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Assessment of the Northern Cod (*Gadus morhua*) stock in NAFO Divisions 2J3KL in 2016

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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 that 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 was assessed through a Regional Peer Review Process (RPR) conducted during March 21-24 and March 30-31, 2016 in St. John's, Newfoundland and Labrador (NL). This stock is currently under a three-year management cycle, and the current assessment provided catch advice for 2016-18. The assessment also identified an indicator (based on 3 year projections of DFO research vessel (RV) total [2+] biomass) that could be used to determine whether a full assessment is warranted during interim years. The current assessment was based mainly on a new state-space population dynamics model (Northern Cod Assessment Model, NCAM) that integrates much of the existing information about the productivity of the stock. Key features of the new model are that it provides annual estimates of natural mortality (M) and fishing mortality (F) rates along with measures of uncertainty; the model also estimates catch and requires an interval identifying a likely range of catch (upper and lower bounds).The model integrates information from DFO RV autumn trawl surveys (1983-2015), Sentinel fishery surveys (1995-2014), inshore acoustic surveys (1995-2009) fishery catch age compositions, and partial fishery landings (1983--2015), and tagging (1983-2015). The latest assessment indicated that stock abundance (ages 2+) has increased from 194 million cod in 2005 to 894 million in 2015. Total biomass (ages 2+) has increased from 78 Kt in 2005 to 539 Kt in 2015. Spawning stock biomass (SSB) has increased from 25 Kt in 2005 to 300 Kt in 2015. Recruitment (age 2) improved slightly in the last decade and the average number of age 2s from the 2011-13 year classes corresponds to about 25% of the numbers of age 2s observed in year classes of the 1980s. Stock status is improving, increasing from 3% of B_{lim} in 2005 to 34% of B_{lim} in 2015, but SSB has been well into the critical zone since the stock collapse. Three year projections (to 2018) were also undertaken to investigate the potential impact of a range of catch options from zero catch (no fishing) to a 5-fold increase in catch, based on model estimates of total catch for 2015 (6,900 t). The results indicated a high probability of achieving a 3-year 28% SSB interim growth milestone over the full range of catch options. Projections also indicate a low risk (<4%) that SSB will decline by 2018 to below the 2015 value, but also a low probability (5-8%) that the stock will grow out of the critical zone and exceed B_{lim} in 2018. The stock is projected to grow but still be much less than B_{lim} (60-66%) and remain in the critical zone in 2018 over the full range of catch options considered, including no fishing. Consistency with the DFO decision-making framework incorporating the precautionary approach requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone.

Évaluation du stock de morue (*Gadus morhua*) dans les divisions 2J3KL de l'OPANO en 2016

RÉSUMÉ

Un processus d'examen régional par les pairs qui s'est tenu du 21 au 24 mars et les 30 et 31 mars 2016 à St. John's, à Terre-Neuve-et-Labrador (T.-N.-L.), a évalué le stock de morue (Gadus morhua) qui vit dans les eaux au large du sud du Labrador et à l'est de Terre-Neuve, au bord du plateau continental, dans les divisions 2J3KL de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO). Ce stock fait l'objet d'un cycle de gestion sur trois ans et l'évaluation actuelle a permis de produire l'avis sur les prises pour 2016-2018. L'évaluation a également fixé un indicateur (fondé sur les projections sur trois ans de la biomasse totale [2+] d'après le navire scientifique du MPO) qui pourrait servir à déterminer si une évaluation complète est justifiée pendant les années intermédiaires. La présente évaluation repose essentiellement sur un nouveau modèle de dynamique des populations de type état-espace (le modèle d'évaluation de la morue) qui intègre une bonne partie des renseignements existants sur la productivité de ce stock. Les principales caractéristiques de ce nouveau modèle résident dans le fait qu'il donne des estimations annuelles des taux de mortalité naturelle (M) et de mortalité par pêche (F), ainsi que des mesures de l'incertitude; il estime aussi les prises et nécessite un intervalle définissant une fourchette probable de prises (limites supérieure et inférieure). Le modèle intègre les données tirées des relevés au chalut d'automne effectués par le navire de recherche du MPO (1983-2015), des relevés de pêche sentinelle (1995-2014), des relevés acoustiques côtiers (1995-2009), des compositions selon l'âge des prises et des débarquements partiels (1983-2015), ainsi que de l'étiquetage (1983-2015). Selon la dernière évaluation, l'abondance du stock (âges 2+) a augmenté, passant de 194 millions de morues en 2005 à 894 millions en 2015. La biomasse totale (âges 2+) a augmenté de 78 kt en 2005 à 539 kt en 2015. La biomasse du stock reproducteur (BSR) a augmenté de 25 kt en 2005 à 300 kt en 2015. Le recrutement (âge 2) s'est légèrement amélioré depuis dix ans et le nombre moyen de poissons d'âge 2 des classes d'âge de 2011 à 2013 correspond à environ 25 % de celui qui était observé dans ces classes d'âge dans les années 1980. L'état du stock s'améliore, passant de 3 % de Blim en 2005 à 34 % de Blim en 2015, mais la BSR se situe largement dans la zone critique depuis que le stock s'est effondré. Des projections sur trois ans (jusqu'en 2018) ont été réalisées afin d'étudier les incidences potentielles d'un éventail d'options de prises allant d'aucune prise (pas de pêche) à une multiplication par cinq des prises, à partir des estimations du modèle des prises totales pour 2015 (6 900 t). Les résultats ont montré une forte probabilité d'atteindre un jalon de croissance intermédiaire de 28 % de la BSR sur trois ans, pour toutes les options de prises. Les projections indiquent aussi un risque faible (< 4 %) que la BSR en 2018 chute en dessous de la valeur de 2015, mais également une faible probabilité (5 à 8 %) que le stock sorte de la zone critique et dépasse la valeur Blim en 2018. On prévoit que le stock va croître, mais demeurer bien inférieur à la valeur Blim (60 à 66 %) et qu'il restera dans la zone critique en 2018 pour tout l'éventail des options de prises envisagées, y compris aucune pêche. Pour être conforme au cadre décisionnel de Pêches et Océans Canada (MPO), qui incorpore l'approche de précaution, il faut que les prélèvements de toutes les sources soient maintenus au plus faible niveau possible jusqu'à ce que le stock quitte la zone critique.

INTRODUCTION

This document gives an account of the 2016 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 (Figs. 1a-1c). The current evaluation was conducted through a Regional Peer Review Process (RPR) conducted during March 21-24 and March 30-31, 2016 in St. John's, Newfoundland and Labrador (NL). A Science Advisory Report (SAR) for the 2J3KL stock from this meeting has been produced (DFO 2016a). Details of previous assessments and stock updates for Northern cod to 2010 are reported elsewhere (Bishop et al. 1993, 1994, 1995; Bishop and Shelton 1997; Shelton et al. 1996; Lilly et al. 1998; 1999, 2000, 2001, 2003, 2004, 2005; 2006; Brattey et al. 2008a, 2009, 2011).

During 2011-16 there have been three assessments of Northern cod (2011, 2013 and 2016) with stock updates in the three intervening years (2012, 2014, 2015). The assessments in 2011 and 2013 were based on an age-based and survey-only stock assessment model (SURBA) that provides absolute estimates of total mortality rates (Z's) and relative estimates of stock size (Cadigan 2010; DFO 2011a, 2013). Modifications to the original survey-based model (SURBA +) were introduced for the 2013 assessment (Cadigan 2013). For stock updates, information on relative trends in the main stock indices (DFO RV survey, and sentinel survey) and tagging were examined (DFO 2012, 2014, 2015). During 2011-15 the stock showed some improvement, but remained well below the Limit Reference Point (LRP) (B_{lim}) established in 2010 (DFO 2011b) and in the lower half of the critical zone.

For the current (2016) assessment a new integrated state-space population dynamics model developed specifically for Northern cod (NCAM) was introduced that utilizes much of the existing information about the productivity of the stock. The original version of NCAM (Cadigan 2015) was modified based on recommendations of a Framework Review (DFO 2016b; Cadigan 2016a). Further modifications to the model and details of data inputs for the current assessment are described below (see Results section). In addition to the NCAM model results, several other sources of information were reviewed at the assessment (e. g. physical and biological oceanography, ecosystem information, predators, prey, acoustic survey of the offshore, inshore pre-recruit surveys, industry surveys, log-books, etc.). Further details on these additional sources of information may be found in the associated Proceedings Document from this assessment (DFO 2018).

REPORTED LANDINGS OF COD

Reported landings from this stock from the 1950's until 2009 are described in detail in previous documents (Lilly et al. 2006; Brattey et al. 2009, 2011). Reported landings for 2010-15 are added to the time-series herein (Table 3, Figs. 2, 3). Fixed gear landings (from 1975) are also updated to 2015 (Table 4, Fig. 4) and show that most of the catch throughout 2006-15 was taken by gillnets.

REPORTED LANDINGS DURING 2010-15

Commercial Fisheries

The "stewardship" fishery, which re-opened in 2006, has continued in the inshore during 2010-15. Note that the management year extends from April 1to March 31 the following year (since 2000), but catch statistics are reported in calendar years herein as there have been no significant landings from this stock during January-March. There was no formal Total Allowable

Catch (TAC); commercial fishers were permitted a fixed annual allowance per license holder. The allowance has varied between 2,500 lb and 5,000 lb (3,000 lb in 2006/07, 2,500 lb in 2007/08, 3,250 lb in 2008/09, 3,750 lb in 2009/10 to 2012/13, and 5,000 lb in 2013/14 to 2015/16). There were strict limits on seasons (approximately three weeks with dates varying by region), amounts of gear (six gill nets or 3,000 hooks of long-line) and areas (typically harvesters were restricted to local areas) that could be fished and further details are available in annual Conservation Harvesting plans prepared by Fisheries Management. Small additional catches of cod also came from the sentinel fishery (<300 t per year) and by-catch taken mostly during fisheries for winter flounder (*Pseudopleuronectes americanus*), lumpfish (*Cyclopterus lumpus*), herring (*Clupea harengus*, gillnet fishery), capelin (*Mallotus villosus*, trap fishery), and the bait-net fishery (<50 t per year combined). There has been no directed fishery for cod in the offshore (i.e. >12 nm from shore) since the moratorium. Some cod by-catch is taken by vessels fishing offshore for Greenland halibut (*Reinhardtius hippoglossoides*), but except for the period 2004-08 (see Brattey et al. 2009), amounts are small (generally < 10 t per annum). Similarly, small amounts of cod (generally <20 t per year) are taken as by-catch in fisheries for other species such as winter flounder, lumpfish and shrimp. By-catch of cod from the offshore of 3L has also been reported by the Scientific Council of NAFO for non-Canadian vessels fishing on the “nose” of the Grand Banks in 3L outside Canadian exclusive economic zone (200 nm limit)(see Table 3) but reported amounts (<300 t per year) are a small fraction of reported total landings.

Reported landings in the past six years ranged from 2,962 t in 2010 to 4,870 t in 2014 (Table 3) with most of the landings coming from the inshore (Table 5). The reported landings in 2015 were 4,436 t. During this period the inshore commercial (“stewardship”) fishery accounted for most (>90%) of the reported landings (Fig. 5). The Sentinel fishery has accounted for less than 300 t per year, with by-catch in all other inshore fisheries typically <100 t per year.

The number of ground-fish licenses in NAFO Divs. 2J3KL has diminished by 23% during 2006-15 from over 2,500 in 2006 to approximately 2,000 in 2015 (Fig. 6). The distribution of licenses by NAFO division shows approximately 6% in 2J, 42% in 3K and 52% in 3L.The number of active licenses has ranged from 2,100 to 1,700 with the lowest value in 2015. The distribution of licenses within each NAFO Division is not uniform (Fig. 7). Although data were not available for the most recent years, the distribution has not changed and there are relatively few harvesters (i.e. 50-120) in the northern unit areas (2J and 3Ka-3Kh) and in the extreme south (3Lj and 3Lq). Most of the harvesters are concentrated in 3Ki (>600) and 3La-3Lf (300-360).

Most of the reported landings during 2010-15 were taken to the west of Notre Dame Bay around Twillingate and Fogo (unit areas 3Kh/3Ki), and in Bonavista Bay (3La) and Trinity Bay (3Lb, Table 5). There were no major changes in the distribution of landings over time as harvesters were given a fixed annual allowance and fished close to their home port; consequently, the distribution of landings largely reflects local effort, i.e. the numbers of active harvesters in each area. Most of the landings in the commercial fishery during 2015 took place in the inshore during August to early October; catches in the remaining months came mostly from the sentinel fishery and by-catch (Table 6); this is the typical monthly distribution of catches since 2006.

Monthly reported landings of cod from NAFO Divs. 2J3KL from 1983-2015 were also compiled from available catch statistics databases for Canada-Newfoundland and Labrador, Canada-Maritimes, and non-Canadian catches (Table 7). These monthly values were used in the assessment model (see below) in conjunction with tag recapture information; these values were required to estimate the fraction of harvesting that took place in any year before tagged fish were released in that year.

A detailed overview of the dockside monitoring program (DMP), which has been in place since 2005 to monitor landings, was described at the 2016 assessment meeting, but no new information on discarding, illegal fishing, or misreporting during commercial fisheries was presented. Harvesters present at the assessment meeting felt that while there could be some improvements to the DMP program and enforcement measures, the combination of these two programs resulted in a high percentage of externally monitored landings and that catches in recent years were more accurately monitored than they were prior to the implementation of the DMP. However, there remains no mechanism to estimate high-grading or discard rates in the historical catch statistics and recreational fishery landings are not directly measured (see below). There was evidence of widespread discarding of small cod during recreational fisheries in 2009 (see Brattey et al. 2011), but this issue appears to have diminished as larger cod are now more available (see below). Discarding of cod during the shrimp fishery was explored at the 2009 Northern cod Zonal Assessment Process and was estimated at <20 t per annum during 2004-08.

Recreational Fisheries

In addition to the amounts described above, recreational fishers were permitted 5 ground-fish per person per day, and no more than 15 fish per boat, for approximately 32-35 days during summer and early autumn (July-October). Within the past decade (2006-15) there are no direct estimates of recreational landings for 2007, 2009-10, and 2013-15. Telephone surveys and estimates from fisheries officers were used to determine recreational fishery landings in 2007 and 2008, but these gave widely differing results. The reason for differences were partly related to differing estimates of effort (boat trips per day), but the reasons for the discrepancies could not be fully resolved and no estimate was used for 2007. For the 2008 recreational fishery the phone survey estimate of 818 t was subsequently revised to 1,089 t based on better sampling of fish weights (DFO 2009) and this value was used in catch-at-age reconstruction and is shown in Fig. 5. The phone survey was discontinued after 2008. For 2011 and 2012 an estimate of recreational landings of a few hundred tons provided by fisheries officers was used in the catch-at-age reconstruction and these estimates, though uncertain, are also included in Fig. 5. Analyses of tag return information from commercial versus recreational fishers suggests that removals from recreational fisheries were substantial and much higher than was reported by fisheries officers (see Brattey et al. 2011) and averaged about 30% of reported stewardship fishery removals during recent years (DFO 2016a). This 30% estimate is slightly lower than was reported in previous years (DFO 2014, 2015), due to a revised method of estimating tag reporting rates which gave a higher proportion of total tags from commercial harvesters during the recent period. However, these analyses of tag returns have provided only general indications of the relatively high magnitude of recreational removals. Estimates from this method are annually quite variable (Brattey et al. 2009, 2011) and are not used in formal compilation of landings statistics.

Samples of the lengths of cod captured during the recreational fishery were taken by fisheries officers who measure cod at sea (on board recreational vessels) and at the dock in various communities; several thousand fish were measured each year (Table 8). Mean lengths tended to vary among regions and were generally highest (>60 cm) in Fogo-Twillingate (3Ki) in 2013 (Fig. 8). Overall, mean lengths tended to increase over time during 2013-2015. Sample sizes per month and site were variable (not shown) but averaged over 120 fish per month/site combination in each year. The mean lengths of cod sampled at the dock were compared with those sampled at sea for each year by month and unit area. Although not subjected to statistical analysis, 12 of 18 sites sampled in 2013 showed higher means among cod sampled at the dock than at sea, but in subsequent years this proportion diminished to 5 of 10 in both 2014 and 2015. These results suggest some discarding of smaller cod at sea by recreational fishers during 2013, but there is no clear evidence, from comparison of these mean lengths, for extensive discarding of small fish during subsequent years.

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 during 2010-15 (Tables 6 and 7). General sampling objectives for the fishery were to obtain a representative length frequency plus otoliths from each commercial area fished (i.e. statistical unit area such as 2Jm, 3Kd, 3La, etc.) for each gear type and fishing period. Fishing has generally been restricted to a single short (3-4 week) period during July-September, and three gear types (gillnet, hand-line and longline) account for most (>95%) of the landings. 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 <200 fish are available. In addition, the objective is to collect five otoliths per cm length group per unit area, gear type, and fishing period. Extensive additional sampling of sentinel fishery catches is conducted by sentinel fishers following a separate protocol described elsewhere (Maddock Parsons 2014).

During 2010-15 the number of cod length measurements per year has exceeded 100,000, and the numbers of otoliths has typically exceeded 5,000. All major sectors of the fishery were sampled for lengths, particularly gillnet and hand-line, and all major sectors except recreational were sampled for otoliths. Sampling was generally well spread across the inshore with most sampling taken during the main fishing period. A large percentage of the total length sampling, i.e. ~80% over 2013-15, comes from the sentinel fishery where all fish are measured. For otoliths, ~40% are obtained from the sentinel fishery. Gears that contribute minor proportions of the total catches in the past six years (i.e. non-Canadian otter-trawl and shrimp trawl) were sampled intermittently.

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 to 2015 (Table 10). For the post-moratorium period, almost all of the catch has come from the inshore fishery which is dominated by gillnets. Descriptions of historical trends in catch at age can be found in previous assessment reports (Lilly et al. 2006; Brattey et al. 2008a, Brattey et al. 2011).

Catch-at-age during 2010-15

In the past six years, the age range represented in samples from the commercial fishery catch extends to about age 15. Most of the catch consists of ages 5-7 (Table 8; Fig. 9) which is typical for a fishery dominated by gillnets (see Table 4). While there are no strong trends in the recent catch at age there are indications of increasing numbers of age 6 and age 7 and of the oldest age-classes (ages 10-12). In assembling the catch at age for the recent period (2010-15), 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, ranging from 0.94 (2011) to 0.99 (2015).

Catch weights-at-age

The following standard relationship was applied in deriving average weight-at-age of cod:

$$\log(weight) = 3.0879*\log(length) - 5.2106$$

The mean weights-at-age calculated from mean lengths-at-age in the landings have been variable, increasing in the late 1970s and early 1980's, followed by a decline through the 1980s to low levels in the early 1990s (Table 11; Fig. 10). There has been substantial increase in the latter half of the 1990s, and weights-at-age calculated for recent years have been at or near the highest levels in the time-series. Interpretation of changes in the weights-at-age is difficult because of changes in the relative contributions of the various gear components and changes in the location and timing of catches from each gear component. For example, much of the landings prior to the moratorium came from otter trawling offshore early in the year, but since the moratorium most of the catch has come from fixed gear inshore in the second half of the year. In addition, the high proportion of landings coming from gillnets in recent years will tend to increase the calculated mean weight-at-age of those age-classes entering the selection range of the gear. This may apply in particular to ages 4 and 5. There may also be an underestimate of weight-at-age for those age-classes leaving the selection range of gillnets. Average weights at age for the oldest ages (>age 10) tend to be more variable due to increased variability in length with age combined with small sample sizes. The overall trend in weights at age indicates values throughout the 2000s that are much higher than the low point in the early 1990s.

There are problems with the 1993 weights-at-age for ages 8 and 9 where the weights were found to be unrealistically high; these problems remain to be resolved and values for these ages have been omitted from Fig. 10.

Deviations from mean weight at age, expressed as proportions and averaged over ages 3-12, show a distinct long term trend (Fig. 11); deviations were strongly negative in the early 1970s, improved to above average during the early 1980s, but subsequently declined to negative values during the mid to late 1980s. There was a precipitous decline to strongly negative values during 1990-92 followed by a rapid increase to marginally above average during 1992-95. From the late 1990s until the present, deviations have generally been positive and weights have generally been about 20% above the long-term average (except in 2013).

SURVEY INDICES

DFO RESEARCH VESSEL BOTTOM-TRAWL SURVEYS OF 2J3KL

Research bottom-trawl surveys have been conducted by Canada during the autumn in Div. 2J, 3K and 3L since 1977, 1978 and 1981, respectively, and these were updated to 2015 herein. Spring surveys have been conducted by Canada in Div. 3L during the years 1971-82 and 1985-present. Spring survey results, which cover only part of the stock area (Div. 3L) have been highly variable in recent years, were not presented at the assessment.

Survey Design

Details of the stratified random trawl survey design and changes in gear are described in previous documents (Lilly et al. 2005, 2006; Brattey et al. 2008a). Additional information on surveys conducted by DFO since the introduction of the Campelen trawl in 1995 is provided by Brodie (2005) and Brodie and Stansbury (2007). The depth-based stratification scheme and location of numbered strata is illustrated by NAFO Division in Figs. 12a-12c. 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 is in Campelen equivalents whereas values for 1995 onwards are based on actual Campelen catches.

Autumn Surveys

Autumn Abundance and Biomass Indices: Indices of cod abundance and biomass are based on the strata-area weighted arithmetic mean catch (numbers and weights) per standard tow. In previous assessments the computations were done using a Fortran-based program (STRAP, Smith and Somerton 1981). To account for incomplete coverage of some strata in some years, estimates of biomass and abundance for non-sampled strata were previously obtained using a multiplicative model, except in 2004 (see Lilly et al. 2005). However, in the current assessment the entire time series of abundance and biomass estimates was recomputed using a new R-based version of STRAP and unfished strata are omitted from the calculations. Consequently, there may be minor differences in the estimates reported here compared with those in previous assessment reports.

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 has been monitored for those strata that have been fished most consistently since the start of the surveys. These "offshore index strata" are those in the depth range 100-500 m in Div. 2J and 3K and 55-366 m (30-200 fathoms) in Div. 3L. The inshore strata fished intermittently from 1996 onwards are not included in this index, nor are deep-water strata (>200 fathoms in Div. 3L, or >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 Brattey et al. 2008a), but coverage in these areas has been poor for several years, few cod have been observed in the deep-water strata, and these are not updated here. Lilly et al. (2006) provide details on the interpretation of the autumn survey data with respect to depth and timing of the survey.

The full time series of autumn DFO research vessel survey index values by NAFO Division and total begins in 1983 and shows that the abundance and biomass indices have been low since the start of the moratorium in 1992 (Table 12; Fig. 13). The abundance index increased during 2005-09 and the biomass index increased during 2005-08; these increasing trends did not persist during 2009-2011, but have resumed during 2012-2015. In the 2015 survey, most of the abundance (87%) and biomass (84%) is located in the northern portion of the stock area (Divs. 2J and 3K). The recent (2012-15) upward trend in the abundance index is mostly due to increased numbers of small cod (≤age 4). The three-year averages (2013-15) for the abundance and biomass indices are 28% and 24%, respectively, of the average during the 1980s.The 2015 survey abundance and biomass index values were 500 million fish and 448,000 t, respectively; the corresponding index values a decade ago (2005) were 61 million fish and 28,000 t.

An index of SSB was also calculated using the product of survey numbers-at-age, modelled estimates of survey mean weights-at-age (Cadigan 2016b), and cohort model estimates of proportion mature at age (see below) from the offshore autumn survey. The SSB index from the autumn DFO RV survey declined rapidly in the late 1980s and early 1990s and remained very low (<7,700 t, Table 12) for over a decade after the 1992 moratorium. After 2005 the SSB index shows an upward trend (Fig. 14). The three-year average SSB index increased from 23% to 32% of the average observed in the 1980s (from 2012-14 to 2013-15). The 2015 survey SSB index values was 266,000 t; the corresponding SSB index value a decade ago (2005) was 3,000 t.

Autumn survey mean catch at age: Survey numbers at age are obtained by applying age-length keys (ALK's) to the numbers of fish at length in the samples from each Division. The current

(2015) sampling design for surveys of cod in Divs. 2J3KL requires that an attempt be made to obtain 10 otoliths per centimeter length group from two broad groupings of strata per division, roughly corresponding to eastern and western portions. This spatial stratification is intended to distribute sampling over the surveyed area. The otoliths are combined into Division specific ALK's and applied to the survey data by Division. Survey catch rates at age for the 2J3KL stock are obtained by averaging the divisional catch rates at age weighted by the area surveyed in each division.

A time series of survey catch rates at age, expressed as mean numbers per tow at age by NAFO Division and for Divs. 2J3KL combined, is given in Tables 11a-d. Mean catch per tow was generally high (mostly 50-200 fish per tow) in all three Divs. in the 1980s, but declined rapidly to generally <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 2005 (less so in 3L) and age structure has been expanding, with cod spawned from 2002 onwards surviving through to older ages (9-13) in recent (2012-15) surveys. Overall catch rates exceeded 50 cod per tow in both the 2014 and 2015 surveys.

The numbers of younger fish (ages 1-4) in survey catches has also improved considerably in the past 4 years, but remains well below the catch rates observed for these younger ages in the 1980s (not shown). Closer inspection of catch rates of younger ages (ages 1-4) plotted by year class indicated three general trends, depicted in Fig. 15. Year classes produced prior to 2003 show poor survival with the numbers at age 4 generally lower than at age 1 for the same year class; this is surprising given that catchability typically increases through ages 1 to 4 and may suggest that high mortality is more than offsetting the increase in catchability. In contrast, year classes produced during 2003 to 2010 show a different trend with catch rates generally increasing with age such that catch rates are generally higher by the time these cod reach age 4. This finding may suggest lower mortality rates on year classes produced during 2003-10 compared with preceding years but could also indicate changes in migratory patterns. Catch rates of the 2011 to 2013 year classes are the highest observed since the moratorium and tend to increase further with age, indicating a general improvement in recruitment and lower mortality at ages 1-4 in the most recent period.

Autumn survey catch distribution: An extensive time series of age-aggregated and disaggregated distribution plots of autumn survey catch numbers and catch weights per tow are available, but for brevity only a subset of these are shown here, to illustrate key changes in cod distribution in the recent period. A detailed history and description of changes in the distribution of cod at the time of the surveys to 2009 is given elsewhere (Shelton et al. 1996; Lilly et al. 2006; Brattey et al. 2011).

The distribution of catches from the two most recent surveys (2014 and 2015) indicate that in the most recent years cod are widely distributed in 2J, 3K, and northern 3L, particularly in the waters around the edges of the banks (Fig. 16a) with several modest (10-100 cod per tow) and some larger catches (>100 per tow). The distributions depicted in Fig. 16 also show that there are consistently few or no cod in catches close to the deeper water (>500 m) along the edge of the continental shelf or in the central and southern portion of 3L on the plateau of the Grand Banks (Figs. 16a and b). In contrast, in the mid to late 2000s, catches of only small numbers of cod per tow (<10) were widespread in 2J, 3K and northern 3L, with a few modest catches (10-100 cod per tow) restricted mostly to the 3K-3L border and the eastern side of Funk Island Bank (Brattey et al. 2011). This distribution pattern persisted through autumn surveys during 2010 and 2011 (Fig. 17a), but in subsequent surveys (2012-15) the number of sets with modest and some with large catches has increased and the distribution of larger catches has expanded northward into northern 3K and 2J. A similar pattern is evident in the distribution of trawl catches by weight (Figs. 16a and b and 17b).

Age-disaggregated plots of catch numbers for age 1's during 2012-15 (Fig. 18a) indicate that smaller juvenile cod were widely distributed across the continental shelf in 2013 and 2014, but closer to the coast in the 2015 survey. Ages 2-4 were, in general, broadly distributed across the shelf but there were more large catches from 2013 onwards (Figs. 18b-d); older ages (≥5, not shown) show a similar pattern to age 4's, but overall catch numbers were lower than those of younger cod.

Growth

The lengths-at-age (Table 14) and weights-at-age (Table 15a) of cod sampled during the autumn surveys are shown in Fig. 19 and Fig. 20. Note that Table 14 gives values only for the period 2001-15; data for previous years are given in Brattey et al. 2011. 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 Division 3L over that period (Fig. 19). Mean length-at-age was mainly above average in 2011-14 in all Divisions. For most ages length was above average in 3K in 2015, although not for age 4 and age 5. Most ages had below average length in 2015 in Div. 3L.

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 (Fig. 20). Mean weight-at-age was above average in 2011-14 in all Divisions and near average in 2015.

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 to 2015 was calculated for each age. Deviation was calculated for each age in each year by subtracting the mean for the age for the time series from the annual observation for that age and then dividing this by the mean for that age. Mean weight-at-age decreased from the beginning of the time series to the early 1990s. It increased to well above average by 1997 and has fluctuated since then but remained at near or above average (Fig. 21). Mean weight-at-age in 2012 and 2013 were among the highest in the time series but declined to near average by 2015.

The DFO RV trawl survey mean weights-at-age were also modelled using a Von Bertalanffy growth model (VonB2 model, Cadigan 2016b) to estimate beginning-of-year and mid-year weights-at-age for Northern cod during 1983-2014 and for ages 2-20. The modelled weights were required along with current assessment model output (see below) to estimate beginning-of-year SSB and for evaluating fishery biomass landings using mid-year weights. An advantage of using modelled weights is to reduce the measurement error in weight estimates. The modelled weights described in Cadigan (2016b) were updated with an additional year of survey data (weights from 2015 survey) and the modelled estimates of beginning of year weights for recent years, and projected weights, changed substantially. These results indicate that weights alone could have a considerable influence on estimates of stock biomass and SSB and in projections. Beginning-of-year model estimates for stock weights-at-age that were used in the calculation of SSB are given in Table 15b. Model estimates of mid-year catch weights-at-age used in the calculation of total catch biomass are given in Table 15c.

Condition

Relative condition (relative K) was calculated by first fitting a length versus gutted weight regression for each division. The condition index is then observed condition divided by the condition predicted from the length weight regression for a fish of that length. Relative liver condition (relative LK) was calculated in a similar fashion using a liver weight versus length regression. Relative K and relative LK for each year were estimated for each division using a generalized linear model with an identity link and a gamma error, with year as a class variable (Tables 16 and 17; Figs. 22 and 23). For relative K, 19 fish were found to be extreme outliers and were removed. Both Div. 2J and 3K show lower relative K in the early-1990s. There has been some increase in relative K in all Divisions since then. Relative condition remains high in Div. 2J but is below 1 (i.e. equal to that predicted from the length-weight relationship) for Div. 3K and 3L. Relative liver condition remains high in Div. 2J but is just below 1 (i.e. equal to that predicted from the length-weight relationship) for Div. 3K and 3L in 2015.

Maturity

Annual estimates of age at 50% maturity (A50) and proportions mature at age for females from the 2J3KL cod stock, collected during annual autumn DFO research bottom trawl surveys, were calculated as described by Morgan and Hoenig (1997). A cohort-specific Binomial logistic regression model was used to estimate the proportion mature as a function of age and these estimated proportions (Table 18) are used in the calculation of spawning stock biomass. The estimated age at 50% maturity (A50) is used as a metric for monitoring changes in age at maturity. 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 1960's to the early 1980s, but declined thereafter (Fig. 24). Age at maturity has remained low but variable (4.9-5.7) for the 1990-2009 cohorts, with no clear trend. Estimates for the last cohort (2010) 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 in the recent period; the confidence intervals for the fit to this recent cohort are not large and close inspection of the raw data indicate consistently lower observed proportions mature at each age. Estimates of A50 for the 1990 cohort onwards from the previous stock update in 2015 are overlaid on the 2016 assessment results (Fig. 23). This comparison shows that the addition of one more year of data resulted in only minor retrospective changes in A50 among 2007-09 cohorts. Males show a similar trend in A50 over time (data not shown), but tend to mature about one year earlier than females.

The number of cod older than age 6 in the offshore has increased in the past 7-8 years, but the spawning stock biomass and age composition of 2J3KL cod remains somewhat contracted relative to the pre-moratorium period. A spawning stock biomass that comprises lots of older fish, or a broad age range, may result in a longer time span of spawning (Hutchings and Myers 1993; Trippel and Morgan 1994). Older, larger fish also produce more viable eggs and larvae (Solemdal et al. 1995; Kjesbu et al. 1996; Trippel 1998; Stares et al. 2007). However, Morgan et al. (2007) found that there was no consistent relationship between age-composition of the spawning stock and recruitment in three populations of cod including those in 2J3KL. To date, the increase in the autumn survey SSB index (Table 12) and expanded age structure in the offshore has translated into only a slight improvement in recruitment (ages 1-4, Table 13d and Fig. 15).

NORTHERN COD ASSESSMENT MODEL (NCAM)

For Northern cod, development of an assessment model that captures the dynamics of the stock has proven difficult. In the past five decades, various assessment models have been used to evaluate stock status (see Bishop and Shelton 1997 and references therein; Cadigan 2010, 2013). Traditional analytic models (i.e. VPA) were used until just after the moratorium (Bishop et al. 1993, 1994) and briefly for the inshore portion of the stock area during 2003-07, but these models assume that catch is measured without error and that the rate of natural mortality (M) is constant. These models typically fit the data poorly (Bishop1994; Shelton et al. 1996; Lilly et al. 1998; Shelton and Lilly 2000) particularly in the early 1990s and were discontinued. In the post-moratorium period, stock status was inferred, either directly from trends in the DFO RV survey indices, or more recently (2009-11, 2013) from a survey based model (SURBA, Cadigan 2010, 2013). Neither direct or modelled survey-only based assessments can be used to evaluate the impact of future fishing (i.e. provide catch advice); the latter provides absolute estimates of trends in total mortality rates (Z) but requires assumptions about natural mortality rates (M). Irrespective of the changes in methodology to assess the stock and lack of a suitable population model, the resource has clearly been at a very low level since the moratorium and well below any reasonable LRP, the latter being formally established at a Framework Review Meeting in 2010 (DFO 2011b).

Cadigan (2015) identified three main problems that need to be addressed in the development of an assessment model for Northern cod:

1. The rate of natural mortality may not be stable and may have increased substantially around the time of the moratorium. Uncertainty about M is a major issue for other Northwest Atlantic cod stocks (Sinclair 2001; Trzcinski et el. 2006; Swain 2010, 2011; Swain and Chouinard 2008);
2. Total fishery removals are uncertain (Halliday and Pinhorn 1996; Hutchings and Myers 1995; DFO 2013) , most recently with respect to recreational fishery removals which are not directly estimated (DFO 2013 and other SARs); and
3. The survey catchability parameter (*q*) should be constant over time if survey trends are to be used to directly infer stock trends; however, there is evidence of distributional changes in Northern cod that indicate *q* for the DFO RV survey changed substantially during at least portions of the post-moratorium period (Brattey et al. 2008b, Cadigan 2015, Rose et al. 2011).

The current assessment was based on a new integrated state-space population dynamics model developed specifically for Northern cod (NCAM). This new model integrates much of the existing information about the productivity of the stock (Cadigan 2015). This model addresses the three main problems described above. Key features of the new NCAM model are that rather than assuming a level of natural mortality (M) it provides annual estimate of *M* and fishing mortality (*F*) along with measures of uncertainty and several sources of data are integrated (see below). The model also estimates the catch, rather than assuming that reported landings are an exact measure of catch. An interval identifying a likely range of catch (lower and upper bounds) is specified and this interval was determined during discussions with stakeholders present at the assessment meeting (see below). The new model also provides estimates of the catchability parameter (*q)* across ages for the survey indices, including a multiplicative adjustment to *q* for the autumn DFO RV survey to account for a shift in distribution of Northern cod during 1995-2009.

DATA INPUTS FOR NCAM

The original NCAM assessment model and subsequent changes following recommendations of 2015 Northern Cod Framework Review (DFO 2016b) are reported elsewhere (Cadigan 2015, 2016a, DFO 2016b). For brevity only the data inputs used in the final assessment model are described herein, along with any changes in how these inputs were used relative to the original and updated versions of NCAM.

The NCAM model uses the following data sources: age-disaggregated information from the autumn DFO offshore bottom-trawl survey (ages 2-14, 1983-2015), inshore Sentinel 5½” mesh gillnet index (ages 3-10, 1995-2014), inshore acoustic biomass estimates (1995-2009), fishery catch age-composition information (ages 2-14, 1983-2015), partial fishery landings information (1983-2015) including catch bounds and monthly landings, and tagging information (1983-2014) including reporting rates. Model process errors and observation equations are included for all data sources, and NCAM provides estimates of population parameters and variance parameters as well as modelled 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)

Autumn DFO Research Vessel (RV) survey

The main source of information on trends in the status of Northern cod is the autumn DFO RV survey. This survey is based on a stratified random design, has a long time-series (1983-2015), captures a broad range of ages, and covers a large portion of the stock area. This survey is not intended to provide a direct estimate of stock size, but can provide an age-disaggregated index of stock size which can be used to scale the entire population provided the catchability coefficient *q* can be estimated for each age class in the population. Some cod can be outside the surveyed area, such as in shallow coastal water (e.g. small juveniles), or in deep water off the shelf edge, but provided there is no trend in the proportion of the population outside the area surveyed (see below), the survey can still be used to infer stock trends.

Cadigan (2015) describes in detail how the DFO RV index was used in the original formulations of NCAM. The following model changes were made for the current assessment, following recommendations of a framework review (DFO 2016). Notably, the DFO RV index time series was extended to include the results of the latest (2015) survey and the age range was expanded to include ages 2-14 with no plus group. The survey catchability (q) was constrained to be equal for ages 6 to 14 (Fig. A1-2) and the 2004 DFO RV index was not used because of problems with survey coverage. Other changes are outlined in Cadigan (2016a). The data for ages 2-14 of Table 13d (age-disaggregated DFO RV survey index values) were used in NCAM.

Inshore acoustic biomass estimates and DFO RV survey catchability parameter (*q*).

Following the collapse of the stock in the early-1990s, there is evidence from several sources that *q* changed for Northern cod, through a distributional shift of the remnant stock to inshore regions that are not part of the autumn DFO RV survey area. A relatively large aggregation of cod was observed in Smith Sound, Trinity Bay (3L) in the spring of 1995 (Rose et al. 2011). Subsequent surveys in winter and spring gave acoustic biomass estimates ranging from 10,000 to 26,000 t during 1995-2007, but the biomass estimates declined rapidly during 2007-09 to less than 1,000 t. Conventional tagging experiments and acoustic telemetry of cod in Smith Sound and neighbouring areas indicated overwintering cod in Smith Sound dispersed around the coast in late spring and summer (Brattey et al. 2008b, 2011; Brattey 2013) and returned to Smith Sound in autumn. Furthermore, these studies showed that the decline in biomass during 2007-09 was not due to fishing mortality or natural mortality, but was more likely a redistribution of these cod to other areas including the offshore. The autumn DFO RV survey indicated that biomass of cod in the offshore was increasing, particularly for older cod, when the Smith Sound biomass was declining and further acoustic telemetry and conventional tagging of offshore cod released in 2008 confirmed that the seasonal shoreward migration of offshore cod was taking place, similar to the pattern observed in the pre-moratorium period. Cadigan (2015) concluded that this change in migration was highly plausible and should be included in the stock assessment model through estimation of a multiplicative q at age adjustment for the DFO RV survey during 1995-2009. The size of the Smith Sound component of the stock was estimated using published (Rose et al. 2011) acoustic biomass estimates (see Table 19) with samples (trawl and hand-line) taken during the acoustic survey providing age composition information (see Table 20).

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 autumn 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 Maddock Parsons (2014) who extended the time series to 2012. The primary goal of these surveys was to obtain information on trends in 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 the biology of cod in the inshore, including age compositions, size at age, condition, maturity and feeding.

An age-disaggregated index of standardized catch rates for cod in the inshore of 2J3KL was calculated from data gathered from sentinel fishing with gillnets (3¼" and 5.½"mesh) and line-trawls (Stansbury et al. 2000). The methodology for calculating the index and full details of the sentinel fishery are described elsewhere (Maddock Parsons 2014 and references therein). For the current assessment, the time series of standardized catch rates was extended to 2014 (data for 2015 were not available at the time of the assessment). The sentinel survey catchability (q) was dome shaped increasing with age to a maximum at age 7 and age 8 and decreasing thereafter (Fig. A1-2). The standardized age-disaggregated catch rate index (fish/net, ages 3-10) from 5½" mesh gillnets was updated and result from 1995-2014 was used as an index in NCAM (Table 21).

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 fishing mortality rates in many assessment models; however, in NCAM the catch data was treated somewhat differently, with separate likelihood components for the total removals (with bounds, see below) and the catch proportions at age based on sampling of commercial (and recreational) landings. Cadigan (2015) notes that sampling protocols for Northern cod are complex and have changed over time and that it is not possible to evaluate the statistical properties of the catch age-composition information. The procedure used in NCAM to model age composition information is complex and based on the continuation-ratio logit, which has been used to model length and age distributions. In this procedure a variance parameter for age proportions was estimated (σ_P), then additional ad-hoc adjustments are made (more variance for younger [age ≤2] and older [age ≥8] ages) to account for residual variability in these ages. The total landings from 1983-2015 in the second last column of Table 1 and catch-at-age (Table 10, ages 2 -14) converted to proportions with zeros replaced (see Cadigan 2015), were used as inputs to NCAM and model predicted estimates of catch biomass generated. Model predicted total landings were derived from mid-year stock weights at age, summed over ages 2-14. Mid-year stock weights were estimated using a growth model described in Cadigan (2016b).

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 sized-based price-differentials are in place. In the post-moratorium period, determination of the recreational catches have also been a concern, as recreational catches are difficult to estimate and for Northern cod no standard procedures are in place to do so. The magnitude of these potential biases in overall catch reporting and how they change over time have not been quantified for Northern cod.

For the current assessment model, an interval was required for the likely range of catch (C) through According to Cadigan (2015) this approach is better than simply assuming an exact catch or ad-hoc adjustment of reported landings. Note that NCAM estimates catch almost freely within these bounds unless there is strong indication otherwise based on all other input data and entire model structure. A censored likelihood approach was used to ensure the estimated catch could be estimated almost freely within the specified range but could only exceed the bounds by a small amount without significant cost in the likelihood function (see Cadigan 2015).

Participants at the 2016 assessment meeting agreed that potential catch inaccuracies for Northern cod likely varied over time and decided to consider three time periods based on different fishery dynamics through the pre- and post-moratorium period, as well as different states of knowledge about potential catch inaccuracies. The three time periods were:

1. A pre-moratorium period (1983-91) when catches were high;
2. An early post-moratorium period (1992-2005) when there were small inshore commercial fisheries and recreational fisheries; and
3. A recent period (2006-15) 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. Period (3) also included short seasonal recreational fisheries.

There are no direct estimates of these 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 2016). For all three time periods the lower catch bound (C_L) was considered by the meeting to be 10% above reported landings. This value was arbitrary but given the potential for discards and misreported landings, 10% seemed reasonable. The catch bounds were as follows: 1983-91 [C_L, C_U]=[1.1, 1.5] with the upper bound to account mainly for discards and non-Canadian misreporting, 1992-2005 [C_L,C_U] =[1.1, 2] with the higher upper bound to account for the period of no DMP and more variable catch. During 2006-15, the lower bound (C_L) was again fixed at 1.1, but annual estimates of the upper bound (C_U) were made through differing adjustment up from reported commercial landings. Computation of C_U for 2006-15 was based on a simple formula:

$$C_U = 1.1 * 1.3 * 1.1 * (\text{Commercial/Total})$$

The rational 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 confirmation of estimated weights on Dockside Monitoring Program authorization numbers. The second factor (1.3) was an adjustment to account for recreational fisher landings, where analysis of tag returns indicated that recreational landings were on average about 30% of reported commercial landings. A third upward adjustment of 1.1 was included to account for other issues such as tagging estimates being based on numbers rather than weight and a general consideration that it was better to have the interval too wide rather than unreasonably narrow. The final ratio term (commercial/total) ensured that scaling factors were applied appropriately depending on whether estimates of recreational landings were already included in the total reported catch (i.e. 2007, 2009-10, and 2011-13). Thus, for years with no recreational landings estimate in the total reported catch, C_U=total reported catch x 1.573, but if estimated recreational catch was already included the adjustment is proportionally less. Note that the catch bounds used in the assessment were slightly different from those used in earlier formulations of NCAM (Cadigan

2015, 2016a) where the upper bound was double reported catch (Table 1). Table 1 summarizes the annual estimates of reported catch from various sectors of the fishery and the values of C_L and computed values of C_U using the formula above.

Table 1. Annual estimates of reported catch and their associated lower catch bounds (C_L) and upper catch bounds (C_U) from 2006-2015.

Year	Commercial Offshore Catch (t)	Commercial Inshore Catch (t)	Recreational Catch (t)	Sentinel Catch (t)	Total Reported Catch (t)	C_L	C_U
2006	22	2,140	380	159	2,701	1.100	1.352
2007	13	2,364	-	182	2,559	1.100	1.573
2008	42	3,089	1089	254	4,474	1.100	1.190
2009	18	2,882	-	216	3,116	1.100	1.573
2010	60	2,693	-	209	2,962	1.100	1.573
2011	292	2,872	289	214	3,667	1.100	1.449
2012	132	3,032	433	271	3,868	1.100	1.497
2013	135	4,001	-	275	4,411	1.100	1.573
2014	112	4,290	-	276	4,678	1.100	1.573
2015	67	4,167	-	268	4,502	1.100	1.573

Tagging

For Northern cod an extensive time-series of mark-recapture information is available which has the potential to provide valuable information about changes in F and M. The tagging data are in two parts. The earlier (i.e. pre-1997) tagging data are summarized in Taggart et al. (1995) and were analyzed by Myers et al. 1996, 1997. The more recent tagging data begin in 1997 and are reported in Brattey and Healey (2007) with the most recent tag return data (2007-14) provided directly by DFO.

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 Z were applied in the year of release; the fraction of fishing that occurred was estimated from a table of monthly landings (Table 7) and this is an improvement over the procedure used in previous versions of NCAM. The population of tagged cod from an experiment diminishes over time due to a combination of initial tagging mortality, tag loss, as well as fishing and natural mortality. For all experiments during 1983-2014 irrespective of capture gear type, short-term tagging survival was assumed to be 97% for tag releases in November-June, and 78% for those during July-October (Brattey and Cadigan 2004).Tag loss was estimated using double tagging and applied using Kirkwood’s model (Kirkwood 1981) with parameter estimates as described in Brattey and Healey (2007). Harvesters do not return the tags from all they fish that are captured, consequently reporting rates have to be estimated and this was achieved using a high-reward tagging scheme initiated in 1997. Tag reporting rates for Northern cod have been extensively studied (Cadigan and Brattey 2006; Konrad et al. 2016) and for the 1997 experiments onwards, annual reporting rates estimated in Konrad et al. (2016) were used as fixed constants in the original formulation of NCAM to adjust the number of tags returned annually to total numbers caught annually. However, in the current assessment formulation of NCAM reporting rates and uncertainties were estimated directly within NCAM. This was achieved by considering reporting rates in NCAM 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.

With tag return data, estimates of tag returns in the year of release often differ substantially from the numbers observed and this can be due to a combination of non-mixing of tagged fish and local changes in F which is a well-known problem in tagging analyses (Hoenig et al. 1998). The original formulation of NCAM may have over- or under-estimated M in accounting for these differences in the release year. A solution to this potential problem was to modify NCAM such that a random effect was included in the F used to estimate tag returns in the release year, to account for incomplete mixing. The F in the release year for each tagging experiment was allowed to vary from the overall stock F to account for possible under- or over-exploitation of tagged fish due to incomplete mixing.

Cadigan (2015) described a procedure for generating age-aggregated information from tagging so the recapture data could be used in an age-based assessment model such as NCAM. However, the procedure limited the number of cohorts that provided useful information. In the current assessment model a different procedure was used, where the age composition of the tagged fish was estimated and then tag returns by experiment and age at capture modelled for successive years at liberty. The estimation of the age of tagged fish is described in Cadigan and Konrad (2016). The tagging data from 1997 onwards used in the assessment model comprised reported tag recaptures for years at liberty 0-9, by experiment and age-at-release for tagging conducted in 2J3KL during 1997-2014. This is substantially more tagging data than was used in the original version of NCAM (Cadigan 2015). Only experiments with >70 fish tagged in total and only experiments and ages with ≥10 fish tagged were used. For the pre-1997 tagging data (i.e. 1983-96) similar selection criteria were used, except that only years at liberty 0-5 were available. In addition, there are no suitable data to estimate reporting rates for the pre-1997 tagging experiments and a composite parameter (θ in Myers et al. 1996) combining tag reporting rates, additional initial tagging mortality, and short-term tag loss, was estimated for each experiment separately within NCAM. Overall, with respect to the tagging data, the main differences between the original version of NCAM and the formulation used in the assessment are: the use of age-disaggregated tag catch data; the amount of *F* applied in the year of release; addition of a random effect in F to estimate tag returns in the release year; the years of tagging data used (extended to 2014); and the estimation of tag reporting rates within NCAM. Tag returns for each experiment are modelled using a simplified assessment model (Baranov catch equation) that treats tag catch-at-age the same as fishery catch at age, except that the tag catch-at-age comes from an initial population whose size is known (number of tagged cod released). Further technical details are described in Cadigan (2015, 2016a). Some addition technical changes to the final formulation of NCAM (e.g. baseline M's, F auto-correlation, and recruitment deviations) are outlined in the Proceedings (DFO 2016b). Several additional formulations and updates of the original NCAM model were also presented at the Northern cod Framework Review Meeting (Cadigan 2016a) to illustrate potential sensitivity of model results to assumptions.

RESULTS FROM NCAM

Several sensitivity runs of NCAM were carried out and reviewed during the assessment meeting based on recommendations from the framework meeting in 2015 (DFO, 2015). These are further outlined in the proceedings document from this meeting (DFO 2016).

Results from four formulations of NCAM were presented at the Northern cod assessment (Table 22). The first formulation (labelled S1 Mshift) was based on the catch bounds used in the original formulation of NCAM, whereas for the other three runs the revised catch bounds developed during the assessment (described above) were used. The three formulations with the new catch bounds involved different treatments of M's (Table 23; baseline M's, median M's and Mshift). These three formulations gave broadly similar results for stock size and mortality rates, but resulted in some substantial changes in NCAM estimates of total catch weight compared to the S1 Mshift run. Framework reviewers suggested that baseline M values used in NCAM should be changed to be consistent with M estimates produced by NCAM and this formulation (labelled Run 1, baseline M's) did not result in much difference in model estimates for the historic data period, but did result in substantially different projections. These changes were much less when the baseline M's were the age-specific medians of the previous estimates (labelled Run 2, median M's) and a formulation using median baseline M's was considered a better formulation. Within NCAM, M is modelled as auto-correlated random effects (over ages and years). Process error variance in M is fairly large and is an important source of variability in projections. A key issue is the large M-deviations in 1991-94 that contribute to the M process error variation. It is unclear whether M changes of similar magnitude to those of 1991-94 will occur again in the short term and a plausible way to remove this source of variation is to use higher baseline M's for 1991-94 compared with other years. This change was applied in the final formulation of NCAM (labelled Run 3, M-Shift) and resulted in slight improvement in overall model fit and a small reduction of M process error standard deviation. Thus, the M-shift formulation was used as the final assessment model formulation to assess the status of the stock and to conduct projections for harvest advice (see below).

Several NCAM fit diagnostics to the various data sources were also presented at the assessment and these demonstrated that overall 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 are given in Appendix A1 (Figs. A1-1 to A1-10).

Stock size and mortality rates

Trends in stock size and mortality rate estimates from the final formulation of NCAM are illustrated in Fig. 25 and estimated values summarized in Appendix A2 (Tables A2-1 to A2-7). The abundance of Northern cod remained low for more than a decade after the collapse and moratorium in 1992, but increased in the past decade, from 194 million in 2005 to 894 million (95% CI, 636-1256) in 2015 (Fig. 25; top row, left panel). Recruitment (age 2) in the 1990s and 2000s has been poor compared to the 1980s, but improved slightly in the last decade and the average number of age 2s from the 2011-13 year classes corresponds to about 25% of the average numbers of age 2s observed in year classes of the 1980's. Total biomass (ages 2+) shows a similar trend to abundance and increased from 78 Kt in 2005 to 539 Kt (95% CI, 444-654) in 2015 (Fig. 25; third row, left panel). Spawning stock biomass declined rapidly in the late-1980s and early-1990s and has remained low but shows an increasing trend in the last decade. Spawning stock biomass has increased from 25 Kt in 2005 to 300 Kt (95% CI, 246-362 Kt) in 2015 (Fig. 25; second row, left panel, dashed lines). Spawning stock biomass has been well into the critical zone of the Precautionary Approach Framework since the stock collapse, but has increased from 3% of B_{lim} in 2005 to 34% of B_{lim} in 2015 (95% CI, 28-40%) (Fig. 25; fourth row, left panel).

Fishing mortality (*F*) has been highly variable during 1983-2015 (Fig. 25, first and second rows, right panels). Averages F's for ages 4-6 and 7-9 show similar trends and were higher in the 1980s and during 1998-2002, but declined abruptly when the moratorium was imposed in 1992 and again when an inshore fishery was closed in 2003. Values for *F* on older ages (ages 7-9) were higher than those for ages 4-6, particularly just before the moratorium (*F*=0.4 for older ages). Directed inshore fisheries for cod have continued throughout most of the post-moratorium period. Fishing mortality was low (<0.10) for both age groups during 1995-97 when inshore fishing was highly restricted, but increased rapidly reaching close to pre-moratorium values (*F*~=0.3) for ages 7-9 when a directed inshore fishery for cod was reopened in

1998-2002. Closure of the directed inshore fishery in 2003-2005 resulted in a substantial reduction in *F* to <0.1. More recently, *F* has remained low and declined even further, to about 0.02 in 2015 in spite of increased inshore catches during the ongoing directed inshore commercial and recreational fisheries (see trends in reported landings in Fig. 5).

The rate of natural mortality (*M*) has been variable during 1983-2015 (Fig. 25, third row, right panel), ranging from 0.3 to 0.5 in the early to mid-1980s, increasing rapidly to a peak of 2.5 during 1992-94, then declining to approximately 0.35 during 1995-99. Additional periods of high *M* are evident in 2000-03 (*M*=0.7 to 0.9) and 2009-10 (*M*=0.6 to 0.7). Recent values of *M* have been declining, from 0.70 (equivalent to an annual reduction of 50%) in 2010 to 0.28 (equivalent to an annual reduction of 24%) in 2015. Trends in Z (Fig. 25; bottom right panel) have been variable but follow the general pattern observed for F, with *Z* averaging ~0.6 in the 1980s followed by a high peak of *Z*~=2.5 in 1991-93 and subsequent smaller peaks in 1998-2001 and 2009-10.

These results on the relative magnitudes of *F* and *M* around the time of the moratorium are different from published studies (e.g. Hutchings and Myers 1995; Myers et al. 1996, 1997) on the causes of the stock collapse. In the NCAM model the rate of natural mortality (*M*) is estimated and information from tagging is integrated directly into the model, whereas in previous population dynamics models of Northern cod *M* was an assumed constant value (typically *M*=0.2) and tagging data were analyzed separately. The current model can assign the sudden disappearance of cod from the DFO RV survey to either *F* or *M*, but to be consistent with the existing tagging data the model assigns the much of the mortality to *M*. However, if there was unreported catch by Canadian and/or non-Canadian fleets and tags from these fish were not returned, then a portion of the *M* estimated in the current analysis would actually be *F*. Investigations on the relative size of *F* versus *M* leading up to the moratorium are continuing.

Overall, NCAM gave estimates of *M* that were variable over time with an extremely high peak at the time of the moratorium and these results generated considerable discussion, both at the Framework review at the assessment meeting. Various additional formulations of NCAM were run to explore this issue, including changing baseline *M* values, and running NCAM formulations with no change in *M* but much wider catch bounds and more catch measurement error, but none of these analyses provided support for the notion that *M* was fairly constant. In addition, estimates of *M* were relatively imprecise across the entire time period; in 2015, the CV on M for the final run was 31%. Diagnostic runs of NCAM with various *M* values indicated that baseline *M* input does not significantly alter current stock size estimates, but does impact the historical estimates of stock size and stock projections.

Projections

Projections were conducted to meet the Terms of Reference objectives for 2016 Northern cod assessment and the specified objectives were:

1. Identify the maximum level of annual removals that will enable a 50% growth in SSB over 2016-20 years with a high probability (>75%) of success; and
2. Provide three year management advice covering the period April 1, 2016 – March 31, 2019.

Three-year projections (to 2018) were conducted to investigate the potential impact of a range of catch options from zero catch (no fishing) to a fivefold increase in catch. Issues regarding the wisdom of five year projections (to 2020) as requested in the Terms of Reference are described below. Three-year projections were based on multiplicative adjustment (again, from 0 to five-fold increase) of the model estimate of catch for 2015 (6,900 t). The age-pattern in *F* values was assumed to be the same as in 2015. Natural mortality rates for the projection period were calculated internally by NCAM. Because *M* process errors are assumed to be auto-correlated across ages and years, projections of *M* will gradually converge on the long term mean. This results in a progressive increase in *M* during the projection period as recent values of *M* are lower than the long-term average. Projected recruitment, stock weights (from cohort model weights), and proportions mature were assumed to be equal to the geometric mean of their 2013-15 values. Assumed recruitment (age 2) has minimal impact on the projected SSB as these fish have barely matured and contributed little to the spawning biomass by the end of the three year projection period.

The future dynamics of Northern cod are difficult to predict and when five-year projections were run CVs were extremely high and results not considered reliable for management advice. A five-year projection window is influenced by recruitment that has not been observed and is highly uncertain, whereas three-year projections use observed recruitment values. As a consequence of the unacceptably high uncertainty in five-year projections, the five-year growth target (50% SSB increase) was converted to an equivalent interim growth milestone over a three year period (28% SSB growth) and the probability of achieving this equivalent was evaluated for the full range of catch options considered (0 to 5 times current catch). The results indicated a high probability (≥85.1%, see below) of achieving the 28% growth milestone over the full range of catch options.

The terms of reference for the current assessment lacked reference to the probability of exceeding the LRP for this stock, which is defined as B_{lim} or the average spawning stock biomass observed in the 1980s (DFO 2011b). Spawning Stock Biomass in 2015 was estimated to be 34% of B_{lim} and the probability of projected SSB exceeding the B_{lim} level were requested by assessment meeting participants (Table 2).

Table 2. Probability of SSB exceeding the LRP at various catch multipliers over a three year projection period.

Projections	0 Catch Multiplier	1 Catch Multiplier	2 Catch Multiplier	3 Catch Multiplier	4 Catch Multiplier	5 Catch Multiplier
Probability (in %) of achieving 28% growth target by 2018	92.9	91.7	90.3	88.7	87.0	85.1
Risk (in %) of SSB declining below 2015 value	1.0	1.3	1.7	2.1	2.6	3.3
Probability (in %) of exceeding B_{lim} in 2018	7.9	7.1	6.5	5.9	5.3	4.8
SSB in 2018 as a % of B_{lim}	66.2	64.9	63.6	62.3	60.9	59.6

The projections indicate a low risk (<4%) that SSB will decline by 2018 to below the 2015 value, but also a low probability (5-8%) that the stock will grow out of the critical zone and exceed B_{lim} in 2018. The stock is projected to grow but still be much less than B_{lim} (60-66%) and remain in the critical zone in 2018 over the full range of catch options considered, including no fishing.

The estimated growth rate of the SSB under the three-year projections corresponds to at least 30% growth per year which is slightly higher than the maximum growth rate for Atlantic cod and therefore is unlikely to be sustained in the longer term. Short periods of high growth can occur when mortality rates are low and/or pulses of strong recruitment appear, but recruitment in Northern cod has typically been episodic and the growth rate observed in the projection results likely does not represent a sustained growth rate for the stock. High growth would also require a considerable forage biomass (i.e. capelin) to sustain the growing stock and the short-term outlook for the capelin stock is not optimistic (DFO 2016b).

Management Advice

The estimated SSB for Northern cod has been well below the LRP since the early-1990s. Although the status of the stock is improving, the estimate of 2015 SSB is 34% of B_{lim} and is therefore in the lower half of the critical zone. At current levels of SSB the stock is considered to have suffered serious harm and the ability to produce good recruitment is seriously impaired. When the stock is at such a low level management actions should focus on promoting increases in SSB until the stock is more resilient to the effects of fishing.

The recent increase in stock size is due to marginally stronger year–classes contributing to the SSB, a decrease in natural mortality rates and low fishing mortality rates. Projections to 2018 indicate that over a wide range of catch multipliers the SSB has a low risk (<4%) of declining below the 2015 value. However, the stock also has a low probability (5-8%) of reaching the LRP within the next three years. Consistency with the DFO decision-making framework incorporating the precautionary approach (DFO 2009) requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone.

The peak in *M* estimated for the period around the time of the moratorium raises the issue of whether this peak is likely to be repeated and if so how frequently. Historical information about Northern cod suggests that large scale changes in stock size have occurred in the past due to natural events rather than fishing, but these have been rare and in broad terms on a century scale rather than decadal scale or less. Nonetheless, the results of the current assessment suggest that *M* can vary considerably over time and given that the mechanism for changes in *M* are currently not well understood, a prudent way for fisheries managers to consider this information would be to acknowledge this variability and limit exploitation such that sufficient biomass is left to make the stock more resilient to the impact of changes in *M*.

Indicators and procedure to trigger full assessment during interim years

The Northern cod stock is currently on a three-year management cycle and an objective of this schedule is to reduce time and resources spent on assessments that could result in no changes in scientific advice to management. A key goal of the assessment meeting was to identify stock status indicators that could be provided from interim updates conducted during periods when there is no full assessment scheduled. Stock updates are currently scheduled for March 2017 and March 2018. Previous stock updates that fell between assessment years have typically updated multi-species survey indices, sentinel indices and tagging. This requires considerable effort, particularly where thousands of otoliths have to be read and a catch-at-age or survey index SSB calculated, and this level of detail is typically not available until March when a full assessment would normally be conducted anyway.

At the assessment, several potential interim metrics of stock status or indicators of future stock performance were considered. The role of environment or prey conditions was discussed but it was unclear what thresholds could be set on environmental variables. A measured decline in capelin biomass and/or reported fisheries removals that are above modelled values were also considered but no clear threshold could be identified at the meeting and there was concern that high natural variability in annual capelin biomass might obscure an underlying signal. There was general agreement that capelin are a key high-quality prey for cod and the cod-capelin trophic relationship could provide useful information when considered in combination with other assessment triggers. Large changes in cod stock distribution were also discussed but it was concluded that it was difficult to establish a meaningful threshold for changes in distribution.

It was generally agreed that total observed cod biomass (ages 2+) from the autumn DFO RV survey provides a reasonable metric of stock status that covers most of the stock area and is available in a reasonable timeframe that could be used as an interim year indicator. An interim indicator value would typically need to be available by early January, as this would allow sufficient time to prepare a full assessment and plan the peer review for the following March if the indicator signals that a full assessment is warranted.

Following examination of stochastic projection results from NCAM of autumn DFO RV survey total (2+) biomass for various catch multipliers (0-5x), it was agreed that a full assessment before the scheduled three-year cycle will be triggered if the autumn DFO RV survey total observed (2+) biomass is outside the 75% confidence intervals (CI) of the projected RV biomass value from NCAM for 2016 or 2017 (Fig. 25, upper panel). The 75% CI threshold was chosen over wider CIs to provide greater sensitivity to resource changes; uncertainty in projected biomass is large and substantial changes in survey biomass will not automatically trigger an assessment. Note that survey values were projected using the same settings used to project SSB.

For example, if there was no change in catch in 2016 (i.e. catch multiplier=1 or 6,900 t), the DFO RV survey biomass in autumn 2016 is projected to be 22% higher than in 2015 with 75% CI of 0.9% and 49% (Fig. 25, upper panel) If the catch in 2016 was double the 2015 value (catch multiplier=2) the projections results change slightly, and the DFO RV survey biomass in autumn 2016 is projected to be 20% higher than in 2015 with 75% CI of -0.3% and 45% (Fig. 25, lower panel). A survey biomass outside the respective ranges for either catch multiplier would trigger a full assessment. Projected values from the current assessment can only be used to evaluate the trigger if the harvest level does not change during the interim years as each projection scenario assumes a constant catch. The NCAM estimates of actual catches can differ substantially from the reported catches and are influenced by the assumed catch bounds. In projections, catch multipliers are applied to the estimated catches from the model, not the reported landings.

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TABLES

Table 3. Reported landings (t) of cod from NAFO Divs. 2J3KL from 1959 onward.

Year	2J Offsh. mobile gear (Can)	2J Offsh. mobile gear (Other)	2J Fixed gear (Can)	2J Total	3K Offsh. mobile gear (Can)	3K Offsh. mobile gear (Other)	3K Fixed gear (Can)	3K Total	3L Offsh. mobile gear (Can)	3L Offsh. mobile gear (Other)	3L Fixed gear (Can)	3L Total	2J3KL (Can)	2J3KL (Other)	2J3KL overall Total	2J3KL TAC (000's t)
1959	0	46,372	17,533	63,905	0	97,678	56,264	153,942	4,515	51,515	85,695	141,725	164,007	195,565	359,572	-
1960	1	164,123	15,418	179,542	53	74,999	47,676	122,728	7,355	63,985	94,192	165,532	164,695	303,107	467,802	-
1961	1	243,144	17,545	260,690	0	64,023	31,159	95,182	4,675	73,899	70,659	149,233	124,039	381,066	505,105	-
1962	0	226,841	23,424	250,265	0	47,015	42,816	89,831	4,383	90,276	72,271	166,930	142,894	364,132	507,026	-
1963	1	197,868	23,767	221,636	0	79,331	47,486	126,817	4,446	83,015	73,295	160,756	148,995	360,214	509,209	-
1964	13	197,359	14,787	212,159	0	121,423	40,735	162,158	10,158	142,370	75,806	228,334	141,499	461,152	602,651	-
1965	0	246,650	25,117	271,767	21	50,097	26,467	76,585	7,353	130,387	58,943	196,683	117,901	427,134	545,035	-
1966	39	226,244	22,645	248,928	13	58,907	32,208	91,128	8,253	120,206	55,990	184,449	119,148	405,357	524,505	-
1967	28	217,255	27,721	245,004	114	78,687	24,905	103,706	13,478	200,343	49,233	263,054	115,479	496,285	611,764	-
1968	4,650	355,108	12,937	372,695	1,849	119,778	40,768	162,395	15,784	211,808	47,332	274,924	123,320	686,694	810,014	-
1969	30	405,231	4,328	409,589	56	80,949	24,923	105,928	18,255	151,945	67,973	238,173	115,565	638,125	753,690	-
1970	0	212,961	1,963	214,924	92	78,274	21,512	99,878	14,471	137,840	53,113	205,424	91,151	429,075	520,226	-
1971	0	154,700	3,313	158,013	31	61,506	21,111	82,648	11,976	148,766	38,115	198,857	74,546	364,972	439,518	-
1972	0	149,435	1,725	151,160	7	133,369	14,054	147,430	4,380	109,052	46,273	159,705	66,439	391,856	458,295	-
1973	1,123	52,985	3,619	57,727	108	159,653	13,190	172,951	1,258	97,734	24,839	123,831	44,137	310,372	354,509	666
1974	0	119,463	1,804	121,267	19	149,189	10,747	159,955	880	67,918	22,630	91,428	36,080	336,570	372,650	657
1975	410	78,578	3,000	81,988	189	112,678	15,518	128,385	670	53,770	22,695	77,135	42,482	245,026	287,508	554
1976	94	30,691	3,851	34,636	771	79,540	20,879	101,190	2,187	40,998	35,209	78,394	62,991	151,229	214,220	300
1977	525	39,584	3,523	43,632	1,051	26,776	28,818	56,645	5,362	26,799	40,282	72,443	79,561	93,159	172,720	160
1978	4,682	17,546	6,638	28,866	7,027	6,373	29,623	43,023	9,213	12,263	45,194	66,670	102,377	36,182	138,559	135
1979	9,194	6,537	8,445	24,176	21,572	16,890	27,025	65,487	14,184	12,693	50,359	77,236	130,779	36,120	166,899	180
1980	13,592	7,437	17,210	38,239	21,920	6,830	37,015	65,765	15,523	13,963	42,298	71,784	147,558	28,230	175,788	180
1981	22,125	4,760	14,251	41,136	23,112	3,847	23,002	49,961	21,754	15,070	42,827	79,651	147,071	23,677	170,748	200

Year	2J Offsh. mobile gear (Can)	2J Offsh. mobile gear (Other)	2J Fixed gear (Can)	2J Total	3K Offsh. mobile gear (Can)	3K Offsh. mobile gear (Other)	3K Fixed gear (Can)	3K Total	3L Offsh. mobile gear (Can)	3L Offsh. mobile gear (Other)	3L Fixed gear (Can)	3L Total	2J3KL (Can)	2J3KL (Other)	2J3KL overall Total	2J3KL TAC (000's t)
1982	58,384	8,923	14,429	81,736	8,881	4,074	42,141	55,096	27,181	9,271	56,490	92,942	207,506	22,268	229,774	230
1983	3,7276	4,158	10,748	52,182	31,621	2,815	40,683	75,119	39,123	10,920	55,001	105,044	214,452	17,893	232,345	260
1984	9,231	2,782	13,150	25,163	48,114	11,059	35,143	94,316	47,668	15,973	49,351	112,992	202,657	29,814	232,471	266
1985	1,466	78	10,211	11,755	68,880	12,945	30,368	112,193	36,863	31,176	39,306	107,345	187,094	44,199	231,293	266
1986	5,734	7,859	12,916	26,509	62,086	5,781	28,384	96,251	57,805	53,946	32,202	143,953	199,127	67,586	266,713	266
1987	39,344	3,999	16,022	59,365	39,686	6,160	27,442	73,288	44,612	25,916	36,743	107,271	203,849	36,075	239,924	256
1988	41,468	9	17,112	58,589	40,260	50	33,820	74,130	57,805	26,748	51,405	135,958	241,870	26,807	268,677	266
1989	33,626	1,003	23,304	57,933	37,350	1,179	20,711	59,240	40,958	36,621	59,238	136,817	215,187	38,803	253,990	235
1990	17,883	183	14,505	32,571	26,920	504	27,516	54,940	31,187	25,488	75,266	131,941	193,277	26,175	219,452	199
1991	621	82	22,14	2,917	30,112	311	13,332	43,755	30,264	49,660[2]	45,416[3]	125,340	121,959	50,053	172,012	190
1992	0	0	18	18	584	273	884	1,741	13,627	14,610[4]	10,960[5]	39,197	26,073	14,883	40,956	0
1993	0	0	13	13	0	0	541	541	2	2,425[6]	8,411[7]	10,838	8,967	2,425	11,392	0
1994	0	0	9	9	0	0	368	368	0	1	936	937	1,313	1	1,314[8]	0
1995	0	0	0	1	0	0	122	122	1	0	290	290	413	0	413[9]	0
1996	0	0	3	3	0	0	961	961	1	1	908	910	1,874	1	1,875[10]	0
1997	0	0	4	4	0	0	280	280	0	0	592	593	877	0	877	0
1998	0	0	16	16	0	0	1,994	1,994	1	6	2,491	2,497	4,501	0	4,507	4
1999	0	0	33	33	0	0	3,554	3,554	0	1	4,938	4,939	8,525	1	8,526	9
2000	0	0	3	3	0	0	1,410	1,410	26	54	3,937	4,017	5,376	54	5,430	7
2001	0	0	21	21	0	0	1,736	1,736	7	82	5,124	5,212	6887	82	6,969	5.6
2002	0	0	13	13	0	0	647	647	3	53	3,533	3,589	4196	53	4,249	5.6
2003	0	0	2	2	0	0	29	29	3	23	937[11]	963	971	23	994	0
2004	0	0	3	3	0	0	152	152	6	6	482	494	643	6	649	0
2005	0	0	6	6	1	0	555	556	1	1	767	769	1,330	1	1,331	0
2006	0	0	65	65	5	0	1,103	1,109	0	22	1,506	1,528	2,679	22	2,701	0[13]
2007	0	0	71	71	0	0	1,178	1,178	0	13	1,668	1,682	2,918	13	2,931	0[13, 14]

Year	2J Offsh. mobile gear (Can)	2J Offsh. mobile gear (Other)	2J Fixed gear (Can)	2J Total	3K Offsh. mobile gear (Can)	3K Offsh. mobile gear (Other)	3K Fixed gear (Can)	3K Total	3L Offsh. mobile gear (Can)	3L Offsh. mobile gear (Other)	3L Fixed gear (Can)	3L Total	2J3KL (Can)	2J3KL (Other)	2J3KL overall Total	2J3KL TAC (000's t)
2008	0	0	71	71	0	0	1,518	1,518	3	42	1,750	1,795	3,343	42	3,385	0[13]
2009	0	0	57	57	0	0	1,186	1,186	0	18	1,856	1,874	3,098	18	3,116	0[13, 14]
2010	0	0	64	64	12	0	1,160	1,172	0	60[12]	1,666	1,726	2,902	60	2,962	0[13, 14]
2011[1]	0	0	54	54	0	0	1,458	1,458	2	292[12]	1,964	2,258	3,478	292	3,770	0[13]
2012[1]	0	0	75	75	2	0	1,845	1,847	0	132[12]	1,817	1,949	3,739	132	3,871	0[13]
2013[1]	1	0	133	134	0	0	2,215	2,215	15	135[12]	2,007	2,157	4,371	135	4,506	0[13, 14]
2014[1]	0	0	119	119	0	0	2,326	2,326	5	112[12]	2,308	2,425	4,758	112	4,870	0[13, 14]
2015[1]	0	0	139	139	0	0	2,256	2,256	15	67[12]	1,959	2,041	4,369	67	4,436	0[13, 14]

[1] Provisional catches.
[2] Includes French catch and other foreign catch as estimated by Canadian surveillance.
[3] Figure is 4,000 t less than Can. statistics (this quantity is 3NO catch misreported as 3L).
[4] Derived from reported catch and Canadian surveillance estimate of foreign catch.
[5] Includes 5,000 t catch from the recreational fishery after the moratorium was declared.
[6] Canadian surveillance estimate of foreign catch.
[7] Includes 5,053 t estimated for the recreational fishery additional to that recorded by Canadian statistics.
[8] 1,300 t is from the food fishery; the remainder is bycatch.
[9] Includes 275 t caught in the sentinel survey and 138 t caught as bycatch.
[10] Comprised of a sentinel survey catch of 296 t, a food fishery catch of 1,155 t and bycatch of 422 t.
[11] 780 t of this catch was the result of a mass mortality in Smith Sound.
[12] NAFO Scientific Council agreed catches.
[13] There was no TAC in 2006-15 but an annual allowance per licence holder for inshore vessels.
[14] Excludes recreational fishery.

Table 4: Fixed gear landings (t) from 1975 onwards (excludes statistical areas other than Newfoundland, GN=gill net, LL= long-line, HL=handline).

Year	2J Trap	2J GN	2J LL	2J HL	2J Total	3K Trap	3K GN	3K LL	3K HL	3K Other	3K Total	3L Trap	3L GN	3L LL	3L HL	3L Total	2J3KL Total
1975	642	2,304	0	54	3,000	4,662	8,645	565	1,646	150	15,518	10,390	7,552	1,641	3,112	22,695	41,213
1976	1,022	2,787	6	36	3,851	7,056	10,666	718	2,439	28	20,879	18,404	9,066	2,904	4,835	35,209	59,939
1977	1,285	2,076	37	125	3,523	11,501	11,611	1,294	4,412	0	28,818	20,988	8,852	3,591	6,851	40,282	72,623
1978	2,872	3,376	55	335	6,638	11,329	11,445	3,647	3,202	0	29,623	23,218	9,023	5,114	7,839	45,194	81,455
1979	1,333	5,663	175	1,274	8,445	3,532	11,474	8,414	3,605	0	27,025	20,785	13,488	7,022	9,064	50,359	85,829
1980	4,679	11,414	204	913	17,210	12,732	13,549	8,059	2,675	0	37,015	12,871	11,231	9,394	8,802	42,298	96,523
1981	3,893	10,105	72	181	14,251	3,952	10,679	6,360	2,011	0	23,002	10,177	13,579	11,425	7,646	42,827	80,080
1982	4,464	9,121	114	730	14,429	16,415	17,571	6,101	2,054	0	42,141	24,248	20,295	5,704	6,243	56,490	113,060
1983	3,870	4,854	842	1,182	10,748	10,490	18,305	2,560	9,328	0	40,683	25,690	16,446	3,834	9,031	55,001	106,432
1984	5,618	6,116	379	1,037	13,150	9,957	14,362	2,499	8,325	0	35,143	23,103	14,985	3,824	7,439	49,351	97,644
1985	4,973	2,992	252	1,994	10,211	13,310	8,082	2,352	6,624	0	30,368	21,594	8,760	3,245	5,707	39,306	79,885
1986	4,373	7,804	109	630	12,916	14,555	7,626	1,555	4,648	0	28,384	15,669	9,865	2,492	4,176	32,202	73,502
1987	5,158	9,228	218	1,418	16,022	11,278	10,223	1,590	4,351	0	27,442	11,370	17,419	3,338	4,616	36,743	80,207
1988	5,907	9,183	272	1,750	17,112	16,261	11,898	935	4,726	0	33,820	22,148	18,576	4,004	6,677	51,405	102,337
1989	6,713	14,846	290	1,455	23,304	8,189	7,921	700	3,901	0	20,711	23,964	22,231	4,676	8,367	59,238	103,253
1990	3,616	9,364	653	872	14,505	11,201	7,726	3,838	4,751	0	27,516	32,158	28,936	4,545	9,627	75,266	117,287
1991	1,016	271	93	834	2,214	7,696	1,384	1,851	2,401	0	13,332	26,524	11,696[2]	1,247	5,949	45,416[2]	60,962
1992	0	0	2	16	18	27	103	9	745	0	884	1,173	1,131	16	8,640[3]	10,960[3]	11,862
1993	0	0	1	12	13	3	37	9	492	0	541	11	93	80	8,227[3]	8,411[3]	8,965
1994	0	0	0	9	9	0	8	0	359	0	367	6	38	22	870	936	1,312
1995	0	0	0	0	0	25	65	31	1	0	122	23	207	41	20	291	413
1996	0	0	0	3	3	65	184	31	680	0	959	42	335	30	501	656	1,500[4]
1997	0	2	0	0	2	57	150	63	8	0	278	71	427	42	45	585	865
1998	0	3	5	8	16	24	1,081	245	644	0	1,994	31	1,377	284	798	2,490	4,501
1999	0	20	4	9	33	14	3,080	110	350	0	3,554	35	4,469	70	365	4,938	8,525
2000	0	4	0	1	5	15	1,126	43	275	0	1,459	63	2,954	189	684	3,891	5,354
2001	0	3	1	17	21	28	796	90	822	0	1,735	175	2,844	110	1,994	5,124	6,880
2002	0	7	0	6	13	2	272	30	342	0	647	128	2,517	30	858	3,533	4,193
2003	0	2	0	0	2	0	25	4	0	0	29	0	152	4	781	937	968[5]
2004	0	1	0	0	1	0	146	5	0	0	152	0	479	2	0	481	635
2005	0	6	0	0	6	0	547	8	1	0	555	0	763	4	0	767	1,328

Year	2J Trap	2J GN	2J LL	2J HL	2J Total	3K Trap	3K GN	3K LL	3K HL	3K Other	3K Total	3L Trap	3L GN	3L LL	3L HL	3L Total	2J3KL Total
2006	0	5	0	31	35	0	856	21	203	0	1,080	5	1,004	58	439	1,505	2,621[6]
2007	0	17	2	52	71	0	783	21	374	0	1,178	6	1,112	13	538	1,668	2,917
2008	0	38	2	32	71	0	1,260	25	233	0	1,518	6	1,407	25	312	1,750	3,340[6]
2009	0	24	3	30	57	0	818	29	335	0	1,182	0	1,476	35	345	1,855	3,094[6]
2010	0	29	1	33	64	0	843	19	299	0	1,160	0	1,349	29	287	1,666	2,889[6]
2011	0	32	4	18	54	0	1,239	16	195	0	1,450	0	1,367	20	576	1,964	3,468
2012[1]	0	49	1	25	75	0	1,571	18	154	0	1,743	0	1,281	22	504	1,807	3,625
2013[1]	0	99	0	34	133	0	2,075	14	114	12[7]	2,203	14	1,691	11	290	2,007	4,342[6]
2014[1]	0	90	0	29	119	0	2,201	16	106	3[7]	2,323	0	1,935	14	358	2,308	4,749[6]
2015[1]	0	113	0	26	139	0	1,969	33	235	19[7]	2,237	0	1,587	23	349	1,959	4,335[6]

[1] Provisional catches.

[2] Catch is 4,000 (t) less than Canadian statistics as this quantity is considered 3NO gillnet catch misreported in 3L.

[3] Estimate for recreational fishery has been reported as 3L handline.

[4] Comprised of sentinel survey catch of 294 t, a food fishery catch of 1,155 t and by-catch 142 t.

[5] 780 t of this catch was the result of a mass mortality in Smith Sound. (Actual gear used was gaff or dip net).

[6] Excludes recreational fishery catch.

[7] Cod pot.

Table 5. Inshore reported landings (t) of cod from NAFO Divs. 2J3KL by statistical unit area. Values include recreational for 2006, 2008, and 2011-2012.

Year	2Jd/m	3Ka	3Kd	3Kh	3Ki	3La	3Lb	3Lf	3Lj	3Lq	Totals
2006	48	32	68	286	573	410	478	260	221	47	2,424
2007	65	34	94	304	601	454	464	274	227	44	2,562
2008	71	52	152	427	885	548	530	349	248	45	3,306
2009	56	28	90	269	795	608	584	416	223	8	3,078
2010	59	34	84	313	742	605	508	339	194	8	2,885
2011	54	17	113	415	902	669	594	388	282	29	3,463
2012	76	54	215	592	983	604	550	369	253	32	3,728
2013	133	66	286	734	1,129	694	648	346	290	29	4,355
2014	126	68	277	745	1,090	706	676	459	378	36	4,561
2015	140	77	306	745	1,128	653	596	383	309	18	4,355

Table 6. Reported monthly landings (t) of cod from inshore statistical unit areas of NAFO Divs. 2J3KL during 2015. Values exclude recreational fishery.

Div/Unit	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2JD	0.0	0.0	0.0	0.0	0.2	2.0	0.0	0.0	0.0	2.2
2JM	0.0	0.0	0.0	3.2	32.8	98.7	2.0	0.0	0.0	136.8
3KA	0.0	0.0	0.0	0.8	72.6	0.9	2.5	0.0	0.0	76.8
3KD	0.0	0.3	0.0	14.8	246.6	36.8	5.1	2.3	0.0	305.9
3KH	0.0	0.2	2.5	13.2	618.4	102.5	6.1	2.1	0.0	745.1
3KI	0.0	0.6	6.1	31.1	1028.1	51.4	8.5	2.7	0.0	1128.3
3LA	0.0	0.0	3.1	17.4	167.8	462.4	1.4	1.5	0.0	653.5
3LB	0.0	0.4	0.6	13.1	101.4	471.2	6.0	2.9	0.0	595.5
3LF	0.0	0.0	1.3	5.0	13.5	361.3	2.0	0.0	0.0	383.0
3LJ	0.0	0.0	0.6	3.6	21.6	277.8	2.7	2.7	0.0	308.9
3LQ	0.0	0.0	0.0	6.4	11.0	0.3	0.0	0.0	0.0	17.7
Total	**0.0**	**1.4**	**14.2**	**108.6**	**2313.9**	**1865.1**	**36.3**	**14.2**	**0.0**	**4353.8**

Table 7. Monthly reported landings of cod from NAFO Divs. 2J3KL combined during 1983-2015. (NA=not available).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Totals
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	232,340
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	232,471
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	231,293
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	266,680
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	239,905
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	268,677
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	250,938
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	219,452
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	150,026
1992	8,959	6,560	273	3,803	2,469	1,410	842	734	1,877	1,214	621	140	28,902
1993	81	82	9	4	23	48	171	451	1,661	1,025	349	171	4,075
1994	17	0	0	0	7	12	17	424	830	2	0	5	1,314
1995	0	1	0	1	6	31	91	91	79	65	20	2	387
1996	0	1	0	1	8	36	284	217	1263	41	19	7	1,878
1997	0	0	0	0	58	96	233	198	177	79	34	6	881
1998	0	0	0	0	18	122	253	505	2,201	1,103	16	4	4,222
1999	0	0	0	8	15	85	3,672	187	3148	1,167	243	1	8,527
2000	1	1	0	31	14	114	1,460	132	1,862	816	408	0	5,539
2001	4	12	27	24	16	40	1,154	1,707	1,080	500	420	12	7,089
2002	5	14	5	19	9	16	281	2,332	961	509	93	0	4,244
2003	0	1	6	792	2	15	137	83	37	5	17	0	1,097
2004	0	4	0	0	1	48	285	338	32	5	17	1	730
2005	1	0	0	0	0	39	106	1,129	35	4	13	1	1,328
2006	0	3	8	10	0	55	106	1,613	779	102	16	1	2,693
2007	1	0	2	10	3	24	760	763	976	436	8	0	2,983
2008	0	0	11	2	16	20	416	648	2,687	406	23	0	4,228
2009	1	2	4	0	1	22	288	403	4,983	460	10	1	6,174
2010	2	14	25	0	0	28	142	1,117	1,686	79	17	0	3,110
2011	2	2	107	74	0	53	191	1,534	1,670	35	58	33	3,759
2012	2	1	17	3	1	37	378	4,449	1,565	25	4	4	6,486
2013	1	10	12	0	1	27	179	2,770	1,167	15	23	3	4,500
2014	0	1	0	2	2	8	356	2,899	1,195	14	4	0	4,890
2015	0	0	0	10	2	3	10	2,200	1,834	29	13	0	4,436

Table 8. Numbers of length measurements by gear type from the cod fishery in NAFO Divs. 2J3KL during 2010-15.

Gear	Year	Total cod measured	Total cells	Unsampled cells	Unsampled cells > 5t	Annual Landings (t)	Unsampled landings (t)	Unsampled landings (%)
Gillnet	2010	85,209	59	10	1	2,221	18.4	0.83
Gillnet	2011	89,273	54	9	0	2,639	10.9	0.41
Gillnet	2012	120,375	49	4	1	2,901	7.4	0.26
Gillnet	2013	131,589	49	5	0	3,867	6.7	0.17
Gillnet	2014	126,207	50	5	0	4,038	6.8	0.17
Gillnet	2015	104,121	55	10	1	3,669	20.5	0.56
Handline	2010	3,272	30	17	7	619	260.2	42.04
Handline	2011	3,231	25	17	6	458	154.4	33.71
Handline	2012	3,214	21	12	6	350	233	66.57
Handline	2013	1,189	23	16	8	438	325.6	74.34
Handline	2014	2,463	21	15	9	486	297.8	61.28
Handline	2015	368	27	24	9	610	561.3	92.02
Line trawl	2010	4,412	23	13	1	49	20.8	42.45
Line trawl	2011	2,662	22	13	0	40	17.7	44.25
Line trawl	2012	3,107	20	10	0	41	13.4	32.68
Line trawl	2013	2,806	15	9	0	24	9.4	39.17
Line trawl	2014	2,297	15	11	0	33	19.8	60.00
Line trawl	2015	1,846	18	13	3	56	32.8	58.57
Otter trawl	2010	50	-	-	-	-	-	-
Otter trawl	2011	872	-	-	-	-	-	-
Otter trawl	2012	1,726	-	-	-	-	-	-
Otter trawl	2013	2,765	-	-	-	-	-	-
Otter trawl	2014	3,884	-	-	-	-	-	-
Recreational	2010	7,703	-	-	-	-	-	-
Recreational	2011	16,459	-	-	-	-	-	-
Recreational	2012	7,462	-	-	-	-	-	-
Recreational	2013	6,038	-	-	-	-	-	-
Recreational	2014	4,590	-	-	-	-	-	-
Recreational	2015	3,882	-	-	-	-	-	-
Shrimp trawl	2010	812	-	-	-	-	-	-

Table 9. Numbers of cod otoliths taken for age determination from the fishery in NAFO Divs. 2J3KL during 2010-15 (Q2=April-June, Q3=July-Sept, Q4=October-December).

Gear	Year	Q2 Otoliths	Q2 Landings (t)	Q2 Otoliths/t	Q3 Otoliths	Q3 Landings (t)	Q3 Otoliths/t	Q4 Otoliths	Q4 Landings (t)	Q4 Otoliths/t	Total otoliths
Gillnet	2010	-	-	-	3,685	1,076	3.42	1,518	1,145	1.33	5,203
Gillnet	2011	-	-	-	4,012	1,482	2.71	990	1,157	0.86	5,002
Gillnet	2012	1	<1	1	5,068	2,329	2.18	500	572	0.87	5,569
Gillnet	2013	0	< 1	0	4,225	2,930	1.44	658	937	0.70	4,883
Gillnet	2014	0	2	0	3,922	3,099	1.27	699	937	0.75	4,621
Gillnet	2015	0	1.43	0	2,067	2,164	0.96	963	1,503	0.64	3,030
Handline	2010	-	-	-	263	134	1.96	444	485	0.92	707
Handline	2011	-	-	-	203	105	1.93	263	353	0.75	466
Handline	2012	-	-	-	890	151	5.89	0	199	0.00	890
Handline	2013	0	<1	0	200	179	1.12	2	258	0.01	202
Handline	2014	-	-	-	402	205	1.96	0	282	0.00	402
Handline	2015	-	-	-	217	240	0.90	101	370	0.27	318
Line trawl	2010	-	-	-	95	17	5.59	180	32	5.63	275
Line trawl	2011	-	-	-	0	10	0.00	288	30	9.60	288
Line trawl	2012	-	-	-	51	14	3.64	250	27	9.26	301
Line trawl	2013	-	-	-	19	10	1.90	121	14	8.64	140
Line trawl	2014	-	-	-	34	19	1.79	130	14	9.29	164
Line trawl	2015	-	-	-	0	15	0.00	64	41	1.56	64

Table 10. Catch numbers-at-age (000s) for the commercial cod fishery in NAFO Divs. 2J3KL from 1962 to 2015 (ages 2-14 and 15+). Recreational catches excluded for 2007, 2009-10, and 2013-15 (see text).

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1962	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	15,308
1963	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	7,790
1964	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	8,044
1965	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	6,536
1966	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	3,132
1967	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	1,692
1968	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	1,753
1969	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	1,753
1970	6,819	18,104	60,102	82,357	101,249	85,696	29,218	10,857	3,825	2,000	1,200	507	224	658
1971	33	12,876	71,557	95,384	98,111	57,865	25,055	11,732	4,470	2,223	1,287	1,140	720	1,307
1972	236	6,737	79,809	116,562	76,196	55,984	29,553	11,750	6,393	2,987	1,660	1,388	725	2,173
1973	0	3,963	40,785	94,844	59,503	35,464	27,351	14,153	7,566	3,815	2,153	1,173	450	745
1974	473	3,231	13,201	34,927	74,403	60,539	35,687	18,854	10,492	5,818	2,934	1,078	652	927
1975	420	3,968	14,101	25,370	34,426	39,105	36,485	13,421	7,514	2,315	1,179	808	372	283
1976	15	13,767	33,727	28,049	20,898	16,811	16,022	10,931	4,637	1,462	631	292	251	304
1977	108	7,128	65,510	40,462	12,107	5,397	3,396	2,730	1,381	532	296	149	75	105
1978	0	1,323	17,556	39,206	20,319	7,711	3,078	1,530	1,083	437	219	105	62	85
1979	0	1,152	12,361	37,493	29,202	10,982	3,460	1,300	757	560	183	116	51	108
1980	92	2,554	12,025	28,814	30,016	18017	4,830	1,217	520	232	229	56	65	88
1981	0	2,185	7,172	13,191	24,800	22,014	11,848	3,175	779	309	195	125	48	77
1982	0	1,702	31,286	19,003	14,397	25,435	16,930	11,936	1,923	338	156	90	153	69
1983	18	2,585	13,616	42,602	19,028	12,044	14,701	8,934	6,341	1,018	248	90	41	60
1984	3	782	14,871	31,760	38,624	12,503	7,246	8,910	4,227	2,536	451	146	48	92
1985	0	650	14,824	36,614	33,922	28,006	7,050	3,836	5,162	2,905	1,681	254	107	85
1986	1	831	15,219	44,168	45,869	26,025	14,722	3,104	2,000	1,977	1,101	574	116	71
1987	42	2,329	9,217	32,340	49,061	28,469	19,505	5,818	1,346	676	873	391	200	67
1988	25	2,779	14,651	20,184	47,917	45,725	18,608	9,026	4,337	774	422	366	223	157
1989	8	1,696	17,639	21,150	25,212	38,708	28,499	8,696	3,640	1,695	572	244	180	151
1990	58	7,693	40,557	36,410	22,695	16,390	17,940	9,156	2,865	1,084	478	103	98	77

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1991	35	3,111	31,654	53,805	29,553	9,064	6,164	4,745	1,696	641	250	88	39	37
1992	0	430	3,860	14,535	12,211	4,526	1,372	376	199	104	18	9	4	0
1993	0	940	4,993	3,343	19,40	700	147	21	0	0	0	0	0	0
1994	0	105	379	575	177	74	22	2	0	0	0	0	0	0
1995	0	12	41	93	76	25	10	2	0	0	0	0	0	0
1996	1	35	157	304	401	131	24	7	2	0	0	0	0	0
1997	0	12	39	92	95	148	35	5	2	0	0	0	0	0
1998	3	96	229	395	689	384	236	74	10	5	2	1	0	0
1999	7	70	238	638	795	1,157	370	253	52	13	3	0	0	0
2000	5	141	258	419	437	328	294	151	136	33	5	3	1	0
2001	10	249	778	710	611	365	190	272	80	117	33	3	1	0
2002	6	166	296	399	335	235	124	77	113	50	52	10	2	1
2003	0	9	11	19	53	44	28	22	9	32	20	27	7	3
2004	1	10	24	33	47	59	32	14	7	3	5	2	2	0
2005	0	16	27	137	182	101	51	19	7	4	2	2	1	1
2006	0	12	159	307	381	168	79	30	13	5	2	1	2	2
2007	0	12	44	357	423	178	69	21	8	5	2	1	1	3
2008	0	11	84	172	649	422	147	37	12	6	2	1	1	4
2009	0	25	96	124	170	410	248	68	15	5	1	1	0	0
2010	3	18	72	122	202	200	329	143	34	6	1	1	0	0
2011	4	27	74	92	186	247	188	202	78	17	2	1	0	0
2012	3	38	63	165	248	271	228	117	131	43	7	1	0	0
2013	0	22	137	287	432	357	231	153	75	55	24	6	1	0
2014	8	36	42	232	438	461	211	115	69	34	38	12	1	0
2015	0	3	26	87	450	397	266	115	52	49	21	21	4	4

Table 11. Mean annual weights-at-age (kg) calculated from lengths-at-age based on samples from commercial fisheries (including food fisheries and sentinel surveys where available) in NAFO Divs. 2J3KL. The weights-at-age from 1971 are extrapolated back to 1962.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20
1962	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1963	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1964	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1965	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1966	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1967	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1968	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1969	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1970	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1971	0.140	0.340	0.550	0.880	1.230	1.660	2.120	2.640	3.180	3.760	4.150	6.060	5.540	6.110	5.830	6.440	6.070	6.610	7.190
1972	0.140	0.440	0.530	0.640	1.080	1.520	2.130	2.860	3.290	3.950	4.120	5.000	9.320	9.400	6.890	14.670	12.040	7.620	17.460
1973	-	0.320	0.470	0.710	0.960	1.300	1.800	2.200	2.820	3.190	3.790	4.530	6.930	7.220	7.050	9.450	11.160	7.620	17.460
1974	0.110	0.350	0.680	0.910	1.110	1.270	1.560	2.050	2.750	3.130	3.410	4.920	4.400	6.330	5.500	7.570	11.070	7.620	17.460
1975	0.260	0.450	0.630	0.960	1.180	1.390	1.740	2.210	2.610	3.340	3.660	4.780	5.200	5.200	5.460	8.510	9.240	7.620	17.460
1976	0.250	0.450	0.610	0.930	1.320	1.750	2.070	2.240	2.990	3.670	4.560	6.180	8.190	9.770	11.230	12.440	11.160	7.620	17.460
1977	0.090	0.450	0.600	0.970	1.660	2.330	2.820	3.460	3.880	4.780	6.130	7.310	8.400	8.810	11.750	10.630	12.270	7.620	17.460
1978	-	0.400	0.720	1.040	1.580	2.460	3.260	4.050	4.460	5.020	6.720	8.100	7.420	8.200	11.260	11.610	8.920	10.570	16.000
1979	-	0.460	0.740	1.130	1.670	2.460	3.570	4.410	5.250	5.800	7.030	8.960	8.540	9.460	10.700	13.120	13.490	15.510	14.770
1980	0.410	0.530	0.770	1.160	1.710	2.380	3.560	5.010	5.490	6.720	7.870	8.380	10.030	11.310	13.870	10.680	16.090	12.040	11.370
1981	-	0.550	0.780	1.170	1.640	2.230	2.860	3.810	5.320	6.290	7.060	7.320	10.010	8.990	11.540	10.480	11.150	9.820	12.590
1982	-	0.530	0.840	1.200	1.770	2.100	2.660	3.090	4.180	6.160	7.190	8.000	8.360	7.860	7.910	9.580	12.950	-	-
1983	0.310	0.620	0.870	1.320	1.750	2.280	2.610	3.180	3.500	4.790	7.760	9.070	9.140	10.620	10.570	13.130	15.970	9.730	15.880
1984	0.340	0.590	0.880	1.200	1.790	2.280	2.710	2.960	3.650	4.280	6.190	8.390	10.260	11.440	11.610	17.470	12.940	15.210	12.810
1985	-	0.480	0.730	1.100	1.430	2.060	2.660	3.230	3.320	4.060	4.550	7.030	9.670	11.370	11.270	12.680	12.420	14.380	19.490
1986	0.210	0.510	0.720	1.040	1.540	1.850	2.350	2.940	3.470	3.800	4.540	5.340	7.120	11.770	11.240	14.150	16.140	12.300	15.720
1987	0.320	0.430	0.660	1.030	1.320	1.870	1.930	2.800	3.510	4.800	4.640	5.740	6.130	8.530	13.510	9.100	21.770	17.660	-
1988	0.290	0.490	0.730	1.080	1.380	1.670	2.210	2.510	3.040	4.370	5.490	6.550	8.600	9.760	9.730	12.580	16.010	16.600	11.030
1989	0.260	0.480	0.740	1.030	1.440	1.830	2.070	2.640	3.020	3.960	5.410	7.500	9.240	10.050	9.340	15.740	18.660	.	17.640
1990	0.290	0.420	0.690	1.060	1.500	1.940	2.220	2.440	3.060	3.580	4.680	6.230	8.510	9.780	12.580	15.450	13.580	17.260	.
1991	0.170	0.360	0.610	0.970	1.410	1.880	2.270	2.630	3.140	3.800	4.960	5.490	7.610	11.580	11.010	12.820	13.000	13.100	.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20
1992	-	0.290	0.580	0.810	1.190	1.730	2.050	2.660	2.240	2.680	4.950	5.340	7.020	-	-	-	-	-	-
1993	-	0.570	0.710	0.970	1.250	1.590	8.400	9.230	-	-	-	-	-	-	-	-	-	-	-
1994	-	0.400	0.680	0.980	1.410	1.850	2.050	3.050	-	-	-	-	-	-	-	-	-	-	-
1995	0.220	0.489	0.798	1.473	1.906	2.270	2.616	3.023	2.812	4.674	-	-	-	-	-	-	-	-	-
1996	0.374	0.702	1.007	1.424	2.039	2.512	2.768	3.222	3.865	5.182	4.035	7.625	4.457	-	-	-	-	-	-
1997	0.325	0.539	0.881	1.465	1.980	2.437	2.913	3.626	4.245	4.357	6.064	6.220	-	-	-	-	-	-	-
1998	0.289	0.627	0.935	1.508	2.144	2.483	3.016	3.348	4.183	4.012	3.797	6.416	-	-	-	-	-	-	-
1999	0.323	0.588	1.049	1.617	2.121	2.513	2.957	3.663	4.696	5.173	5.566	6.232	7.656	-	-	-	-	-	-
2000	0.263	0.662	0.966	1.710	2.143	2.791	3.386	3.949	4.539	4.879	6.025	5.627	4.798	9.423	-	11.281	-	-	-
2001	0.381	0.632	0.906	1.362	2.017	2.538	3.236	3.932	4.428	5.062	6.561	7.209	5.460	7.625	-	-	-	-	-
2002	0.410	0.627	0.906	1.561	2.095	2.705	3.244	3.825	4.450	4.766	5.131	5.902	5.699	6.095	-	-	8.401	-	-
2003	0.310	0.498	0.819	1.409	2.033	2.543	3.034	3.635	4.356	4.912	5.719	5.919	6.071	5.379	-	6.898	-	-	-
2004	0.335	0.557	0.868	1.538	2.123	2.731	3.329	4.176	5.020	5.457	6.342	6.263	6.555	6.812	-	-	-	-	-
2005	0.280	0.528	0.847	1.775	2.170	2.597	3.137	3.894	4.706	5.682	6.429	7.795	6.693	7.726	8.263	8.430	-	-	-
2006	0.273	0.567	1.116	1.536	2.269	2.823	3.293	4.099	4.706	5.586	6.627	7.150	7.189	6.755	7.624	7.857	7.515	-	7.625
2007	0.380	0.585	1.119	1.683	2.084	2.788	3.525	4.234	4.939	5.904	6.355	6.785	7.572	7.976	8.014	9.207	12.447	6.423	-
2008	0.376	0.623	1.052	1.657	2.343	2.870	3.436	4.237	5.485	6.290	6.567	8.442	7.855	10.290	9.064	7.309	8.655	-	-
2009	0.321	0.602	0.901	1.418	2.089	2.854	3.361	4.154	5.150	5.105	6.693	7.236	7.742	8.764	6.220	-	7.625	6.646	-
2010	0.215	0.602	0.868	1.283	2.031	2.597	3.253	3.889	4.507	5.670	7.232	5.938	8.611	7.192	6.220	9.230	-	14.211	5.001
2011	0.272	0.608	0.928	1.457	1.922	2.404	2.993	3.840	4.306	4.883	5.625	6.382	8.095	7.869	-	-	-	-	-
2012	0.303	0.637	0.995	1.642	2.082	2.454	2.962	3.633	4.526	5.058	5.914	5.695	-	16.061	-	-	-	-	-
2013	0.282	0.709	1.333	2.051	2.511	2.808	3.474	4.364	5.436	5.922	6.135	6.995	8.953	6.898	6.898	-	-	-	-
2014	0.297	0.587	0.950	1.773	2.271	2.737	3.162	3.905	4.575	5.371	6.292	6.263	7.935	8.974	-	13.097	-	-	-
2015	0.312	0.561	1.100	1.873	2.336	2.755	3.255	3.624	4.379	4.857	5.199	6.322	6.594	9.759	-	-	-	-	-

Table 12. Cod abundance (000's), biomass (t) and spawning stock biomass (SSB, t) indices for Northern cod from DFO autumn RV stratified random trawl surveys.

Year	2J Abundance Index	3K Abundance Index	3L Abundance Index	Total Abundance Index	2J Biomass Index	3K Biomass Index	3L Biomass Index	Total Biomass Index	Total SSB Index (t)
1983	1,124,316	468,804	495,838	2,088,958	722,492	384,498	336,789	1,443,779	631,790
1984	743,274	461,368	993,963	2,198,605	557,160	381,136	477,354	1,415,650	525,288
1985	615,282	208,953	464,125	1,288,360	472,147	209,685	368,519	1,050,351	445,752
1986	1,249,077	891,392	362,233	2,502,702	1,285,763	964,857	391,063	2,641,683	1,082,371
1987	410,570	284,540	325,352	1,020,462	491,599	303,036	284,229	1,078,864	519,161
1988	509,739	457,192	256,383	1,223,314	600,352	216,736	274,554	1,091,642	750,039
1989	647,594	1,307,523	172,300	2,127,417	425,387	830,045	160,687	1,416,119	775,254
1990	260,268	971,812	395,567	1,627,647	128,352	624,993	405,669	1,159,014	519,371
1991	323,637	649,349	144,684	1,117,670	150,136	467,502	121,759	739,397	177,472
1992	30,960	61,622	147,158	239,740	12,795	35,344	126,323	174,462	53,889
1993	16,989	36,907	36,813	90,709	5,129	14,227	24,596	43,952	11,032
1994	8,145	9,361	4,291	21,797	2,693	4,241	2,874	9,808	2,998
1995	12,305	23,200	7,735	43,240	2,312	4,578	5,115	12,005	2,891
1996	13,081	18,550	7,067	38,698	4,261	5,457	6,140	15,858	3,556
1997	6,936	8,428	9,859	25,223	3,609	3,978	8,991	16,578	4,586
1998	6,636	15,612	6,454	28,702	4,483	7,280	4,804	16,567	5,207
1999	6,074	29,308	25,281	60,663	2,527	12,230	13,611	28,368	6,351
2000	7,516	35,774	29,010	72,300	3,082	11,994	15,070	30,146	4,855
2001	7,033	28,535	27,724	63,292	2,646	9,890	18,706	31,242	7,657
2002	9,534	41,853	10,984	62,371	3,680	11,889	7,460	23,029	3,168
2003	9,315	19,908	13,638	42,861	3,065	4,912	4,849	12,826	2,896
2004	9,503	34,468	18,605	62,576	4,921	9,609	5,266	19,796	3,608
2005	18,519	33,834	8,780	61,133	5,719	16,696	5,118	27,533	3,145
2006	11,739	52,285	18,711	82,735	6,818	38,009	16,982	61,809	20,037
2007	26,656	54,122	47,249	128,027	8,755	58,427	35,722	102,904	45,097
2008	24,492	62,848	53,957	141,297	10,281	71,329	66,401	148,011	84,809
2009	15,250	47,949	111,782	174,981	6,473	51,106	85,410	142,989	58,791
2010	17,278	83,060	39,012	139,350	9,905	89,388	29,255	128,548	72,031
2011	17,937	59,233	29,204	106,374	8,542	71,541	41,615	121,698	68,195
2012	26,108	101,579	39,584	167,270	21,900	112,824	50,985	185,709	99,902
2013	97,136	170,174	58,344	325,654	37,986	181,106	78,927	298,019	182,476
2014	163,877	210,793	88,706	463,376	94,457	166,597	82,471	343,525	190,667
2015	154,411	281,296	64,706	500,413	120,154	256,608	70,820	447,581	266,316

Table 13a. Mean number of cod per tow at age in the index strata for the autumn DFO RV bottom-trawl surveys of NAFO Divs. 2J.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL
1983	0.00	46.58	147.86	61.64	61.08	25.59	10.44	4.87	12.46	5.05	2.87	0.58	0.04	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	379.11
1984	0.00	7.57	41.01	86.28	38.75	53.27	14.98	2.87	1.83	3.46	1.49	0.54	0.12	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	252.19
1985	0.00	1.71	14.01	48.03	74.50	28.44	27.11	9.75	1.35	0.83	1.14	0.39	0.17	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	207.46
1986	0.00	0.65	18.71	39.16	97.79	153.27	68.45	29.99	10.84	0.70	0.64	0.55	0.29	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	421.13
1987	0.00	1.46	3.03	8.12	12.11	50.67	43.15	9.98	6.58	2.64	0.41	0.04	0.16	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	138.45
1988	0.00	20.52	17.69	10.83	12.14	16.35	41.46	42.71	6.93	4.27	2.06	0.28	0.11	0.08	0.02	0.01	0.01	0.00	0.00	0.00	0.00	175.48
1989	0.00	4.86	108.44	33.77	16.27	10.85	12.35	17.99	11.13	1.45	0.77	0.35	0.12	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	218.36
1990	0.00	2.75	13.80	46.34	12.48	4.79	2.39	1.44	2.35	1.08	0.23	0.06	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	87.76
1991	0.00	0.37	11.17	19.04	60.31	14.89	1.73	0.70	0.42	0.28	0.14	0.02	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	109.11
1992	0.00	0.00	0.68	4.45	1.70	3.29	0.31	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.44
1993	0.00	0.00	3.22	1.03	1.05	0.32	0.27	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.91
1994	0.00	0.18	1.21	0.83	0.34	0.15	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.74
1995	0.05	2.46	1.24	0.80	0.31	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.96
1996	0.00	0.52	2.15	1.24	0.49	0.13	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.57
1997	0.00	0.00	0.41	1.42	0.39	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33
1998	0.00	0.10	0.19	0.72	0.89	0.29	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.24
1999	0.01	0.21	0.79	0.56	0.30	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04
2000	0.02	0.57	0.66	0.77	0.45	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55
2001	0.00	0.16	0.69	1.25	0.19	0.06	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.37
2002	0.33	0.43	0.76	0.80	0.78	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.21
2003	0.74	0.66	0.47	0.79	0.31	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12
2004	0.00	0.38	1.22	0.70	0.58	0.24	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.18
2005	2.43	0.27	0.80	1.69	0.80	0.17	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.20
2006	0.00	0.06	0.90	1.27	1.17	0.45	0.07	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.94
2007	1.66	1.56	2.65	1.73	0.63	0.55	0.16	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.95
2008	0.03	1.50	2.06	3.20	0.94	0.34	0.11	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.20
2009	0.01	0.69	1.86	1.45	0.91	0.17	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.12
2010	0.00	0.99	0.79	2.57	0.89	0.45	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.79
2011	0.00	0.32	3.01	2.01	0.54	0.22	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.23
2012	0.00	0.32	0.72	4.26	2.62	0.55	0.14	0.10	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.76
2013	1.02	12.32	10.08	3.17	3.68	1.58	0.47	0.19	0.04	0.01	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.59
2014	0.00	5.86	21.01	12.07	6.66	5.94	2.67	0.47	0.15	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	54.95

2015	0.00	1.06	11.94	16.96	10.43	4.16	5.05	1.58	0.42	0.16	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	51.82

Table 13b. Mean number of cod per tow at age in the index strata for the autumn DFO RV bottom-trawl surveys of NAFO Divs. 3K.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL
1983	0.00	22.84	32.49	27.87	15.09	17.24	4.39	2.58	4.26	2.98	0.91	0.22	0.12	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	131.02
1984	0.00	8.27	32.45	24.34	22.21	11.98	8.97	3.12	1.41	2.12	1.06	0.34	0.11	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	116.45
1985	0.00	0.28	5.07	13.32	12.39	10.93	4.13	3.23	0.86	0.65	0.55	0.40	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	51.91
1986	0.00	7.91	18.35	21.13	65.26	56.87	29.01	13.32	6.66	2.41	0.64	0.79	0.58	0.09	0.07	0.00	0.00	0.00	0.00	0.00	0.00	223.09
1987	0.00	7.35	6.63	8.34	10.01	17.27	11.21	4.17	2.67	1.21	0.52	0.21	0.08	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	69.75
1988	0.00	37.54	29.28	18.49	8.40	6.92	7.54	3.70	1.00	0.44	0.22	0.04	0.04	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	113.64
1989	0.00	36.91	111.95	58.16	44.92	25.69	17.17	14.93	7.06	2.54	1.41	0.65	0.16	0.09	0.07	0.01	0.02	0.00	0.00	0.00	0.00	321.74
1990	0.00	22.21	32.45	83.98	48.74	23.11	12.35	7.74	7.62	2.35	0.68	0.22	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	241.51
1991	0.00	0.59	15.74	23.97	70.05	37.29	9.09	2.80	1.03	0.56	0.24	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	161.39
1992	0.00	0.65	2.85	4.12	2.33	4.01	1.16	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.31
1993	0.00	0.28	4.67	2.24	1.27	0.30	0.34	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.20
1994	0.00	0.20	0.39	1.16	0.38	0.14	0.02	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.34
1995	0.04	2.77	1.56	0.98	0.34	0.10	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.82
1996	0.00	0.70	2.28	1.20	0.34	0.10	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63
1997	0.08	0.07	0.92	0.85	0.20	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.21
1998	0.15	1.13	0.80	0.92	0.59	0.20	0.06	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.91
1999	0.28	1.07	2.71	2.01	0.87	0.36	0.03	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.36
2000	0.71	2.61	2.33	2.24	1.17	0.27	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.39
2001	0.05	1.46	2.22	2.37	0.71	0.30	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.16
2002	0.04	2.09	5.19	2.03	0.92	0.21	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.50
2003	0.54	2.35	0.88	0.85	0.27	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.99
2004	0.03	2.58	4.04	1.10	0.66	0.17	0.04	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.66
2005	0.28	0.73	1.97	3.68	1.35	0.44	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.49
2006	1.47	1.06	1.94	2.49	3.61	2.28	0.77	0.06	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.72
2007	0.17	1.67	2.58	2.40	1.92	3.13	1.45	0.32	0.06	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.72
2008	0.01	2.58	2.72	2.90	2.47	1.48	2.03	1.09	0.20	0.13	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.62
2009	0.07	0.61	2.28	2.17	2.44	2.27	0.88	0.94	0.29	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.02
2010	0.00	3.30	2.44	4.37	3.53	2.73	2.05	1.01	0.81	0.41	0.13	0.04	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	20.83
2011	0.00	0.45	4.68	3.31	2.18	1.24	1.13	0.75	0.52	0.38	0.21	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.86
2012	1.08	3.68	2.62	5.85	5.61	2.87	1.20	0.86	0.71	0.37	0.44	0.15	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.47

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL
2013	1.45	10.77	6.88	3.82	6.84	5.37	3.71	1.49	1.03	0.57	0.38	0.22	0.14	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.69
2014	0.33	10.42	14.91	11.21	4.25	5.82	2.78	1.64	0.79	0.39	0.19	0.04	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52.88
2015	0.57	6.93	12.40	18.30	13.84	7.46	5.73	2.76	1.37	0.67	0.19	0.17	0.11	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	70.58

Table 13c. Mean number of cod per tow at age in the index strata for the autumn DFO RV bottom-trawl surveys of NAFO Divs. 3L.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL
1983	0.00	17.62	27.24	40.89	9.53	9.21	1.50	1.45	2.36	1.26	0.44	0.13	0.06	0.02	0.05	0.00	0.01	0.02	0.00	0.00	0.05	111.87
1984	0.00	7.68	75.48	56.42	35.05	6.44	10.12	1.48	1.02	0.88	0.94	0.38	0.22	0.04	0.03	0.03	0.03	0.01	0.01	0.00	0.00	196.27
1985	0.00	0.15	11.11	32.05	24.62	13.18	5.23	3.04	0.57	0.69	0.35	0.25	0.11	0.04	0.01	0.01	0.00	0.01	0.00	0.00	0.00	91.42
1986	0.00	1.03	9.71	9.02	22.23	13.13	10.20	2.97	2.09	0.80	0.32	0.41	0.22	0.09	0.03	0.03	0.01	0.00	0.00	0.00	0.00	72.30
1987	0.00	3.87	22.54	7.70	6.96	10.93	6.81	2.86	1.10	0.85	0.09	0.12	0.19	0.10	0.03	0.01	0.01	0.01	0.01	0.00	0.00	64.19
1988	0.00	1.26	12.57	13.43	4.08	5.57	5.91	4.19	1.86	0.90	0.46	0.12	0.10	0.12	0.07	0.03	0.00	0.01	0.00	0.00	0.00	50.68
1989	0.00	0.54	5.36	12.73	7.03	2.17	2.30	2.20	0.81	0.56	0.17	0.06	0.03	0.03	0.04	0.01	0.00	0.00	0.00	0.00	0.00	34.04
1990	0.00	0.82	6.54	22.12	24.38	11.06	5.29	3.21	2.38	1.31	0.51	0.24	0.15	0.08	0.06	0.03	0.01	0.00	0.00	0.00	0.00	78.19
1991	0.00	1.06	5.27	5.02	7.89	5.59	2.66	0.44	0.22	0.23	0.09	0.07	0.02	0.00	0.00	0.01	0.01	0.00	0.01	0.00	0.00	28.59
1992	0.00	0.08	3.25	8.14	7.96	5.64	3.07	0.79	0.06	0.04	0.03	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.08
1993	0.00	0.00	1.66	2.44	2.46	0.79	0.32	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.73
1994	0.00	0.00	0.19	0.28	0.23	0.09	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
1995	0.00	0.11	0.34	0.52	0.27	0.15	0.11	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54
1996	0.00	0.04	0.21	0.36	0.43	0.19	0.09	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
1997	0.00	0.07	0.64	0.61	0.27	0.15	0.04	0.07	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.95
1998	0.32	0.14	0.17	0.32	0.17	0.04	0.03	0.01	0.05	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28
1999	0.30	0.79	1.51	1.86	0.20	0.15	0.08	0.01	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.98
2000	0.04	1.18	1.59	1.62	0.98	0.31	0.09	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88
2001	0.03	0.67	1.66	1.49	0.95	0.45	0.10	0.02	0.01	0.02	0.00	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.48
2002	0.03	0.30	0.90	0.37	0.31	0.18	0.05	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.18
2003	0.17	1.54	0.32	0.40	0.13	0.06	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.69
2004	0.27	0.98	2.64	0.33	0.12	0.08	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.49
2005	0.02	0.07	0.25	0.99	0.31	0.05	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73
2006	0.03	0.06	0.67	0.78	1.13	0.72	0.18	0.05	0.01	0.02	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.68
2007	0.69	1.76	1.78	1.58	1.43	1.38	0.45	0.16	0.04	0.02	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.32
2008	0.01	0.43	1.70	2.55	1.97	1.31	1.77	0.58	0.17	0.08	0.00	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.64

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL
2009	0.03	0.60	3.17	8.09	5.99	2.68	0.79	0.56	0.10	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.04
2010	0.01	1.04	1.82	1.88	1.53	0.60	0.34	0.20	0.20	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.69
2011	0.06	0.04	0.82	1.44	1.20	0.72	0.58	0.34	0.18	0.30	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.76
2012	0.11	1.26	0.75	1.69	1.22	1.04	0.65	0.47	0.22	0.15	0.18	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.80
2013	0.33	1.37	1.98	1.53	2.00	1.61	0.93	0.77	0.41	0.12	0.19	0.18	0.07	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	11.50
2014	0.21	3.18	3.96	4.41	1.54	1.80	0.86	0.55	0.39	0.18	0.09	0.07	0.20	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	17.48
2015	0.06	0.91	2.95	3.00	2.47	0.94	0.94	0.40	0.40	0.26	0.14	0.13	0.04	0.05	0.04	0.03	0.00	0.00	0.00	0.00	0.00	12.76

Table 13d. Mean number of cod per tow at age in the index strata for the autumn DFO RV bottom-trawl surveys of NAFO Divs. 2J3KL. The 2J3KL total is the overall mean of the Divisional means, weighted by the total area surveyed within each Division.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL
1983	0.00	26.49	58.68	41.65	24.08	15.93	4.67	2.67	5.48	2.77	1.20	0.27	0.07	0.02	0.03	0.00	0.00	0.01	0.00	0.00	0.02	184.04
1984	0.00	7.85	52.62	53.05	31.67	19.82	10.93	2.37	1.35	1.93	1.12	0.41	0.16	0.04	0.02	0.02	0.01	0.00	0.00	0.00	0.00	183.38
1985	0.00	0.58	9.81	29.73	32.81	16.18	10.25	4.76	0.86	0.71	0.61	0.33	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	106.79
1986	0.00	3.23	14.81	20.48	55.20	62.23	30.82	13.08	5.77	1.31	0.51	0.57	0.36	0.09	0.04	0.01	0.00	0.00	0.00	0.00	0.00	208.52
1987	0.00	4.44	12.42	8.02	9.25	22.83	17.22	5.05	2.97	1.41	0.31	0.13	0.15	0.08	0.03	0.00	0.00	0.00	0.00	0.00	0.00	84.33
1988	0.00	18.12	19.41	14.48	7.51	8.67	15.21	13.51	2.82	1.58	0.77	0.13	0.08	0.07	0.04	0.02	0.00	0.00	0.00	0.00	0.00	102.43
1989	0.00	13.75	66.33	33.08	21.96	12.16	9.74	10.34	5.44	1.44	0.73	0.33	0.10	0.04	0.04	0.01	0.01	0.00	0.00	0.00	0.00	175.50
1990	0.00	8.44	16.98	48.74	29.59	13.54	6.93	4.29	4.12	1.60	0.50	0.19	0.10	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.00	135.09
1991	0.00	0.73	10.22	14.80	41.55	18.47	4.58	1.29	0.54	0.35	0.15	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	92.76
1992	0.00	0.25	2.48	5.89	4.54	4.52	1.75	0.39	0.04	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.89
1993	0.00	0.09	3.05	2.03	1.72	0.51	0.31	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.77
1994	0.00	0.11	0.51	0.71	0.31	0.12	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81
1995	0.02	1.51	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	0.00	0.00	0.00	0.00	0.00	0.00	3.69
1996	0.00	0.38	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	0.00	0.00	0.00	0.00	0.00	0.00	3.26
1997	0.03	0.07	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	0.00	0.00	0.00	0.00	0.00	0.00	2.13
1998	0.16	0.47	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	0.00	0.00	0.00	0.00	0.00	0.00	2.39
1999	0.22	0.73	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	0.00	0.00	0.00	0.00	0.00	0.00	5.04
2000	0.26	1.49	1.61	1.53	0.98	0.21	0.07	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.18
2001	0.02	0.80	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	0.00	0.00	0.00	0.00	0.00	0.00	5.26
2002	0.10	0.92	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	0.00	0.00	0.00	0.00	0.00	0.00	5.18
2003	0.43	1.59	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	0.00	0.00	0.00	0.00	0.00	0.00	3.56

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20	TOTAL
2004	0.07	1.57	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	0.00	0.00	0.00	0.00	0.00	0.00	5.63
2005	0.72	0.31	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	0.00	0.00	0.00	0.00	0.00	0.00	5.08
2006	0.47	0.38	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	0.00	0.00	0.00	0.00	0.00	0.00	6.97
2007	0.76	1.67	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	0.00	0.00	0.00	0.00	0.00	0.00	10.68
2008	0.03	1.36	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	0.00	0.00	0.00	0.00	0.00	0.00	11.69
2009	0.04	0.63	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	0.00	0.00	0.00	0.00	0.00	0.00	14.53
2010	0.00	1.70	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	0.00	0.00	0.00	0.00	0.00	0.00	11.58
2011	0.03	0.24	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	0.00	0.00	0.00	0.00	0.00	0.00	8.91
2012	0.32	1.87	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	0.00	0.00	0.00	0.00	0.00	0.00	13.90
2013	0.84	6.81	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	0.00	0.00	0.00	0.00	0.00	0.00	27.05
2014	0.20	6.14	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	0.00	0.00	0.00	0.00	0.00	0.00	38.49
2015	0.22	2.87	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	0.01	0.00	0.00	0.00	0.00	0.00	41.57

*Table 14. Average length (cm) at age of cod caught during autumn bottom-trawl surveys in Divs. 2J3KL in 2001-15. Mean lengths at age were calculated by adjusting to the length-frequency of the population. * entries are based on sample sizes <5.*

Division 2J

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	23.0	21.1	20.2	22.6	22.7	**22.0**	22.0	22.1	20.9	21.5	21.8	22.8	20.9	20.8	22.7
2	29.6	28.0	31.6	31.1	28.9	27.4	27.4	27.9	29.4	31.2	31.0	32.0	30.0	29.7	29.3
3	35.1	37.5	38.2	38.1	36.5	35.6	36.5	35.8	37.2	39.4	36.9	41.5	35.0	36.8	38.0
4	44.1	43.6	43.2	45.7	43.3	43.6	43.3	45.0	44.2	44.5	45.5	46.0	48.0	42.4	45.4
5	50.0	45.9	50.7	50.3	51.1	48.2	52.2	43.8	52.5	47.4	49.9	55.0	51.4	53.5	51.1
6	**55.0**	**41.0**	61.4	55.7	**52.8**	57.9	57.2	59.2	**57.7**	58.8	56.3	58.3	61.4	56.1	58.6
7	**57.0**	-	-	-	**66.0**	-	**62.0**	**59.4**	**59.0**	**67.7**	**63.0**	63.5	64.7	63.4	58.5
8	-	-	-	-	-	**74.0**	-	-	-	-	-	**76.7**	**70.7**	64.3	67.1
9	-	-	-	-	-	-	-	**67.0**	-	-	-	**80.0**	**82.0**	**70.1**	72.8
10	-	-	-	-	-	-	-	-	-	-	-	-	-	**92.0**	**72.5**
11	-	-	-	-	-	-	-	-	-	-	-	**95.0**	**93.9**		**75.0**
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Division 3K

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	20.1	22.1	19.4	20.9	20.4	17.9	20.6	20.8	19.7	20.6	20.6	21.9	20.6	18.8	20.4
2	28.2	28.5	30.5	28.1	29.1	25.1	27.4	27.9	28.4	28.6	32.4	30.0	29.1	29.4	28.7
3	34.9	35.5	39.0	35.0	38.3	37.1	37.9	37.5	37.7	39.5	38.1	41.5	37.9	39.2	38.4
4	42.7	41.7	45.4	43.7	44.5	47.0	47.9	46.4	45.5	43.9	47.6	47.1	51.2	44.9	44.6
5	52.7	47.6	53.8	49.4	51.6	52.5	57.2	55.2	52.8	51.6	53.3	55.6	54.7	56.5	50.1
6	**55.4**	**56.7**	-	57.4	60.4	56.2	61.2	64.0	59.9	57.5	59.2	58.1	62.5	62.5	59.6
7	-	**57.0**	-	**60.5**	-	**71.1**	66.9	67.8	68.0	64.7	65.4	66.0	65.1	68.8	64.3
8	**73.0**	-	-	**81.0**	-	**65.6**	**74.0**	66.7	75.9	70.9	70.0	70.1	69.5	72.5	72.0
9	**74.0**	-	-	-	-	-	**90.0**	71.3	**73.2**	73.2	77.2	74.5	75.6	77.3	75.2
10	-	-	-	**58.0**	-	-	**80.0**	-	**82.0**	72.7	79.8	80.9	79.6	80.9	82.7
11	-	-	-	-	-	-	-	-	-	**102.7**	**78.0**	84.0	84.0	**85.2**	92.1
12	-	-	-	-	-	-	-	**102.0**	-	-	-	**91.4**	86.0	93.7	89.9

Division 3L

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	18.4	20.6	17.7	20.1	18.6	18.1	18.2	19.2	19.5	20.1	18.4	18.7	18.8	18.5	20.8
2	29.0	29.6	29.1	29.0	29.8	28.2	26.8	29.4	28.8	29.0	31.6	29.3	28.7	28.6	27.0
3	36.7	38.8	39.8	37.3	38.6	38.9	38.6	36.9	39.0	37.8	39.9	41.1	38.9	38.5	35.1
4	45.0	47.3	50.1	48.0	43.9	46.5	47.3	46.6	43.5	44.0	46.1	47.3	48.6	46.3	43.7
5	51.5	56.5	51.0	50.1	49.6	51.0	55.1	53.9	50.3	49.9	53.5	53.6	54.1	55.1	51.6
6	58.4	63.0	**60.5***	**58.9***	**59.5***	54.3	59.9	62.1	58.4	56.2	57.9	59.4	61.2	60.6	58.7
7	**65.9***	**68.0***	**70.0***	**72.0***	**61.0***	**72.0***	67.1	67.6	64.8	64.5	65.4	63.6	65.7	68.5	66.6
8	**67.9***	-		**57.0***	**65.7***	**63.0***	**78.1***	67.8	73.9	71.0	71.3	70.8	70.6	70.5	68.9
9	**75.1***	-	**71.0***	**69.0***	-	**87.7***	**93.6***	-	**77.0***	81.5	74.0	76.6	74.3	74.9	77.4
10	-	-	-	**82.0***	-	**81.5***	**90.0***	64.5	-	-	**70.7***	83.0	77.3	84.6	81.6
11	**91.0***	-	**89.0***	-	-	-	-	**75.8***	**104.0***	-	**77.5***	84.6	84.7	81.0	82.0
12	**101.0***	**97.0***	-	-	-	**75.0***	**100.0***	**103.3***	**105.0***	-	-	**103.0***	89.2	87.3	**83.6***

*Table 15a. Average weight (kg) at age of cod caught during autumn bottom-trawl surveys in Divs. 2J3KL in 2001--15. Actual weights at age were adjusted to the length-frequency of the population. * entries are based on sample sizes < 5. Values prior to 2001 are given in Brattey et al. (2011).*

Division 2J

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.10	0.09	0.07	0.09	0.10	**0.08***	0.09	0.09	0.07	0.09	0.09	0.10	0.08	0.07	0.10
2	0.22	0.19	0.27	0.29	0.22	0.18	0.20	0.20	0.23	0.27	0.28	0.28	0.27	0.23	0.21
3	0.41	0.47	0.50	0.51	0.45	0.41	0.46	0.41	0.45	0.58	0.50	0.64	0.40	0.48	0.51
4	0.77	0.77	0.75	0.88	0.80	0.77	0.75	0.85	0.79	0.85	0.88	0.99	1.02	0.76	0.89
5	1.15	0.92	1.24	1.25	1.40	1.09	1.31	0.93	1.29	1.07	1.31	1.64	1.43	1.50	1.34
6	**1.49***	**0.58***	**2.16***	1.82	**1.32***	1.85	1.85	1.89	**1.65***	2.08	1.96	2.15	2.25	1.92	1.98
7	**1.64***	-	-	-	**2.67***	-	**2.54***	**1.94***	**1.88***	**3.18***	**2.45***	2.63	2.95	2.75	2.08
8	-	-	-	-	-	**3.82***	-	-	-	-	-	**5.39***	**3.68***	2.84	3.30
9	-	-	-	-	-	-	-	**2.40***	-	-	-	**5.85***	**6.04***	**3.73***	4.40
10	-	-	-	-	-	-	-	-	-	-	-	-	-	**8.76***	**4.50***
11	-	-	-	-	-	-	-	-	-	-	-	**11.33***	**9.62***	-	**5.19***
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Division 3K

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.07	0.09	0.06	0.08	0.07	0.05	0.07	0.07	0.06	0.07	0.07	0.09	0.07	0.06	0.07
2	0.19	0.21	0.25	0.21	0.22	0.14	0.18	0.21	0.20	0.21	0.32	0.25	0.22	0.22	0.21
3	0.38	0.40	0.52	0.43	0.51	0.46	0.52	0.48	0.48	0.54	0.56	0.63	0.50	0.55	0.52
4	0.72	0.65	0.87	0.83	0.86	0.96	1.06	1.01	0.85	0.83	1.09	1.01	1.23	0.90	0.87
5	1.28	1.00	1.44	1.20	1.36	1.36	1.77	1.68	1.32	1.29	1.48	1.65	1.64	1.69	1.27
6	**1.77***	**1.52***	-	1.91	2.32	1.78	2.41	2.64	1.93	1.87	2.13	2.07	2.45	2.42	1.95
7	-	**1.71***	-	**2.55***	-	**3.40***	3.11	3.24	2.91	2.65	2.99	2.96	2.86	3.26	2.75
8	**3.45***	-	-	**4.57***	-	**2.84***	**4.21***	3.02	4.17	3.52	4.01	3.72	3.77	4.12	3.73
9	**3.71***	-	-	-	-	-	**7.65***	4.05	**3.84***	4.09	4.89	4.66	4.87	5.20	4.62
10	-	-	-	**2.00***	-	-	**5.57***	-	**5.60***	4.20	6.45	6.09	5.73	5.99	6.21
11	-	-	-	-	-	-	-	-	-	**9.19***	**6.69***	7.08	7.48	**7.58***	8.30
12	-	-	-	-	-	-	-	**12.15***	-	-	-	**9.60***	7.74	9.75	7.70

Division 3L

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	0.05	0.08	0.05	0.07	0.05	0.05	0.05	0.07	0.06	0.06	**0.05***	0.06	0.06	0.05	0.07
2	0.22	0.24	0.22	0.24	0.23	0.20	0.18	0.24	0.21	0.22	0.29	0.23	0.22	0.21	0.20
3	0.50	0.55	0.56	0.53	0.54	0.55	0.53	0.48	0.53	0.49	0.61	0.64	0.56	0.52	0.46
4	0.87	0.97	1.12	1.00	0.80	0.97	1.02	0.99	0.81	0.84	0.97	1.01	1.07	0.93	0.88
5	1.36	1.73	1.23	1.26	1.16	1.31	1.64	1.55	1.16	1.21	1.58	1.54	1.55	1.52	1.40
6	1.92	2.54	**2.17***	**2.39***	**2.05***	1.50	2.23	2.32	1.82	1.76	2.11	2.10	2.25	2.15	2.00
7	2.92	**3.02***	**2.94***	**3.14***	**2.53***	**3.74***	3.13	3.02	2.61	2.59	2.96	2.68	2.91	3.17	2.89
8	**3.43***	-	-	**1.67***	**2.83***	**2.67***	4.89	3.44	4.13	3.64	3.94	3.93	3.80	3.58	3.28
9	**3.88***	-	**3.64***	**3.87***	-	**6.95***	**8.45***	2.79	**4.22***	6.24	4.64	4.80	4.42	4.53	4.82
10	-	-		**5.81***	-	**6.06***	**8.07***	-	-	-	**4.13***	6.53	5.09	6.48	5.78
11	8.26	-	**7.70***	-	-	-	-	**4.41***	**14.81***	-	**5.15***	6.89	6.72	5.94	6.07
12	**12.80***	**9.95***	-	-	-	**4.90***	**10.90***	**11.31***	**14.14***	-	-	**13.20***	8.78	8.08	**6.69***

Table 15b. Beginning of year weight-at-age estimates (kg) from a generalized Von Bertalanffy (VonB2) growth model described in Cadigan (2016b) fitted by cohort to average weight at age data for cod from autumn bottom-trawl surveys in Divs. 2J3KL from 1983-2015. Weights are projected to 2018.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20
1983	0.01	0.07	0.21	0.44	0.78	1.26	1.89	2.55	3.43	4.34	5.84	7.49	9.39	11.29	13.48	15.35	16.54	18.09	19.57	20.98
1984	0.01	0.08	0.21	0.45	0.77	1.22	1.84	2.61	3.36	4.35	5.35	7.04	8.84	10.88	12.85	15.10	16.97	18.09	19.57	20.98
1985	0.01	0.08	0.21	0.44	0.78	1.21	1.77	2.52	3.43	4.26	5.37	6.43	8.31	10.24	12.39	14.42	16.70	18.53	19.57	20.98
1986	0.01	0.08	0.22	0.45	0.77	1.22	1.76	2.42	3.30	4.35	5.25	6.45	7.57	9.62	11.67	13.92	15.97	18.25	20.03	20.98
1987	0.01	0.08	0.22	0.46	0.78	1.21	1.77	2.40	3.17	4.18	5.35	6.30	7.60	8.76	10.97	13.11	15.42	17.48	19.74	21.45
1988	0.01	0.08	0.22	0.46	0.80	1.23	1.75	2.42	3.14	4.00	5.14	6.43	7.41	8.79	9.98	12.33	14.55	16.90	18.94	21.16
1989	0.01	0.08	0.22	0.46	0.81	1.26	1.78	2.39	3.16	3.95	4.90	6.16	7.57	8.57	10.01	11.21	13.69	15.97	18.34	20.34
1990	0.01	0.08	0.22	0.46	0.81	1.27	1.83	2.43	3.12	3.98	4.84	5.87	7.24	8.75	9.76	11.25	12.46	15.04	17.35	19.71
1991	0.01	0.08	0.23	0.47	0.81	1.28	1.84	2.50	3.17	3.93	4.87	5.79	6.88	8.35	9.96	10.97	12.50	13.70	16.36	18.69
1992	0.01	0.09	0.25	0.50	0.83	1.28	1.86	2.52	3.27	3.99	4.82	5.82	6.78	7.93	9.50	11.20	12.18	13.74	14.92	17.65
1993	0.01	0.08	0.25	0.54	0.90	1.32	1.86	2.55	3.30	4.13	4.89	5.76	6.82	7.81	9.01	10.67	12.43	13.40	14.97	16.13
1994	0.01	0.08	0.24	0.55	0.99	1.43	1.93	2.56	3.34	4.17	5.06	5.85	6.74	7.86	8.87	10.11	11.84	13.67	14.60	16.18
1995	0.02	0.08	0.24	0.53	1.00	1.60	2.12	2.67	3.35	4.21	5.11	6.06	6.85	7.77	8.92	9.94	11.22	13.01	14.88	15.78
1996	0.02	0.08	0.24	0.52	0.95	1.63	2.39	2.93	3.51	4.24	5.17	6.12	7.10	7.89	8.82	10.00	11.03	12.32	14.17	16.08
1997	0.02	0.09	0.24	0.51	0.93	1.52	2.43	3.34	3.88	4.45	5.21	6.19	7.18	8.19	8.96	9.88	11.08	12.11	13.42	15.32
1998	0.02	0.09	0.25	0.51	0.91	1.48	2.25	3.39	4.45	4.95	5.48	6.24	7.27	8.28	9.30	10.05	10.96	12.17	13.19	14.50
1999	0.02	0.09	0.26	0.53	0.90	1.45	2.18	3.13	4.52	5.70	6.12	6.58	7.33	8.38	9.40	10.43	11.14	12.03	13.25	14.25
2000	0.02	0.09	0.26	0.55	0.94	1.42	2.12	3.02	4.15	5.79	7.07	7.37	7.74	8.46	9.53	10.55	11.56	12.23	13.10	14.31
2001	0.02	0.09	0.27	0.56	0.98	1.49	2.07	2.92	3.99	5.30	7.19	8.54	8.69	8.95	9.62	10.69	11.70	12.69	13.31	14.15
2002	0.02	0.09	0.26	0.57	1.00	1.55	2.18	2.84	3.84	5.08	6.56	8.68	10.08	10.06	10.18	10.79	11.86	12.85	13.82	14.38
2003	0.02	0.09	0.26	0.55	1.02	1.58	2.27	3.00	3.73	4.87	6.26	7.90	10.23	11.66	11.46	11.43	11.97	13.02	13.98	14.92
2004	0.02	0.09	0.27	0.54	0.97	1.61	2.31	3.13	3.94	4.71	6.00	7.53	9.31	11.84	13.27	12.86	12.69	13.15	14.17	15.10
2005	0.02	0.09	0.27	0.56	0.95	1.53	2.36	3.19	4.11	4.99	5.78	7.19	8.86	10.76	13.46	14.86	14.27	13.94	14.32	15.31
2006	0.02	0.09	0.27	0.56	0.98	1.50	2.23	3.26	4.19	5.20	6.12	6.91	8.45	10.24	12.25	15.07	16.44	15.66	15.18	15.47
2007	0.02	0.09	0.27	0.56	0.99	1.53	2.16	3.06	4.28	5.31	6.39	7.33	8.11	9.75	11.64	13.73	16.66	17.97	17.01	16.39
2008	0.02	0.10	0.27	0.56	0.99	1.56	2.21	2.95	4.00	5.43	6.52	7.66	8.60	9.34	11.08	13.05	15.21	18.20	19.45	18.33
2009	0.02	0.10	0.27	0.56	0.99	1.55	2.25	3.02	3.85	5.05	6.67	7.81	8.98	9.91	10.60	12.41	14.46	16.66	19.68	20.85
2010	0.02	0.10	0.28	0.58	0.99	1.55	2.24	3.08	3.93	4.84	6.18	7.99	9.16	10.35	11.24	11.87	13.75	15.85	18.06	21.09
2011	0.02	0.10	0.29	0.59	1.01	1.55	2.24	3.05	4.01	4.94	5.91	7.38	9.36	10.55	11.73	12.58	13.14	15.07	17.20	19.42
2012	0.02	0.10	0.29	0.60	1.05	1.59	2.24	3.05	3.97	5.04	6.03	7.04	8.63	10.78	11.95	13.13	13.92	14.39	16.36	18.51
2013	0.02	0.10	0.29	0.61	1.06	1.64	2.30	3.06	3.98	4.99	6.15	7.18	8.22	9.92	12.21	13.36	14.51	15.23	15.63	17.62
2014	0.02	0.10	0.29	0.60	1.08	1.66	2.38	3.14	3.98	5.00	6.09	7.32	8.38	9.44	11.24	13.65	14.76	15.87	16.52	16.84
2015	0.02	0.10	0.28	0.60	1.06	1.70	2.41	3.25	4.09	5.01	6.10	7.25	8.55	9.61	10.68	12.55	15.07	16.14	17.19	17.78
2016	0.02	0.10	0.28	0.60	1.06	1.67	2.46	3.29	4.23	5.14	6.11	7.26	8.46	9.80	10.86	11.92	13.86	16.46	17.48	18.48
2017	0.02	0.10	0.28	0.59	1.05	1.66	2.41	3.36	4.29	5.32	6.27	7.27	8.47	9.70	11.08	12.12	13.16	15.16	17.82	18.77
2018	0.02	0.10	0.28	0.59	1.04	1.65	2.40	3.29	4.38	5.39	6.49	7.47	8.48	9.72	10.96	12.36	13.37	14.38	16.42	19.12

Table 15c. Mid-year weight-at-age estimates (kg) from a generalized Von Bertalanffy (VonB2) growth model described in Cadigan (2016b) fitted by cohort to average weight at age data for cod from autumn bottom-trawl surveys in Divs. 2J3KL from 1983-2015. Weights are projected to 2018.

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15	Age 16	Age 17	Age 18	Age 19	Age 20
1983	0.04	0.13	0.32	0.59	0.99	1.53	2.23	2.94	3.88	4.83	6.43	8.16	10.13	12.07	14.29	16.16	17.32	18.84	20.29	21.66
1984	0.04	0.13	0.31	0.60	0.98	1.48	2.16	3.00	3.80	4.85	5.88	7.67	9.53	11.64	13.64	15.90	17.76	18.84	20.29	21.66
1985	0.04	0.14	0.32	0.59	0.99	1.47	2.09	2.90	3.88	4.74	5.90	6.99	8.96	10.95	13.16	15.20	17.48	19.29	20.29	21.66
1986	0.04	0.14	0.32	0.60	0.98	1.49	2.07	2.79	3.73	4.84	5.77	7.02	8.16	10.29	12.39	14.67	16.73	19.00	20.75	21.66
1987	0.04	0.14	0.32	0.62	0.99	1.47	2.08	2.76	3.57	4.65	5.89	6.85	8.19	9.36	11.65	13.83	16.17	18.22	20.46	22.13
1988	0.04	0.14	0.33	0.62	1.02	1.49	2.06	2.78	3.54	4.44	5.64	7.00	7.99	9.40	10.59	13.01	15.26	17.62	19.65	21.83
1989	0.04	0.14	0.33	0.62	1.02	1.53	2.09	2.75	3.56	4.39	5.38	6.69	8.16	9.16	10.63	11.84	14.37	16.66	19.03	21.01
1990	0.04	0.14	0.33	0.62	1.03	1.54	2.15	2.79	3.52	4.42	5.31	6.37	7.79	9.36	10.36	11.88	13.08	15.70	18.03	20.38
1991	0.04	0.15	0.35	0.64	1.03	1.55	2.17	2.88	3.57	4.37	5.34	6.28	7.40	8.93	10.58	11.58	13.12	14.31	17.01	19.34
1992	0.04	0.15	0.38	0.68	1.06	1.56	2.19	2.90	3.69	4.43	5.28	6.32	7.29	8.47	10.08	11.81	12.79	14.36	15.53	18.28
1993	0.04	0.15	0.38	0.75	1.15	1.61	2.20	2.93	3.72	4.59	5.36	6.24	7.34	8.34	9.56	11.25	13.05	14.00	15.58	16.72
1994	0.04	0.15	0.37	0.76	1.28	1.76	2.29	2.94	3.76	4.63	5.55	6.34	7.25	8.39	9.41	10.66	12.43	14.28	15.19	16.77
1995	0.04	0.15	0.37	0.72	1.29	1.97	2.51	3.07	3.79	4.68	5.61	6.57	7.37	8.29	9.46	10.49	11.77	13.60	15.49	16.36
1996	0.04	0.15	0.36	0.71	1.22	2.00	2.84	3.39	3.97	4.71	5.68	6.64	7.64	8.42	9.35	10.54	11.57	12.87	14.75	16.67
1997	0.04	0.16	0.36	0.70	1.19	1.87	2.89	3.88	4.40	4.95	5.72	6.73	7.72	8.74	9.50	10.42	11.63	12.65	13.96	15.88
1998	0.04	0.16	0.38	0.69	1.16	1.81	2.67	3.94	5.06	5.52	6.02	6.78	7.82	8.84	9.86	10.59	11.49	12.71	13.72	15.04
1999	0.04	0.16	0.39	0.72	1.15	1.77	2.58	3.63	5.14	6.38	6.74	7.15	7.89	8.95	9.97	10.99	11.69	12.57	13.78	14.77
2000	0.04	0.17	0.39	0.75	1.20	1.73	2.51	3.49	4.71	6.48	7.80	8.03	8.34	9.03	10.11	11.12	12.13	12.77	13.63	14.83
2001	0.04	0.16	0.40	0.76	1.25	1.82	2.44	3.37	4.52	5.92	7.92	9.30	9.37	9.56	10.20	11.27	12.27	13.26	13.85	14.67
2002	0.04	0.16	0.39	0.77	1.27	1.89	2.58	3.27	4.35	5.66	7.22	9.45	10.87	10.76	10.81	11.38	12.44	13.42	14.37	14.91
2003	0.05	0.17	0.39	0.75	1.29	1.93	2.68	3.46	4.21	5.42	6.89	8.60	11.03	12.46	12.16	12.06	12.56	13.60	14.55	15.47
2004	0.05	0.17	0.39	0.73	1.24	1.97	2.73	3.60	4.45	5.23	6.59	8.19	10.03	12.65	14.07	13.57	13.32	13.74	14.74	15.66
2005	0.05	0.17	0.40	0.75	1.21	1.87	2.79	3.67	4.64	5.55	6.34	7.82	9.55	11.50	14.27	15.66	14.96	14.56	14.90	15.87
2006	0.05	0.17	0.40	0.76	1.24	1.81	2.63	3.75	4.73	5.79	6.72	7.50	9.10	10.94	12.99	15.87	17.21	16.34	15.79	16.03
2007	0.05	0.17	0.40	0.76	1.26	1.86	2.54	3.52	4.84	5.90	7.02	7.96	8.72	10.41	12.35	14.47	17.44	18.72	17.67	16.98
2008	0.05	0.17	0.40	0.76	1.25	1.89	2.60	3.39	4.51	6.04	7.16	8.32	9.25	9.97	11.74	13.76	15.94	18.95	20.16	18.97
2009	0.05	0.18	0.41	0.76	1.25	1.88	2.65	3.46	4.33	5.60	7.32	8.48	9.66	10.57	11.23	13.08	15.16	17.37	20.39	21.52
2010	0.05	0.18	0.42	0.78	1.25	1.88	2.63	3.53	4.42	5.37	6.77	8.67	9.85	11.04	11.91	12.50	14.41	16.53	18.75	21.76
2011	0.05	0.18	0.43	0.80	1.28	1.88	2.63	3.50	4.51	5.47	6.47	8.00	10.07	11.25	12.43	13.25	13.77	15.72	17.86	20.07
2012	0.05	0.18	0.43	0.81	1.33	1.93	2.64	3.50	4.47	5.58	6.60	7.63	9.28	11.49	12.66	13.82	14.58	15.02	16.99	19.15
2013	0.05	0.18	0.43	0.83	1.34	1.99	2.71	3.51	4.48	5.53	6.73	7.77	8.83	10.58	12.93	14.07	15.19	15.88	16.24	18.23
2014	0.05	0.18	0.43	0.81	1.37	2.02	2.80	3.60	4.48	5.54	6.66	7.93	8.99	10.06	11.89	14.36	15.46	16.53	17.15	17.43
2015	0.05	0.18	0.42	0.81	1.35	2.06	2.83	3.73	4.60	5.55	6.67	7.85	9.17	10.23	11.30	13.21	15.77	16.81	17.84	18.39
2016	0.05	0.18	0.42	0.80	1.34	2.02	2.89	3.78	4.77	5.70	6.68	7.86	9.07	10.44	11.49	12.54	14.51	17.15	18.13	19.10
2017	0.05	0.18	0.42	0.80	1.33	2.02	2.84	3.86	4.83	5.90	6.86	7.87	9.09	10.32	11.72	12.74	13.77	15.79	18.48	19.40
2018	0.05	0.18	0.42	0.80	1.32	2.00	2.83	3.77	4.93	5.98	7.11	8.08	9.10	10.34	11.59	13.00	13.99	14.99	17.04	19.76

Table 16. Relative gutted condition of cod in NAFO Divs. 2J, 3K and 3L in 1978-2015, as determined from sampling during DFO RV bottom-trawl surveys in autumn. There were no surveys in Division 3L in 1978-1980 and 1984. See text for details.

Year	Div. 2J	Div. 3K	Div. 3L
1978	0.95	0.94	-
1979	1.01	0.95	-
1980	0.99	0.97	-
1981	1.06	1.01	0.99
1982	0.99	0.95	0.99
1983	1.00	1.02	0.95
1984	1.00	0.98	-
1985	0.97	0.97	0.97
1986	1.07	1.01	1.00
1987	1.00	1.02	0.98
1988	1.03	1.04	0.99
1989	1.02	0.99	0.99
1990	0.99	0.96	0.97
1991	0.97	0.98	0.99
1992	0.97	0.96	1.03
1993	1.01	0.99	0.98
1994	1.02	1.03	1.00
1995	1.03	1.01	1.03
1996	1.02	1.02	1.02
1997	1.01	1.02	1.04
1998	0.99	1.01	1.01
1999	1.00	1.02	1.02
2000	0.97	1.00	0.99
2002	1.01	1.00	1.02
2003	0.98	0.96	0.97
2004	1.03	1.04	1.04
2005	1.01	1.02	1.02
2006	1.01	1.00	1.02
2007	1.00	1.01	1.00
2008	1.00	1.02	1.05
2009	0.99	1.00	0.99
2010	1.01	1.01	1.01
2011	1.02	1.06	1.05
2012	1.00	1.02	1.02
2013	1.01	1.00	1.02
2014	1.01	1.02	0.98
2015	1.00	0.99	0.98

Table 17. Relative liver condition of cod in NAFO Divs. 2J, 3K and 3L in 1978-2015, as determined from sampling during DFO RV bottom-trawl surveys in autumn. There were no surveys in Division 3L in 1978-80 and 1984. See text for details.

Year	Div. 2J	Div. 3K	Div. 3L
1978	-	0.73	-
1979	1.25	0.88	-
1980	1.18	0.86	-
1981	1.15	1.05	0.88
1982	1.04	0.87	0.81
1983	1.10	0.96	0.66
1984	1.22	0.90	-
1985	1.04	0.96	0.85
1986	1.57	1.33	0.87
1987	1.22	1.12	0.82
1988	1.25	1.18	0.9
1989	1.35	1.31	0.95
1990	1.26	1.06	0.98
1991	0.94	1.06	1.26
1992	0.82	1.06	1.41
1993	0.96	1.02	1.23
1994	0.93	1.09	1.18
1995	1.15	1.13	1.11
1996	1.04	1.01	1.03
1997	1.09	1.02	1.19
1998	1.04	1.08	1.11
1999	1.14	1.19	1.19
2000	0.92	1.03	1.07
2001	1.13	1.04	1.12
2002	1.02	1.17	1.19
2003	0.95	1.05	1.18
2004	1.25	1.21	1.19
2005	0.95	1.15	1.11
2006	0.92	1.15	1.07
2007	1.02	1.12	1.16
2008	1.00	1.02	1.11
2009	0.84	0.92	0.96
2010	1.02	1.02	1.04
2011	1.38	1.29	1.33
2012	1.18	1.12	1.13
2013	1.24	1.14	1.17
2014	1.13	1.07	0.93
2015	1.16	0.96	0.95

*Table 18. Estimated proportions mature for female cod from NAFO Div. 2J3KL from DFO RV autumn bottom trawl surveys projected forward to 2018 and back to 1958. Estimates were obtained from a cohort-specific binomial logistic regression model fitted to observed proportions mature at age. * are averages of the first or last three estimates extrapolated back or forward. † are the average of adjacent estimates for the same age group.*

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1958	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*	0.001*	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	0.001*	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	0.011*	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	0.001	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	0.001	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	0.001†	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	0.001†	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	0.002	0.00†5	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	0.008	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	0.001	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	0.009	0.166	0.440†	0.795	0.973†	0.999	1.000	1.000	1.000	1.000*	1.000*
1970	0.000	0.001†	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	0.009†	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	0.017	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	0.042	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	0.101	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	0.222	0.299†	0.543	0.874†	0.995	0.999	1.000	1.000	1.000†	1.000	1.000†
1976	0.000	0.001	0.002	0.004	0.422	0.597†	0.868	0.984†	1.000	1.000	1.000	1.000	1.000†	1.000
1977	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	0.005	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	0.002	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	0.017	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	0.003	0.113	0.553	0.834	0.987	0.999	0.987	0.997†	1.000	1.000†	1.000
1982	0.000	0.001	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	0.005	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	0.024	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	0.005	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	0.001	0.003	0.053	0.389	0.926	0.995	1.000	1.000	1.000	1.000	1.000	1.000

Year	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1987	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	0.002	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	0.002	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	0.001	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	0.018	0.130	0.434	0.931	0.993	1.000	1.000	1.000	1.000	1.000	1.000
1992	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	0.008	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	0.029	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	0.003	0.098	0.404	0.966	0.997	1.000	0.999	0.999	1.000	1.000	1.000	1.000
1996	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	0.001	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	0.003	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	0.014	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	0.004	0.067	0.325	0.900	0.990	0.999	0.985	1.000	1.000	1.000	1.000	1.000
2001	0.001	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	0.005	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	0.001	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	0.001	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	0.001	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	0.004	0.019	0.089	0.315	0.748	0.982	1.000	1.000	0.999	0.999	1.000	1.000	1.000
2007	0.001	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	0.003	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	0.002	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	0.002	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	0.009	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	0.001*	0.001	0.047	0.103	0.404	0.714	0.956	0.989	1.000	1.000	1.000	1.000	1.000	1.000
2013	0.001*	0.004*	0.006	0.201	0.424	0.830	0.932	0.994	0.998	1.000	1.000	1.000	1.000	1.000
2014	0.001*	0.004*	0.023*	0.036	0.563	0.826	0.972	0.987	0.999	1.000	1.000	1.000	1.000	1.000
2015	0.001*	0.004*	0.023*	0.113*	0.184	0.869	0.968	0.996	0.998	1.000	1.000	1.000	1.000	1.000
2016	0.001*	0.004*	0.023*	0.113*	0.391*	0.576	0.971	0.995	0.999	1.000	1.000	1.000	1.000	1.000
2017	0.001*	0.004*	0.023*	0.113*	0.391*	0.757*	0.891	0.994	0.999	1.000	1.000	1.000	1.000	1.000
2018	0.001*	0.004*	0.023*	0.113*	0.391*	0.757*	0.944*	0.980	0.999	1.000	1.000	1.000	1.000	1.000

Table 19. Acoustic biomass estimates (t) for Smith Sound, Trinity Bay, from Rose et al. (2011).

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

Table 20. 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
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

Table 21. Standardized age-disaggregated sentinel gill-net (5½" mesh) catch rates (fish/net) of cod in NAFO Divs. 2J3KL during 1995-2014.

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Total
1995	0.0016	0.0469	1.0677	1.3948	0.5709	0.3249	0.0810	0.0171	3.5048
1996	0.0333	0.1321	0.8931	4.9451	2.0625	0.5993	0.1323	0.0351	8.8328
1997	0.0178	0.0842	1.3871	2.0860	3.7466	0.9294	0.1215	0.0514	8.4241
1998	0.0328	0.0821	1.0777	5.2863	3.4165	1.8720	0.5224	0.0700	12.3599
1999	0.0135	0.0957	1.1341	1.9669	2.6957	0.7868	0.4260	0.1045	7.2231
2000	0.0165	0.0676	0.6944	1.1477	0.8003	0.9878	0.4404	0.2088	4.3636
2001	0.0099	0.0571	0.3056	0.7670	0.4710	0.2301	0.3384	0.0993	2.2784
2002	0.0203	0.0566	0.4128	0.5822	0.4883	0.2062	0.1109	0.1393	2.0166
2003	0.0293	0.0744	0.3324	1.3050	0.7982	0.2964	0.1326	0.0531	3.0214
2004	0.0121	0.1201	0.7236	1.2497	1.3073	0.4079	0.1418	0.0413	4.0037
2005	0.0244	0.0711	1.3809	2.0667	1.1028	0.5287	0.1918	0.0537	5.4201
2006	0.0130	0.3149	1.0785	2.5537	1.2409	0.4227	0.1975	0.0689	5.8901
2007	0.0264	0.0638	2.0965	2.9405	1.4049	0.4527	0.1393	0.0665	7.1905
2008	0.0195	0.0748	0.4258	4.3769	2.7518	0.8231	0.2206	0.0623	8.7548
2009	0.0193	0.0491	0.3001	0.8850	2.8871	1.7788	0.4349	0.1058	6.4601
2010	0.0107	0.0248	0.2541	1.3278	1.2750	2.2320	1.0425	0.2452	6.4121
2011	0.0137	0.0464	0.2869	1.0361	1.8311	1.2986	1.4521	0.5875	6.5523
2012	0.0288	0.0842	1.0929	2.1915	2.4083	1.6488	0.9031	0.9527	9.3102
2013	0.0084	0.0738	0.9418	3.6057	2.5364	1.8940	1.0609	0.5853	10.7063
2014	0.0256	0.0980	1.9488	4.3551	4.3153	1.7460	0.9827	0.4173	13.8889

Table 22. Estimates of model fits, population parameters and variance parameters (with percent coefficients of variation, CV x 100) for four formulations of NCAM.

Quantity	S1 Mshift estimates	S1 Mshift CV (%)	Baseline M estimates	Baseline M CV (%)	med M estimates	medM CV (%)	Mshift estimates	Mshift CV (%)
Index: σ_{RV}	0.350	6	0.343	6	0.344	6	0.348	6
Index: σ_{SN}	0.407	7	0.402	7	0.402	7	0.405	7
YE RW:σ_{SN_RW}	0.240	23	0.254	22	0.254	22	0.244	22
Age comps: σ_P	0.247	6	0.249	6	0.249	6	0.250	6
NB k 1983-96	45.26	49	42.79	46	44.73	48	43.81	48
NB k 1997-15	7.565	15	7.480	15	7.512	15	7.523	15
PE: σ_δ	0.255	15	0.271	15	0.269	15	0.250	16
F RW: σ_F	0.269	7	0.277	7	0.276	7	0.277	7
SS: σ_D	0.801	16	0.804	16	0.802	16	0.798	17
Rec: σ_R	0.428	17	0.433	17	0.431	17	0.414	17
PE: $\varphi_{\delta,age}$	0.819	8	0.901	4	0.900	4	0.822	8
PE: $\varphi_{\delta,yr}$	0.534	24	0.641	16	0.617	18	0.525	25
SS: $\varphi_{D,yr}$	0.866	6	0.866	6	0.866	6	0.854	6
SS: $\varphi_{D,age}$	0.851	6	0.848	6	0.858	6	0.849	6
F: $\varphi_{F,age}$	0.883	5	0.884	5	0.885	5	0.882	5
F: $\varphi_{F,yr}$	0.994	0	0.994	0	0.994	0	0.994	0
B_{lim} (Kt)	839	7	909	8	917	8	885	8
SSB_{2015} (Kt)	294	9	304	10	305	10	299	10
SSB_{2015}/B_{lim}	0.351	9	0.335	10	0.332	10	0.338	9
Tot. B_{2015} (Kt)	496	9	517	10	512	10	507	10
q_{full}	0.817	6	0.756	8	0.754	7	0.774	8
$\bar{Z}_{2015}$	0.307	30	0.259	38	0.255	38	0.291	30
$\bar{M}_{2015}$	0.289	31	0.246	40	0.242	40	0.278	31
$\bar{F}_{4\text{-}6,2015}$	0.005	17	0.003	17	0.003	17	0.003	17
$\bar{F}_{7\text{-}9,2015}$	0.036	12	0.027	13	0.027	12	0.028	12
nll/AIC	8305	16842	8332	16896	8330	16891	8321	16875

Note: PE=process error; SS=Smith Sound; YE=year effects; RW=random walk; see Table 1 in Cadigan (2015) for definitions of quantities listed in column 1.

Table 23. Baseline levels of natural mortality (M) at age used in the three formulations of NCAM.

Formulation of NCAM	Years	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age8+
Run 1 Baseline M	1983-2015	0.57	0.48	0.48	0.48	0.44	0.42	0.37
Run 2 Median baseline M	1983-2015	0.49	0.41	0.38	0.43	0.41	0.43	0.40
Run 3 Median baseline M with M Shift	1983-1990, 1995-2015	0.43	0.38	0.38	0.40	0.38	0.42	0.36
	1991-1994	1.02	1.16	1.23	1.84	2.15	2.54	2.05

FIGURES

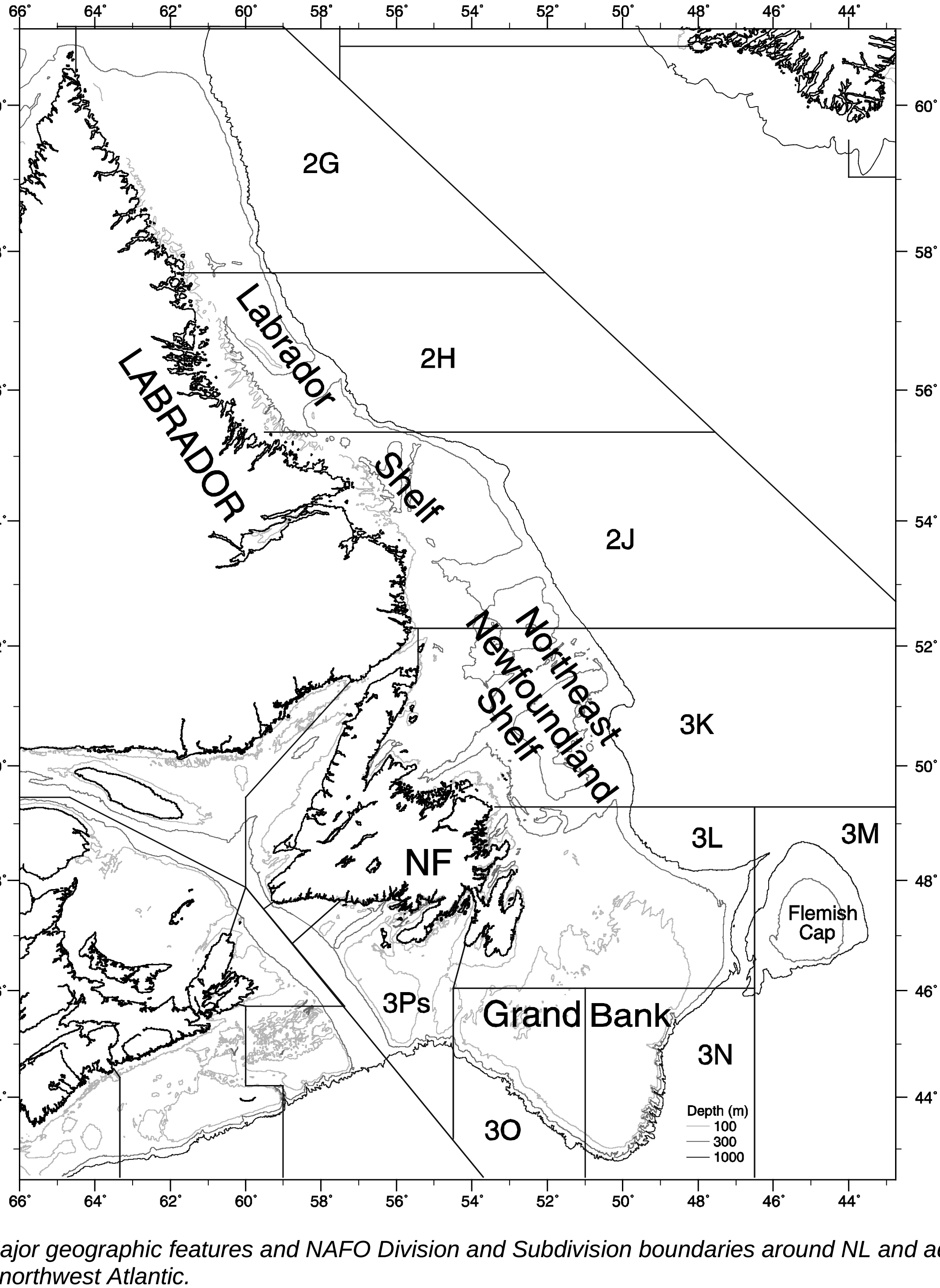


Figure 1a. Major geographic features and NAFO Division and Subdivision boundaries around NL and adjacent areas of the northwest Atlantic.

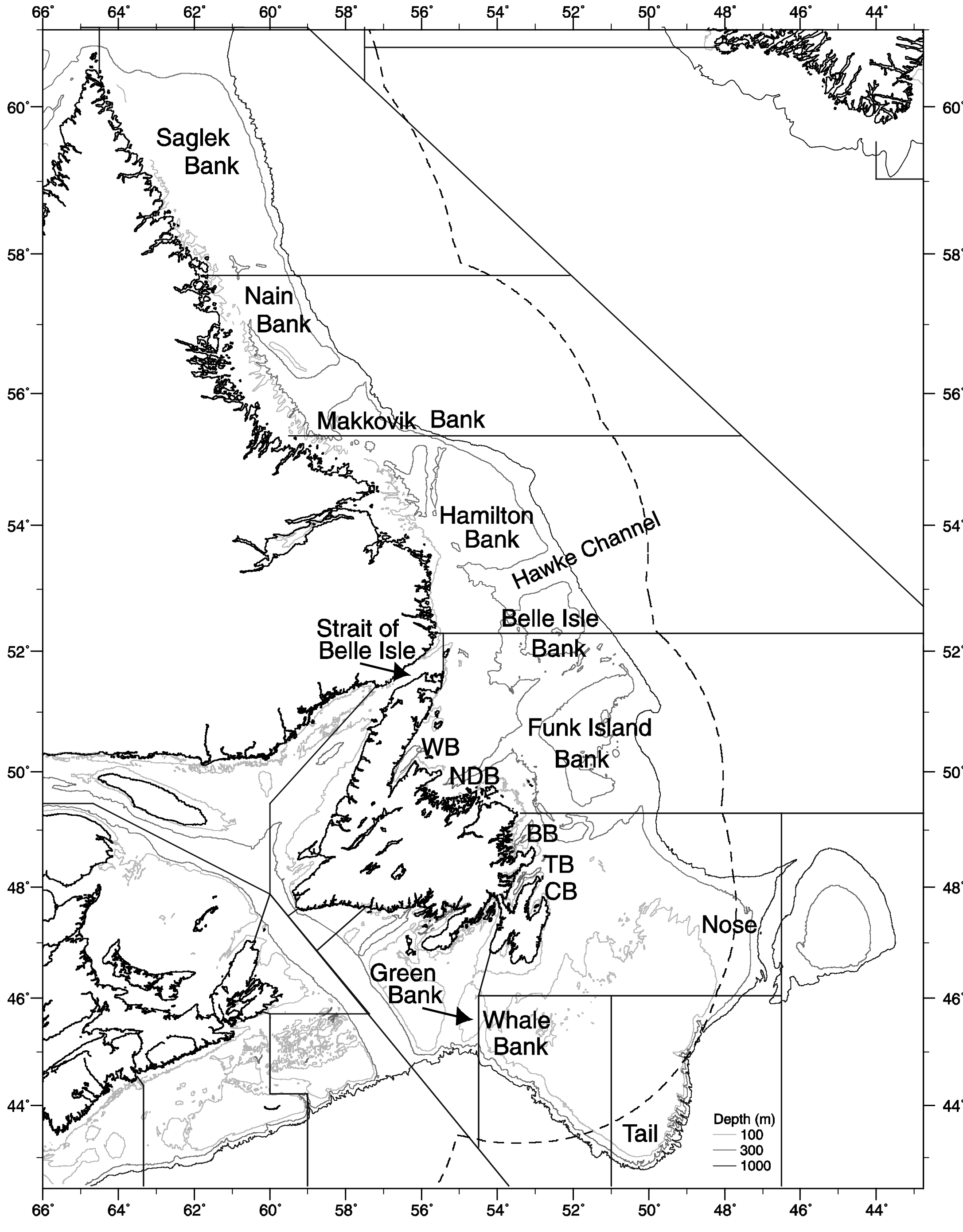


Figure 1b. Bathymetry, fishing banks, and major bays around eastern Newfoundland and Labrador. The dashed line is Canada's 200 nautical mile limit. WB=White Bay, NDB=Notre Dame Bay, BB=Bonavista Bay, TB=Trinity Bay, and CB=Conception Bay.

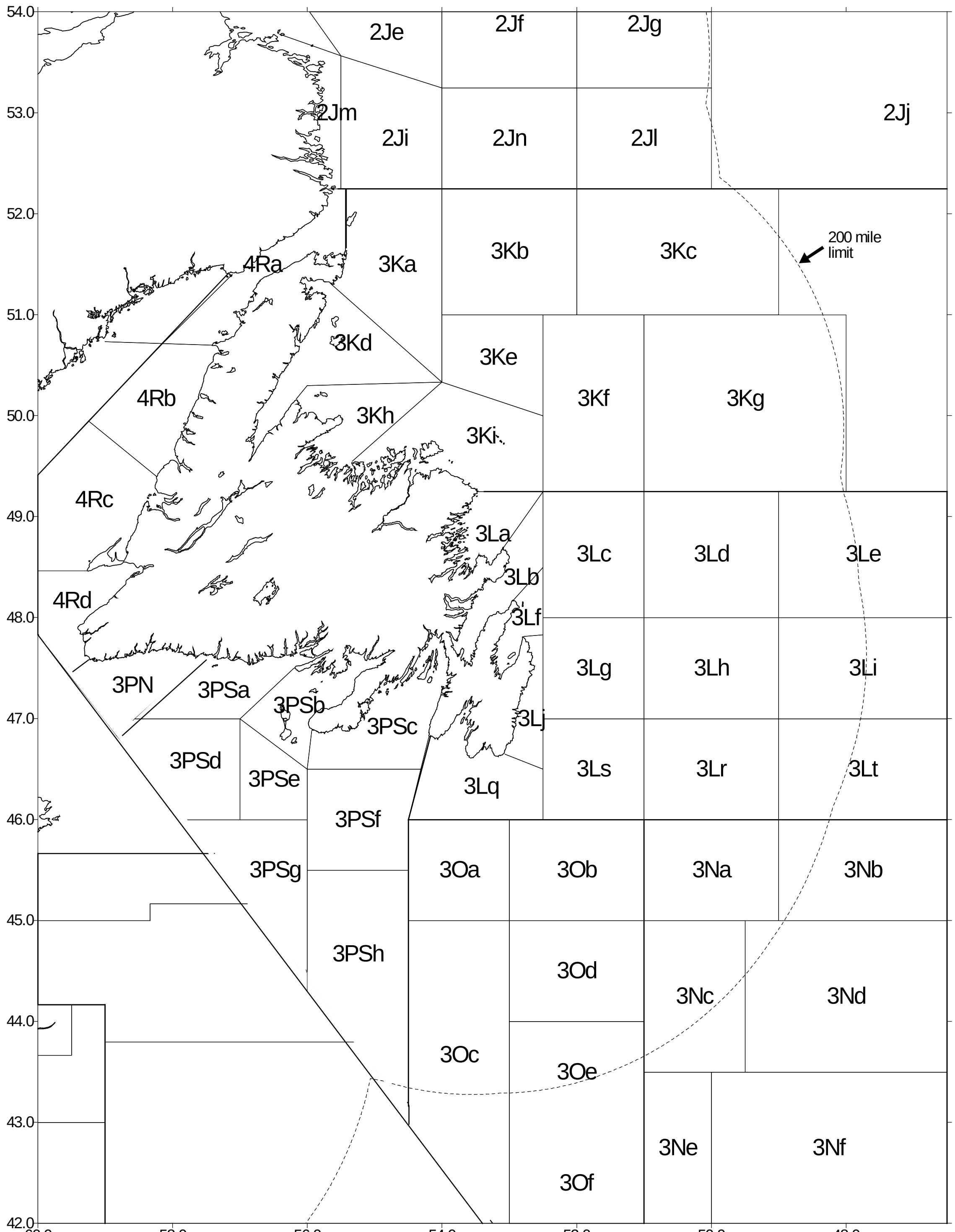


Figure 1c. Boundaries of commercial fishery statistical unit areas and Canada's 200 nautical mile limit (dotted line).

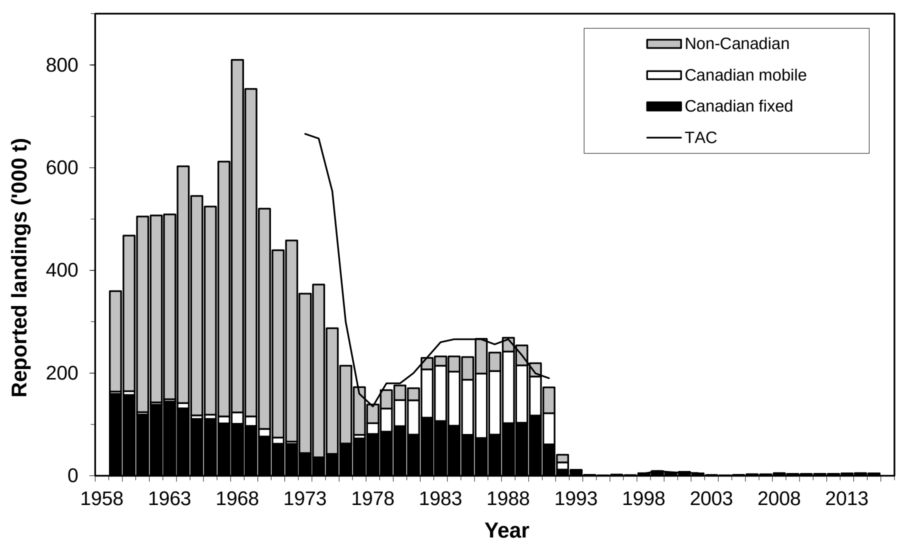


Figure 2. Total allowable catches (TACs) and reported landings (000's t) of cod from NAFO Divs. 2J3KL by Canadian mobile fleets (offshore), Canadian fixed gear fleets (mostly inshore), and non-Canadian fleets.

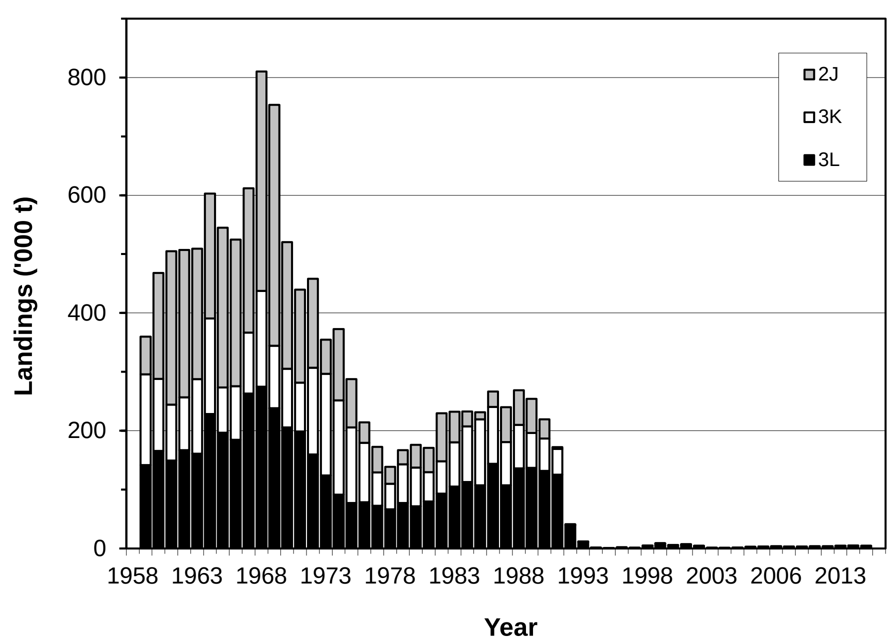


Figure 3. Reported landings (000's t) of cod in NAFO Divs. 2J3KL.

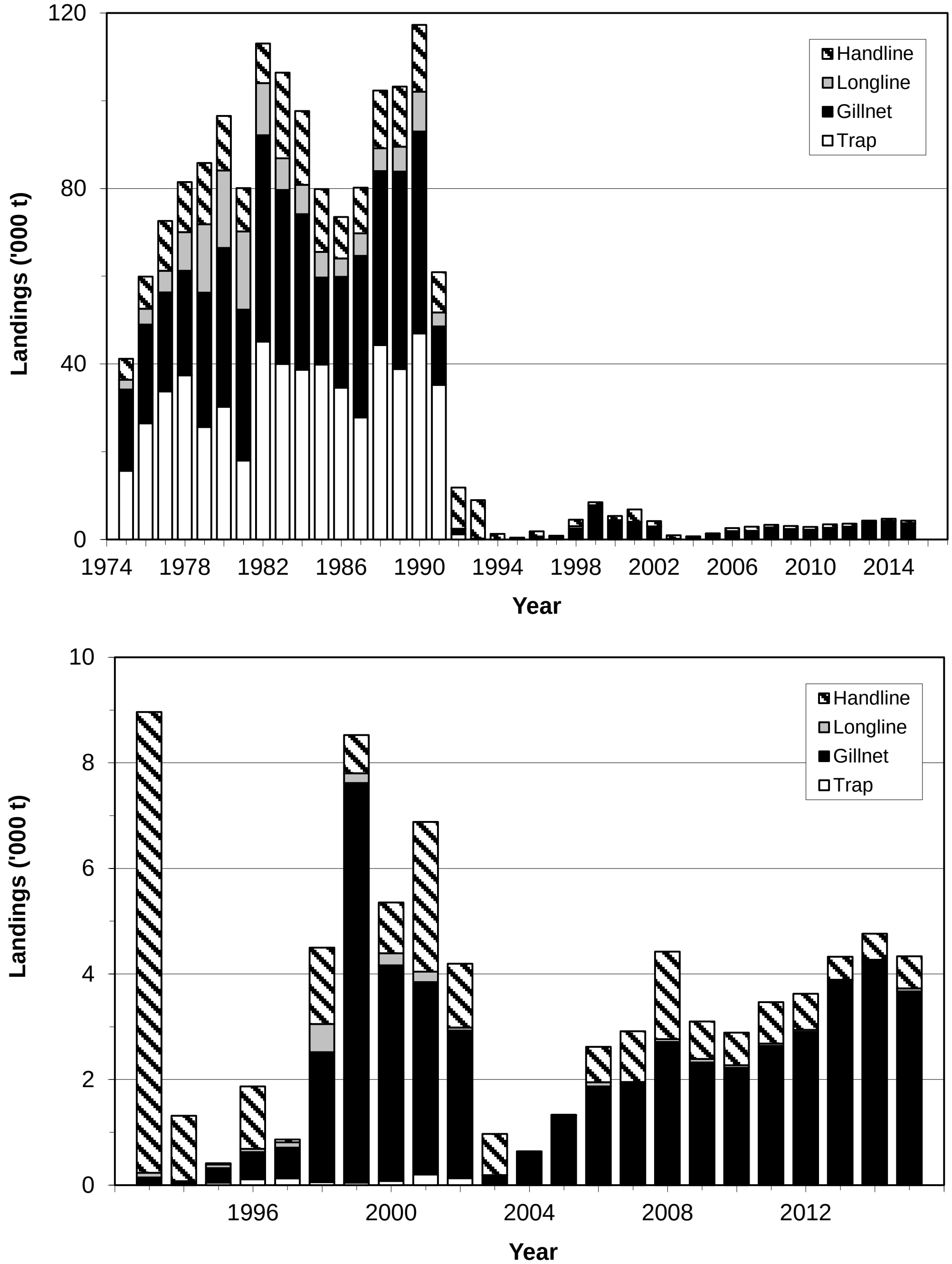


Figure 4. Reported fixed gear landings (000s t) of cod from NAFO Divs. 2J3KL by gear type. Upper panel from 1975-2015; lower panel (on expanded scale) from 1993-2015 where small scale directed inshore fisheries were permitted (within 12 nm of the coast). Note that lower panel excludes recreational fishery landings except during 2008 and 2011-12.

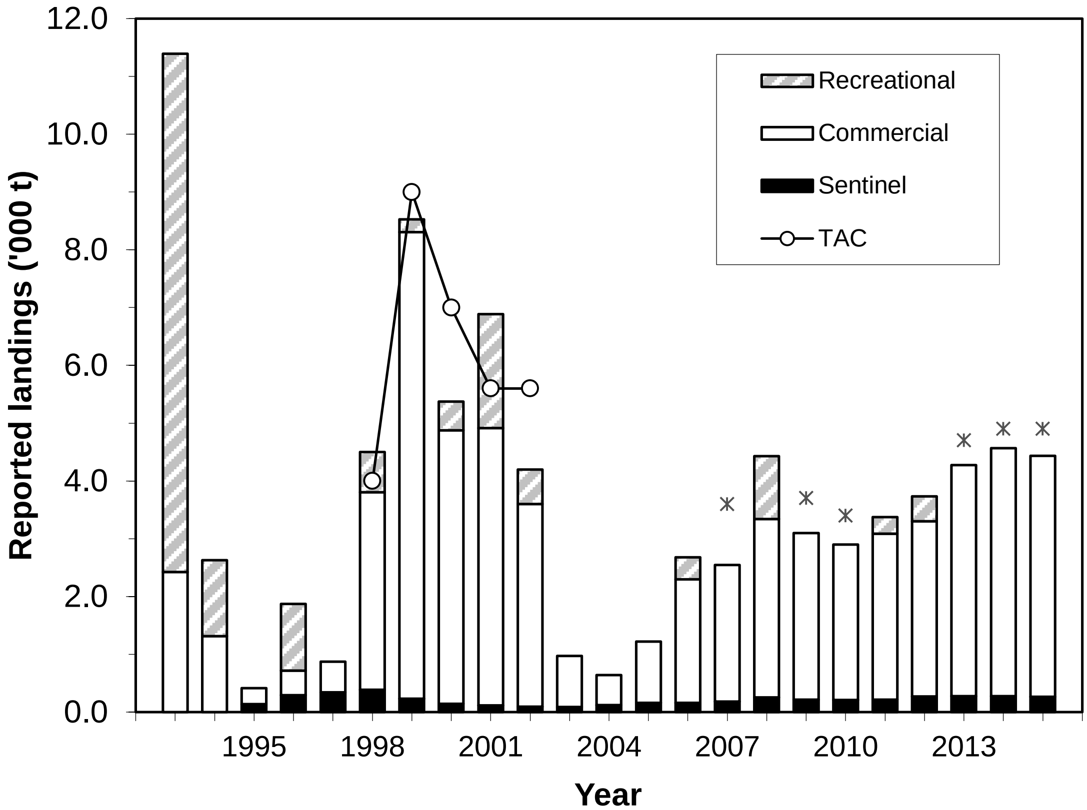


Figure 5. Total allowable catches (TACs) and reported inshore fixed-gear landings (000's t) of cod from NAFO Divs. 2J3KL for the fisheries during 1993-2015. Asterisks indicate years where recreational catches were taken but no estimates are available.

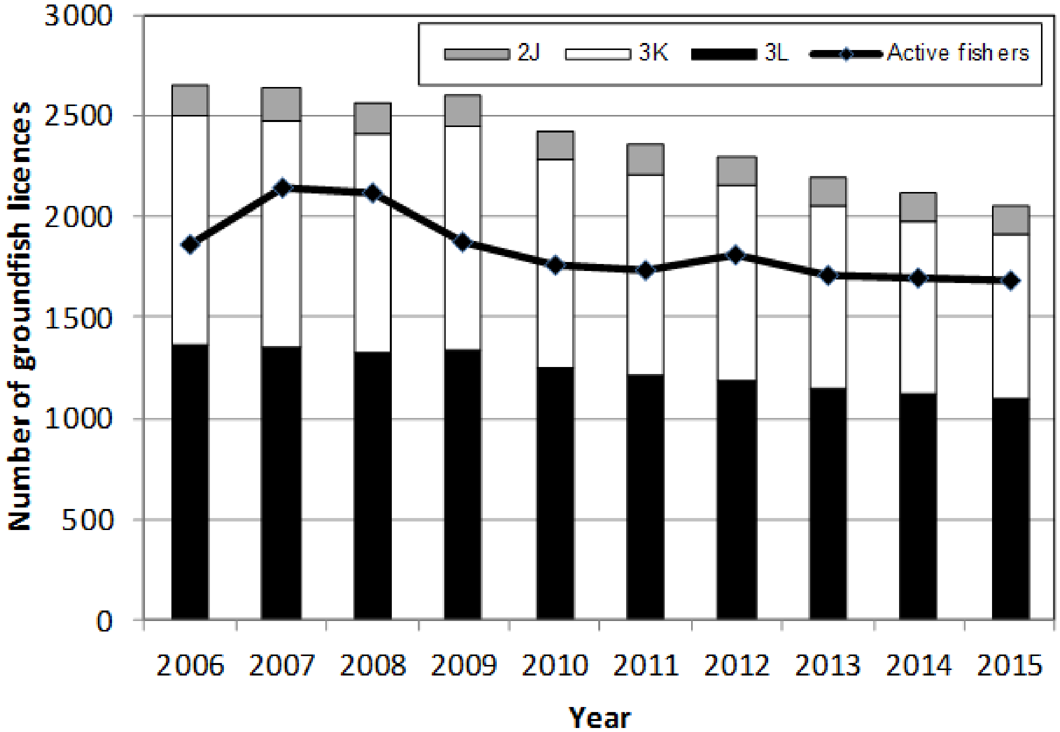


Figure 6. Trends in the number of groundfish licences in NAFO Divs. 2J3KL and overall number of active licences durig 2006-15.

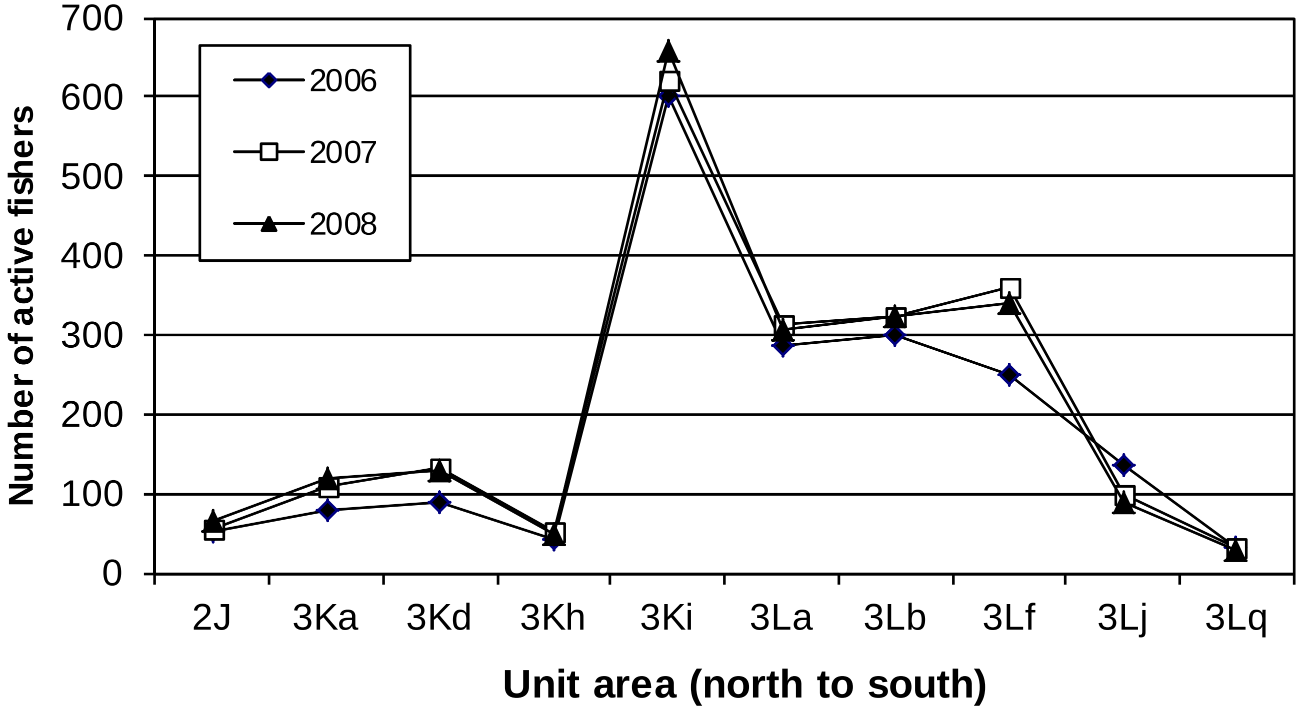


Figure 7. Numbers of active harvesters per statistical unit area for the commercial cod fishery in NAFO Divs. 2J3KL (see Figure 1c for location of unit areas).

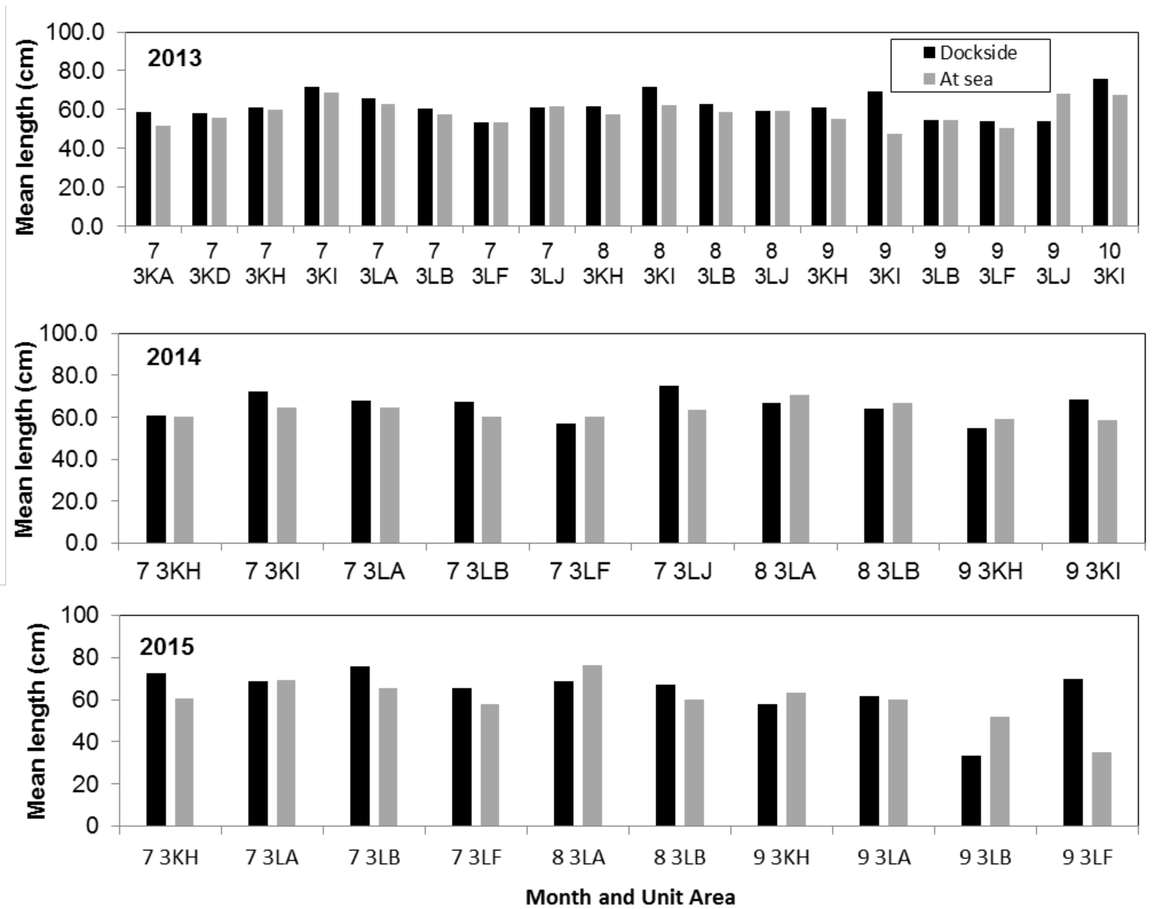


Figure 8. Comparison of mean lengths of cod measured at sea and at the dock by fisheries officers during the recreational fishery in NAFO Divs. 2J3KL during 2013-15.

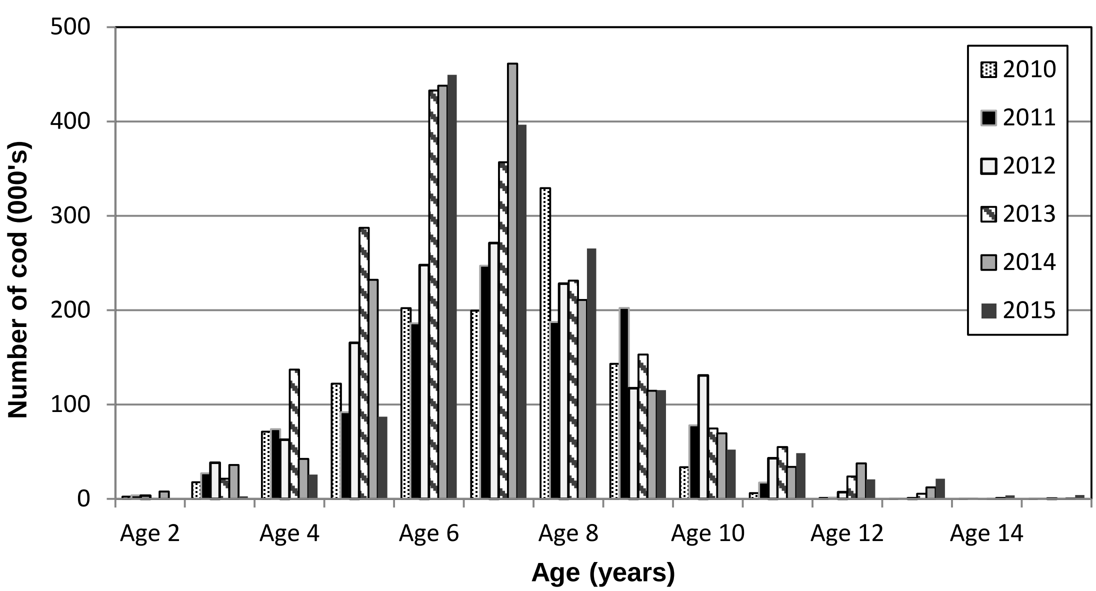


Figure 9. Comparison of the catch numbers at age for 2J3KL cod from 2010-15.

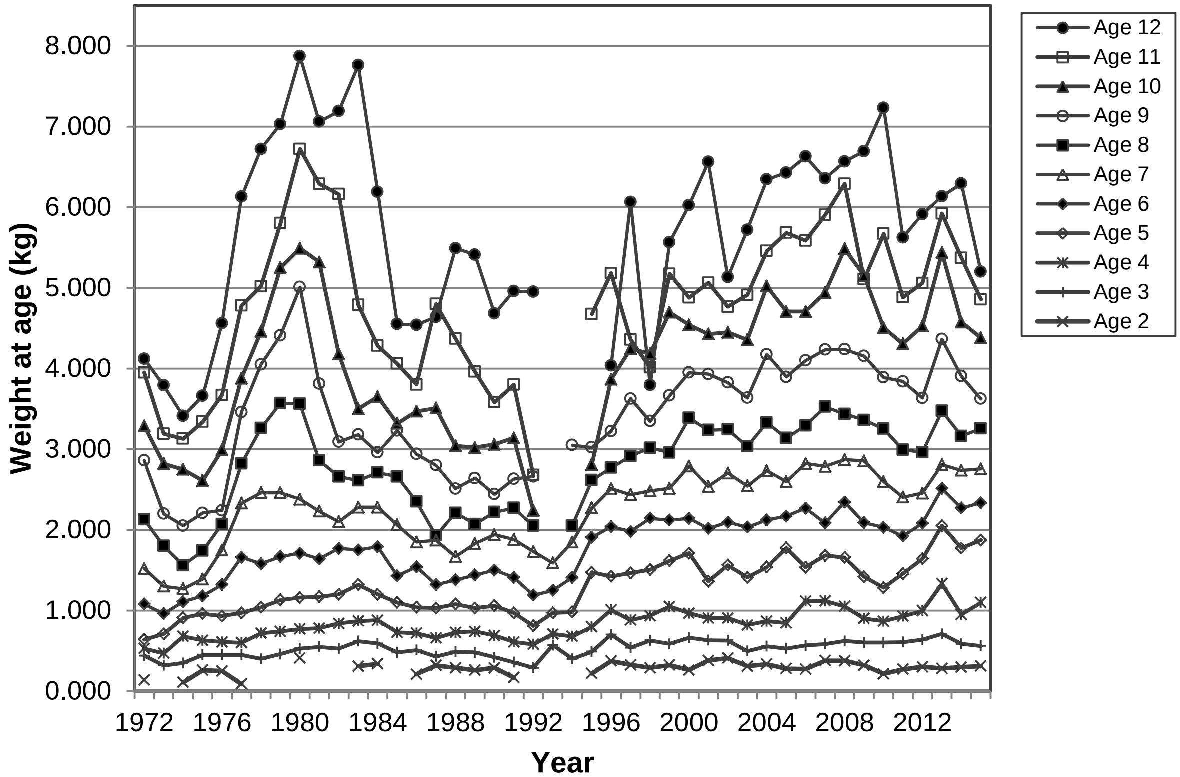


Figure 10. Mean weight at age of 2J3KL cod calculated from mean lengths at age in the commercial catch from 1972 onwards. Values for 8 and 9 yrs olds for 1993 were anomalous and are omitted.

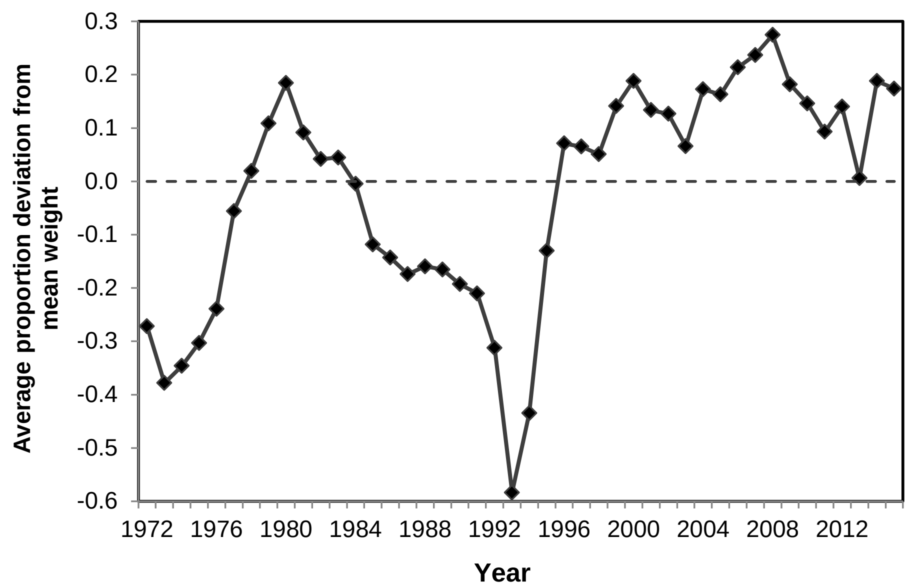


Figure 11. Trends in deviations of mean-weight-at-age (kg) from the long-term average, calculated from mean lengths at age, for 2J3KL cod ages 3-12 in the commercial catch from 1972 onwards.

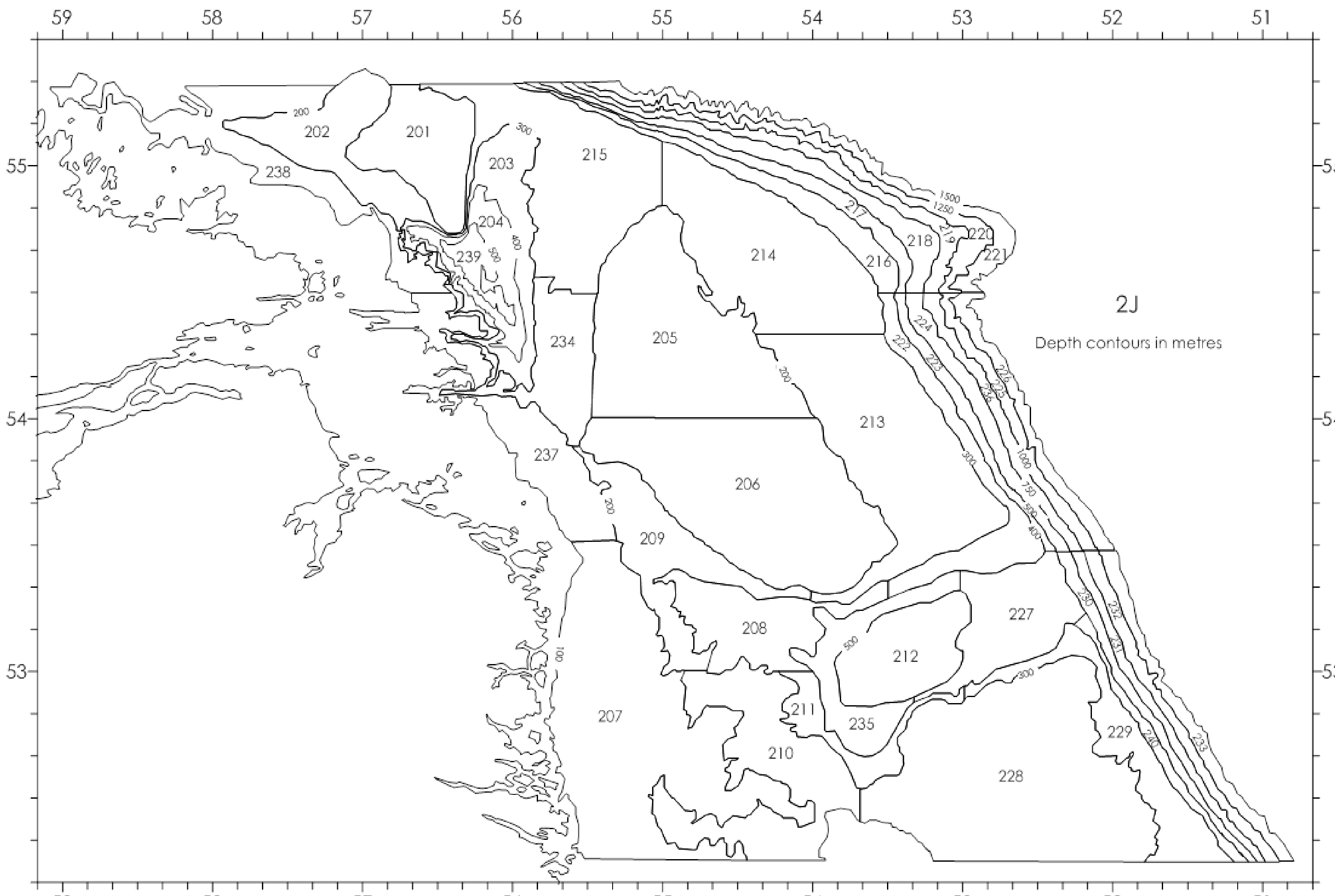


Figure 12a. Boundaries of strata used in autumn DFO research vessel bottom trawl surveys in NAFO Div. 2J.

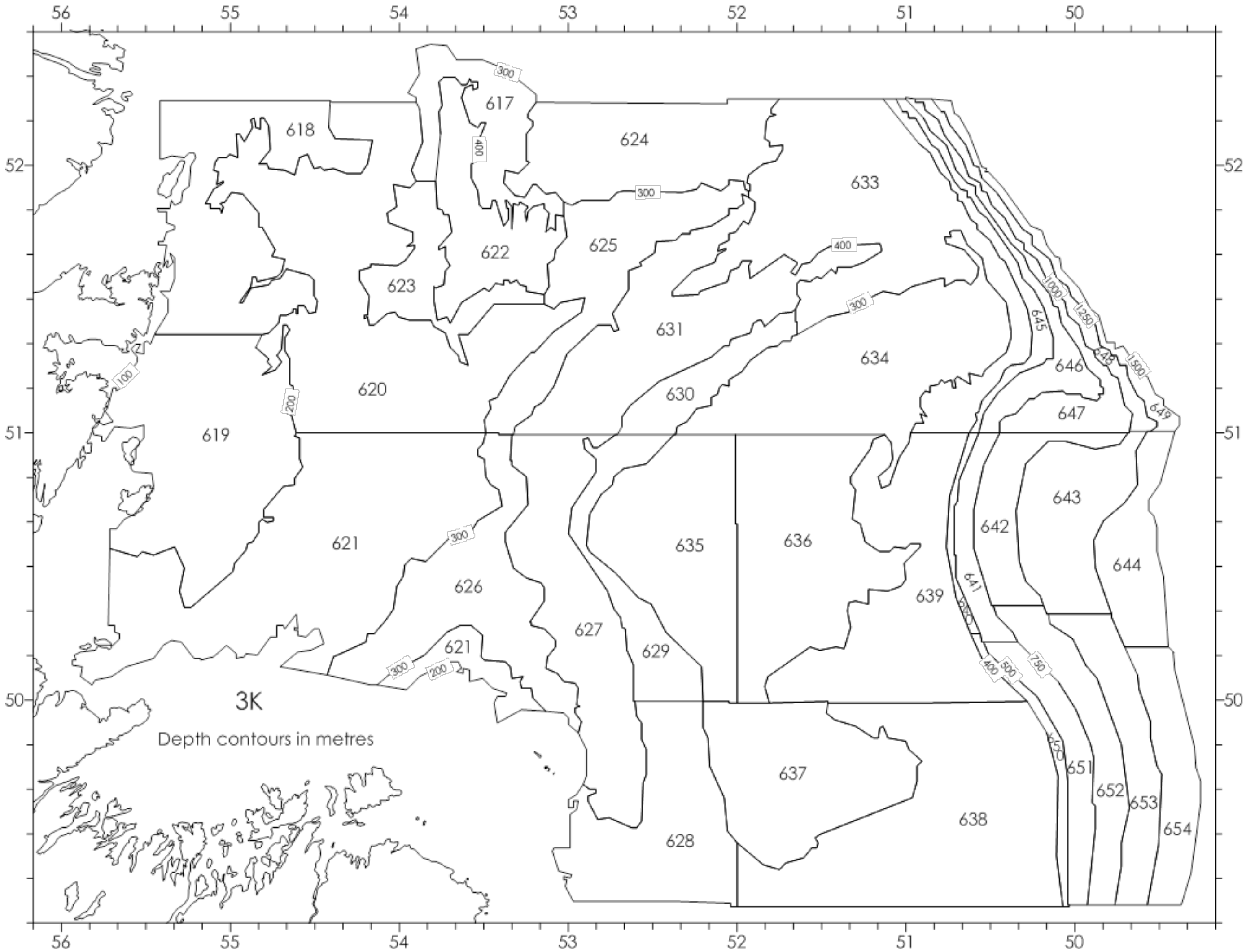


Figure 12b. Boundaries of strata used in autumn DFO research vessel bottom trawl surveys in NAFO Div. 3K.

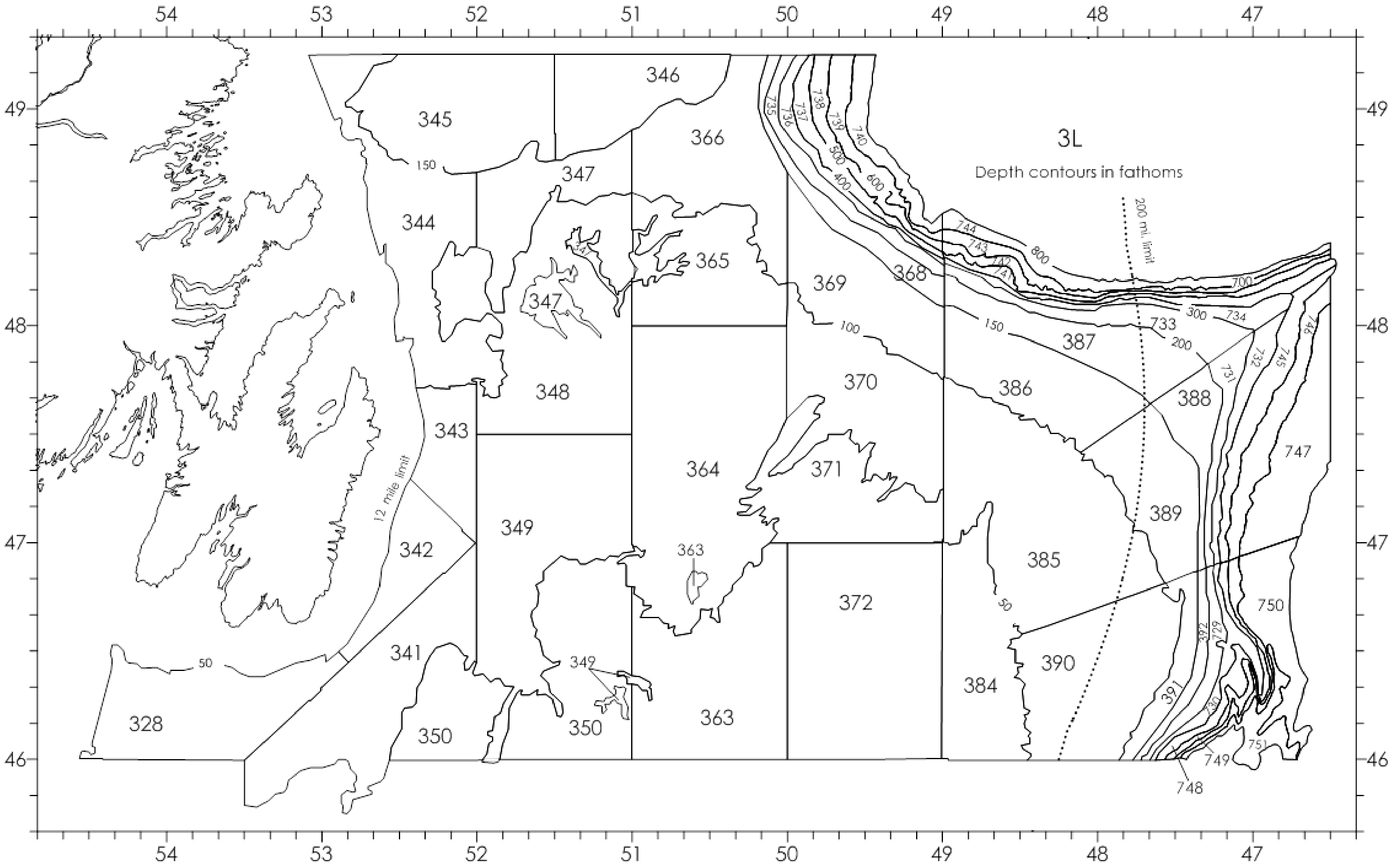


Figure 12c. Boundaries of strata used in autumn DFO research vessel bottom trawl surveys in NAFO Div. 3L.

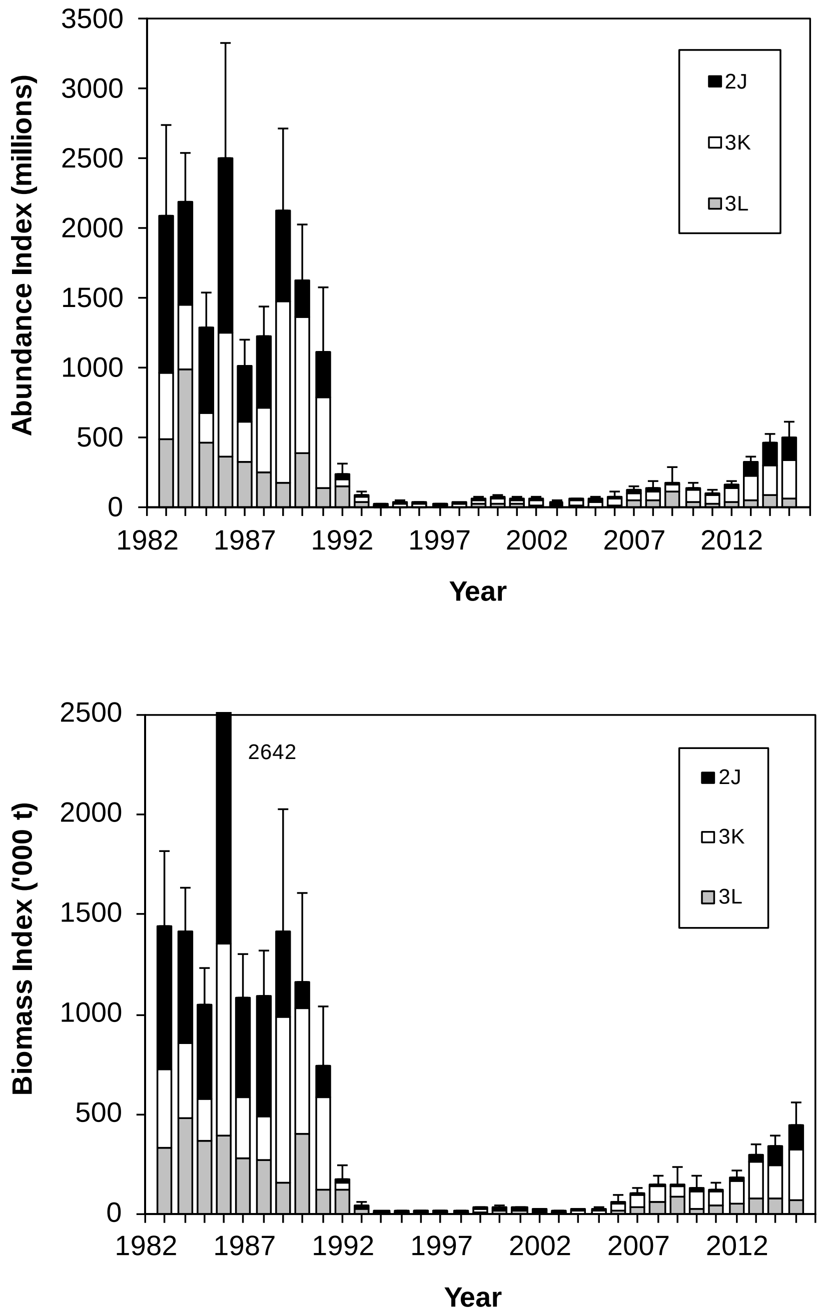


Figure 13. Trends in the offshore indices of cod abundance (upper panel) and total biomass (lower panel) from the autumn DFO research vessel bottom trawl surveys of NAFO Divs. 2J3KL. Error bars are ±2 SE's.

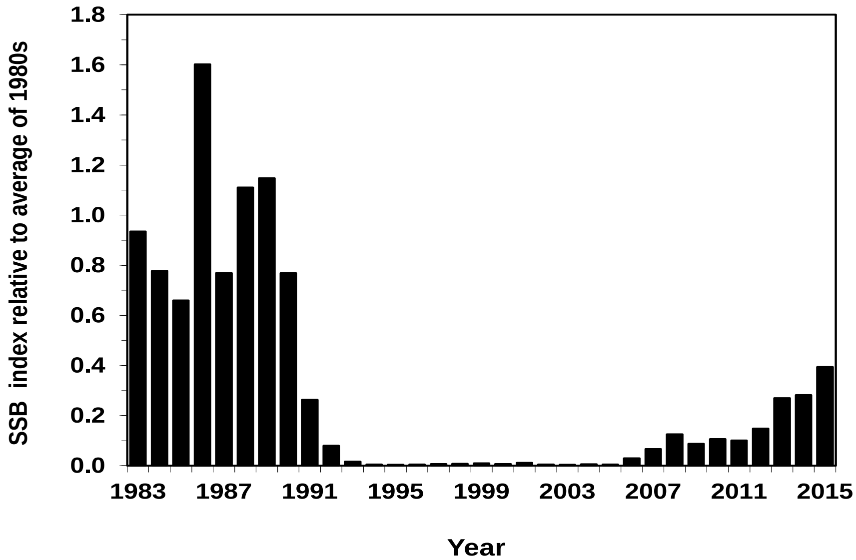


Figure 14. Trends in the SSB index for cod from the autumn DFO research vessel bottom trawl surveys of NAFO Divs. 2J3KL. The y-axis is scaled relative to the 1980s average.

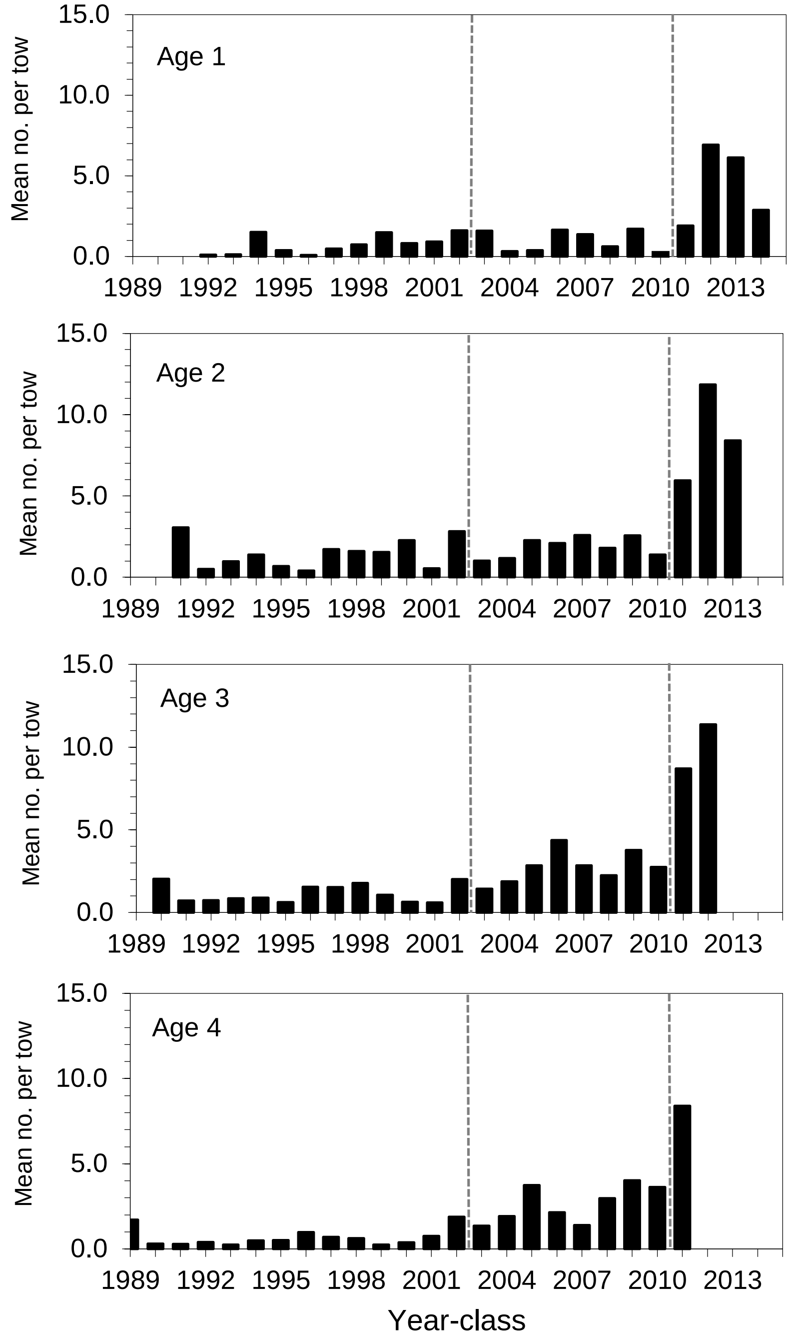


Figure 15. Trends in catches rates (mean numbers per tow, MNPT) of cod ages 1-4 from the autumn DFO RV bottom trawl surveys of NAFO Divs. 2J3KL. Vertical dashed grey lines delineate three groups of year-classes with differing general trends in catch rates with age. See text for details.

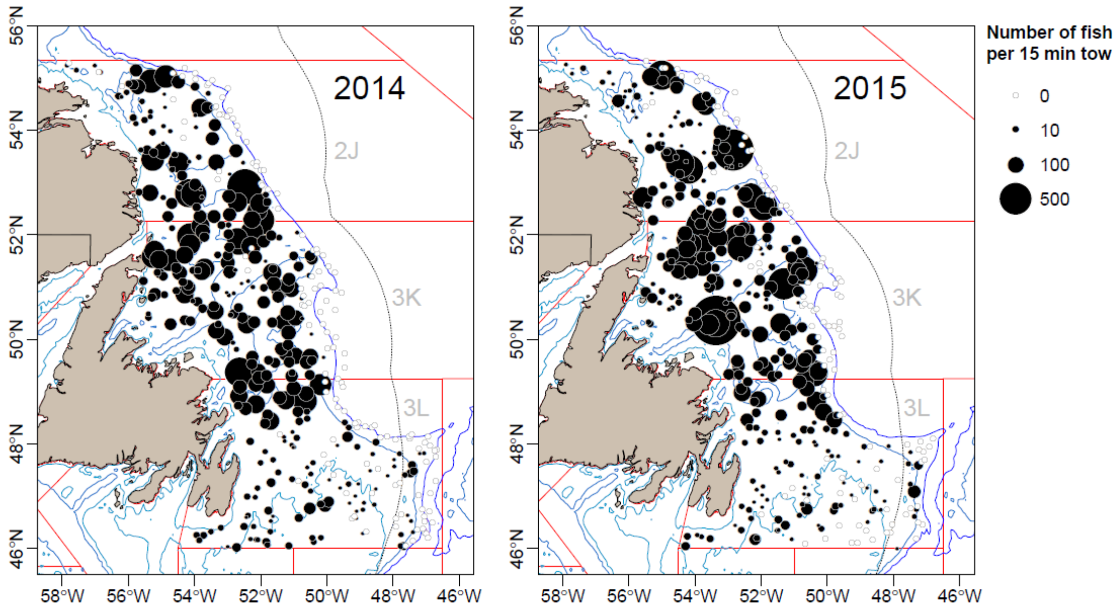


Figure 16a. Age-aggregated distribution of cod catches (nos. per tow), from the autumn DFO RV survey of all strata in NAFO Divs. 2J3KL during 2014-15. Symbol size (continuous scaling) is proportional to numbers caught.

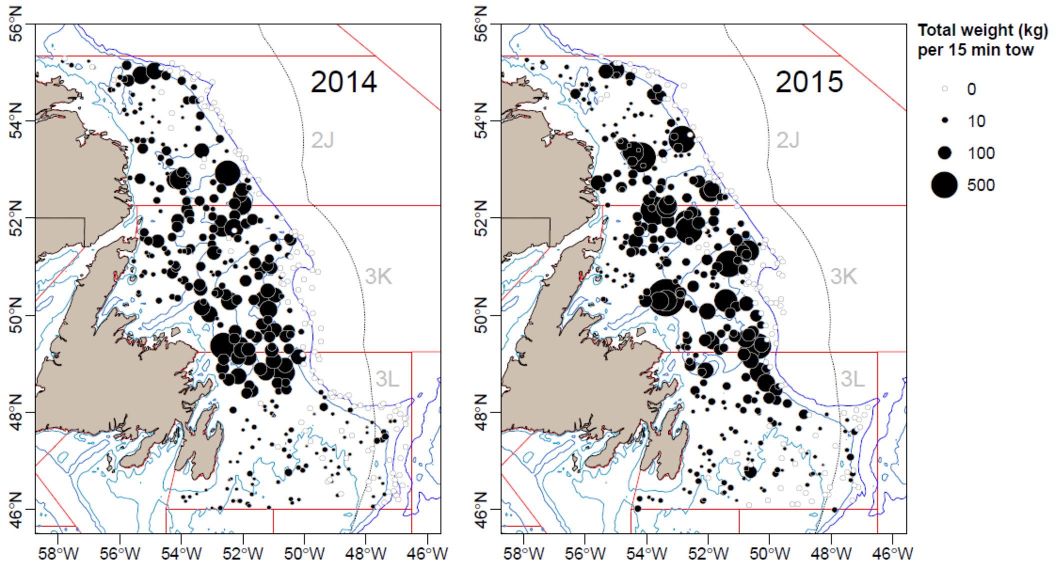


Figure 16b. Age-aggregated distribution of cod catches (weight [kg] per tow) from the autumn DFO RV survey of all strata in NAFO Divs. 2J3KL during 2014-15. Symbol size (continuous scaling) is proportional to numbers caught.

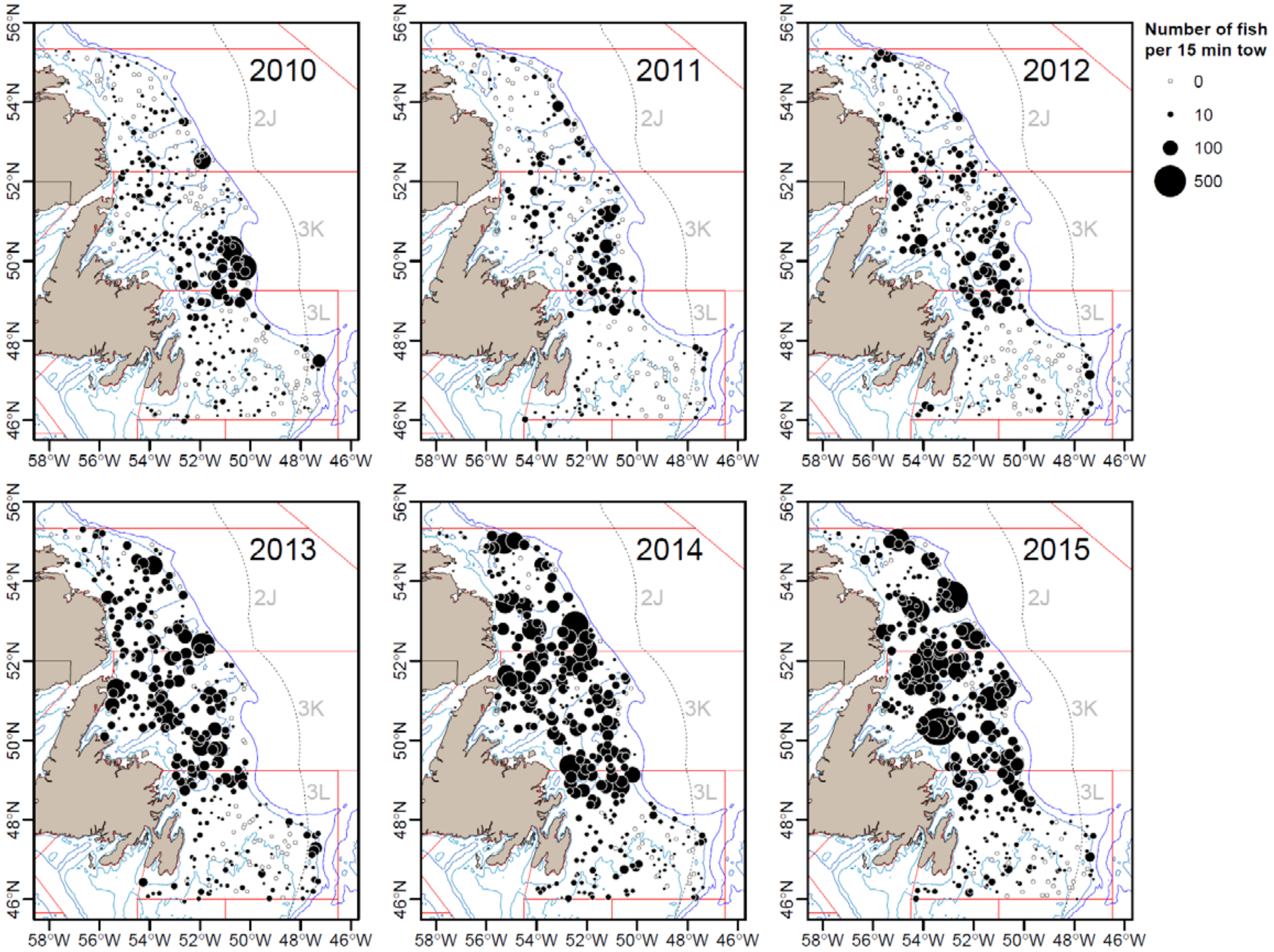


Figure 17a. Age-aggregated distribution of cod catches (nos. per tow) from the autumn DFO RV survey of index strata in NAFO Divs. 2J3KL during 2010-15. Symbol size (continuous scaling) is proportional to numbers caught.

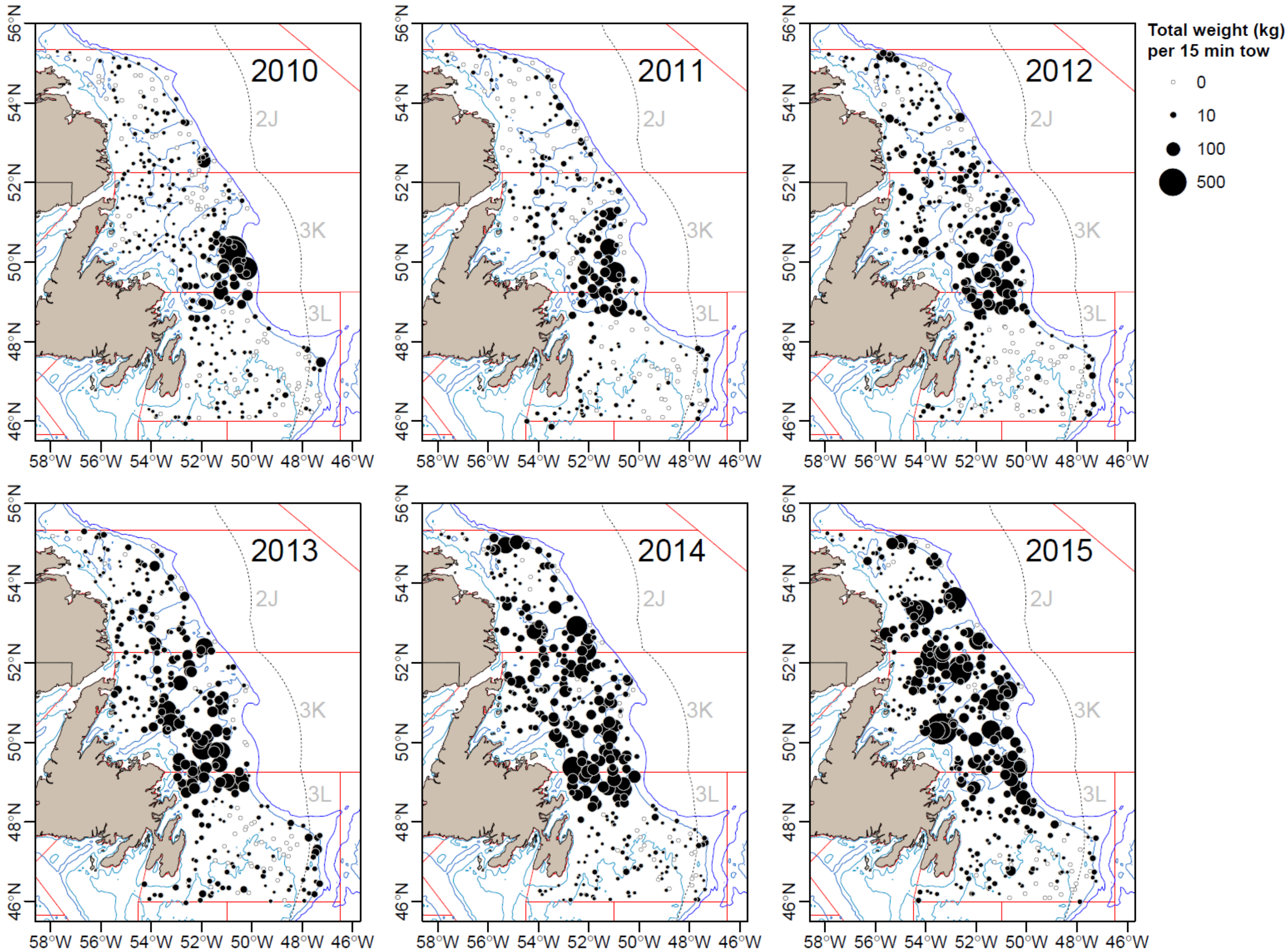


Figure 17b. Age-aggregated distribution of cod catches (weight per tow) from the autumn DFO RV survey of index strata in NAFO Divs. 2J3KL during 2010-2015. Symbol size (continuous scaling) is proportional to catch weight (kg).

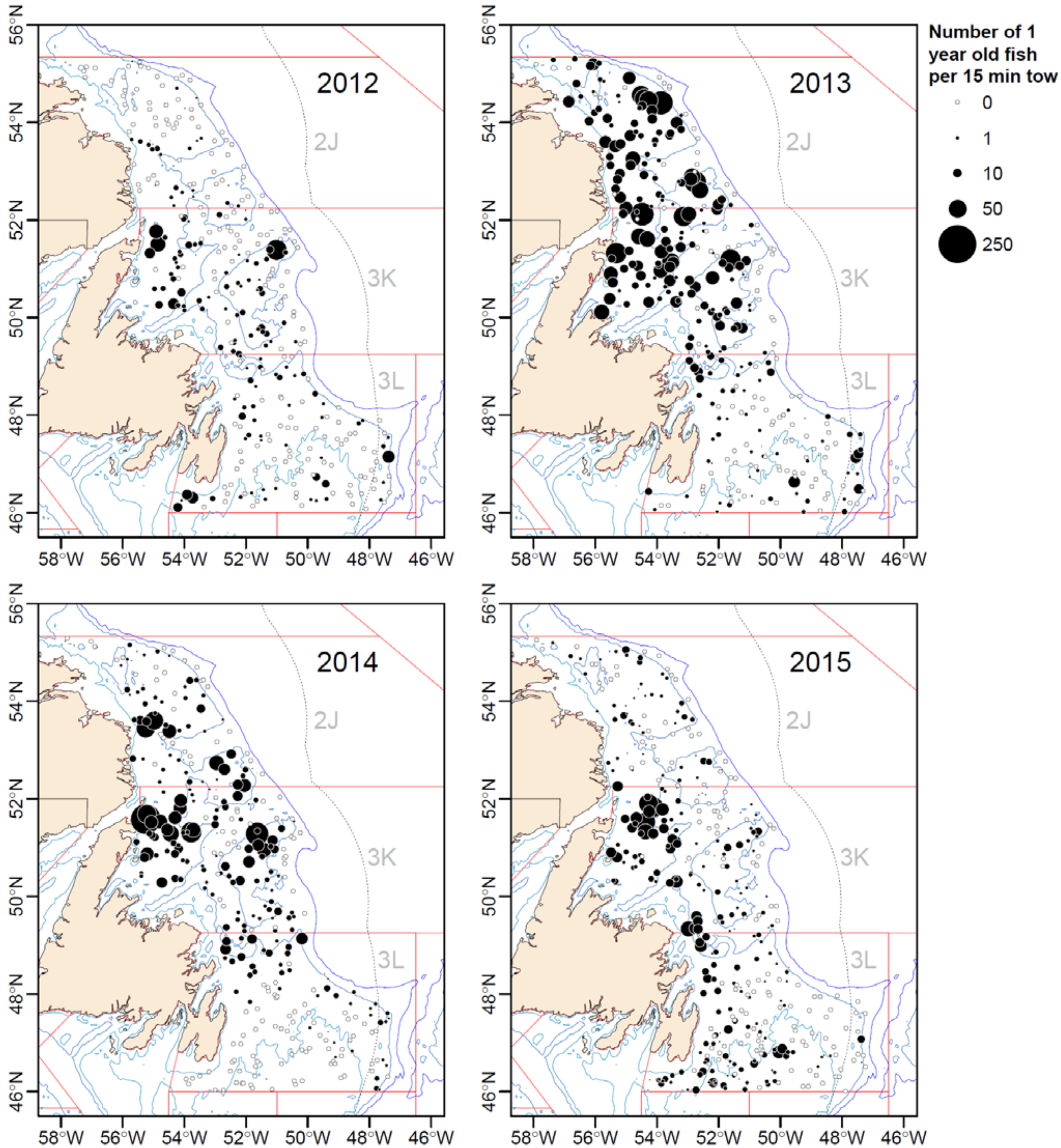


Figure 18a. Age dis-aggregated distribution of cod catches (nos. per tow, age 1) from the autumn DFO RV survey of index strata in NAFO Divs. 2J3KL during 2012-15. Symbol size (continuous scaling) is proportional to numbers caught.

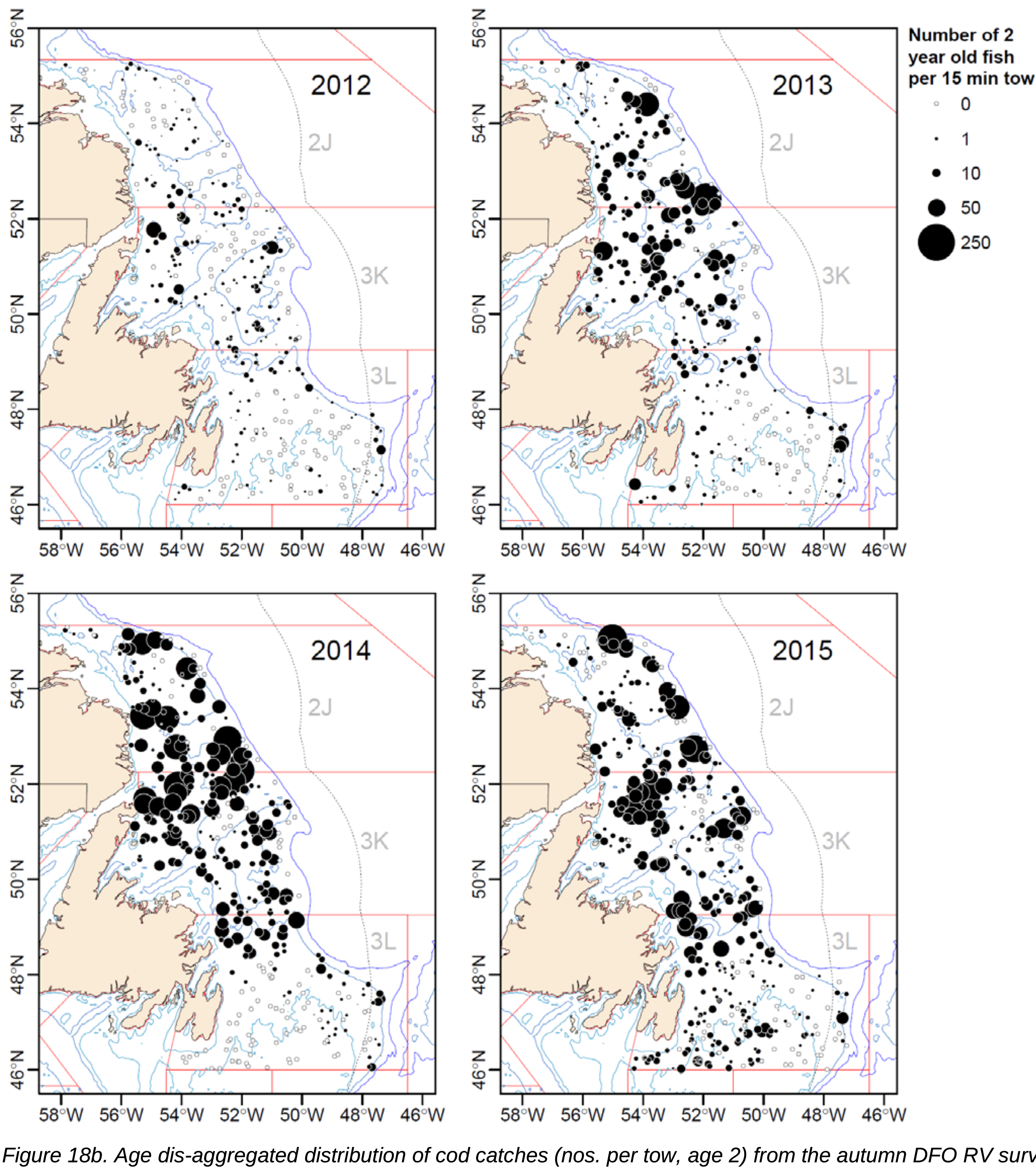


Figure 18b. Age dis-aggregated distribution of cod catches (nos. per tow, age 2) from the autumn DFO RV survey of index strata in NAFO Divs. 2J3KL. Symbol size (continuous scaling) is proportional to numbers caught.

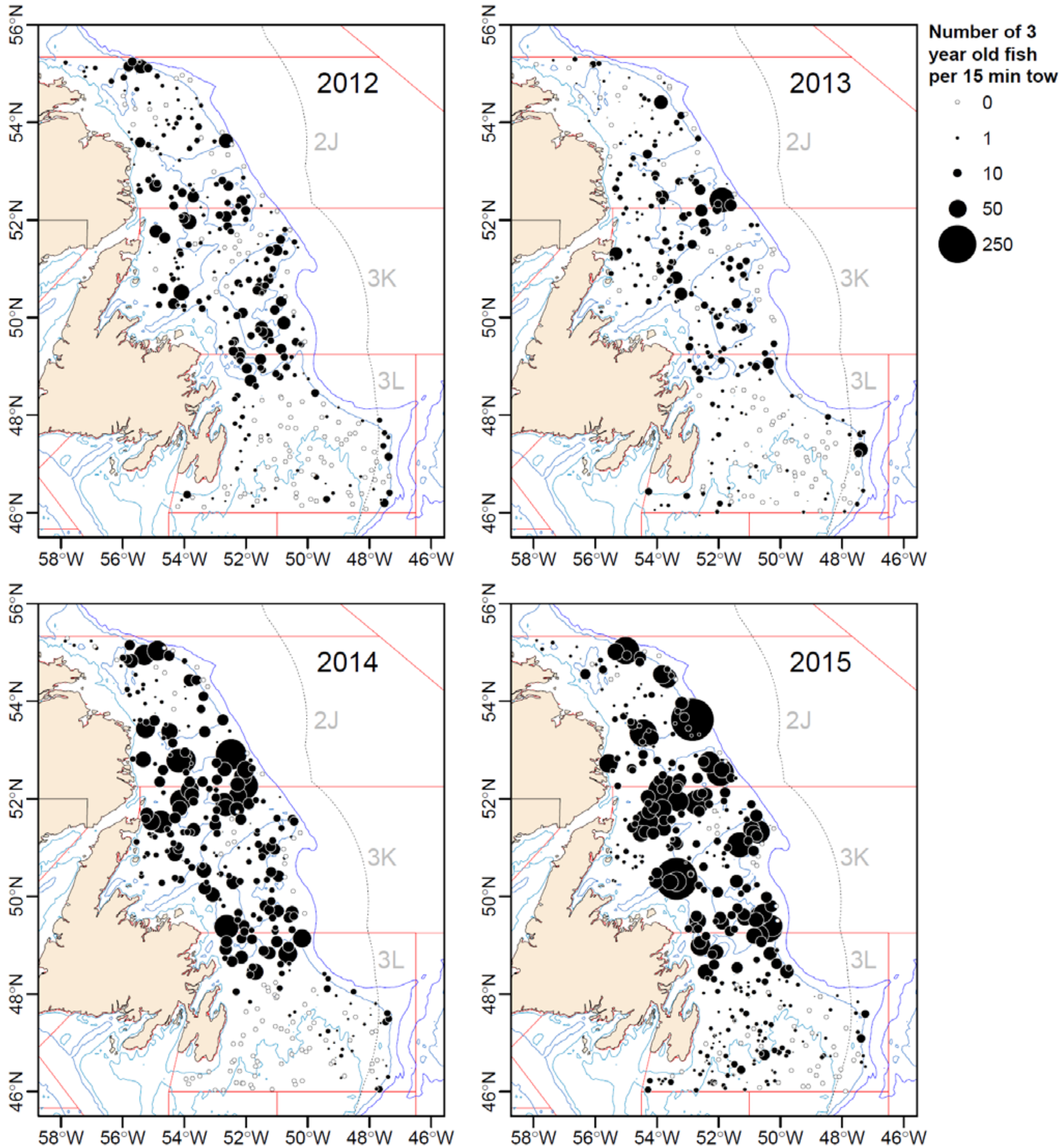


Figure 18c. Age dis-aggregated distribution of cod catches (nos. per tow, age 3) from the autumn DFO RV survey of index strata in NAFO Divs. 2J3KL during 2012-15. Symbol size (continuous scaling) is proportional to numbers caught.

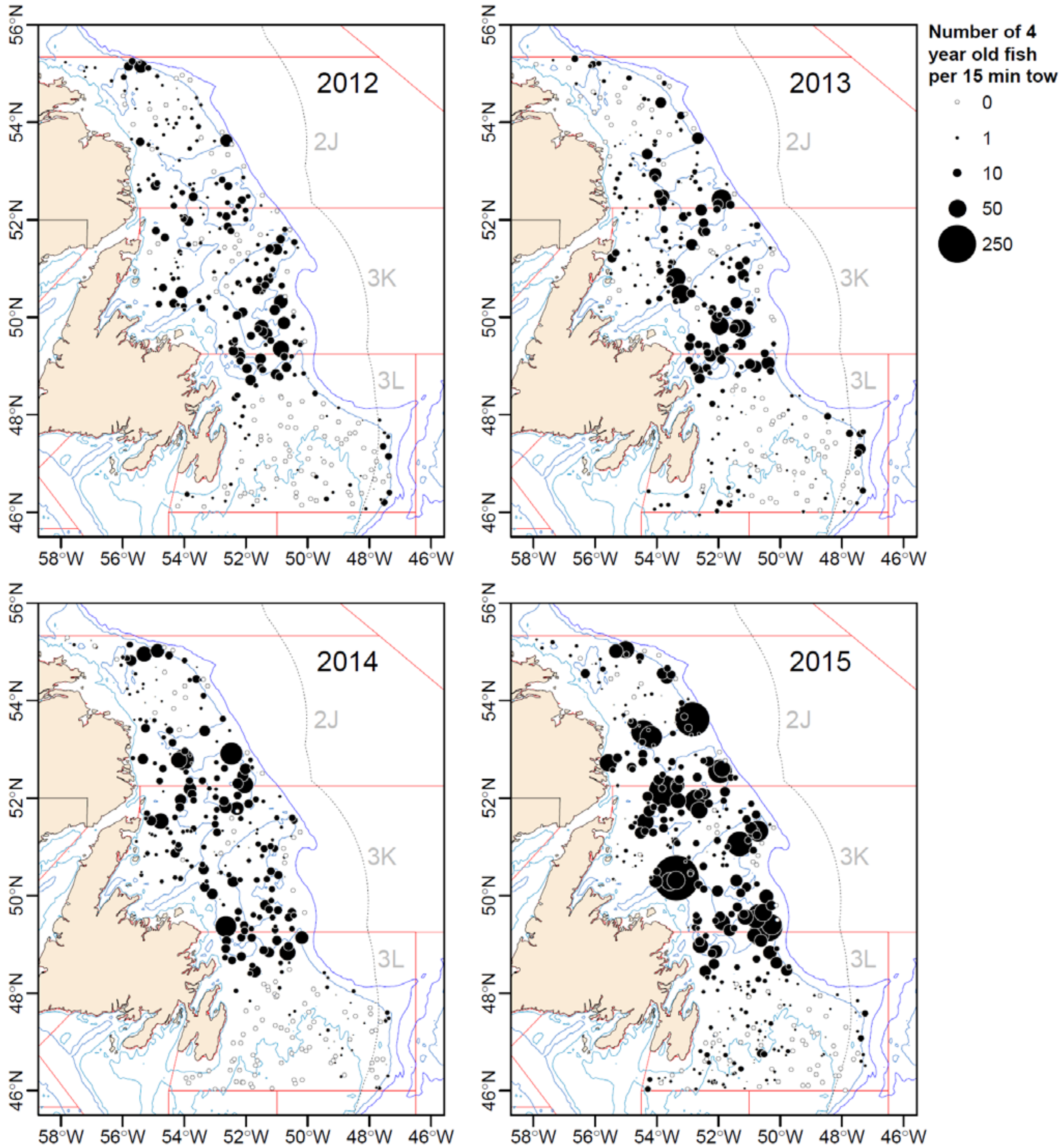


Figure 18d. Age dis-aggregated distribution of cod catches (nos. per tow, age 4) from the autumn DFO RV survey of index strata in NAFO Divs. 2J3KL during 2012-15. Symbol size (continuous scaling) is proportional to numbers caught.

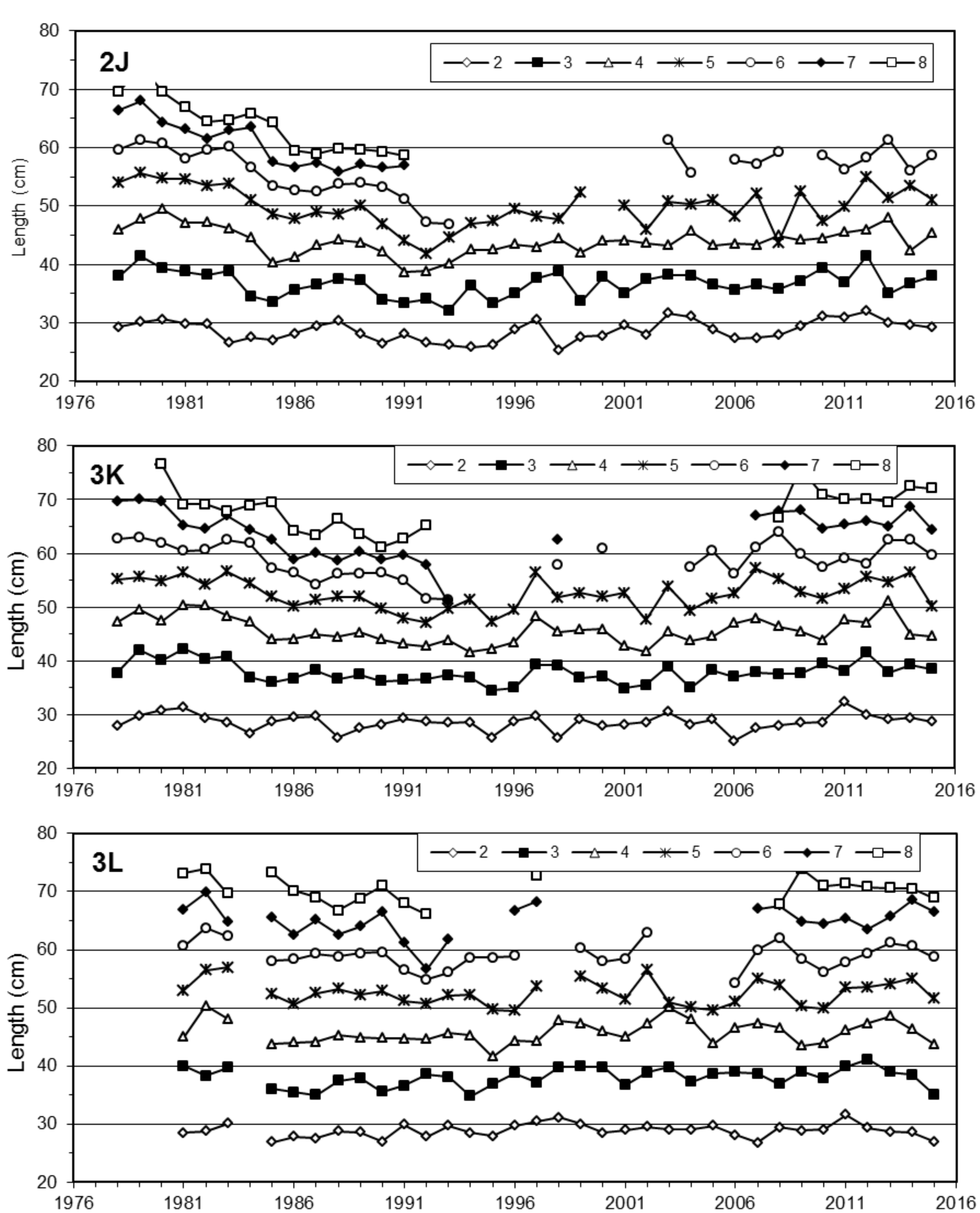


Figure 19. Mean lengths (cm) at ages 2-8 of cod in NAFO Divs. 2J, 3K and 3L in 1978-2015, as determined from sampling during autumn research vessel bottom-trawl surveys. Values calculated from fewer than 5 aged fish are not plotted. There were no surveys in Div. 3L in 1978-80 and 1984.

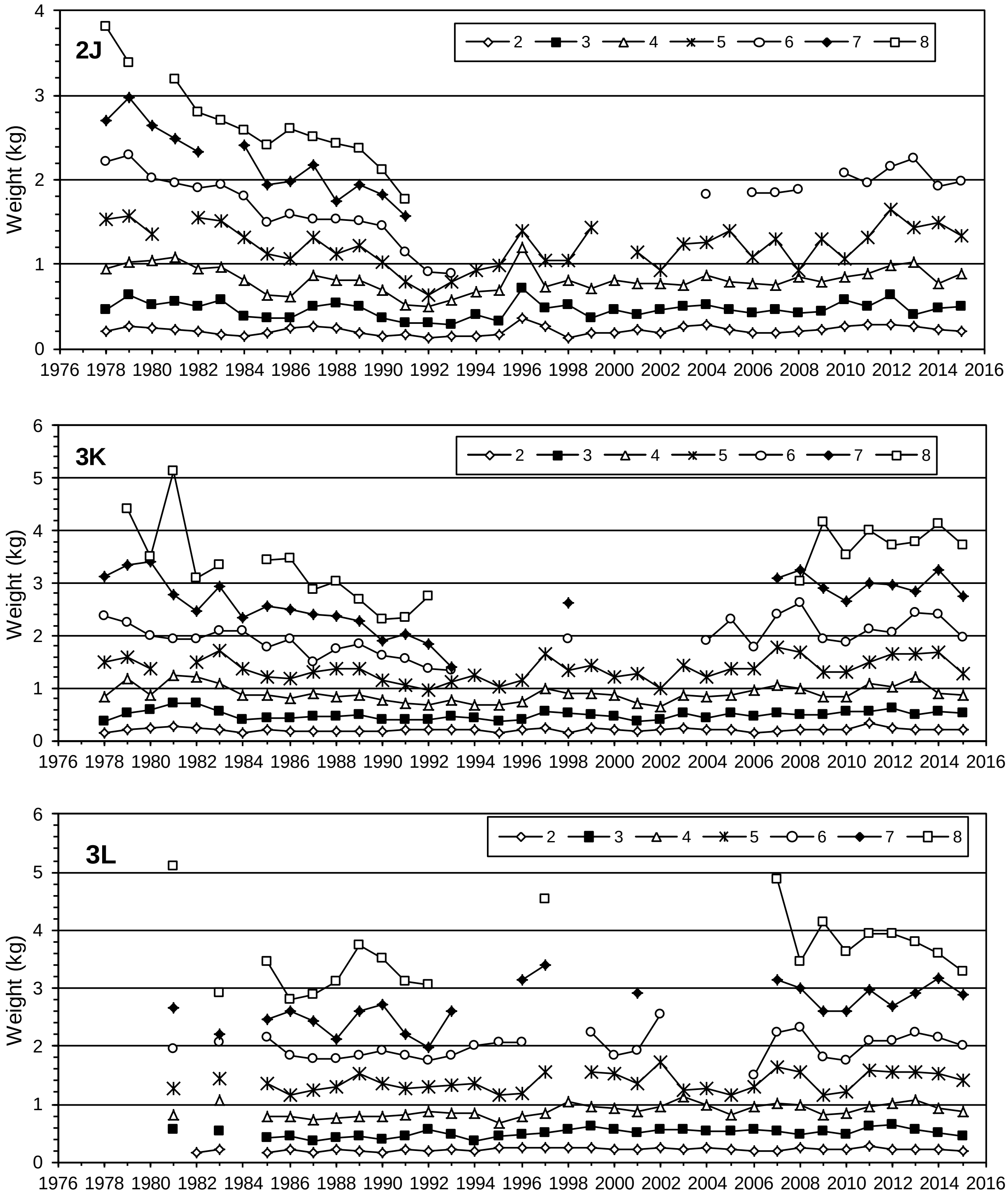


Figure 20. Mean weights at ages 2-8 of cod in NAFO Divs. 2J, 3K and 3L in 1978-2015, as determined from sampling during autumn research vessel bottom-trawl surveys. Values calculated from fewer than 5 aged fish are not plotted. There were no surveys in Div. 3L in 1978-80 and 1984.

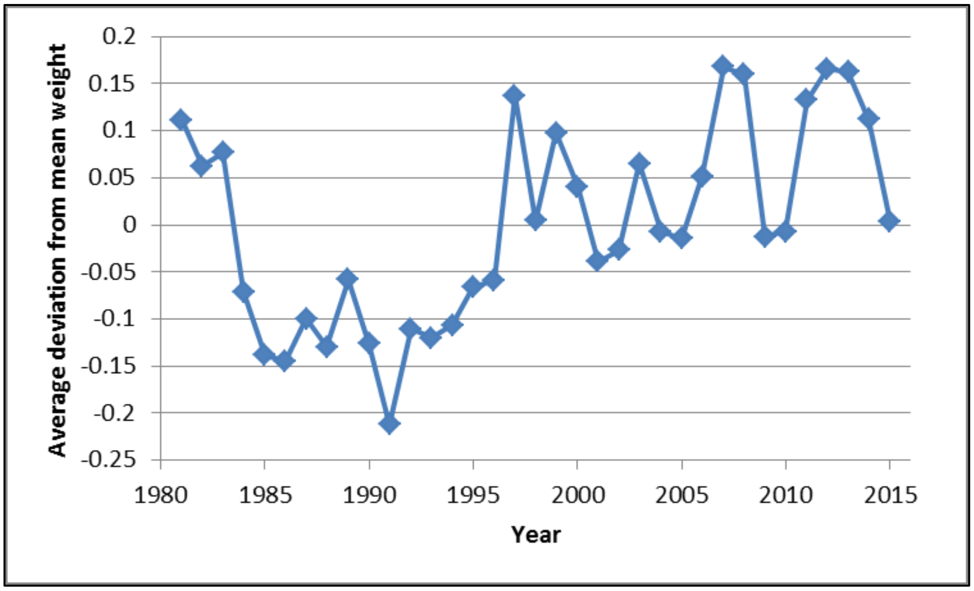


Figure 21. Average deviation from mean weight-at-age for ages 3-7 from autumn RV bottom-trawl surveys from 1981-2015 in NAFO Divs. 2J3KL combined.

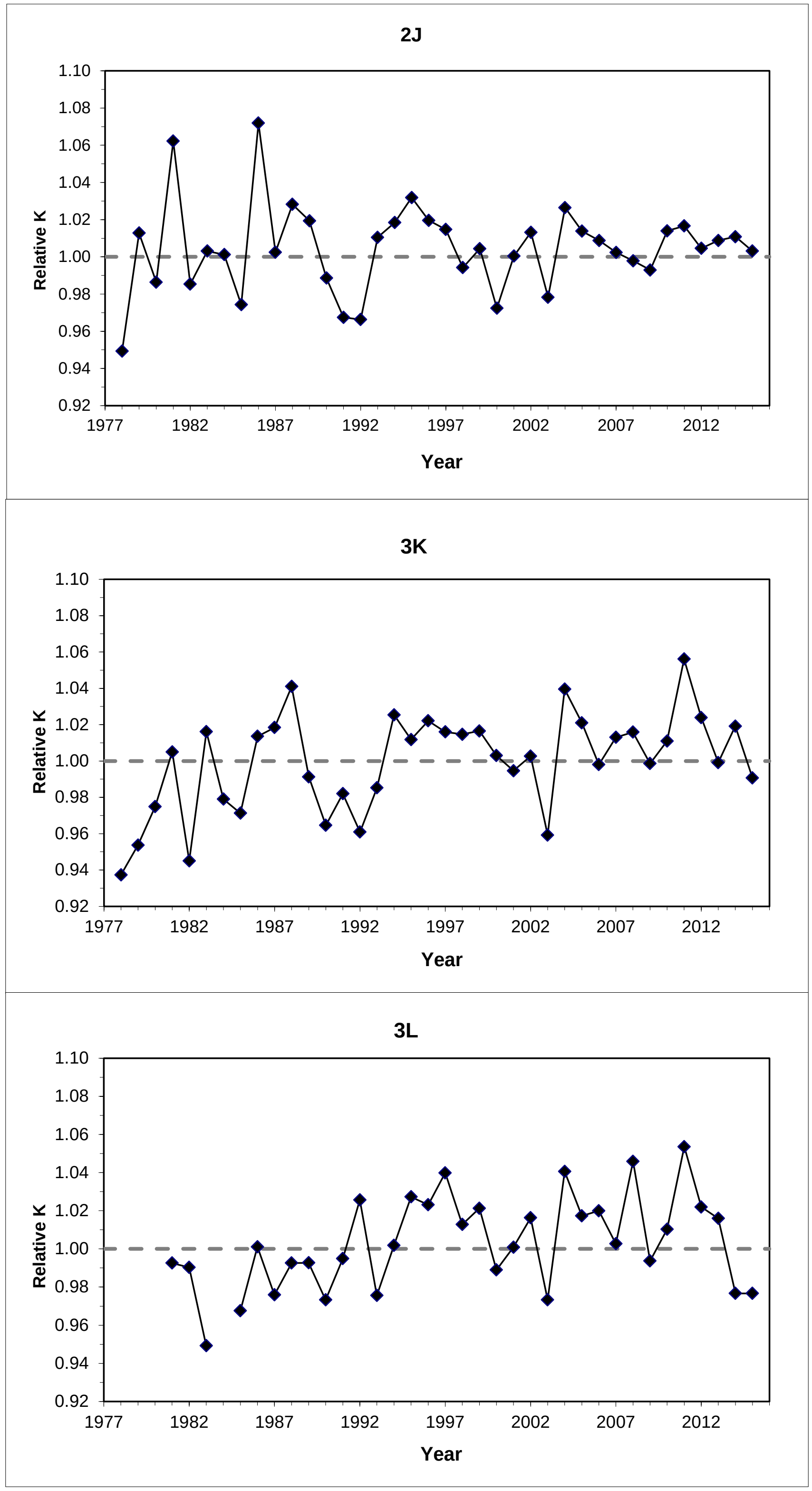


Figure 22. Relative gutted condition of cod in Divs. 3K and 3L in 1978-2015, as determined from sampling during bottom-trawl surveys in autumn. There were no surveys in Div. 3L in 1978-80 and 1984. The horizontal dashed grey line indicates a relative K of 1.

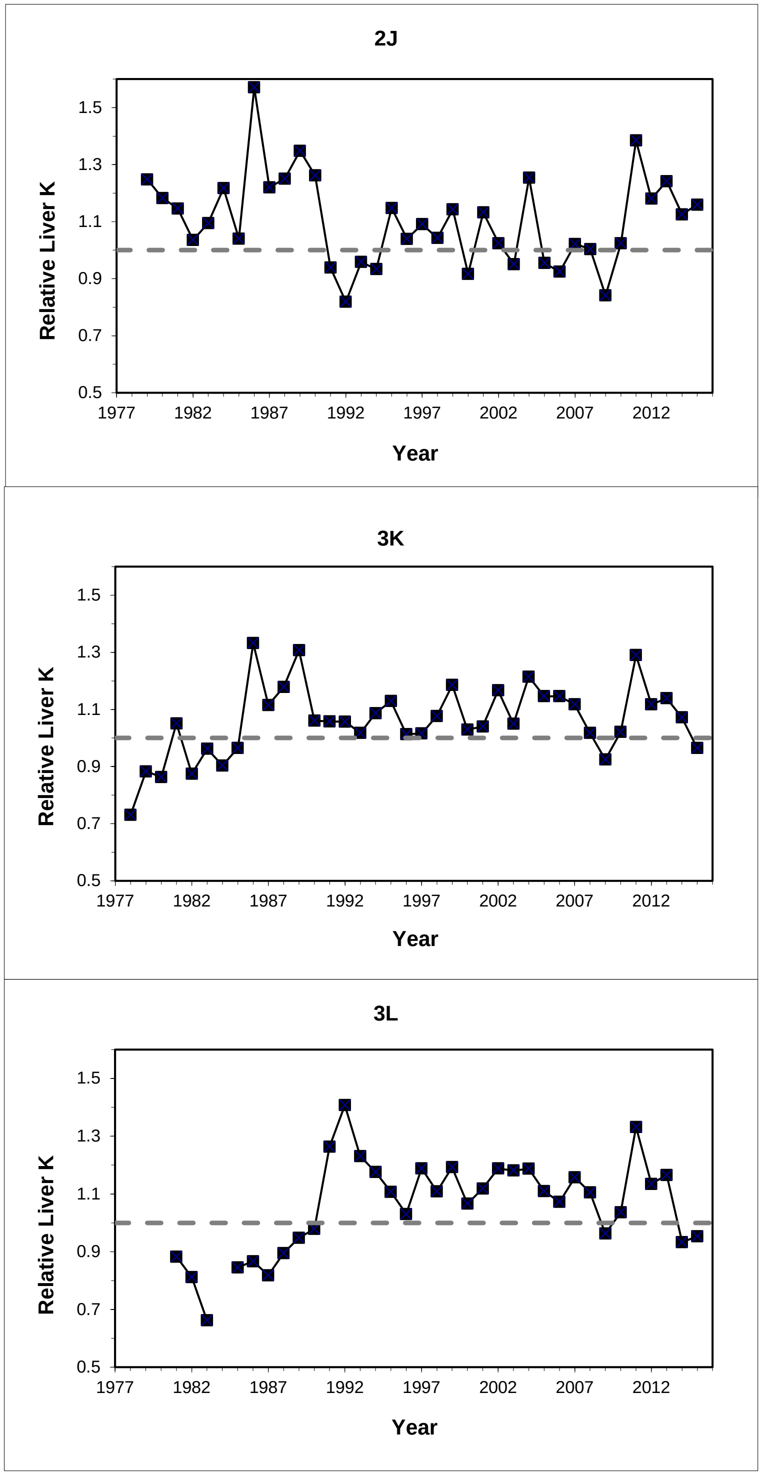


Figure 23. Relative liver condition of cod in Divs. 2J, 3K and 3L in 1978-2015, as determined from sampling during bottom-trawl surveys in autumn. There were no surveys in Division 3L in 1978-80 and 1984. The horizontal dashed grey line indicates a relative liver K of 1.

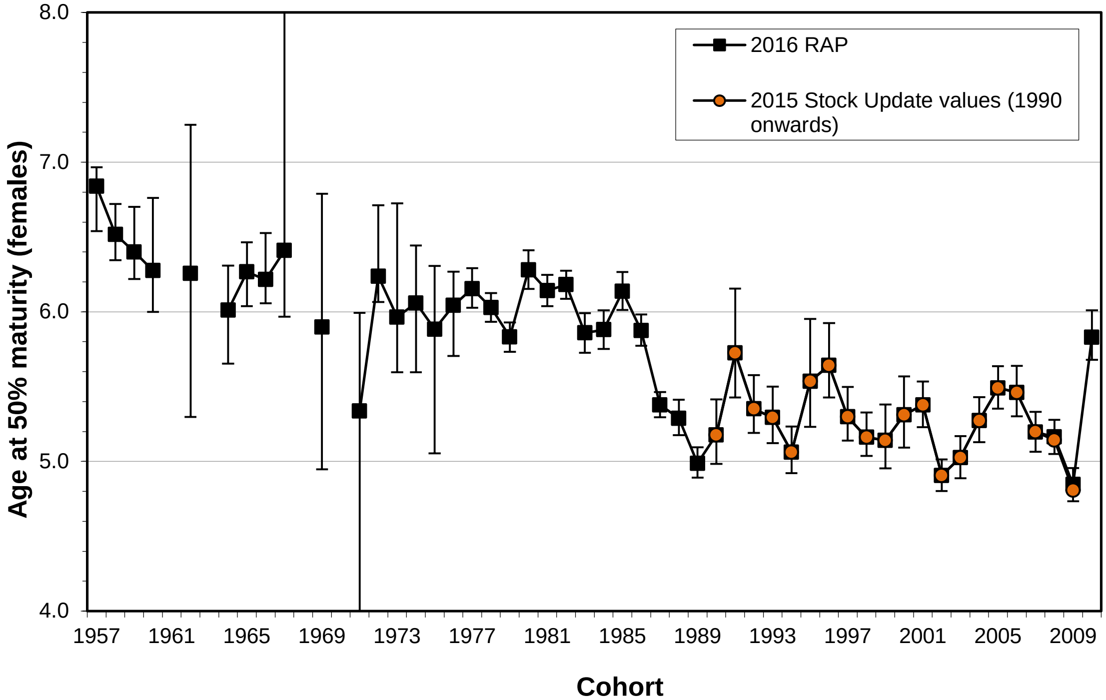


Figure 24. Age at 50% maturity (± 95% CI) by cohort for female cod in Divs. 2J3KL combined based on sampling during autumn research bottom-trawl surveys. The open circles show the results from the 2015 stock update back to the 1990 cohort. See text for details.

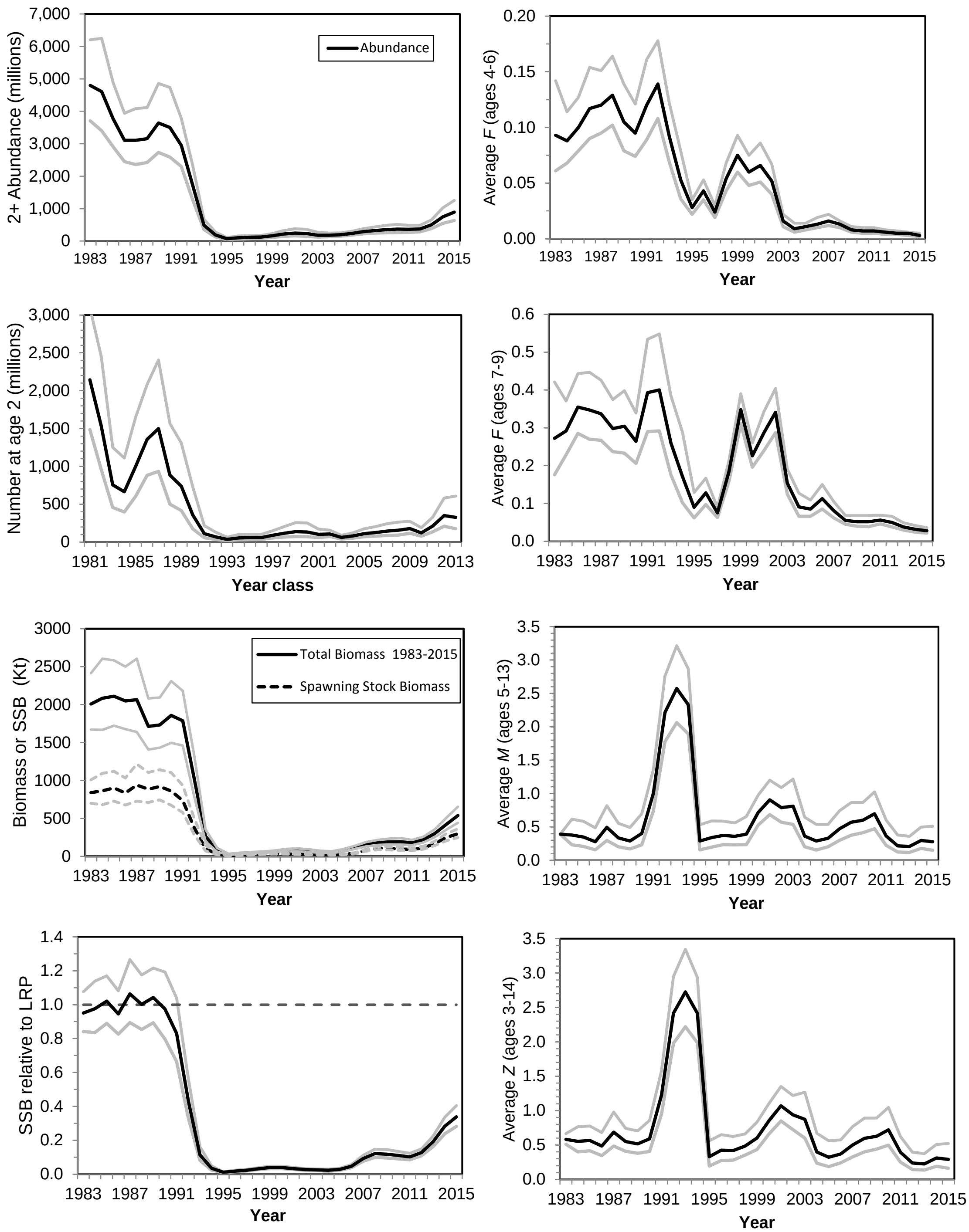


Figure 25. Stock size (left panels) and mortality rate estimates (right panels) ±95% confidence intervals (grey lines) for 2J3KL cod during 1983-2015 from the M-shift NCAM formulation. Quantities are indicated on y-axis labels. SSB=Spawning Stock Biomass; LRP=Limit Reference Point (horizontal dashed grey line in lower left panel).

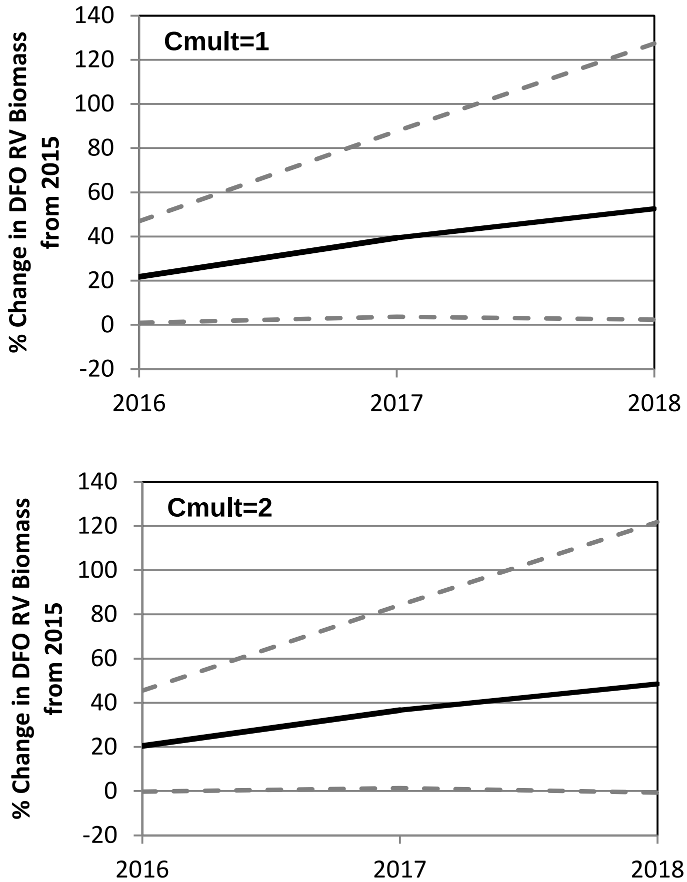


Figure 26. Upper panel: Projected changes in DFO RV 2+ biomass (solid line) ±75% confidence intervals (grey dashed lines) relative to the 2015 survey biomass estimate for a constant catch multiplier of 1 (6,900 t per year). Lower panel: same as above except catch multiplier=2.

APPENDIX A1 – FIGURES OF NCAM M-SHIFT FORMULATION MODEL FITS

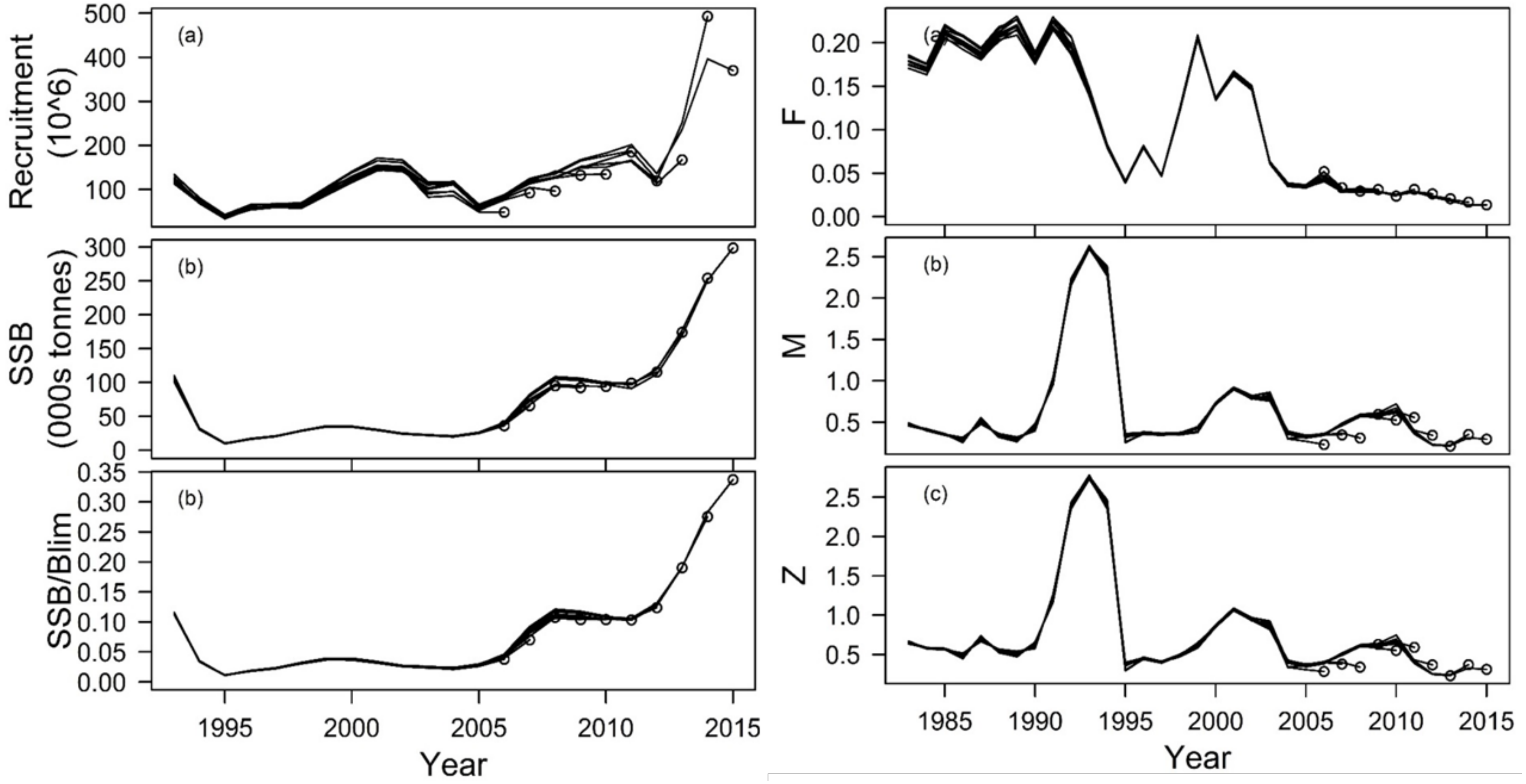


Figure A1-1. Retrospective estimates of recruitment, stock size, and stock size relative to B_{lim} (left panels) and mortality rates (F, M, Z, right panels) from the M-shift formulation of NCAM. Circles indicate the most recent estimate for each retrospective year.

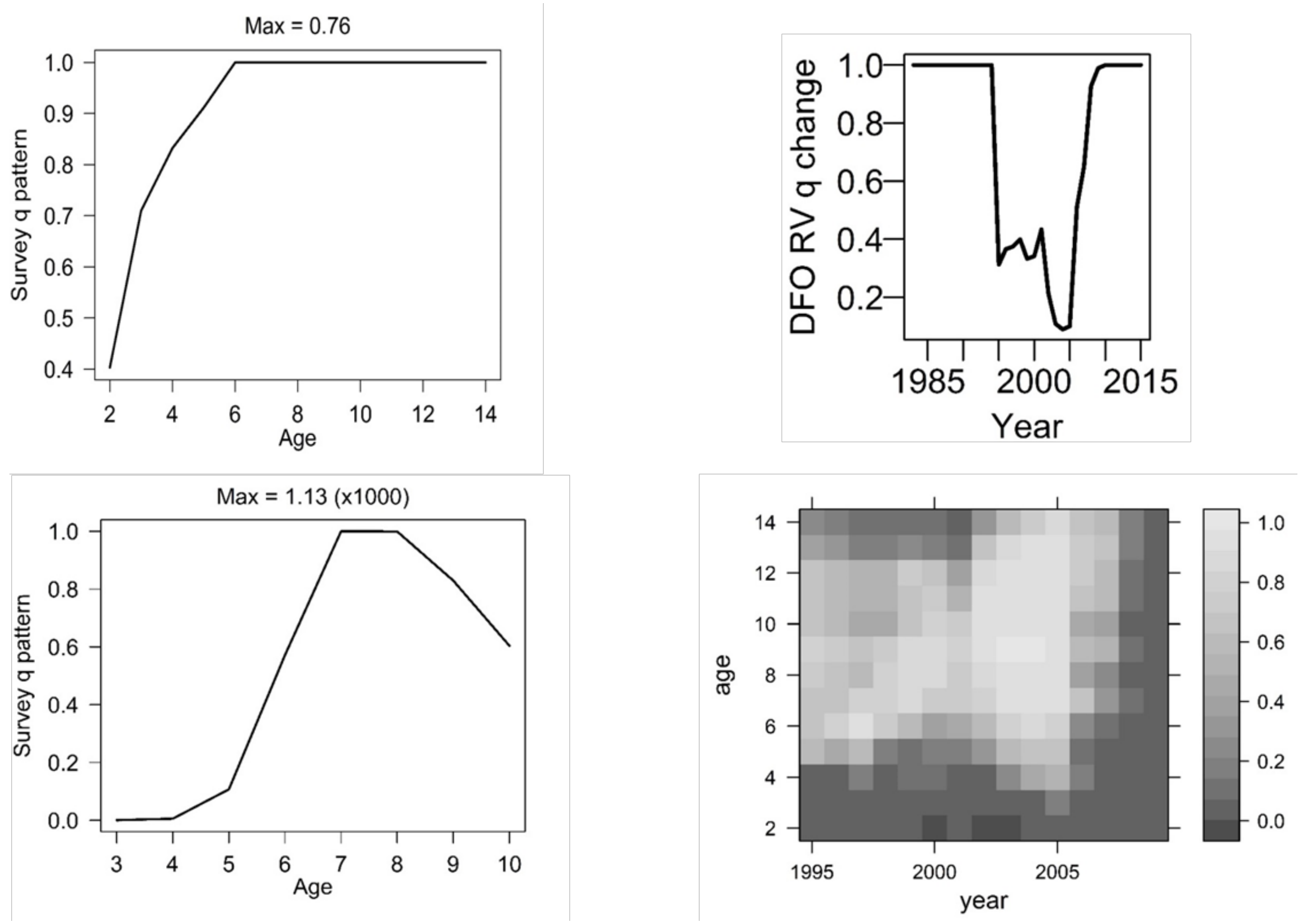
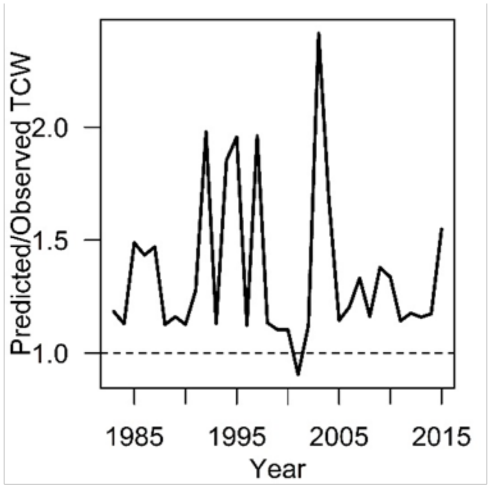
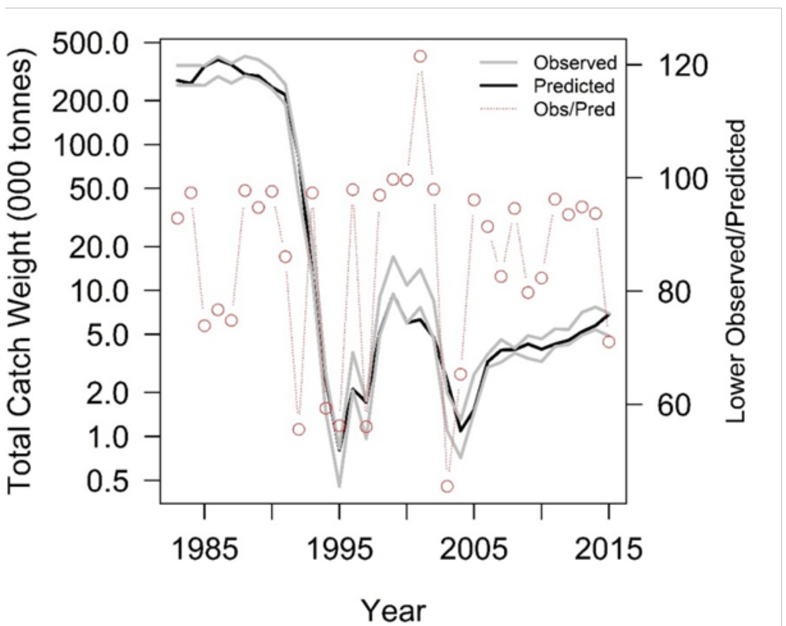


Figure A1-2. NCAM estimates of survey catchability (q), with age re-scaled to the maximum (left panels), for the DFO RV survey (upper left panel) and the sentinel gillnet catch rate index for NAFO Divs. 2J, 3K and 3L (lower left panel). The maximum value of q is indicated at the top of each panel. The estimated multiplicative temporal change in q for the DFO RV survey for ages 5+ during 1995-2009 is shown in the upper right panel along with an illustration of the model estimates of the proportion of the stock in Smith Sound (lower right panel).





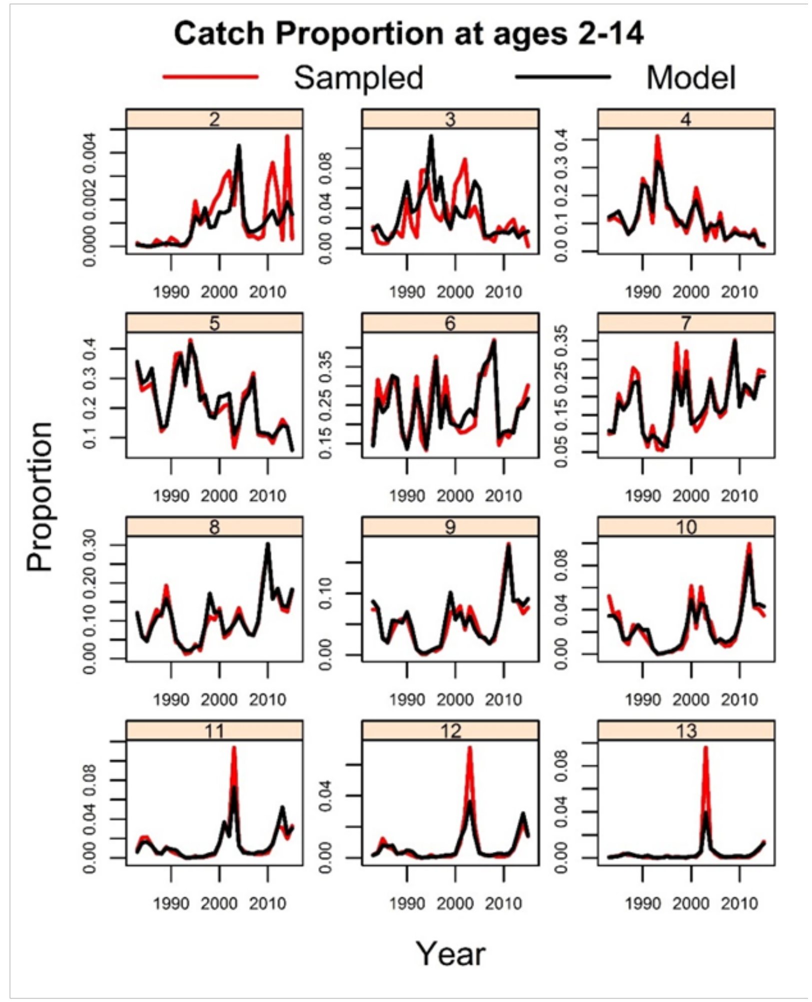


Figure. A1-3. Model predicted total catch weight relative to observed catch weight (upper left panel) and model predicted catch weight relative to assumed catch bounds (grey lines, lower panel). The left hand y-axis is in log scale. Superimposed is the observed relative to predicted catch in percent (circles) with the y-axis scale on the right hand side. Observed and predicted catch proportions-at-age are shown in the right panels.

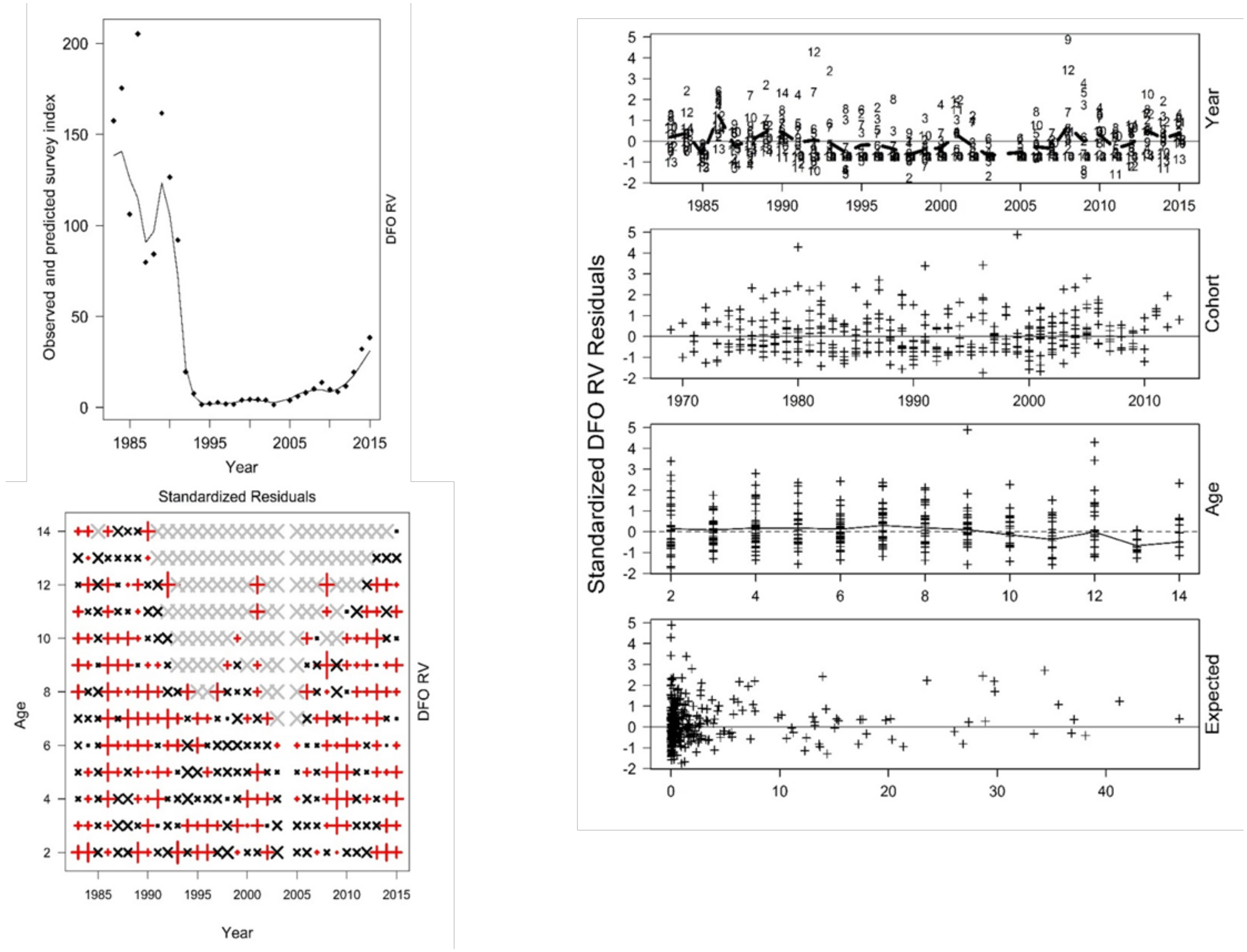


Figure A1-4. Total observed (dots) and model predicted values (lines) for the DFO RV survey index (upper left panel) and scaled matrix plot of age-disaggregated standardized log residuals (lower left panel; black=positive, red=negative, symbols scaled by size; grey = index values of zero). Standardized residual plots by year, cohort, age, and predicted value are shown on the right panels. These residuals are the log observed survey catch minus the estimate and divided by the survey estimated standard deviation. The grey horizontal lines in the right panels indicate the average residual each year; the plotting symbols in the top right panel indicate age.

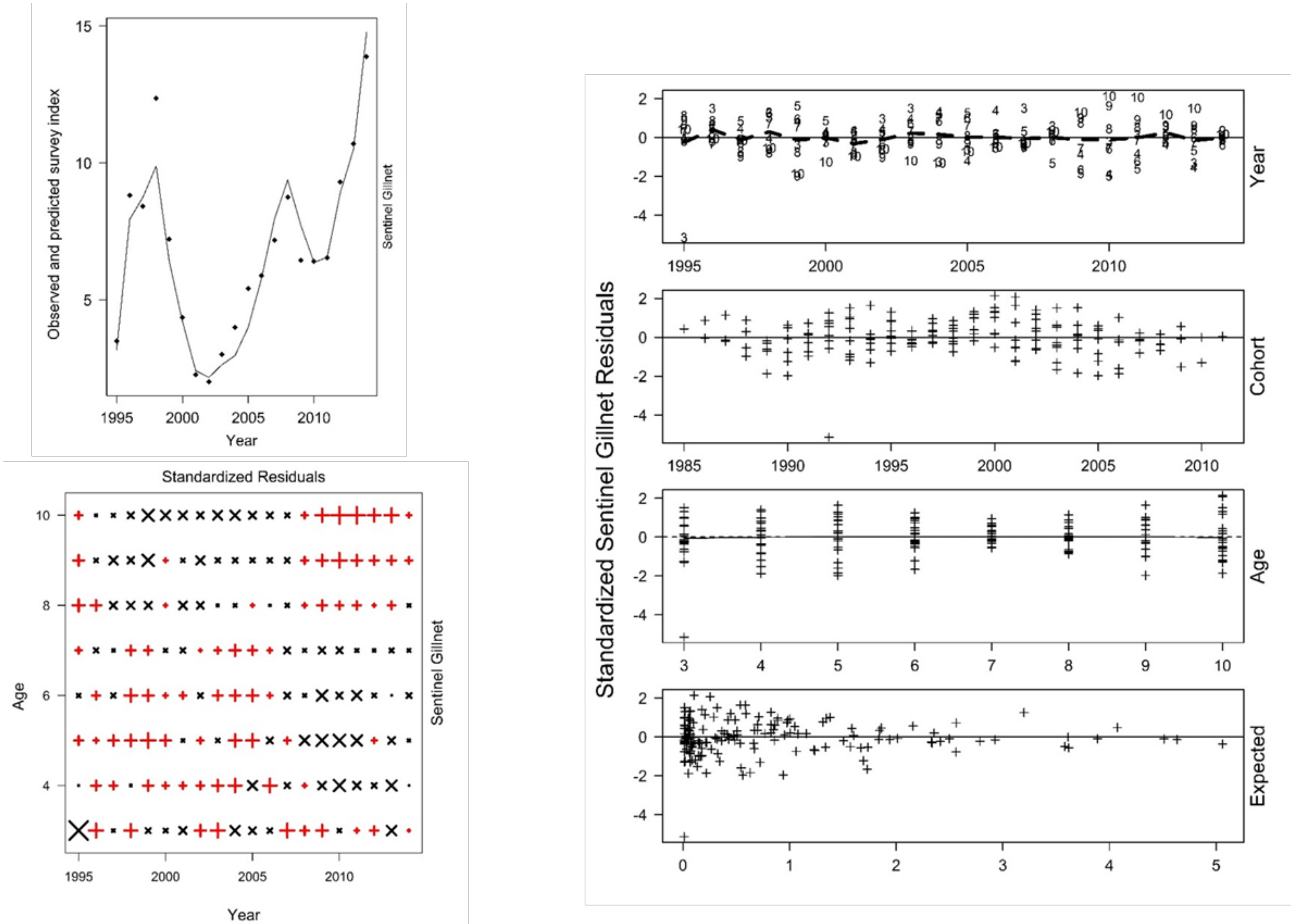


Figure A1-5. Total observed (dots) and model predicted values (lines) for the sentinel gillnet index (upper left panel) and scaled matrix plot of age-disaggregated standardized log residuals (lower left panel; black=positive, red=negative, symbols scaled by size; grey = index values of zero). Standardized residual plots by year, cohort, age, and predicted value are shown on the right panels. These residuals are the log observed survey catch minus the estimate and divided by the survey estimated standard deviation. The grey horizontal lines in the right panels indicate the average residual each year; the plotting symbols in the top right panel indicate age.

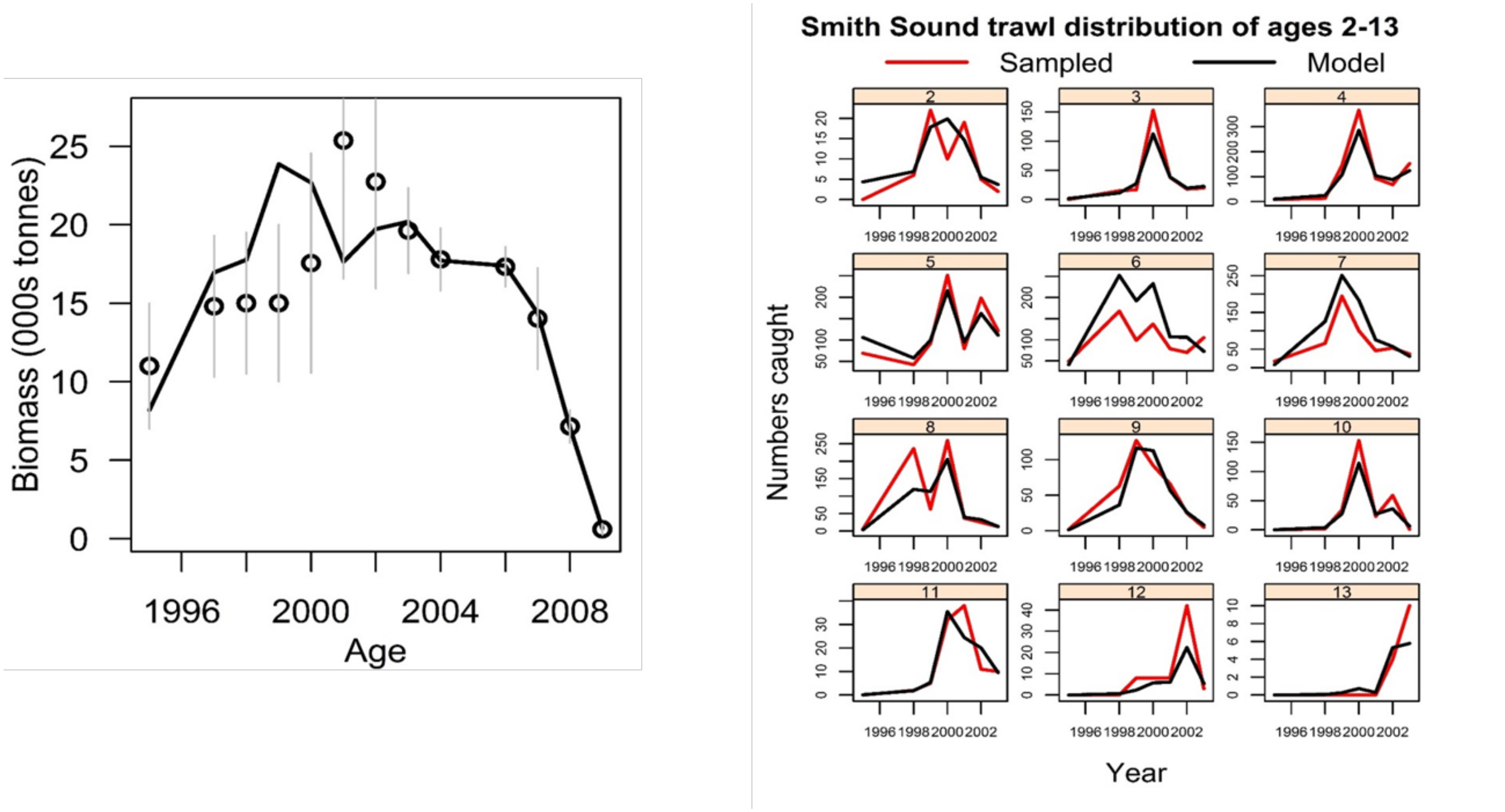


Figure. A1-6. Observed and model predicted fits (± 95% CIs) to the Smith Sound acoustic biomass estimates (left panel) and trawl sampled age compositions (right panels).

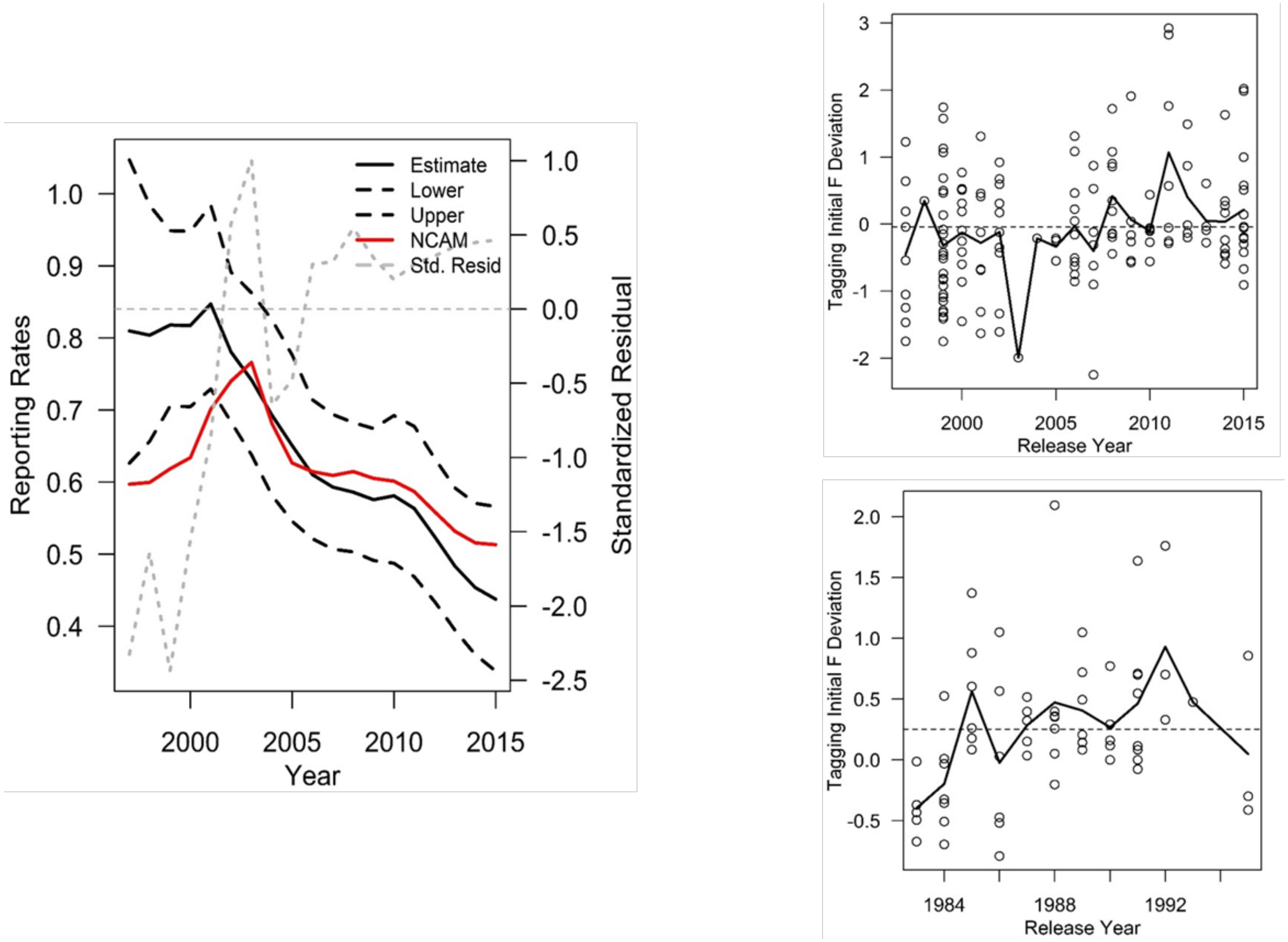


Figure A1-7. Trends in tag reporting rates estimated externally using a binomial logistic mixed effects model with temporal auto-correlation (solid black line with dashed black lines indicating 95% CIs) or internally within NCAM (solid red line). Right panels show tagging initial F deviations by experiment for tagging experiments conducted from 1997 onwards (upper panel) and prior to 1997 (lower panel).

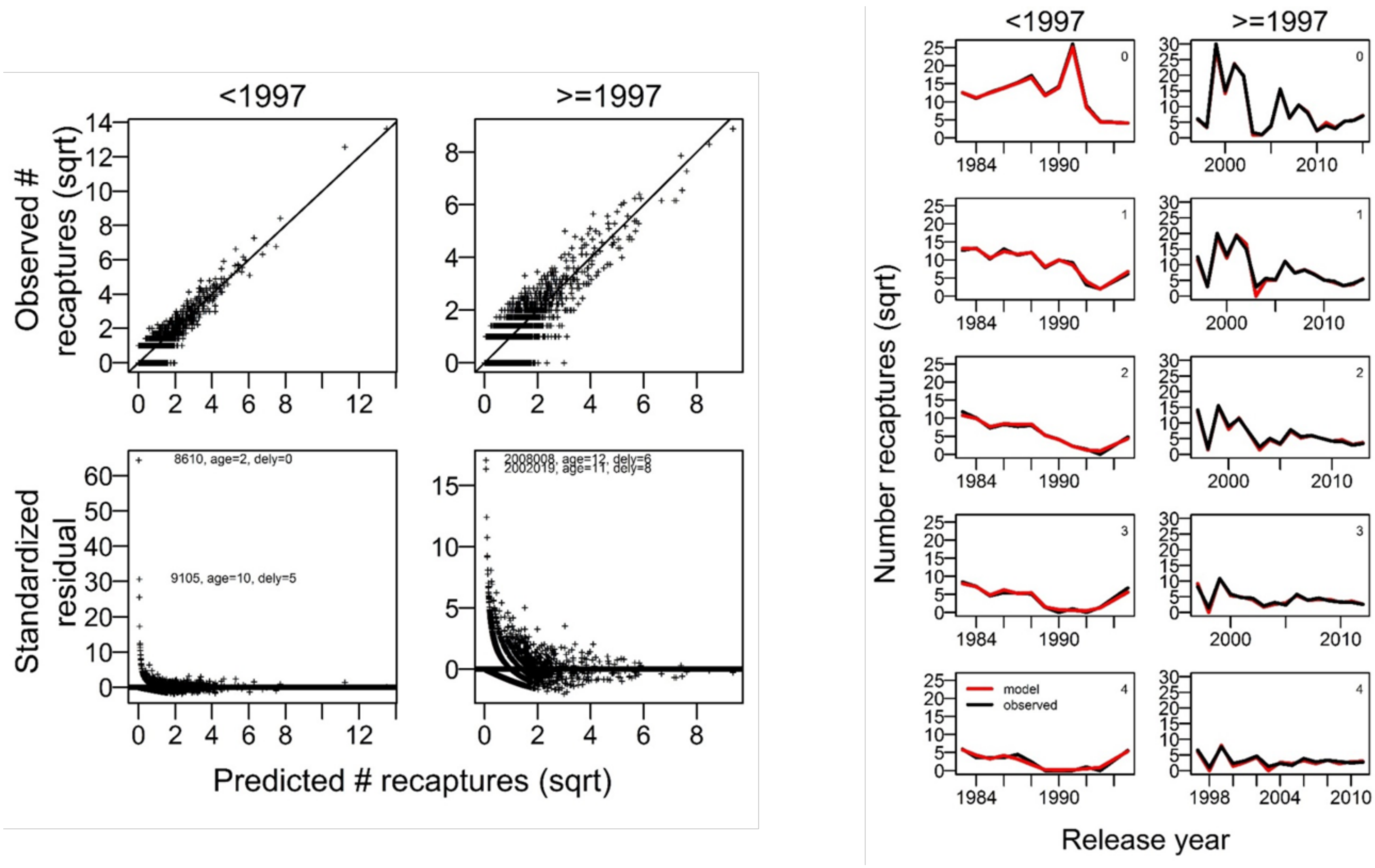


Figure A1-8. Observed versus model predicted reported catches of tagged cod (two upper left panels) from tagging experiments prior to 1997 (left side) and from 1997 onward (right side) and conditional Poisson standardized residuals (two bottom left panels). The panels on the right show aggregate observed versus model predicted total recaptures by year. Numbers in upper right corner of right panels indicate years at liberty.

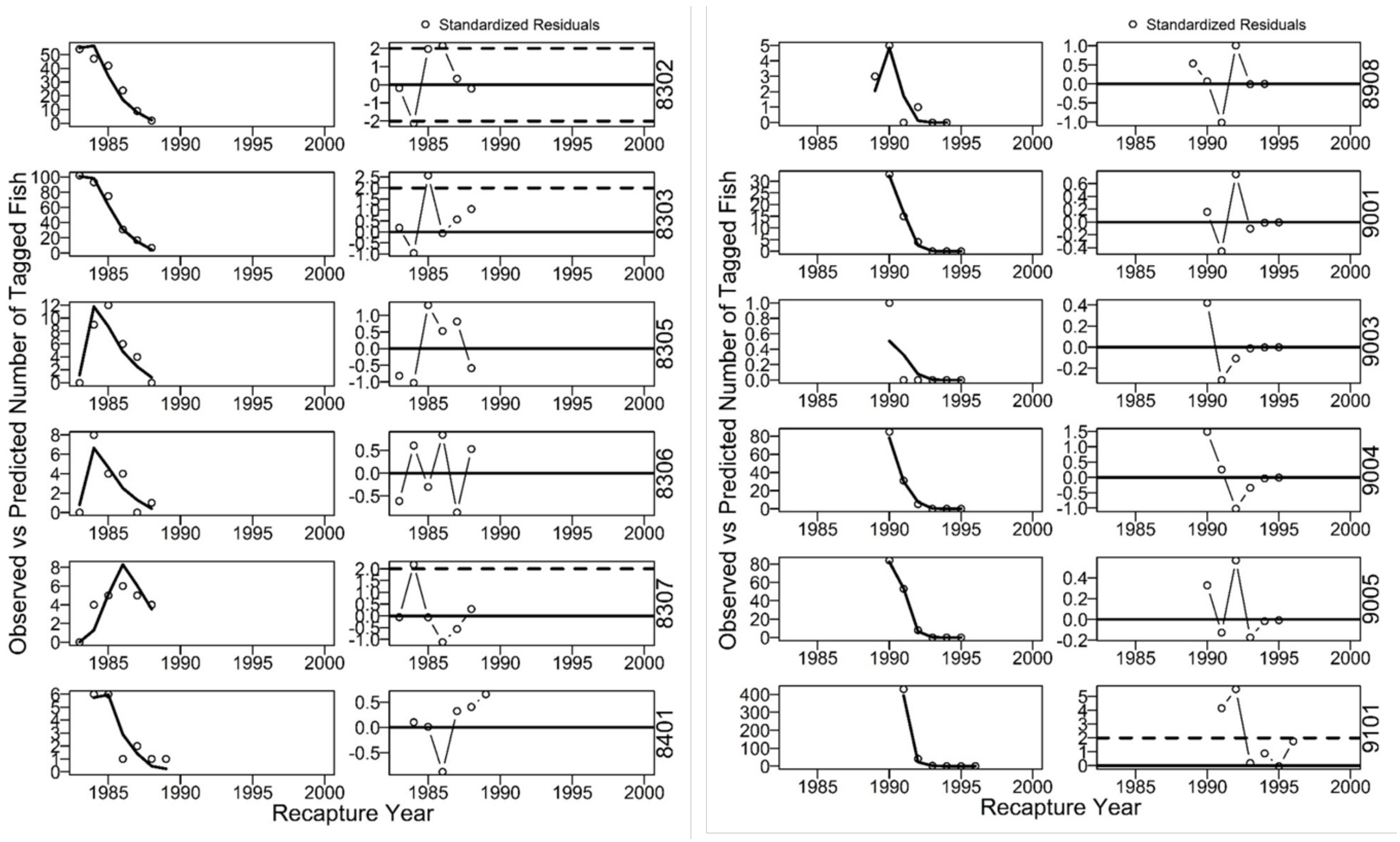


Figure A1-9. Examples of aggregate (all ages) observed versus model predicted numbers of recaptures of tagged cod by experiment and recapture year along with Poisson aggregate standardized residuals for some tagging experiments (labelled on right side y-axis) conducted prior to 1997.

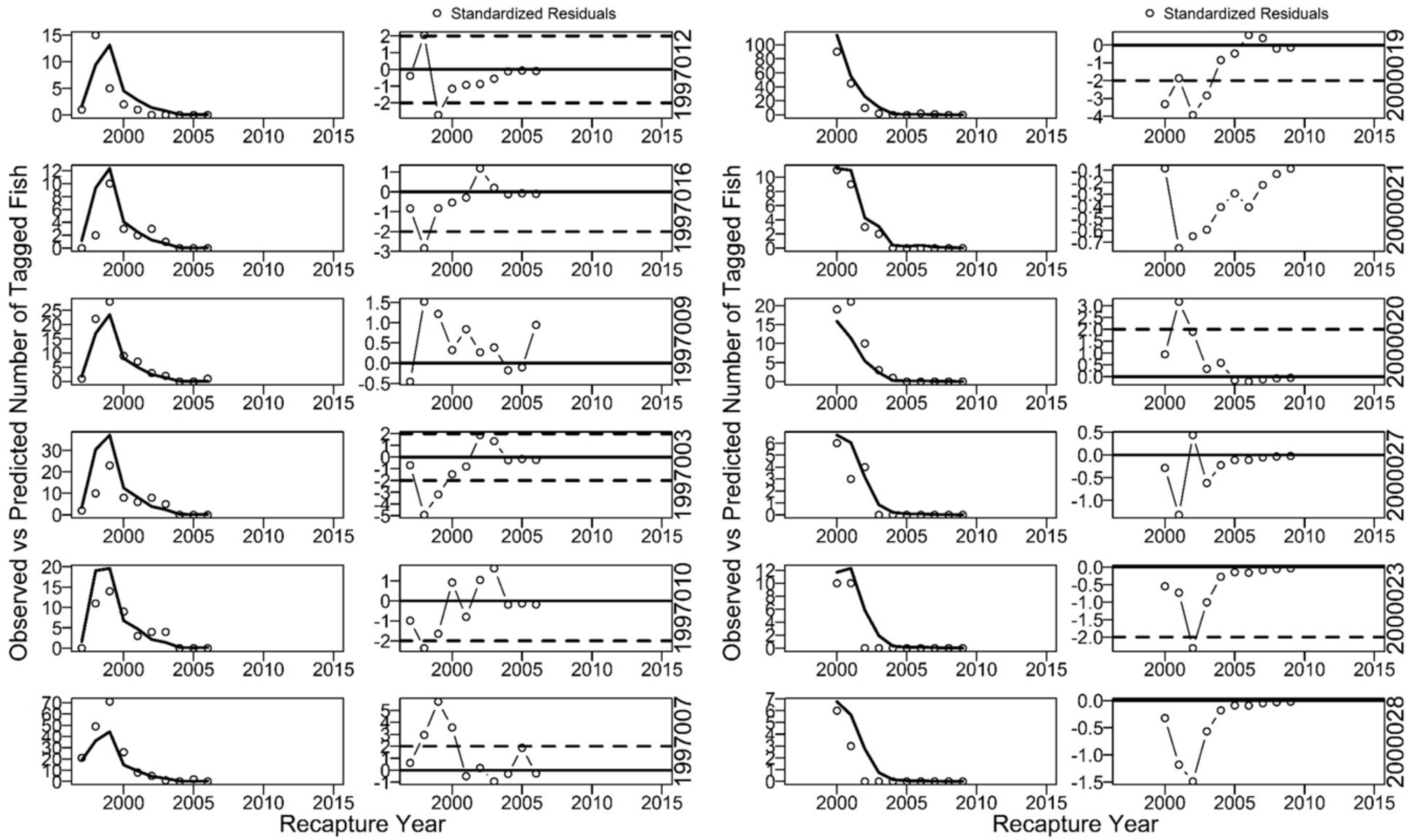


Figure A1-10. Examples of aggregate (all ages) observed versus model predicted numbers of recaptures of tagged cod by experiment and recapture year along with Poisson aggregate standardized residuals for some tagging experiments (labelled on right side y-axis) conducted from 1997 onwards.

APPENDIX A2 – TABLES OF POPULATION SIZE AND MORTALITY RATE ESTIMATES FROM THE M-SHIFT FORMULATION OF NCAM

Table A2-1. Northern cod stock size estimates with lower (L) and upper (U) 95% confidence intervals (CI).

Year	2+ Abundance (000s)	2+Abundance L 95% CI	2+Abundance U 95% CI	2+Biomass (Kt)	2+Bio- mass L 95% CI	2+Biomass U 95% CI	SSB (Kt)	SSB L 95% CI	SSB U 95% CI	SSB/B_{lim}	SSB/B_{lim} L 95% CI	SSB/B_{lim} U 95% CI
1985	3,772	2,909	4,891	2,110	1,723	2,584	903	728	1,120	1.02	0.89	1.17
1986	3,106	2,449	3,939	2,049	1,679	2,500	836	677	1,033	0.95	0.83	1.08
1987	3,106	2,362	4,086	2,067	1,639	2,606	941	728	1,216	1.06	0.89	1.27
1988	3,156	2,423	4,111	1,713	1,409	2,083	886	711	1,106	1.00	0.85	1.18
1989	3,642	2,731	4,856	1,731	1,431	2,094	922	744	1,141	1.04	0.89	1.22
1990	3,502	2,590	4,734	1,859	1,497	2,310	862	673	1,104	0.97	0.80	1.19
1991	2,950	2,301	3,783	1,786	1,462	2,182	735	577	934	0.83	0.66	1.04
1992	1,721	1,269	2,335	1,028	792	1335	382	289	505	0.43	0.33	0.56
1993	491	356	677	263	196	355	101	71	145	0.11	0.08	0.16
1994	189	128	279	82	59	113	31	21	44	0.04	0.02	0.05
1995	74	51	106	26	21	33	10	8	12	0.01	0.01	0.01
1996	103	68	156	38	30	47	16	13	20	0.02	0.02	0.02
1997	117	81	169	47	39	57	21	18	24	0.02	0.02	0.03
1998	125	89	174	55	47	65	28	25	32	0.03	0.03	0.04
1999	162	115	227	65	56	76	35	31	38	0.04	0.03	0.05
2000	219	148	324	80	66	97	34	31	39	0.04	0.03	0.05
2001	248	162	380	84	68	105	30	26	34	0.03	0.03	0.04
2002	233	149	365	73	58	93	24	21	27	0.03	0.02	0.03
2003	183	124	269	59	47	74	22	19	25	0.03	0.02	0.03
2004	181	134	245	55	44	68	20	16	25	0.02	0.02	0.03
2005	194	150	252	78	65	95	25	21	30	0.03	0.02	0.04
2006	234	183	301	116	97	139	41	35	48	0.05	0.04	0.06
2007	292	224	381	157	131	187	81	69	96	0.09	0.08	0.11
2008	326	245	435	180	151	216	107	89	128	0.12	0.10	0.15
2009	354	258	485	192	157	234	105	86	127	0.12	0.10	0.15
2010	367	263	513	194	156	241	97	79	119	0.11	0.09	0.13
2011	362	270	487	179	148	216	91	75	109	0.10	0.09	0.12
2012	372	286	484	218	184	259	112	95	133	0.13	0.11	0.15

Year	2+ Abun-dance (000s)	2+Abu-ndance L 95% CI	2+Abun-dance U 95% CI	2+Bio-mass (Kt)	2+Bio- mass L 95% CI	2+Bio-mass U 95% CI	SSB (Kt)	SSB L 95% CI	SSB U 95% CI	SSB/B_{lim}	SSB/B_{lim} L 95% CI	SSB/B_{lim} U 95% CI
2013	500	384	650	301	255	357	169	143	200	0.19	0.16	0.22
2014	749	548	1023	424	353	509	250	208	300	0.28	0.24	0.34
2015	894	636	1256	539	444	654	299	246	362	0.34	0.28	0.40

Table A2-2. Northern cod abundance-at-age estimates (millions) from the M-shift formulation of NCAM.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1983	2,144.4	1,088.0	676.0	474.7	139.7	90.0	95.8	55.1	25.0	5.5	1.8	0.7	0.6
1984	1,530.0	1,394.9	741.8	447.4	275.1	77.8	46.1	51.7	27.6	13.1	3.0	1.1	0.4
1985	755.7	1,006.5	957.2	510.9	279.2	159.1	37.7	21.6	23.1	13.0	6.2	1.5	0.5
1986	663.8	484.2	693.6	667.4	317.2	159.9	72.1	17.5	10.0	10.6	5.9	2.8	0.7
1987	1,000.2	451.7	357.8	518.5	447.6	187.3	82.7	36.9	9.0	4.8	5.4	2.9	1.5
1988	1,355.3	613.8	295.2	240.3	312.3	209.1	72.4	34.2	14.3	3.5	2.0	2.1	1.2
1989	1,498.1	958.1	454.4	217.8	166.1	179.8	103.6	35.4	16.8	7.5	1.9	1.1	1.1
1990	884.0	1,106.3	734.7	341.5	153.0	101.9	93.8	53.7	18.6	8.6	4.0	1.0	0.6
1991	737.3	552.7	734.1	495.9	219.3	88.4	48.8	38.4	21.8	7.8	3.7	1.6	0.4
1992	358.0	407.6	289.5	394.3	194.5	56.9	10.9	3.9	3.0	1.8	0.6	0.3	0.1
1993	110.9	125.4	124.0	71.3	43.6	13.3	1.6	0.5	0.2	0.2	0.1	0.0	0.0
1994	67.2	45.6	38.1	29.9	5.8	2.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0
1995	35.2	19.0	8.1	7.8	2.6	0.5	0.2	0.1	0.0	0.0	0.0	0.0	0.0
1996	53.3	22.5	13.2	6.0	5.6	1.9	0.4	0.1	0.1	0.0	0.0	0.0	0.0
1997	57.4	29.4	12.6	8.9	3.9	3.8	1.2	0.2	0.1	0.0	0.0	0.0	0.0
1998	59.7	30.3	15.4	7.2	5.7	2.6	2.5	0.8	0.1	0.1	0.0	0.0	0.0
1999	89.0	33.9	17.8	9.0	4.0	3.6	1.7	1.7	0.5	0.1	0.0	0.0	0.0
2000	115.3	58.0	22.9	11.5	4.8	2.1	1.9	1.0	1.1	0.4	0.1	0.0	0.0
2001	136.9	61.3	29.2	11.0	4.3	1.8	0.9	1.2	0.6	0.7	0.2	0.0	0.0
2002	132.6	59.2	24.5	9.5	3.1	1.3	0.7	0.5	0.7	0.4	0.4	0.1	0.0
2003	101.2	49.0	18.6	7.3	3.3	1.2	0.5	0.3	0.2	0.4	0.2	0.2	0.1
2004	107.0	43.8	18.4	6.5	2.5	1.5	0.7	0.3	0.2	0.1	0.2	0.1	0.1
2005	60.0	79.5	33.3	13.4	4.4	1.6	0.9	0.5	0.2	0.1	0.1	0.2	0.1
2006	79.7	46.8	65.3	27.2	10.0	3.0	1.1	0.6	0.3	0.2	0.1	0.1	0.1
2007	111.7	61.2	37.5	52.1	20.2	6.2	1.6	0.6	0.4	0.2	0.1	0.1	0.1
2008	124.7	80.4	45.4	26.6	32.9	11.8	3.0	0.9	0.4	0.2	0.1	0.1	0.0
2009	145.3	83.4	55.0	28.6	14.8	17.7	6.5	1.7	0.5	0.2	0.1	0.1	0.0
2010	156.3	90.1	52.3	30.9	15.2	8.1	9.5	3.3	0.9	0.3	0.1	0.1	0.0
2011	176.9	82.1	47.8	22.4	12.7	8.3	4.5	5.2	1.8	0.5	0.1	0.1	0.0
2012	120.9	121.8	59.0	32.9	14.8	8.9	5.7	3.0	3.4	1.2	0.3	0.1	0.0
2013	210.9	89.3	96.8	47.5	26.3	11.9	6.8	4.3	2.3	2.6	0.9	0.3	0.1
2014	349.6	163.6	73.1	80.6	39.2	21.3	9.0	5.0	3.1	1.7	1.9	0.7	0.2
2015	325.7	262.5	128.5	58.1	62.8	29.3	13.8	5.5	3.1	1.9	1.0	1.2	0.4

Table A2-3. Northern cod biomass-at-age estimates (Kt) from the M-shift formulation of NCAM.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1983	160.7	232.4	298.5	369.3	176.1	170.2	244.7	189.0	108.3	31.8	13.6	6.6	6.9
1984	115.7	295.0	330.6	346.6	336.0	142.8	120.0	173.6	120.0	69.8	21.1	9.3	4.6
1985	58.1	215.0	422.2	399.2	339.0	282.0	94.9	74.0	98.4	69.7	39.9	12.2	5.6
1986	51.0	105.5	309.3	516.1	388.5	281.2	174.7	57.8	43.3	55.3	38.1	20.9	6.9
1987	77.2	98.5	163.1	405.8	542.1	332.0	198.6	116.9	37.6	25.9	33.8	22.1	12.9
1988	104.2	134.6	135.0	192.8	383.0	366.6	175.3	107.4	57.2	17.9	13.1	15.4	10.6
1989	116.3	209.7	209.2	175.4	209.2	319.5	247.9	111.8	66.5	36.6	11.7	8.1	9.6
1990	71.1	246.0	337.9	277.2	193.8	186.3	227.7	167.7	74.0	41.8	23.5	7.2	5.2
1991	62.3	129.1	345.2	402.7	280.3	162.6	122.1	121.8	85.7	38.0	21.6	11.3	3.5
1992	30.6	102.0	144.7	329.2	249.0	105.7	27.4	12.8	11.9	8.6	3.7	2.0	0.9
1993	9.3	31.8	67.5	64.0	57.7	24.8	4.2	1.6	0.8	0.8	0.6	0.3	0.1
1994	5.6	11.2	21.0	29.6	8.3	4.2	1.0	0.4	0.2	0.1	0.1	0.1	0.0
1995	3.0	4.6	4.3	7.8	4.2	1.1	0.5	0.2	0.1	0.0	0.0	0.0	0.0
1996	4.5	5.4	6.8	5.7	9.1	4.5	1.0	0.5	0.2	0.1	0.0	0.0	0.0
1997	5.0	7.1	6.5	8.3	6.0	9.1	4.0	0.8	0.4	0.2	0.1	0.0	0.0
1998	5.4	7.6	7.9	6.6	8.5	5.9	8.6	3.6	0.7	0.3	0.1	0.1	0.0
1999	8.1	8.8	9.5	8.1	5.8	8.0	5.2	7.8	3.0	0.6	0.3	0.1	0.0
2000	10.6	15.2	12.6	10.9	6.9	4.4	5.8	4.1	6.3	2.6	0.5	0.2	0.1
2001	12.5	16.4	16.3	10.8	6.4	3.8	2.6	4.6	3.2	5.1	2.1	0.4	0.2
2002	12.1	15.5	13.9	9.5	4.8	2.8	1.8	1.8	3.3	2.4	3.6	1.4	0.3
2003	9.4	12.7	10.2	7.4	5.2	2.8	1.5	1.2	1.2	2.3	1.6	2.5	1.0
2004	10.1	11.6	10.0	6.3	4.1	3.4	2.0	1.2	0.8	0.8	1.5	1.1	1.7
2005	5.7	21.4	18.5	12.7	6.8	3.9	2.9	1.9	1.0	0.7	0.7	1.3	0.9
2006	7.5	12.6	36.9	26.6	14.9	6.7	3.4	2.7	1.7	0.9	0.6	0.6	1.1
2007	10.5	16.4	21.1	51.8	30.9	13.4	4.9	2.7	2.1	1.3	0.7	0.5	0.5
2008	12.0	21.6	25.5	26.3	51.2	26.1	8.8	3.6	1.9	1.5	0.9	0.5	0.3
2009	14.3	22.9	31.0	28.2	22.9	40.0	19.5	6.6	2.6	1.4	1.0	0.6	0.3
2010	15.6	25.4	30.2	30.6	23.5	18.1	29.2	13.2	4.3	1.6	0.9	0.7	0.4
2011	17.9	23.5	28.3	22.7	19.7	18.7	13.6	20.7	9.0	2.8	1.1	0.6	0.4
2012	12.1	35.4	35.4	34.3	23.6	20.0	17.2	11.8	17.3	7.3	2.3	0.9	0.4
2013	21.1	25.6	59.2	50.3	43.1	27.4	20.8	16.9	11.2	16.2	6.7	2.1	0.8
2014	34.8	46.9	44.0	87.0	65.2	50.7	28.2	20.0	15.7	10.1	14.2	5.8	1.7
2015	32.1	74.6	77.2	61.6	106.6	70.6	44.6	22.5	15.4	11.8	7.4	10.2	4.1

Table A2-4. Northern cod mature biomass-at-age estimates (Kt) from the M-shift formulation of NCAM.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1983	0.00	1.14	5.55	21.72	70.07	147.90	239.70	187.79	108.29	31.84	13.59	6.63	6.86
1984	0.00	0.12	7.97	49.11	161.46	129.31	117.57	172.99	119.89	69.79	21.12	9.29	4.61
1985	0.01	0.04	1.90	44.48	199.93	262.81	94.26	73.77	98.39	69.65	39.90	12.24	5.56
1986	0.01	0.15	0.84	27.51	150.91	260.44	173.86	57.73	43.31	55.32	38.13	20.86	6.94
1987	0.02	0.13	2.27	16.03	223.03	253.38	196.82	116.83	37.57	25.87	33.80	22.14	12.87
1988	0.02	0.30	1.71	23.57	145.55	328.66	165.18	107.24	57.15	17.92	13.10	15.38	10.62
1989	0.01	0.40	3.14	20.19	121.32	288.03	245.56	110.47	66.49	36.62	11.73	8.14	9.56
1990	0.00	0.25	5.68	27.05	110.28	173.55	226.05	167.59	73.82	41.80	23.53	7.17	5.15
1991	0.01	0.06	6.18	52.43	121.57	151.30	121.23	121.74	85.70	37.94	21.55	11.30	3.50
1992	0.03	0.14	1.90	82.30	141.29	89.27	27.15	12.77	11.86	8.63	3.73	1.95	0.93
1993	0.08	0.27	2.46	17.64	49.54	22.77	4.06	1.63	0.81	0.84	0.60	0.25	0.11
1994	0.00	0.33	1.49	15.10	7.62	4.19	0.98	0.39	0.18	0.10	0.10	0.07	0.02
1995	0.00	0.01	0.42	3.16	4.04	1.07	0.54	0.23	0.10	0.04	0.02	0.02	0.01
1996	0.00	0.01	0.23	1.61	7.83	4.50	1.02	0.49	0.20	0.09	0.04	0.02	0.02
1997	0.04	0.06	0.19	2.43	3.50	8.95	3.95	0.81	0.38	0.16	0.06	0.03	0.01
1998	0.02	0.23	0.60	2.04	7.07	4.93	8.59	3.56	0.70	0.32	0.13	0.05	0.02
1999	0.00	0.12	1.03	3.75	5.09	7.82	4.97	7.76	3.04	0.60	0.26	0.10	0.03
2000	0.00	0.05	0.84	3.54	6.20	4.31	5.76	4.04	6.33	2.57	0.49	0.21	0.08
2001	0.01	0.02	0.65	2.83	4.17	3.71	2.58	4.60	3.23	5.11	2.05	0.38	0.16
2002	0.07	0.16	0.39	3.09	3.07	2.49	1.84	1.81	3.30	2.38	3.60	1.41	0.27
2003	0.01	0.32	0.82	2.80	4.42	2.54	1.48	1.15	1.15	2.25	1.63	2.50	0.99
2004	0.01	0.09	1.12	2.68	3.75	3.37	1.99	1.14	0.81	0.81	1.51	1.10	1.69
2005	0.02	0.16	1.03	4.84	5.83	3.87	2.89	1.85	1.02	0.71	0.71	1.31	0.94
2006	0.03	0.23	3.27	8.38	11.18	6.60	3.41	2.69	1.71	0.93	0.64	0.63	1.14
2007	0.01	0.38	2.50	28.97	24.14	12.51	4.87	2.66	2.11	1.31	0.71	0.48	0.46
2008	0.03	0.13	2.78	12.81	48.29	25.20	8.70	3.55	1.93	1.49	0.92	0.49	0.33
2009	0.03	0.35	1.40	10.98	19.98	39.83	19.42	6.62	2.58	1.36	1.04	0.64	0.34
2010	0.04	0.33	2.33	8.19	18.08	17.76	29.22	13.14	4.29	1.63	0.85	0.65	0.39
2011	0.17	0.41	2.45	7.13	14.59	17.63	13.60	20.74	8.98	2.84	1.06	0.55	0.41
2012	0.01	1.65	3.64	13.88	16.81	19.10	17.05	11.78	17.33	7.32	2.27	0.85	0.44
2013	0.09	0.16	11.88	21.37	35.79	25.50	20.65	16.89	11.22	16.15	6.66	2.05	0.76
2014	0.15	1.10	1.59	48.96	53.88	49.24	27.78	19.93	15.66	10.12	14.20	5.76	1.74
2015	0.14	1.75	8.74	11.35	92.60	68.36	44.46	22.47	15.35	11.76	7.40	10.19	4.09

Table A2-5. Northern cod F-at-age estimates from the M-shift formulation of NCAM.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1983	0.00	0.00	0.03	0.15	0.21	0.25	0.26	0.33	0.29	0.24	0.19	0.15	0.10
1984	0.00	0.00	0.03	0.12	0.19	0.28	0.27	0.32	0.27	0.26	0.23	0.18	0.13
1985	0.00	0.00	0.04	0.15	0.22	0.35	0.36	0.37	0.38	0.38	0.41	0.31	0.22
1986	0.00	0.00	0.04	0.14	0.23	0.33	0.38	0.38	0.44	0.39	0.42	0.34	0.24
1987	0.00	0.01	0.04	0.10	0.20	0.29	0.39	0.45	0.45	0.37	0.46	0.39	0.29
1988	0.00	0.01	0.05	0.11	0.22	0.26	0.37	0.37	0.31	0.26	0.30	0.28	0.25
1989	0.00	0.01	0.05	0.12	0.22	0.29	0.33	0.32	0.34	0.30	0.33	0.28	0.25
1990	0.00	0.01	0.06	0.13	0.18	0.22	0.29	0.30	0.27	0.24	0.29	0.26	0.29
1991	0.00	0.01	0.06	0.15	0.24	0.33	0.45	0.48	0.42	0.42	0.48	0.56	0.77
1992	0.00	0.01	0.05	0.14	0.26	0.37	0.55	0.46	0.32	0.32	0.34	0.48	0.80
1993	0.00	0.01	0.05	0.11	0.17	0.25	0.38	0.20	0.09	0.08	0.11	0.21	0.46
1994	0.00	0.01	0.03	0.07	0.12	0.16	0.23	0.11	0.06	0.07	0.11	0.22	0.53
1995	0.00	0.00	0.01	0.03	0.06	0.09	0.10	0.07	0.05	0.07	0.13	0.24	0.55
1996	0.00	0.00	0.02	0.05	0.09	0.13	0.14	0.12	0.09	0.10	0.17	0.32	0.69
1997	0.00	0.00	0.01	0.03	0.05	0.07	0.08	0.07	0.06	0.07	0.12	0.22	0.51
1998	0.00	0.00	0.02	0.07	0.13	0.18	0.18	0.20	0.17	0.17	0.22	0.29	0.54
1999	0.00	0.00	0.02	0.09	0.26	0.38	0.35	0.28	0.21	0.22	0.21	0.21	0.35
2000	0.00	0.00	0.02	0.09	0.17	0.24	0.22	0.19	0.15	0.14	0.13	0.12	0.16
2001	0.00	0.00	0.03	0.11	0.22	0.34	0.28	0.22	0.17	0.19	0.18	0.14	0.13
2002	0.00	0.00	0.02	0.08	0.22	0.36	0.34	0.28	0.19	0.16	0.12	0.10	0.10
2003	0.00	0.00	0.00	0.02	0.08	0.14	0.17	0.20	0.17	0.19	0.16	0.15	0.12
2004	0.00	0.00	0.00	0.01	0.05	0.09	0.09	0.08	0.06	0.05	0.04	0.04	0.03
2005	0.00	0.00	0.00	0.01	0.06	0.09	0.09	0.06	0.04	0.04	0.03	0.03	0.03
2006	0.00	0.00	0.00	0.02	0.07	0.11	0.13	0.09	0.08	0.07	0.05	0.05	0.06
2007	0.00	0.00	0.00	0.01	0.05	0.08	0.10	0.08	0.07	0.05	0.04	0.04	0.04
2008	0.00	0.00	0.00	0.01	0.03	0.05	0.08	0.08	0.08	0.06	0.04	0.04	0.04
2009	0.00	0.00	0.00	0.01	0.02	0.04	0.07	0.08	0.07	0.06	0.05	0.05	0.04
2010	0.00	0.00	0.00	0.01	0.02	0.04	0.06	0.06	0.06	0.06	0.04	0.04	0.03
2011	0.00	0.00	0.00	0.01	0.03	0.05	0.06	0.06	0.06	0.05	0.03	0.03	0.02
2012	0.00	0.00	0.00	0.01	0.02	0.04	0.06	0.05	0.05	0.05	0.03	0.03	0.02
2013	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.02
2014	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.04	0.03	0.04	0.04	0.03	0.01
2015	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.04	0.04	0.04	0.03	0.01

Table A2-6. Northern cod M-at-age estimates from the M-shift formulation of NCAM.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8+
1983	0.43	0.38	0.38	0.40	0.38	0.42	0.36
1984	0.42	0.37	0.34	0.35	0.36	0.44	0.48
1985	0.45	0.37	0.32	0.33	0.33	0.44	0.41
1986	0.38	0.30	0.25	0.26	0.29	0.33	0.29
1987	0.49	0.42	0.36	0.40	0.56	0.66	0.49
1988	0.35	0.29	0.25	0.26	0.34	0.44	0.34
1989	0.30	0.26	0.23	0.23	0.27	0.37	0.33
1990	0.47	0.40	0.33	0.31	0.37	0.52	0.60
1991	0.59	0.63	0.56	0.79	1.11	1.77	2.08
1992	1.05	1.18	1.35	2.06	2.43	3.18	2.53
1993	0.89	1.18	1.37	2.40	2.82	3.29	2.25
1994	1.26	1.72	1.56	2.37	2.31	2.21	1.52
1995	0.45	0.37	0.29	0.30	0.27	0.29	0.27
1996	0.59	0.58	0.37	0.37	0.31	0.34	0.37
1997	0.64	0.64	0.55	0.41	0.35	0.32	0.31
1998	0.57	0.53	0.52	0.51	0.32	0.26	0.21
1999	0.43	0.39	0.41	0.52	0.41	0.27	0.17
2000	0.63	0.68	0.71	0.91	0.81	0.60	0.28
2001	0.84	0.92	1.09	1.16	0.98	0.69	0.35
2002	1.00	1.16	1.20	0.98	0.69	0.57	0.41
2003	0.84	0.98	1.05	1.05	0.73	0.51	0.39
2004	0.30	0.27	0.31	0.38	0.37	0.40	0.27
2005	0.25	0.20	0.20	0.28	0.32	0.36	0.26
2006	0.26	0.22	0.22	0.28	0.41	0.52	0.39
2007	0.33	0.30	0.34	0.45	0.49	0.65	0.49
2008	0.40	0.38	0.46	0.57	0.59	0.55	0.47
2009	0.48	0.47	0.57	0.62	0.58	0.58	0.59
2010	0.64	0.63	0.85	0.88	0.58	0.55	0.55
2011	0.37	0.33	0.37	0.41	0.33	0.34	0.35
2012	0.30	0.23	0.21	0.22	0.20	0.23	0.22
2013	0.25	0.20	0.18	0.19	0.19	0.25	0.26
2014	0.29	0.24	0.23	0.25	0.28	0.41	0.45
2015	0.31	0.26	0.25	0.25	0.26	0.33	0.33

Table A2-7. Northern cod Z-at-age estimates from the M-shift formulation of NCAM.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1983	0.43	0.38	0.41	0.55	0.59	0.67	0.62	0.69	0.65	0.60	0.55	0.51	0.46
1984	0.42	0.38	0.37	0.47	0.55	0.73	0.76	0.80	0.75	0.74	0.71	0.66	0.61
1985	0.45	0.37	0.36	0.48	0.56	0.79	0.77	0.77	0.78	0.79	0.81	0.71	0.63
1986	0.38	0.30	0.29	0.40	0.53	0.66	0.67	0.67	0.72	0.68	0.71	0.63	0.53
1987	0.49	0.43	0.40	0.51	0.76	0.95	0.88	0.95	0.95	0.86	0.95	0.88	0.78
1988	0.35	0.30	0.30	0.37	0.55	0.70	0.72	0.71	0.65	0.61	0.64	0.62	0.59
1989	0.30	0.27	0.29	0.35	0.49	0.65	0.66	0.64	0.67	0.62	0.65	0.60	0.57
1990	0.47	0.41	0.39	0.44	0.55	0.74	0.89	0.90	0.87	0.84	0.89	0.86	0.89
1991	0.59	0.65	0.62	0.94	1.35	2.10	2.53	2.56	2.50	2.50	2.56	2.64	2.85
1992	1.05	1.19	1.40	2.20	2.68	3.55	3.09	2.99	2.85	2.85	2.88	3.02	3.34
1993	0.89	1.19	1.42	2.51	2.99	3.54	2.64	2.45	2.34	2.34	2.36	2.46	2.71
1994	1.26	1.72	1.59	2.44	2.43	2.38	1.75	1.63	1.58	1.59	1.63	1.74	2.04
1995	0.45	0.37	0.31	0.33	0.32	0.38	0.37	0.34	0.32	0.34	0.39	0.51	0.82
1996	0.59	0.58	0.39	0.43	0.40	0.47	0.51	0.49	0.46	0.46	0.53	0.68	1.06
1997	0.64	0.64	0.56	0.44	0.40	0.39	0.39	0.39	0.38	0.38	0.43	0.54	0.83
1998	0.57	0.53	0.54	0.58	0.45	0.45	0.39	0.41	0.38	0.38	0.43	0.50	0.75
1999	0.43	0.39	0.44	0.62	0.68	0.65	0.53	0.45	0.38	0.39	0.39	0.39	0.53
2000	0.63	0.69	0.73	0.99	0.99	0.84	0.50	0.48	0.43	0.42	0.41	0.41	0.44
2001	0.84	0.92	1.12	1.27	1.19	1.03	0.63	0.57	0.52	0.54	0.54	0.49	0.49
2002	1.00	1.16	1.22	1.06	0.91	0.93	0.74	0.69	0.59	0.57	0.53	0.50	0.50
2003	0.84	0.98	1.05	1.06	0.80	0.65	0.56	0.59	0.56	0.58	0.55	0.54	0.51
2004	0.30	0.27	0.32	0.39	0.42	0.49	0.36	0.35	0.33	0.32	0.31	0.31	0.30
2005	0.25	0.20	0.20	0.29	0.38	0.45	0.35	0.32	0.30	0.30	0.29	0.29	0.29
2006	0.26	0.22	0.23	0.30	0.48	0.64	0.52	0.48	0.47	0.46	0.44	0.45	0.45
2007	0.33	0.30	0.34	0.46	0.54	0.73	0.59	0.56	0.55	0.54	0.52	0.52	0.53
2008	0.40	0.38	0.46	0.59	0.62	0.60	0.55	0.55	0.55	0.53	0.52	0.51	0.51
2009	0.48	0.47	0.58	0.63	0.60	0.62	0.66	0.66	0.66	0.65	0.64	0.64	0.63
2010	0.64	0.63	0.85	0.89	0.60	0.59	0.61	0.61	0.61	0.61	0.59	0.59	0.58
2011	0.37	0.33	0.37	0.41	0.36	0.39	0.41	0.41	0.40	0.40	0.38	0.38	0.37
2012	0.30	0.23	0.22	0.22	0.22	0.27	0.28	0.28	0.27	0.27	0.26	0.26	0.25
2013	0.25	0.20	0.18	0.19	0.21	0.28	0.30	0.31	0.30	0.30	0.30	0.30	0.28
2014	0.29	0.24	0.23	0.25	0.29	0.44	0.49	0.49	0.49	0.49	0.49	0.48	0.46
2015	0.31	0.26	0.25	0.25	0.27	0.35	0.37	0.38	0.37	0.37	0.37	0.36	0.34