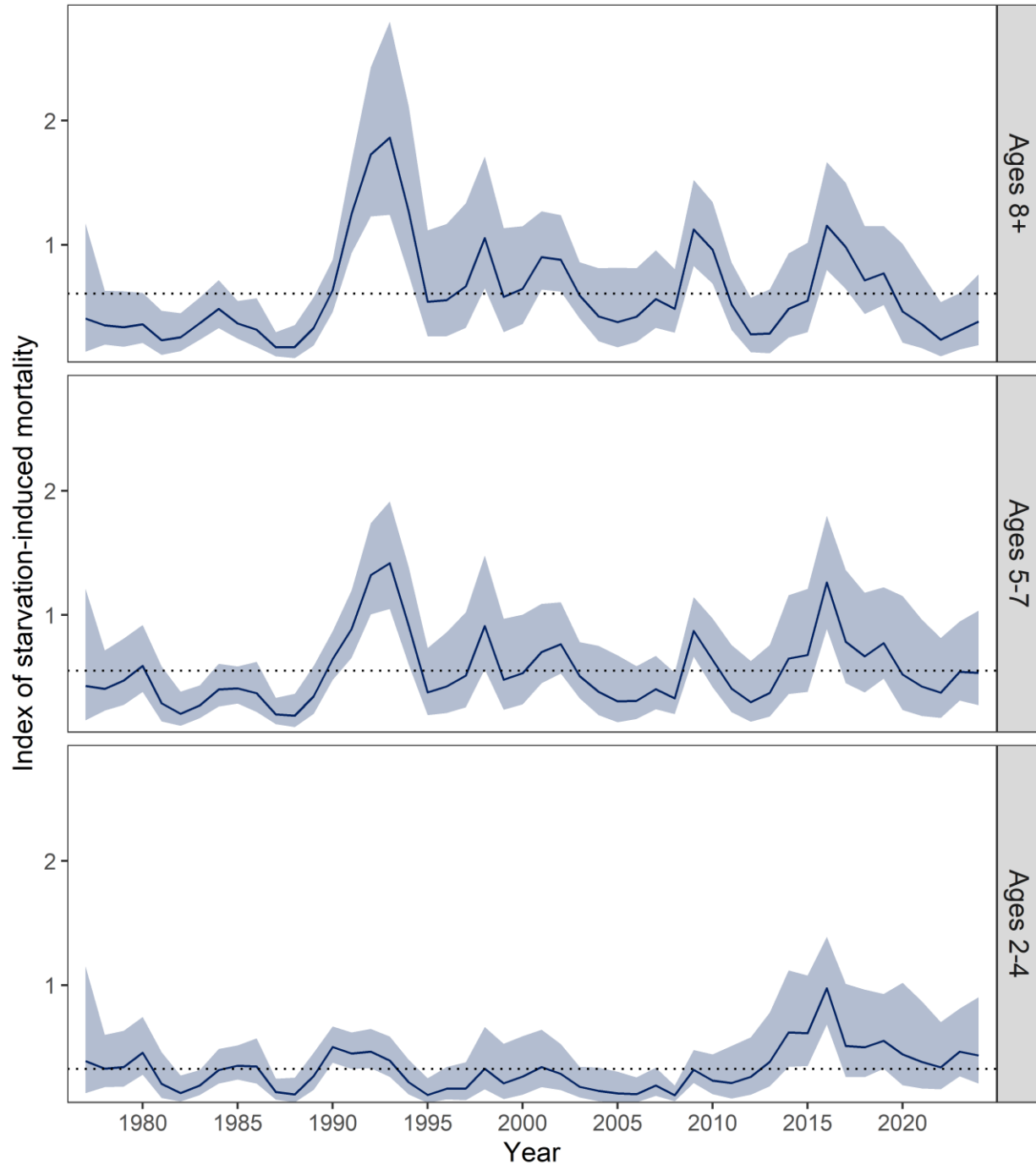


Figure 25. Index of starvation-induced natural mortality for cod in NAFO Divs. 2J3KL, analyzed from 1977 onwards through the spring and fall research vessel surveys and the sentinel gillnet survey. The dotted line represents average levels by age group. Shaded region represents 95% confidence intervals. 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).

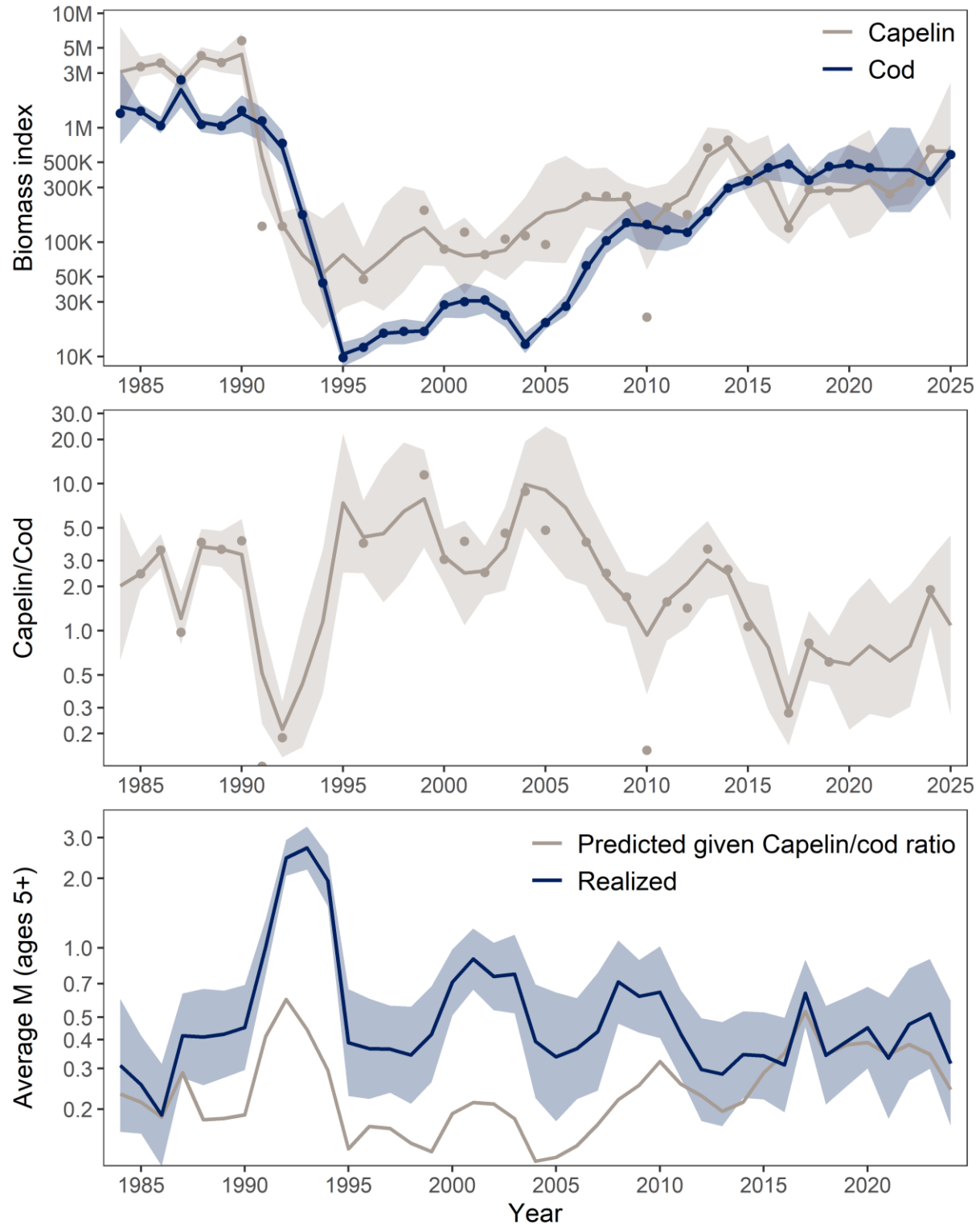


Figure 26. (Upper Panel) Observed (dots) and predicted (lines) biomass index of cod and Capelin, (Middle Panel) Capelin/cod biomass ratio, and (Lower Panel) predicted and realized levels of population weighted average natural mortality (M) for cod ages 5+. Predicted levels of M are informed by changes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

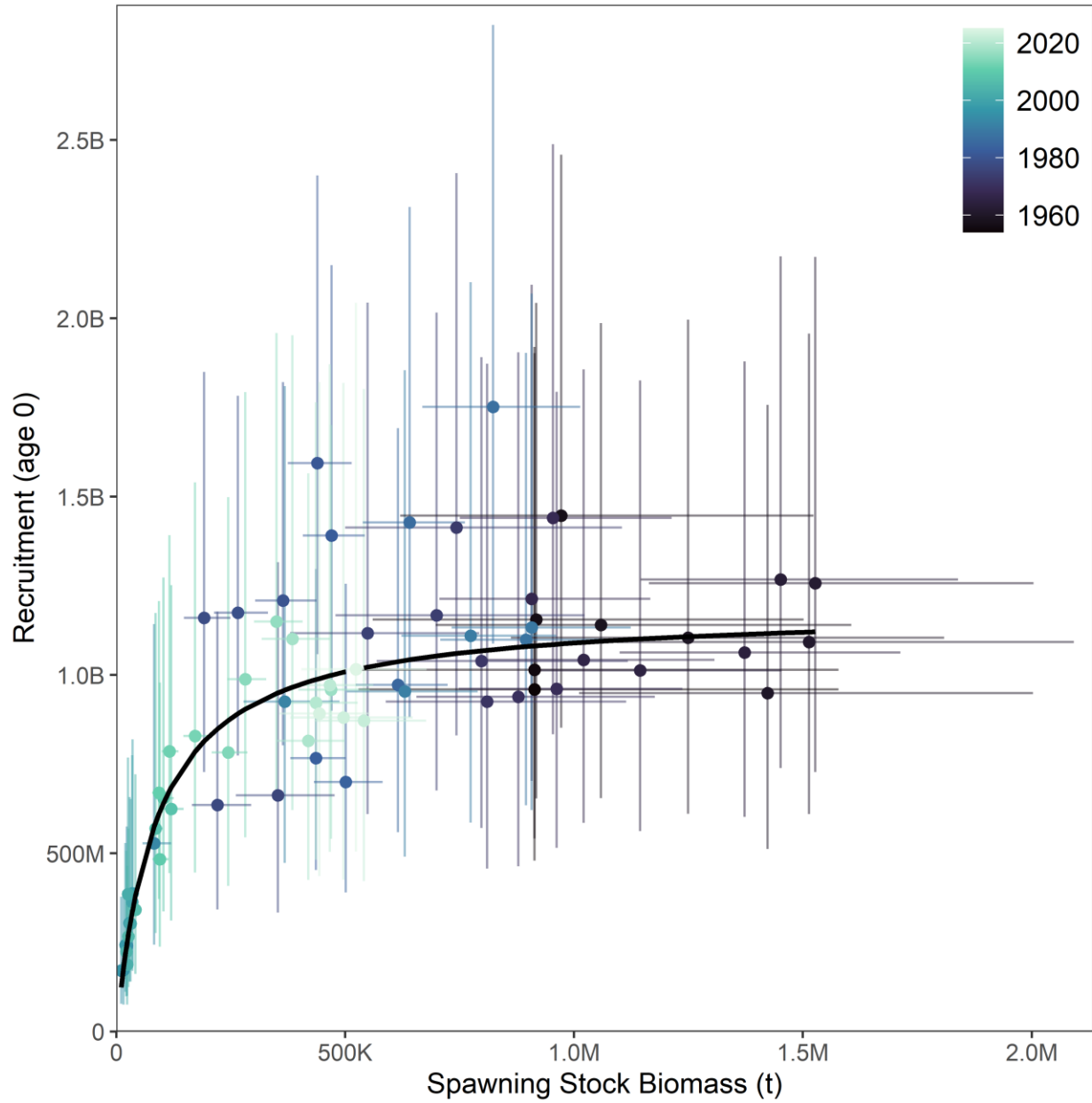


Figure 27. Beverton-Holt stock-recruitment relationship estimated by xteNCAM. Horizontal and vertical whiskers represent 95% confidence intervals around estimates of recruitment (dots), and black lines are predicted levels of recruitment.

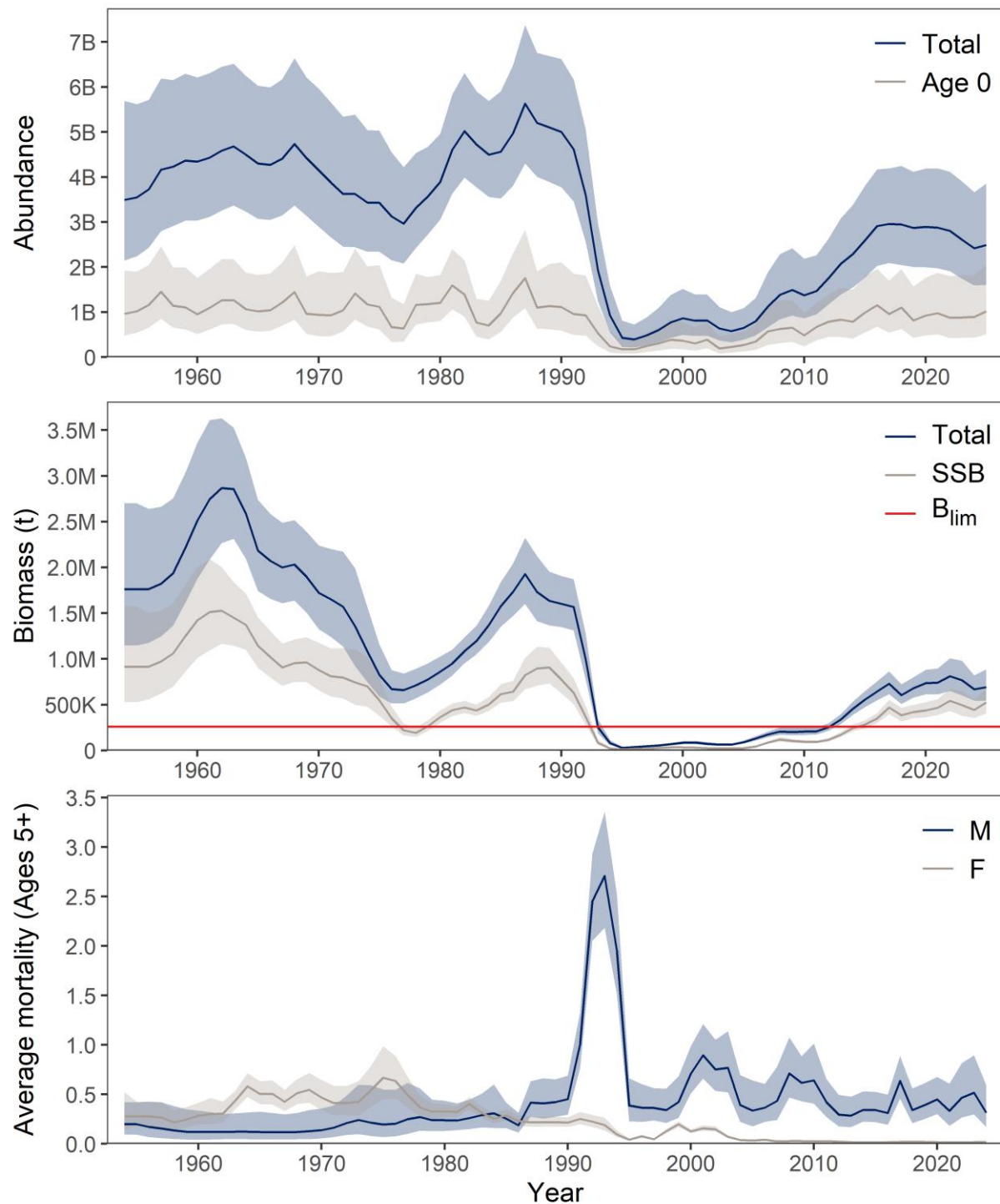


Figure 28. (Upper Panel) Stock abundance, (Middle Panel) total biomass and spawning stock biomass (SSB), and (Lower Panel) natural (M) and fishing (F) mortality rate estimates $\pm$ 95% confidence intervals (shaded regions) for 2J3KL cod since 1954 from xteNCAM. Quantities are indicated in the legends in each panel. B_{lim} (horizontal solid red line) is defined as 40% of the SSB that produces maximum sustainable yield (B_{MSY}).

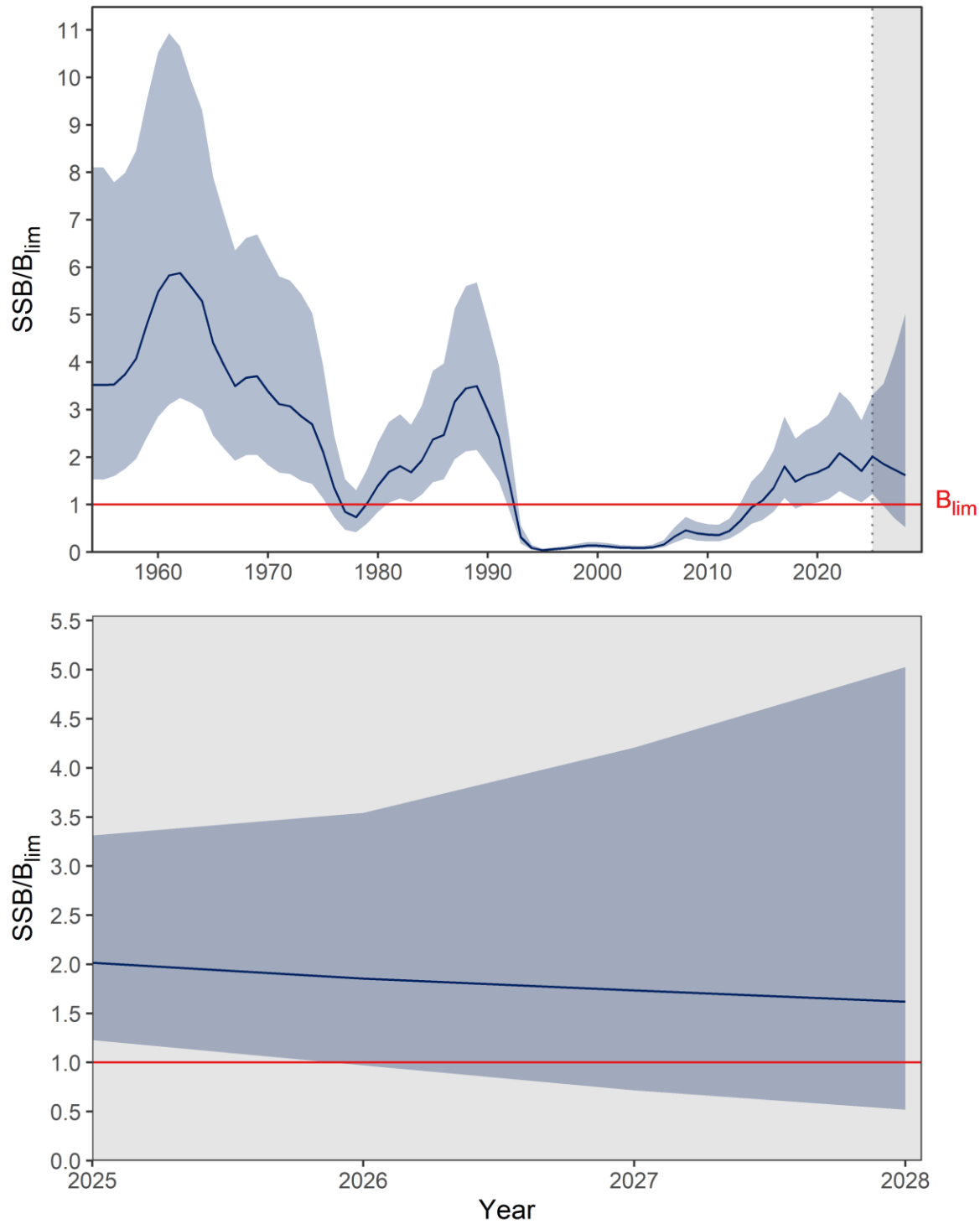


Figure 29. Projected spawning stock biomass relative to the Limit Reference Point (SSB/B_{lim}) assuming status quo levels of Capelin and catch, where B_{lim} (horizontal solid red line) is defined as 40% of the SSB that produces maximum sustainable yield (B_{MSY}). Solid blue line is the model estimate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

APPENDIX A: ASSESSMENT MODEL DIAGNOSTICS

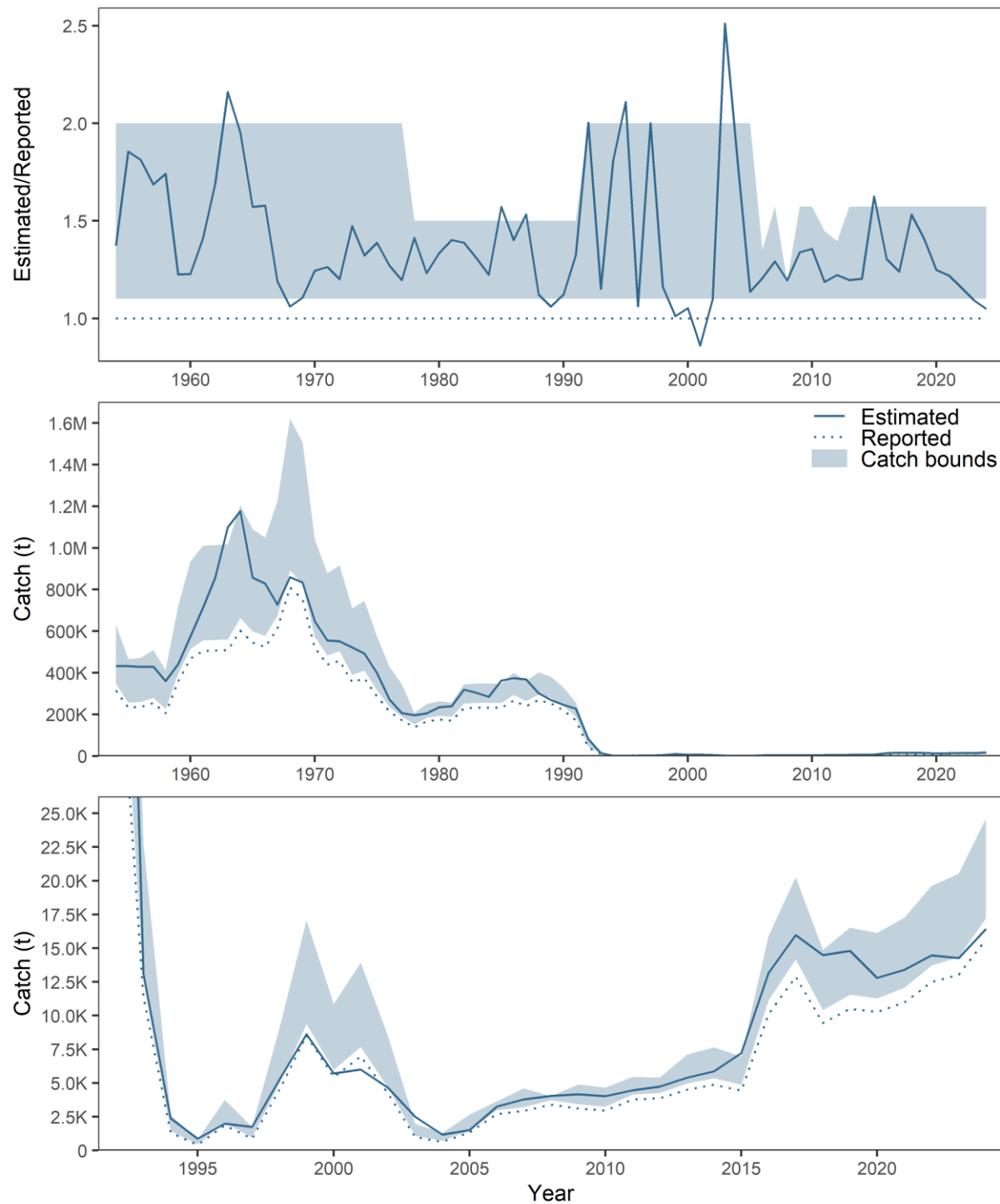


Figure A1. (Upper Panel) Estimated total catch weight relative to reported catches and (Middle Panel) estimated total catch weight since 1954 and (Lower Panel) since 1992. Shaded regions represent catch bounds.

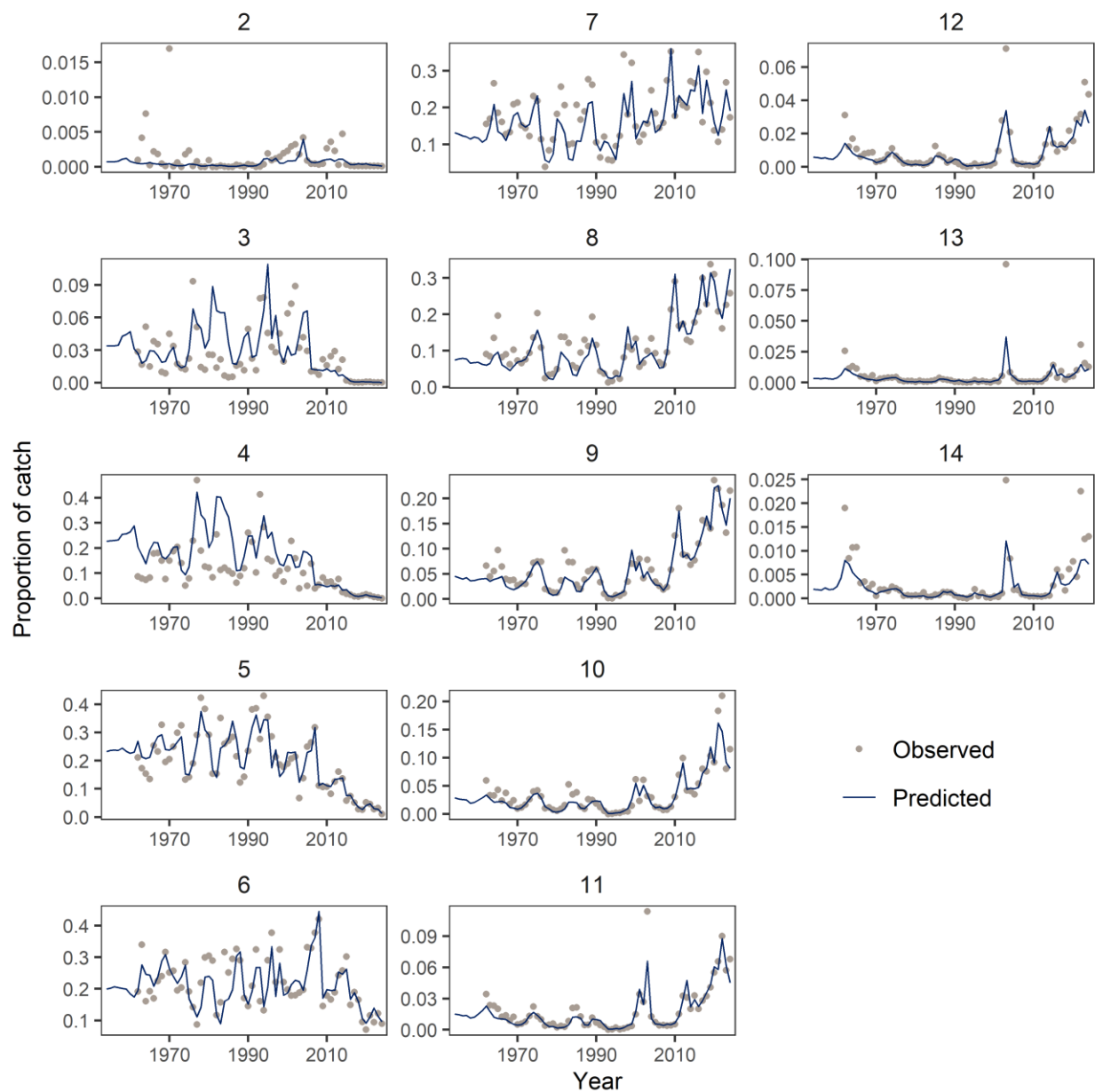


Figure A2. Observed (dots) and model-predicted values (lines) for the proportions of each age in the catch.

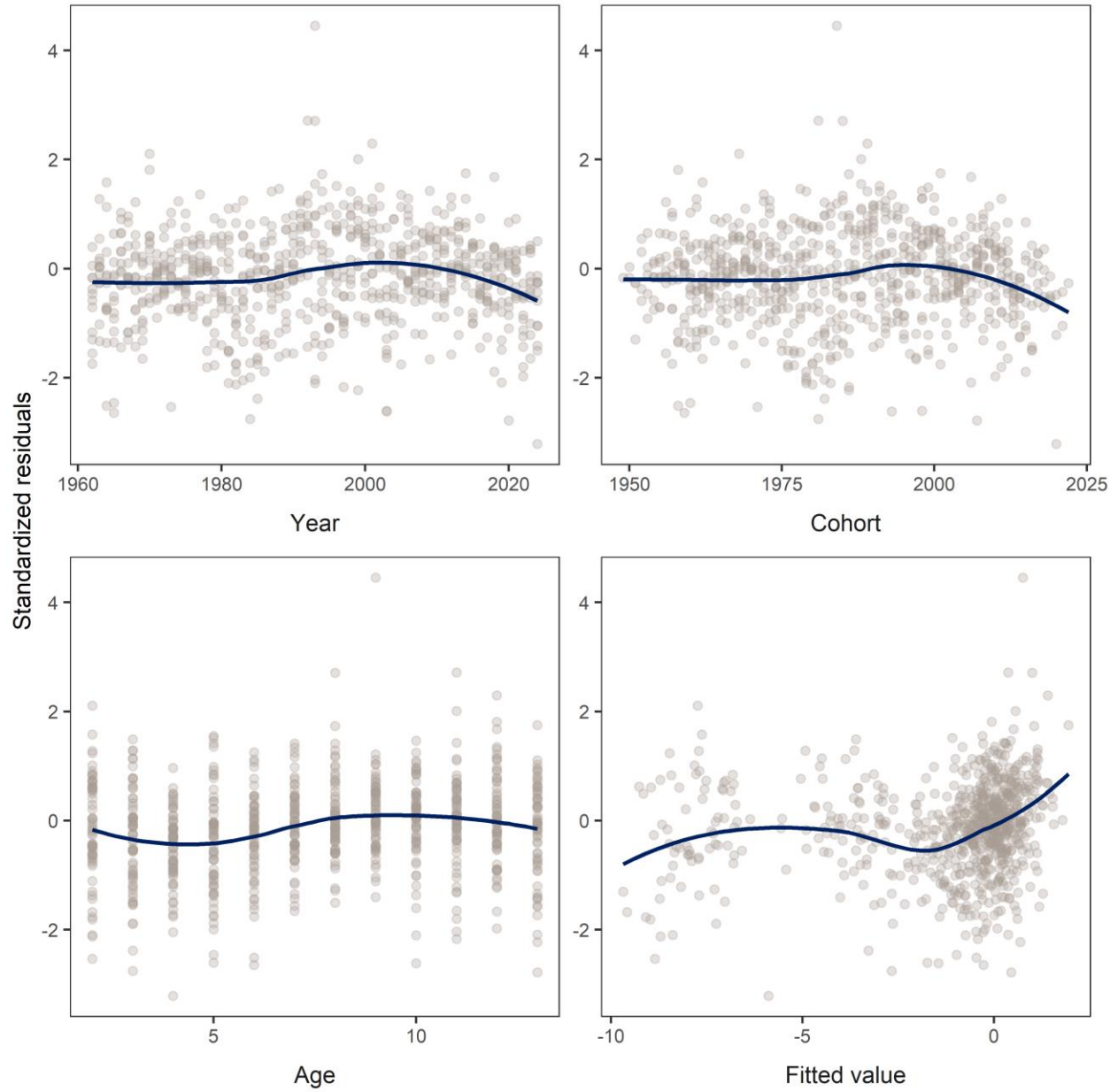


Figure A3. Standardized residuals from catch composition continuation ratio logits faceted by age, cohort, year, and fitted value from xteNCAM. Lines are lowess curves.

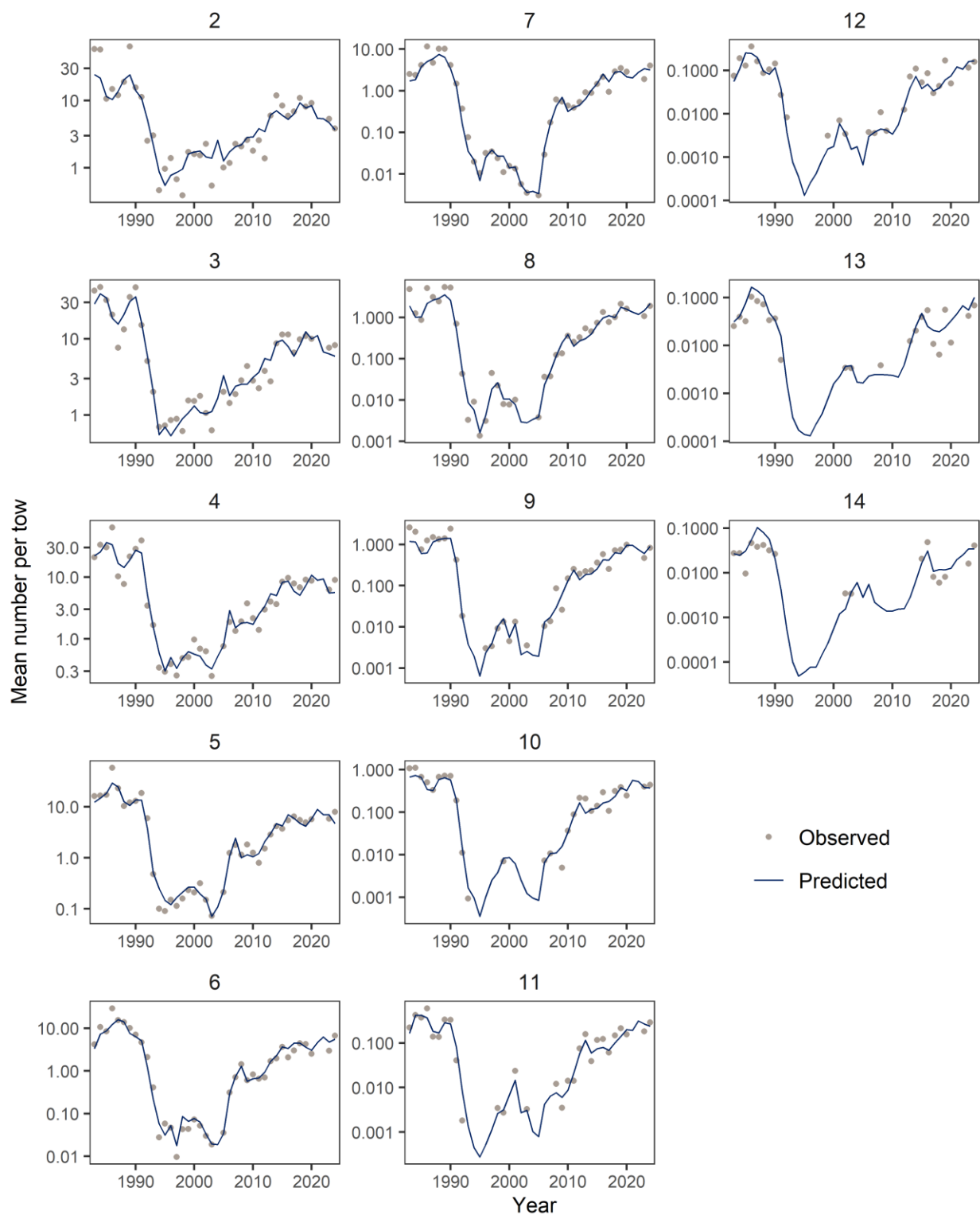


Figure A4. Observed (dots) and model-predicted values (lines) for the age-disaggregated RV survey index. Y-axis is in log scale.

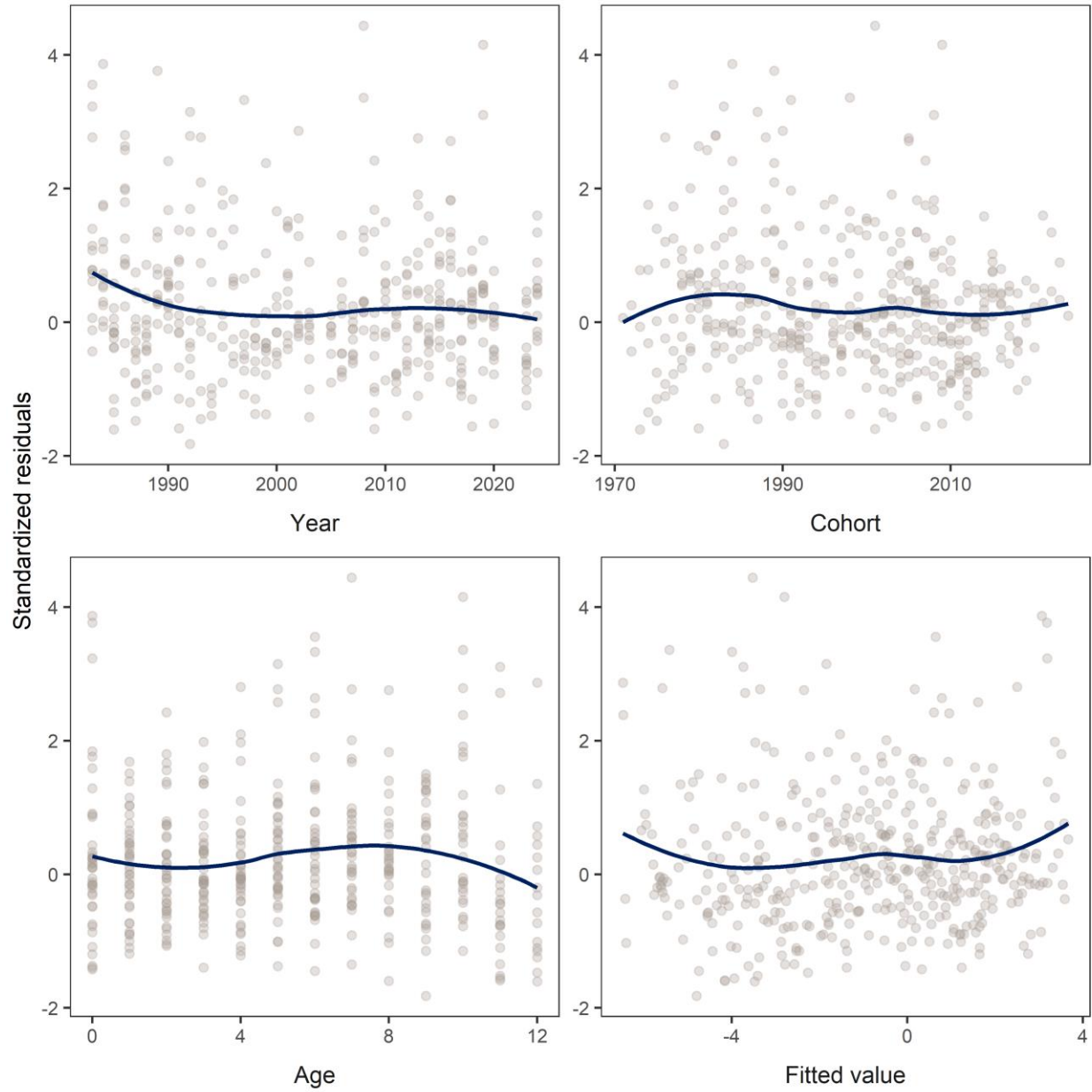


Figure A5. Standardized residuals from the RV survey faceted by age, cohort, year, and fitted value from xteNCAM. Lines are lowess curves.

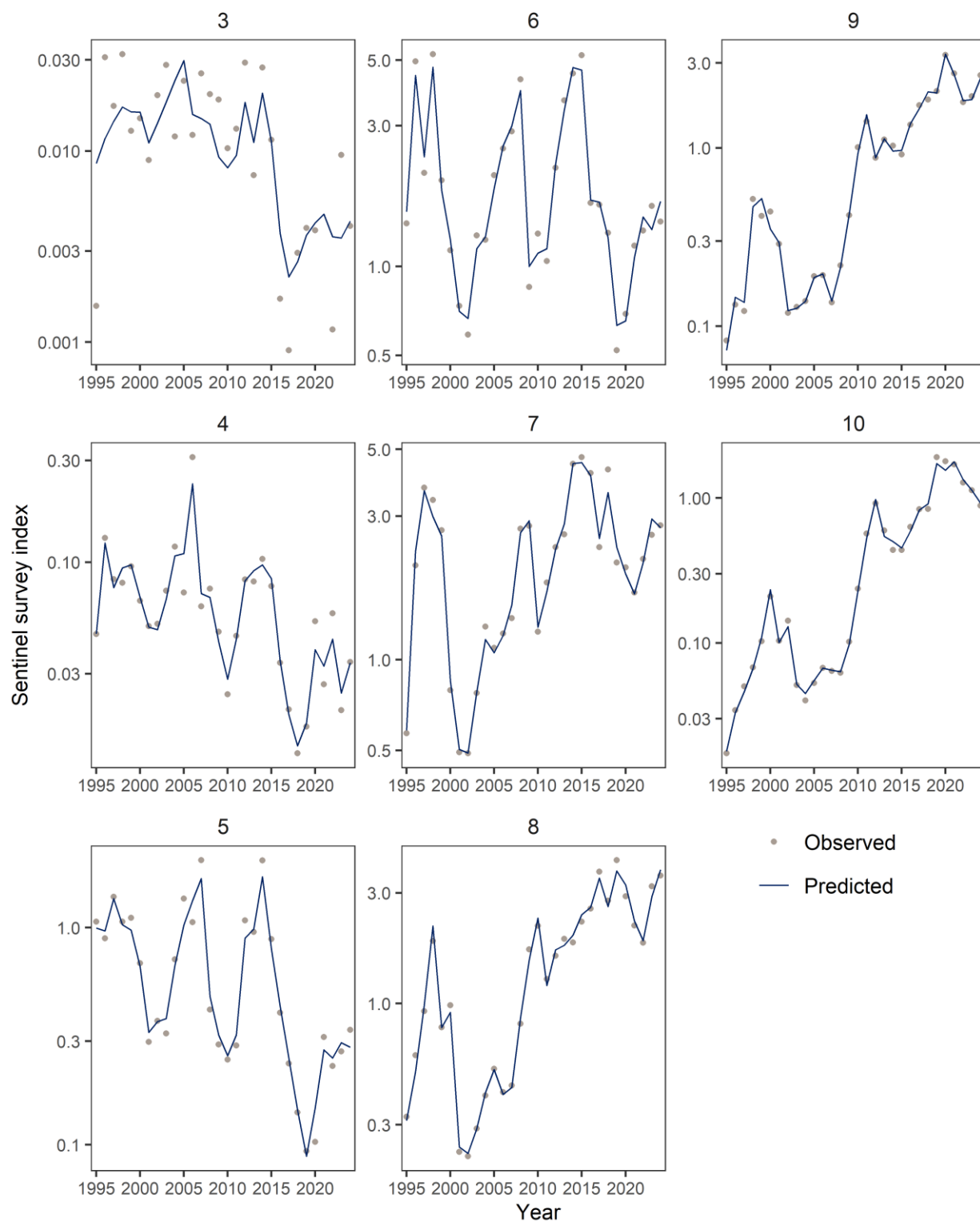


Figure A6. Observed (dots) and model-predicted values (lines) for the age-disaggregated sentinel survey index. Y-axis is in log scale.

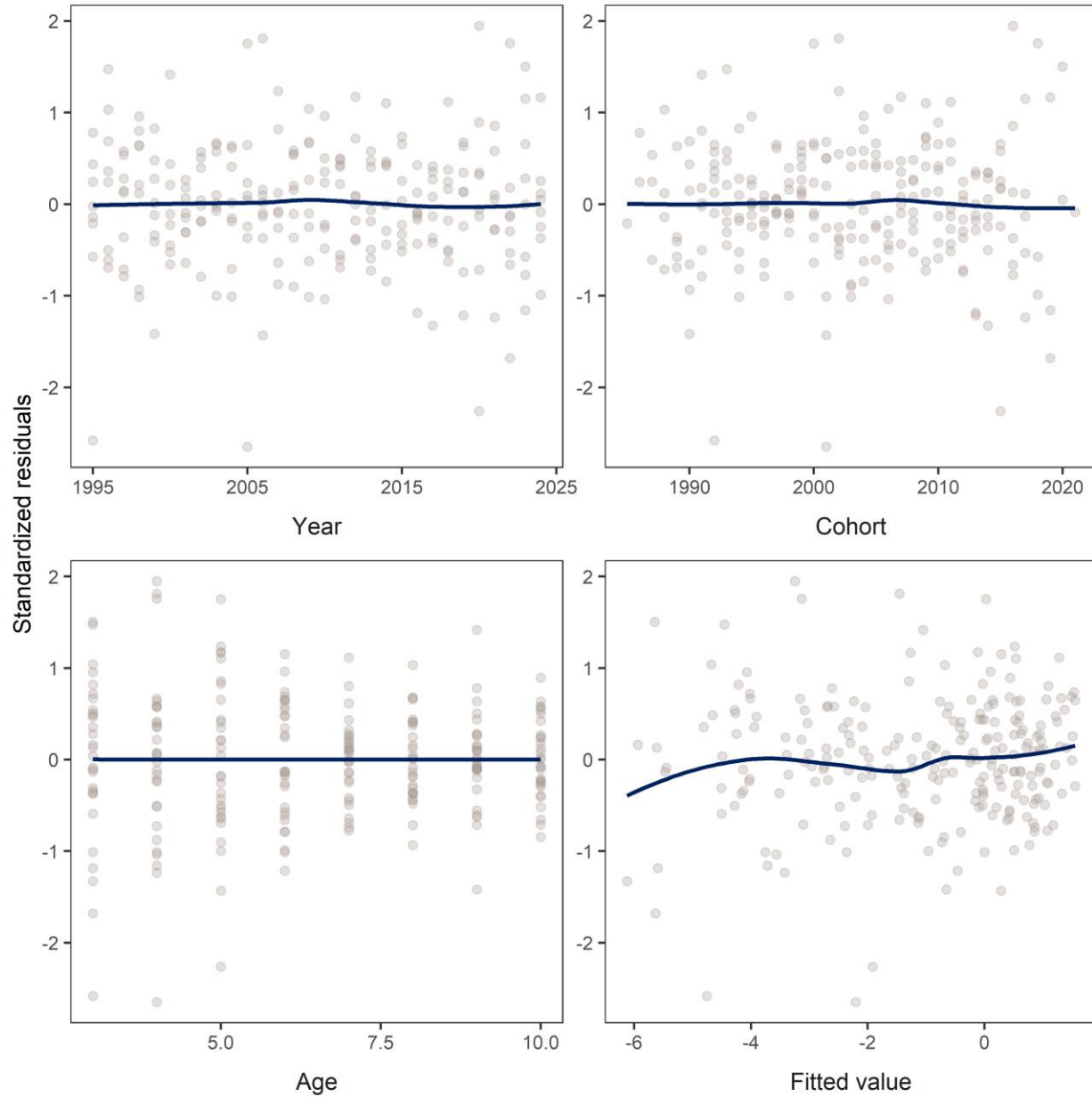


Figure A7. Standardized residuals from the sentinel survey faceted by age, cohort, year, and fitted value from xteNCAM. Lines are loess curves.

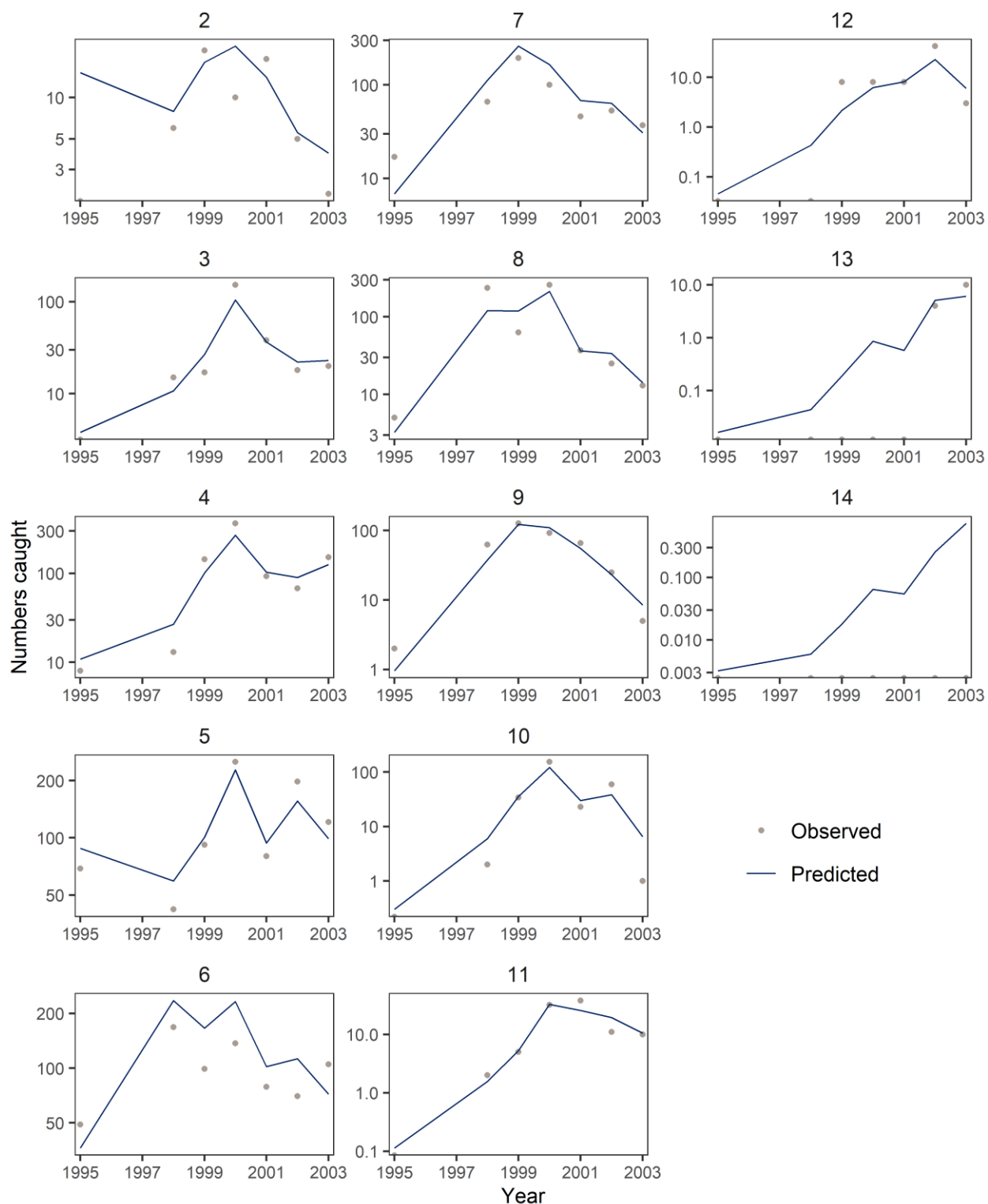


Figure A8. Observed (dots) and model-predicted values (lines) for the age-disaggregated Smith Sound survey index. Y-axis is in log scale.

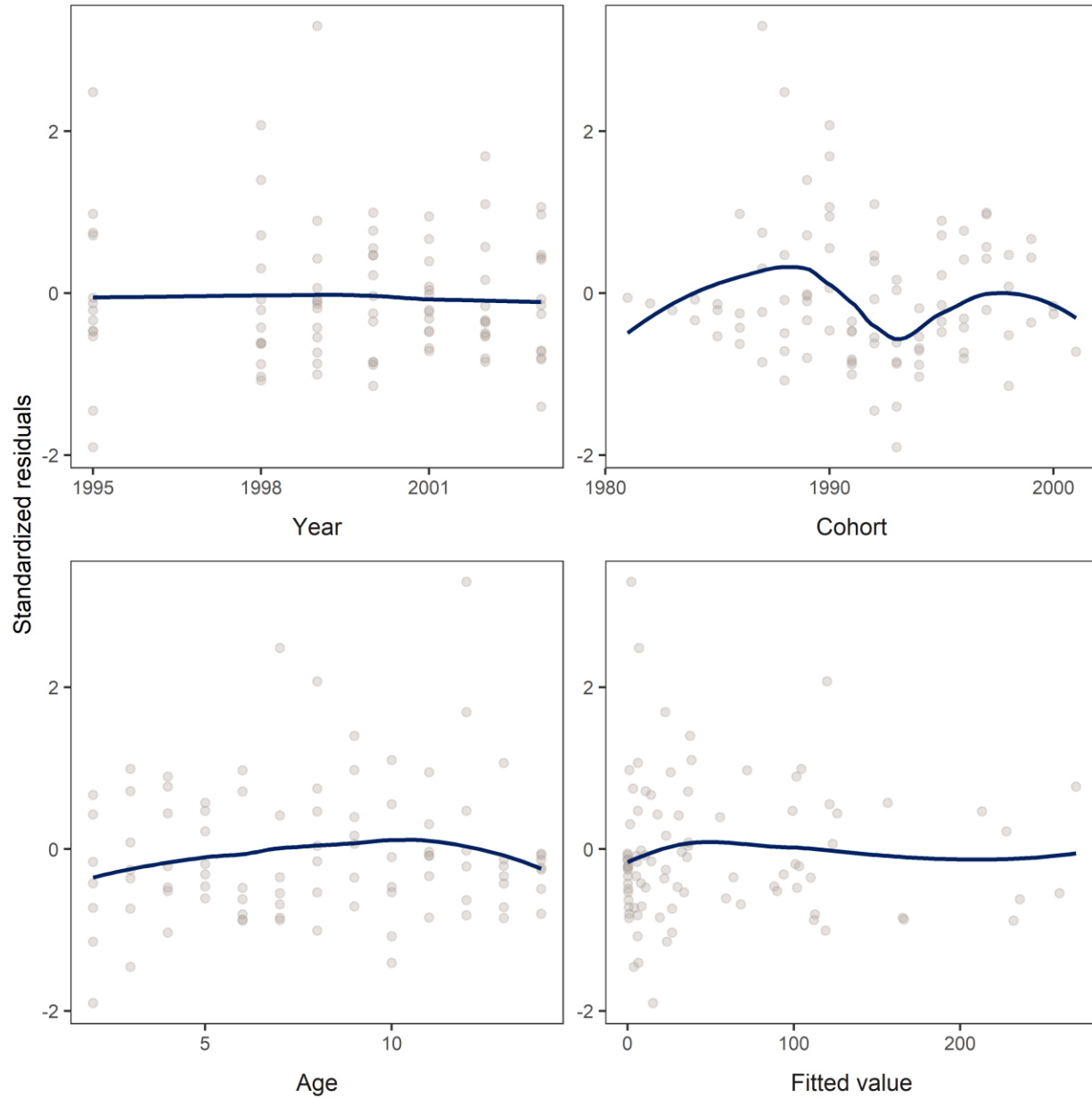


Figure A9. Standardized residuals from the Smith Sound survey faceted by age, cohort, year, and fitted value from xteNCAM. Lines are lowess curves.

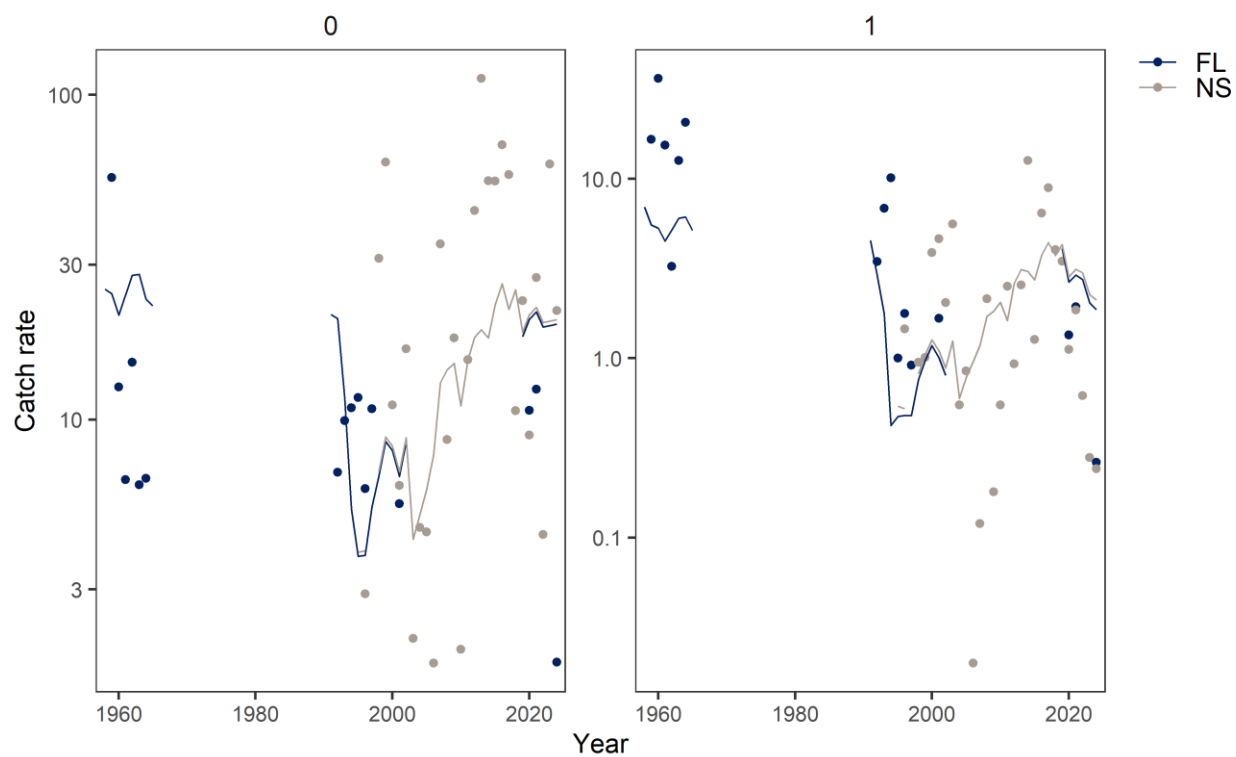


Figure A10. Observed (dots) and model-predicted values (lines) for the juvenile survey indices. Y-axis is in log scale. FL = Fleming survey; NS = Newman Sound survey.

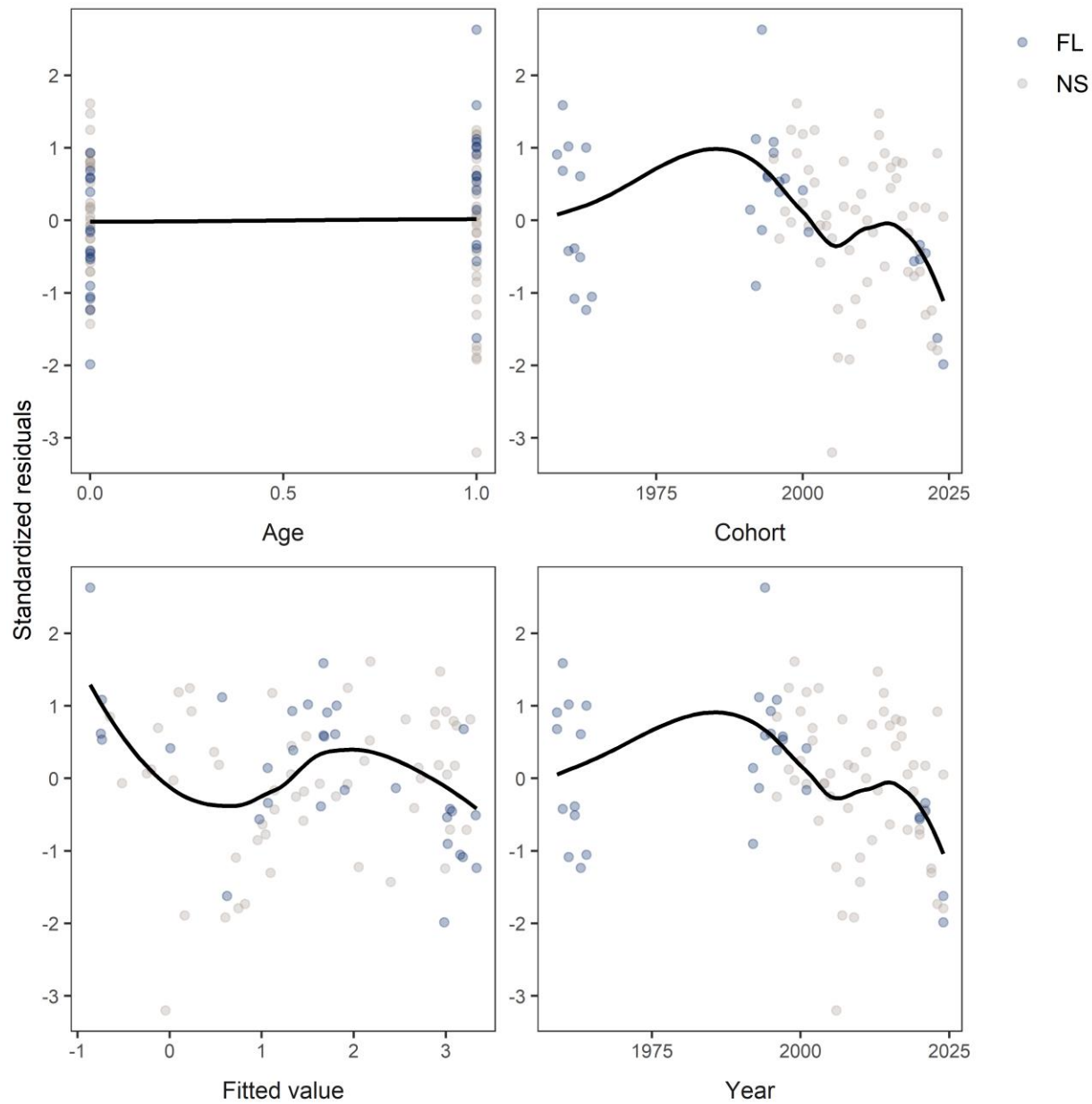


Figure A11. Standardized residuals from juvenile survey indices faceted by age, cohort, year, and fitted value from xteNCAM. Lines are lowess curves.

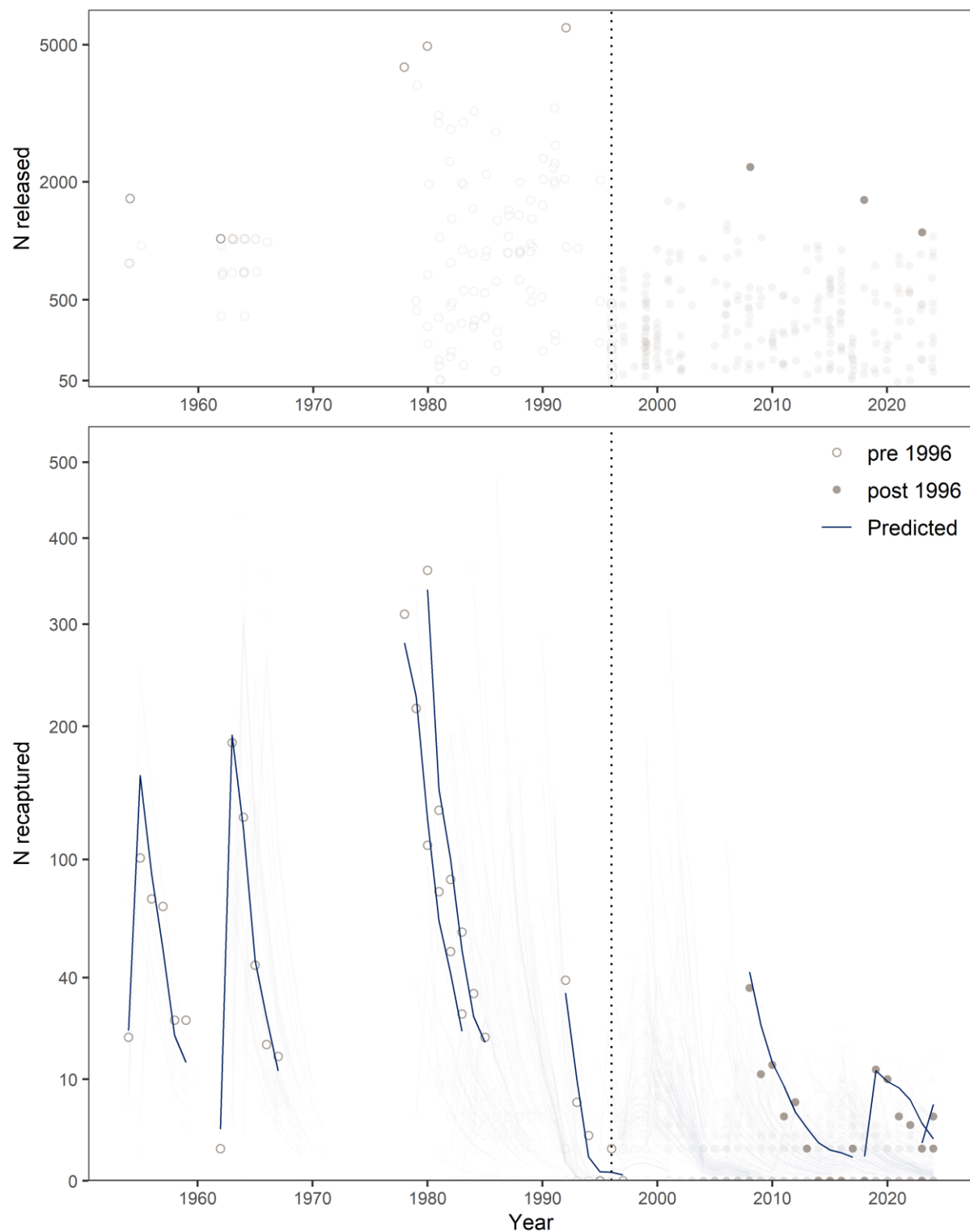


Figure A12. (Upper Panel) Number of tag releases and (Lower Panel) aggregate (all ages) observed (points) versus model-predicted (lines) number of recaptures of tagged cod by experiment and recapture year. The largest experiments in each decade are emphasized. Y-axes are in square root scale.

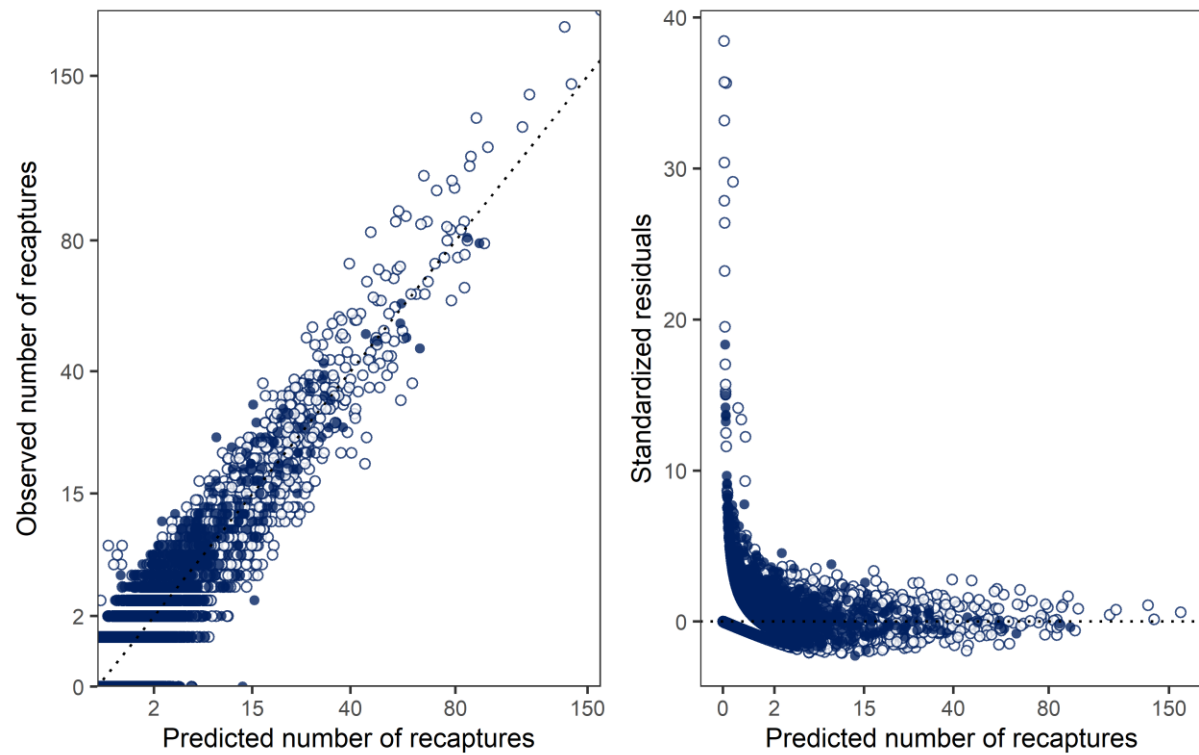


Figure A13. (Left Panel) Observed versus model-predicted reported catches of tagged cod from tagging experiments and (Right Panel) conditional Poisson standardized residuals. Axes of predicted and observed number of recaptures are in square root scale.

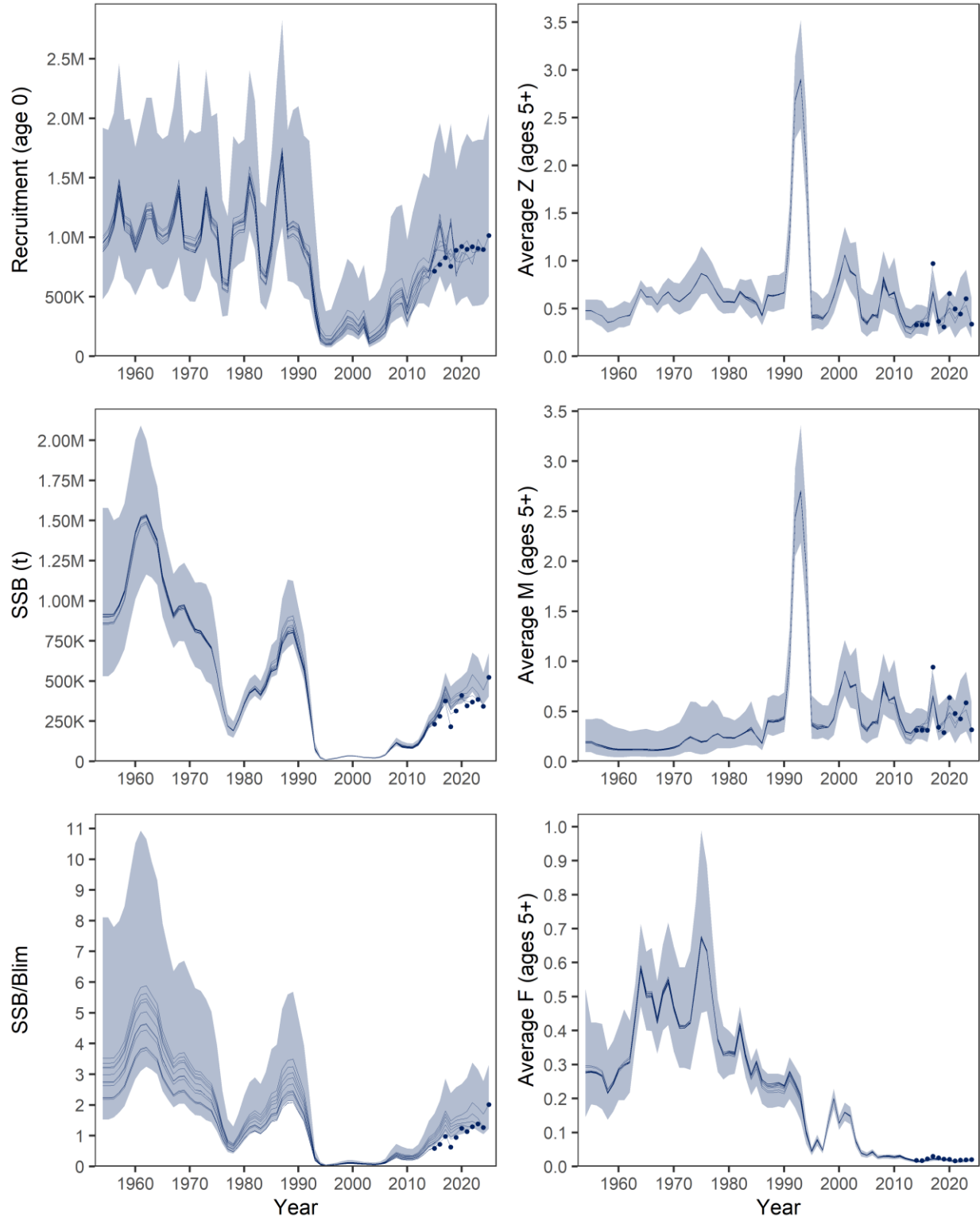


Figure A14. (Left Panels) Retrospective estimates of recruitment, spawning stock biomass (SSB), and SSB relative to the Limit Reference Point (B_{lim}) and (Right Panels) mortality rates (total [Z], natural [M], and fishing [F]) from *xtENCAM*. Dots indicate terminal estimates from each retrospective fold.