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Assessing the status of the cod (*Gadus morhua*) stock in NAFO Subdivision 3Ps in 2020

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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 status of the cod stock in the Northwest Atlantic Fisheries Organization (NAFO) Subdivision (Subdiv.) 3Ps was assessed during a Fisheries and Oceans Canada (DFO) Regional Peer Review Process meeting held November 2–7, 2020.

Total landings for the 2019–20 management year (April 1–March 31) were 3,499 t, or 59% of the Total Allowable Catch (TAC). This marks the tenth consecutive season that the entire TAC has not been taken.

There was no DFO research vessel (RV) survey during spring 2020 due to the pandemic. Sentinel gillnet catch rates have been very low and stable since 1999. Sentinel line trawl catch rates were below average over 2011–18, but the 2019 catch rates were relatively high.

An integrated state space model resulting from the 2019 3Ps Cod Framework meeting was used to assess the status of the stock and estimate fishing mortality.

The Limit Reference Point (LRP) is 66,000 t of Spawning Stock Biomass (SSB). SSB at January 1, 2021, is estimated to be 25 kt (18 kt–35 kt). The stock is in the Critical Zone (38% of B_{lim} [27–53%]) as defined by the DFO Precautionary Approach (PA) Framework. The probability of being below B_{lim} is >99.9%. The estimated fishing mortality rate (ages 5–8) has generally declined, from 0.16 in 2015 to 0.11 in 2019. With an assumed catch of 2,702 t in 2020, fishing mortality (*F*) is projected to be 0.07 (0.05–0.09) in 2020. Natural mortality (ages 5–8) was estimated to be 0.43 (0.35–0.52) in 2019. Values of natural mortality (*M*) during the last four years are the among the highest in the time series. Recruitment (age 2) estimates have been below the long term average since the mid-1990s. Projection of the stock to 2023 was conducted assuming:

1. fishery removals to be within ±60% of current values,
2. a catch of 2,702 t for 2020, and
3. no catch in 2021 and 2022.

Under these scenarios, there was a >99% probability that the stock will remain below B_{lim} between 2021 and the beginning of 2023. The probability of stock growth to 2023 ranged between 39% and 78% across catch scenarios (+/-60% of current levels) and was 88% when there are no removals. Natural mortality plays an important role in projections for this stock. If natural mortality rates are appreciably different from those used, outcomes will differ from those projected above.

Bottom temperatures in Subdiv. 3Ps remained above normal between 2009–19, but no data were available for 2020. No zooplankton data were available for 2019 and 2020. Satellite imagery indicates that the timing and magnitude of the spring phytoplankton bloom were normal in 2020, after two consecutive years of early onset and above-normal production. Ongoing warming trends, together with an increased dominance of warm water fishes, indicate that this ecosystem continues to experience structural changes. Reduced condition is indicative of diminished productivity in 3Ps cod.

INTRODUCTION

This document gives an account of the 2020 assessment of the Atlantic Cod (*Gadus morhua*) stock in Northwest Atlantic Fisheries Organization (NAFO) Subdiv. 3Ps, located off the south coast of Newfoundland, Canada (Figures 1 and 2). The French overseas territory of St. Pierre et Miquelon (SPM) also lies within the boundaries of NAFO Subdiv. 3Ps, and only Canada and France have fished in this area since the extension of jurisdiction by each country to 200 miles in the late 1970s. The stock is jointly managed by Canada and France through formal agreements.

A Regional Assessment Process meeting was conducted during November 2020 (DFO 2020) with participation from Fisheries and Oceans Canada (DFO) Science, Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER; France), DFO Fisheries Management, academia, the Canadian fishing industry, non-governmental organizations, and the province of Newfoundland and Labrador (NL).

Various sources of information on Subdiv. 3Ps cod were available to update the status of this stock. Commercial landings through September 2020 were presented. There was no DFO-RV survey during 2020 due to the pandemic. However, the population model incorporating scientific data from bottom trawl surveys (Canada, 1983–2019; France, 1978–92) and industry association surveys (GEAC, 1997–2007; the Sentinel Survey, 1995–2019) utilizing gillnets and linetrawls near the coast, and landings data, was updated. Included in the new model run were revised landings and catch-at-age estimates for 2019, the 2019 Sentinel survey data, and revised estimates of cod condition (2016–17) in addition to more recent (2019) condition values. Natural mortality (*M*) estimates in the model were informed by a cod condition-based index of mortality, and new sensitivity testing was performed on the treatment of *M* in the model. The model provided estimates of biomass, recruitment, and both natural and fishing (*F*) mortality for the stock. Additional sources of information presented included data from the Science logbooks for vessels <35 feet (1997–2019), logbooks from vessels >35 feet (1998–2019) and at sea observer sampling. Information from tagging experiments in Placentia Bay (and more recently Fortune Bay) was also available.

ASSESSMENT

TOTAL ALLOWABLE CATCHES AND COMMERCIAL CATCH

Total Allowable Catch

The cod stock in Subdiv. 3Ps was subject to a moratorium on all fishing from August 1993 to the end of 1996. Excluding these years, the magnitude of the TAC has varied considerably over time, ranging from 70,500 t in 1973 (the initial year of TAC regulation), to 2,691 t in the ongoing 2020/21 season (Figure 3a). Beginning in 2000, TACs were established for seasons beginning April 1 and ending March 31 of the following year (during January-March 2000, an interim TAC was set to facilitate this change) whereas previously, they were set annually. The TAC was set at 11,500 t for five consecutive management years (2009/10–2013/14) and was subsequently increased to 13,225 t for the 2014/15 management year. In 2015/16, Canada adopted a Conservation Plan and Rebuilding Strategy (CPRS) for 3Ps cod that included a harvest control rule (HCR) for suggesting the TAC for the upcoming year. In 2015/16 and 2016/17, the HCR suggested TACs of 13,490 t and 13,043 t respectively, which both Canada and France agreed to accept. It was not considered prudent to provide management advice for 2017/18 and subsequent seasons based on the HCR. Canada and France agreed on TACs of 6,500 t for the

2017/18 season and 5,980 t for both the 2018/19 and 2019/20 seasons. A TAC of 2,691 t was agreed on by Canada and France for the ongoing 2020/21 season. Under the terms of the 1994 Canada France agreement, the Canadian and French shares of the 2020 TAC were 84.4% and 15.6%, respectively.

Commercial Catch

Prior to the moratorium, Canadian landings for vessels <35 feet (ft; see "Can-NL fixed" in Table 1) were estimated mainly from purchase slip records collected and interpreted by Statistics Division, DFO. Shelton et al. (1996) emphasized that these data may be unreliable. Post moratorium landings for Canadian vessels <35 ft came mainly from a dock side monitoring program initiated in 1997. Landings for Canadian vessels >35 ft came from logbooks. Non-Canadian landings (attributable only to France since 1977) were compiled from national catch statistics reported to NAFO by individual countries. In recent years, French landings have been provided directly by French government officials.

In the 1960s and early 1970s, cod in Subdiv. 3Ps were heavily exploited by non-Canadian fleets, mainly from Spain and Portugal, with reported landings peaking at about 87,000 t in 1961 (Figure 3a). After extension of Canadian jurisdiction in 1977, cod landings averaged between 30,000 t and 40,000 t until the mid-1980s, when increased fishing effort by France led to increased total reported landings, which reached about 59,000 t in 1987. Subsequently, reported catches declined gradually to 36,000 t in 1992. Catches exceeded the TAC throughout the 1980s and into the 1990s. The Canada France boundary dispute at this time led to fluctuations in the French catch during the late 1980s. Under advice from the Fisheries Resource Conservation Council, a moratorium was imposed on all directed cod fishing in August 1993 after only 15,216 t had been landed. Access to Canadian waters by French vessels was restricted in 1993.

Since 1997, most of the TAC has been landed by Canadian inshore fixed gear fishers, where "inshore" is typically defined as unit areas 3Psa, 3Psb, and 3Psc (Figure 1); remaining catch was taken mainly by the mobile gear sector fishing the offshore, typically defined as unit areas 3Psd, 3Pse, 3Psf, 3Psg, and 3Psh (Table 1, Figures 3a and 3b).

Line trawl (i.e., longline) catches dominated the fixed gear landings over the period 1977–93, reaching a peak of over 20,000 t in 1981 and typically accounting for 40–50% of the annual total for fixed gear (Table 2, Figure 4). In the post moratorium period, line trawls accounted for 7–26% of the fixed gear landings. Gillnet landings increased steadily from about 2,300 t in 1978 to a peak of over 9,000 t in 1987 and remained relatively stable until the moratorium. Gillnets have been the dominant gear used for the inshore fishery since it reopened in 1997, with gillnet landings exceeding 50% of the TAC for the first time in 1998. Gillnets have typically accounted for 70–80% of the fixed gear landings since 1998, but accounted for a lower percentage of the fixed gear landings in 2001 (60%), partly due to a temporary management restriction in their use that was removed part way through the fishery following extensive complaints from industry. Gillnets have also been used extensively in offshore areas in the post moratorium period. Cod trap landings from 1975 up until the moratorium varied considerably, ranging from approximately 1,000–7,000 t. Since 1998, trap landings have been reduced to negligible amounts (<120 t). Hand line catches were a small component of the inshore fixed gear fishery prior to the moratorium (about 10–20%) and accounted for about 6% of landings on average for the post moratorium period. However, hand line catch for 2001 showed a substantial increase (to 17% of total fixed gear), concomitant with the temporary restriction in use of gillnets described above. Increases in the proportion of hand line catch in some years (e.g., 2009, 2013) are likely due to buyers paying a higher price for hook-caught fish than for those caught in gillnets.

Total landings for the 2019–20 management year (April 1–March 31) were 3,499 t, or 59% of the 5,980 t TAC. This marked the tenth consecutive season in which the landings were less than the TAC. Industry participants have indicated multiple reasons for the low landings, including reduced availability of fish, poor market conditions/economics, and technical issues with the French vessel. A voluntary suspension of fishing activities by the trawler fleet was the primary reason the 2016/17 TAC was not taken. Prior to the 2009–10 season, the TAC had been fully utilized, if not exceeded, in each year since Canadian jurisdiction was extended in 1977. Furthermore, excluding the moratorium years, current landings are among the lowest of the available time series. Preliminary landings data for 2020/21 to October 1 totaled 930 t. Although the 2020/21 fishing season was incomplete at the time of the assessment, landings to date are a 55% reduction from those of the same time last year.

The 2013–14 (April 1–March 31) CPRS placed various seasonal and gear restrictions on the Subdiv. 3Ps cod fishery in Canadian waters, and these restrictions still apply. For example, unit areas 3Psa and 3Psd were closed from November 15–April 15 of the following year to avoid potential capture of migrating cod from the Northern Gulf stock (NAFO Divisions 3Pn4RS) and all of Subdiv. 3Ps was closed from April 1 to May 14, a closure intended to protect spawning aggregations. Full details of these and other measures, which may differ among fleet sectors, are available from the DFO Fisheries and Aquaculture Management (FAM) branch in St. John's.

The spatial-temporal details of reported landings are provided in Table 3 and shown in Figure 5. During 2019–20, most of the inshore landings were reported in 3Psc (over 60% of Canadian landings).

Inshore landings were low early in the year (Table 3), arising mostly from by-catch of cod in other fisheries. The vast majority of landings from the inshore areas was taken in June-November, with highest landings in June and July, particularly in 3Psc. The inshore unit areas consistently accounted for most of the reported landings. These have typically been highest in Placentia Bay (3Psc), ranging from 1,500 t to almost 11,650 t, with 26–61% of the annual Subdiv. 3Ps catch coming from this unit area alone. In 2019/20, the landings from 3Psc were 2,078 t, representing 61% of the Subdiv. 3Ps total. Most of the offshore landings have come from 3Psh and 3Psf (Halibut Channel and the southeastern portion of St. Pierre Bank; Figure 2). Unit areas 3Psd, 3Pse, and 3Psg accounted for a very small portion of the total catch in recent years. Catches in these areas thus far in 2020–21 have again been very low. The breakdown of landings by unit area excludes landings by France from 2009 to present. Resource managers from France have reported that the majority of these landings was taken in either 3Psf or 3Psh, but the exact unit area was unavailable.

CATCH-AT-AGE

Estimates of numbers-at-age for the Canadian catch during 2019 were revised for the 2020 assessment. Note that the catch-at-age time series was reconstructed for the 2019 framework meeting and this reconstructed series was used in the 2020 assessment. The amount of landings sampled was highly variable among gear types and years, but generally the otter trawl fleet was sampled well compared to other fleets, while inshore and offshore line trawl landings were sampled poorly (Table 4).

Landings in 2019 were composed mostly of age 8 fish (Figure 6). Detailed catch-at-age estimates for 2019 can be found in Table 5 and the complete time series (1959–2019) of available catch numbers-at-age (ages 3–14 shown) for the 3Ps cod fishery can be found in Table 6. Age 8 fish, representing the 2011 cohort, dominated the 2017–19 catch.

WEIGHT-AT-AGE

The time series of available mean weights-at-age in the 3Ps fishery (including landings from the commercial and recreational fisheries, and the Sentinel surveys) are given in Table 7a and Figure 7. These data are no longer used for stock weights, as selectivity of the fishery has changed over time. Estimates of mean weights-at-age are derived from sampling of the catches stratified by gear type, unit area, and month. Seasonal age-length keys are applied to length frequency data to age the catch and calculate proportions at-age. Weights from the annual DFO-RV survey (Table 7b), rather than the commercial weights, are now used. Weights-at-age are calculated using a length-weight relationship for Atlantic Cod that has been applied to all cod stocks in the Newfoundland and Labrador Region.

For young cod (ages 3–6), weights-at-age computed in recent years tended to be higher than those in the 1970s and early 1980s (Table 7a, Figure 7). The converse was generally true for older fish. Sample sizes for the oldest age groups (>10) were low in recent years due to their scarcity in the catch. The current extremely low weights-at-age for ages >10 could be related to these low sample sizes. Interpretation of trends in weights-at-age computed from fishery data is difficult because of among-year variability in the proportion at age caught by gear, time of year, and location.

RESEARCH VESSEL (RV) SURVEYS

Stratified-random surveys have been conducted by Canada in the offshore areas of Subdiv. 3Ps during the winter-spring since 1972, and by France over 1978–92. The two surveys were similar with regard to the stratification scheme used, sampling methods, and data analysis, but differed in the type of fishing gear used and the daily timing of trawls (24 hours for Canadian surveys; daylight hours only for French surveys).

DFO Research Vessel (RV) Surveys by Canada

Canadian surveys were conducted using the research vessels CCGS *A.T. Cameron* (1972–82), CCGS *Alfred Needler* (1983–84; 2009–19), and CCGS *Wilfred Templeman* (1985–2008). There was no DFO-RV survey during 2020. From the limited amount of comparable fishing data available, it has been concluded that the three vessels had similar fishing power and no adjustments were necessary to achieve comparable catchability factors, even though the CCGS *A.T. Cameron* was a side trawler. Cadigan et al. (2006) found no significant differences in catchability for several species, including cod, between the *Wilfred Templeman* and *Alfred Needler* research vessels. The CCGS *Teleost* has also been used during exceptional events (e.g., severe mechanical issues on regular survey vessel), and any potential vessel effect is unaccounted for. Surveys by France were conducted using the research vessels *Cyros* (1978–91) and *Thalassa* (1992), and the results are summarized in Bishop et al. (1994).

The Canadian DFO-RV surveys from 1983 to 1995 employed an Engel 145 high-rise bottom trawl. In 1996, the surveys began using the Campelen 1800 shrimp trawl. The Engel trawl catches for 1983–95 were converted to Campelen 1800 shrimp trawl-equivalent catches using a length-based conversion formulation derived from comparative fishing experiments (Stansbury 1996, 1997; Warren 1996; Warren et al. 1997).

The stratification scheme used in the DFO-RV bottom-trawl survey in 3Ps is shown in Figure 8. Canadian surveys have covered strata ranging down to 300 fathoms (ftm) in depth (1 fathom = 1.83 meters) since 1980. Five new inshore strata were added to the survey in 1994 (numbered 779–783) and a further eight inshore strata were added in 1997 (numbered 293–300) resulting in a combined 18% increase in the surveyed area. Beginning in the 2007 assessment, new indices using survey results from the augmented survey area were presented.

Two survey time series were constructed from the catch data from Canadian surveys, and used in the assessment model. The series from the expanded surveyed area that includes new inshore strata is referred to as the “All Strata <300 ftm” index and extends from 1997–present. The original smaller surveyed area series is referred to as the “Offshore” survey index and extends from 1983–present.

The timing of the survey has varied considerably (Table 8). In 1983 and 1984 the mean date of sampling was in April; in 1985–87 it was in March; and from 1988 to 1992, it was in February. Both a February and an April survey were carried out in 1993; subsequently, the survey has generally been carried out in April. The change to April was aimed at reducing the possibility of stock mixing with cod from the adjacent Northern Gulf stock (3Pn4RS) in the western portion of 3Ps. The stock mixing issue is described in more detail in previous assessments (e.g., Brattey et al. 2007). Due to extensive mechanical problems with the RV, the survey in 2006 was incomplete: only 48 of 178 planned sets were completed. Therefore, results for 2006 for the full survey area are not considered comparable to the remainder of the time-series. All subsequent surveys were considered complete. The 2019 survey completed 169 of the intended 178 fishing sets (Figure 9) with sampling in all index strata. There was no survey of 3Ps in 2020 due to the COVID-19 pandemic.

Evaluation des Ressources Halieutiques de la région 3PS (ERHAPS) Surveys by France

The new assessment model incorporates bottom trawl data from the ERHAPS surveys by France that were conducted from 1978 to 1992 using the same stratification scheme as the DFO-RV survey. There was a change in vessel in 1992 and there was no comparative fishing to compare the catchabilities of the two vessels. Therefore, the assessment used only data from 1978 to 1991. The ERHAPS survey was conducted in February-March using a Lofoten trawl in daylight hours only. When strata were missed during the survey, adjustments to the results were made using a multiplicative model (Champagnat and Vigneau pers. comm.)

Groundfish Enterprise Allocation Council (GEAC) Survey

GEAC (presently Atlantic Groundfish Council) conducted a fall survey (November-December) within 3Ps from 1997 to 2007 using the same stratification scheme as the Canadian offshore RV survey (McClintock 2011). An Engel 96 high lift trawl was used to conduct 30 minute tows. Twenty-four strata were sampled during most years, but coverage was incomplete in 1997 and the survey was not conducted in 2006. In 2007, a different vessel was used, and several additional strata were included. Eight years of data from this series (1998–2005) were included in the new assessment model.

Sentinel Survey in NAFO Subdivision 3Ps

The ongoing Sentinel survey of Atlantic Cod has been conducted in NAFO Subdivision 3Ps since 1995 using gillnets and linetrawls (see Mello and Simpson 2022). Annually, between 8 and 17 sites are sampled along the coast over a 9–12 week period. Age disaggregated catch rates are standardized (Generalized Linear Model) with month nested within fishing Site and age nested within year.

ASSESSMENT MODEL DESCRIPTION

From 2009 to 2018, the Subdiv. 3Ps cod stock was assessed using a SURBA (SURvey Based Assessment) model (Cadigan 2010, DFO 2019a), fit to the DFO-RV survey data. An assessment framework meeting was held from October 8–10, 2019, where a range of state-space models for assessing the status of this stock were examined. Candidate models were developed within three different state-space modelling approaches: SAM (State-space Assessment Model, Nielsen and Berg 2014), 3Ps SSAM (State-Space Assessment Model for 3Ps Cod, Cadigan 2023), and HYBRID (Varkey et al. 2022). Several model formulations within each of these three modelling approaches were presented and reviewed. The goal was to adopt one of the candidate models for assessing the status of the 3Ps cod stock.

The assessment framework meeting decided that a formulation of the HYBRID modelling approach should be used for assessing the stock (Varkey et al. 2022). The HYBRID model is named as such because it uses a variety of features from SAM – mainly the use of random-effects for modelling *N* and *F* matrices – and the Northern Cod Assessment Model (Cadigan 2016) – mainly the inclusion of expert opinion on reliability of landings time series through the use of censored likelihood. Further, HYBRID uses time-varying natural mortality which is modelled as a function of scaled fish condition-based index. In 2019 and 2020, the Subdiv. 3Ps cod stock was assessed using the HYBRID model.

This model has the following main features:

1. all the available surveys (Canadian DFO-RV survey, French ERHAPS survey, industry trawl survey, and gillnet and line trawl Sentinel surveys) are included,
2. two types of commercial data are used–fisheries catch-at-age is fit using continuation ratio logits, and the fisheries landings are fit via censored likelihood,
3. Multivariate normal (MVN) random walk for *F* with age 2 decoupled from the MVN correlation and with a discontinuity in the random walk at the moratorium,
4. time-varying *M*, and
5. starts in 1959, which is the first year for which landings data are available.

Of the surveys included in the model, the DFO-RV spring survey and the Sentinel survey are the only ones presently ongoing. At the time of the 2019 assessment, the 2019 DFO-RV survey data were available, but the 2019 Sentinel survey was still ongoing. Hence, in the terminal year of the model, data from only one of the surveys was available (Table 9). In 2020, the DFO-RV survey could not be conducted due to the restrictions imposed during the pandemic. Complete information from the Sentinel survey, for the Sentinel indices and cod condition data to inform *M*, was available for 2019. Therefore, information from both the surveys was available until 2019 (typically, DFO-RV spring survey data is available for an additional year). The landings and catch-at-age were also updated for 2019. Projections of the stock-status were produced up to and including 2023.

State Equation

The state equation follows the parameterization of the state equation in the SAM (Nielsen and Berg 2014). The matrices of *log N* (log abundance) are treated as random variables and represent the underlying unobserved state. Age *a* in the model spans from 2 to 14+ and the plus group is represented by *A*. Years (*y*) in the model span from 1959 to 2019. First year abundances (for ages 3 to *A*) are estimated as part of the random variable matrix for log $N_{a,y}$. Recruitment (first age-age 2-in all years) is modelled to follow a random walk with standard deviation σ_R. The process error is normally distributed with standard deviation σ_P. Age-specific fishing mortality ($F_{a,y}$) and natural mortality ($M_{a,y}$) are used to model the exponential decay in the cohort.

$log\ N_{2,y} = log\ N_{2,y-1} + \eta_{2,y};\ \eta_{2,y} \sim N(0, \sigma_R)$	**1**
$log\ N_{a,y} = log\ N_{a-1,y-1} - F_{a-1,y-1} - M_{a-1,y-1} + \eta_{a,y}; 3 \leq a < A-1;\ \eta_{3:A,y} \sim N(0, \sigma_P\ )$	**2**
$log\ N_{A,y} = log\begin{pmatrix} N_{A,y-1} * \exp(-F_{A,y-1} - M_{A,y-1}) + \\ N_{A-1,y-1} * \exp(-F_{A-1,y-1} - M_{A-1,y-1}) \end{pmatrix} + \eta_{A,y};\ A = 14+$	**3**

Parameterization of *F* - Time Varying Fisheries Selectivity in the Model

To account for some of the temporal dynamics in the fishery, time varying selectivity was incorporated into the model. The primary gears used have varied considerably over time, with the fishery changing from a predominately offshore mobile fishery heavily exploited by non-Canadian fleets in the 1960s and early 1970s to a fishery based mostly inshore using fixed gear in the later years. Since 1997, most of the TAC has been landed by Canadian inshore fixed gear fishers, with the remaining catch taken mainly by the mobile gear sector fishing the offshore.

Therefore, the $F_{a,y}$ matrix was modeled as a multivariate normal (MVN) random walk over years, similar to the implementation in SAM (Nielsen and Berg 2014). Breaks to the MVN random walk were added at the beginning of the fishing moratorium. Further, the standard deviation for age 2 was de-coupled from the older ages in the fishery (ages 3+). Correlation in the random walks between ages was enabled through MVN deviations. For the covariance matrix of MVN deviations, a simple autoregressive (AR1) process for the correlation (ρ) was adopted, such that similar age groups developed similar trends in the fishing mortality.

$\log(F_{2:A,y}) = \log(F_{2:A,y-1}) + e_{2:A,y};\ e_{2:A,y} \sim MVN_{2:A}(0, \Sigma\ )$	**4**
$\Sigma_{a,\bar{a}} = \rho^{\lvert a-\bar{a}\rvert}\sigma_a^2$	**5**

Each element in Σ is a function of the standard deviation of the random walk and the estimated correlation coefficient. This parameterization of *F* allows for flexibility for the shape of the selectivity function over the two dimensional space of ages and years. Selectivity is derived as:

$s_{a,y} = \frac{F_{a,y}}{\sum_a F_{a,y}}$	**6**

Parameterization of Natural Mortality (*M*)

When information on *M* is not available, a base assumption in fisheries stock assessments has been that it is invariant over age and year, and often assigned a value of *M*=0.2 (Hilborn and Liermann 1998). For neighboring cod stocks (Northern cod Div. 2J3KL, DFO 2019b; Flemish Cap Div. 3M, González-Troncoso et al. 2020), *M* was estimated to be higher than 0.2 (Cadigan 2016, and the two most recent assessments for 2J3KL and 3M); for this reason, *M*=0.3 was chosen as the base level. Analysis of tagging data for 3Ps cod also suggested *M* levels to be higher than 0.2, although the tagging data is limited to the post-moratorium time period (Appendix B in Varkey et al. 2022). Previous assessments also indicated an increase in total mortality, *Z* (Ings et al. 2019a, Ings et al. 2019b).

The model applies time-varying $M_{a,y}$, where a trend based on fish condition is applied to a base level *M* (M_{base}= 0.3).

$$M_{a,y} = M_{base}\exp\left(\delta_{a,y}\right)$$	***7***

The $\delta_{a,y}$ term is covariate associated estimation, such that the resulting *M* follows the trend in the covariate X_y.

$$\delta_{a,y} = mpar_a * X_y$$	***8***

Estimates of *mpar* close to zero suggest no, or little, influence of the covariate on *M*, a positive *mpar* indicates that *M* follows the trend in the covariate and a negative *mpar* indicates an *M* trend opposite to the trend in the covariate. Here, the covariate X_y is a normalized index of *Mc,* a condition-based index of *M* (Appendix C in Varkey et al. 2022).

$$X_y = \frac{Mc_y - \mu_{Mc}}{\sigma_{Mc}}$$	***9***

This scaling allows the treatment of the covariate as an anomaly resulting in estimates above or below the baseline M_{base} provided, similar to the scaling for temperature anomaly for time-varying carrying capacity (Kumar et al. 2013). The mean (μ_{Mc}) and standard deviation (σ_{Mc}) are calculated for the reference period 1978–2012, the first 35 years of data; therefore, the normalization of *Mc* is based on a reference period from 1978 to 2012. The *mpar* parameter was estimated for two age groups (immature and mature) to allow these different age groups to respond differently to the trends in fish condition. A similar implementation of time-varying *M* was undertaken for the Kootenay lake kokanee population (Kurota et al. 2016). Hence the final equation for *M* is:

$$M_{a,y} = M_{base}\exp\left(mpar_a * \left(\frac{Mc_y - \mu_{Mc}}{\sigma_{Mc}}\right)\right)$$	***10***

Likelihoods

Surveys

We fit the model to four surveys,

1. the Canadian DFO-RV survey,
2. the French ERHAPS survey,
3. the GEAC survey, and
4. the Sentinel survey.

$I_{a,y,s}$ represents the expected index-at-age in survey *s*, *ts***Z* (where instantaneous rate of total mortality *Z* = *F* + *M)* represents an adjustment to *Z* to account for the timing of survey in the year (e.g., *ts*=0.5 for a survey in June; the model year is January–December, although the management year is April–March). The observation error standard deviation $\sigma_{ag.}$ can be estimated separately for age-group ‘ag’ and survey ‘*s*’. *q* represents survey catchability.

$$\log \hat{I}_{a,y,s} = \log q_{a,s} + \log N_{a,y} - sf_{y,s} * Z_{a,y} + e_{a,y,s};\ e_{a,y,s} \sim N\left(0, \sigma_{ag,s}\right)$$	***11***

The Canadian DFO-RV survey provides continuous (except 2006) records of mean numbers per tow throughout the time series; however, survey timing shifted in the early 1990s and inshore strata were added when the fishery reopened in 1997. An inshore-offshore adjustment (offset for q) is applied only to fish aged 8 and older. The average fraction of fish age 8 and older in the inshore area was less than 5% in the DFO-RV combined inshore-offshore index (Figure 10). The catchability for fish aged 2–7 is estimated independently for the offshore and the combined inshore-offshore survey. For fish aged 8 and older, the catchability in the offshore survey (DFO-RV-OFF) is calculated as the catchability of the combined inshore-offshore survey (DFO-RV-IO) plus an offset. The offset for q at age is calculated as the log ratio of the average (median) index-at-age for the combined inshore-offshore region versus the same for the offshore region. A comparison of several approaches to adjust for the addition of inshore strata and estimate catchability for the DFO-RV survey series were explored in Varkey et al. (2022). This adjustment was adopted based on fewer assumptions required on the ratio of fish present in the inshore versus offshore, as well as better performance in retrospective analyses.

$log\ q_{8:A,DFO\ RV\ OFF\ 1983:1996} = log\ q_{8,DFO\ RV\ IO\ 1997:2018} + \log q_{offset\ 8:A}$	***12***
$log\ q_{offset\ 8:A} = -log\left(\frac{median\ (I_{DFO\ RV\_IO\ 8:A})}{median(I_{DFO\ RV\_OFF\ 8:A})}\right)$	***13***

Fisheries Catch-at-Age

Catch is predicted using the Baranov catch equation:

$\hat{C}_{a,y} = N_{a,y}\left(1 - \exp(-Z_{a,y})\right) {F_{a,y}}/{Z_{a,y}}$	***14***

In the model fitting exercise, the magnitude of the catch total weights (i.e., landings) and the age-composition information in the catch-at-age data were fitted separately. Continuation ratio logits (CRLs; Cadigan 2016) are the logit transformation of the conditional probability $\pi_{a,y}$ of proportions at age $P_{a,y}$ in a given year.

$\hat{P}_{a,y} = \frac{\hat{C}_{a,y}}{\sum_2^A \hat{C}_{a,y}}$	***15***
$\pi_{a,y} = Prob(age = a \mid age \geq a) = \frac{\hat{P}_{a,y}}{\sum_a^A \hat{P}_{a,y}}, 2 \leq a \leq A$	***16***
$\hat{X}_{a,y} = \log\left(\frac{\pi_{a,y}}{1 - \pi_{a,y}}\right), 2 \leq a \leq A - 1$	***17***

The observed CRLs $X_{a,y}$ were calculated similarly from the proportions at age in the observed catch-at-age data. When the estimated catch-at-age was equal to zero, it was replaced by the minimum value in the observed catch-at-age. The continuation ratio logits were fit using a normal likelihood.

$X_{a,y} = \hat{X}_{a,y} + \epsilon_{a,y}, \epsilon_{a,y} \sim N(0, \sigma_c)$	***18***

The standard deviations for the catch-age-CRLs were estimated separately for age groups 2, 3–4, 5–8, 9+. The decision to do so was based on the comparison of performance of several models at the assessment framework (Varkey et al. 2022).

Fisheries Landings

A censored likelihood was applied to the landings time series, similar to the application in Cadigan (2016), which allows the provision for including asymmetrical bounds to specify uncertainty. LB_y and UB_y indicate the lower and upper bounds on landings for a given year, $L_{obs\ 1:Y}$ indicate the reported landings time series, and L_y indicates the predicted landings for the year. Φ_N is the cumulative distribution function (CDF) for a $N(0,1)$ random variable, σ_L is fixed at 0.02 - a small value to ensure that predicted landings are unlikely to be estimated outside the provided bounds (Cadigan 2016).

$$l(L_{obs\ 1:Y}|\theta) = \sum_{y=1}^{Y} log \left\{ \Phi_N \left[\frac{\log\left({UB_y}/{L_y} \right)}{\sigma_L} \right] - \Phi_N \left[\frac{\log\left({LB_y}/{L_y} \right)}{\sigma_L} \right] \right\}, 1 \leq y \leq Y \qquad \textbf{19}$$

At the assessment framework meeting in October 2019, the history of the fishery and associated monitoring programs was presented (Carruthers and Ings pers. comm.) The information presented confirmed that, at different periods, the available landings data could be biased higher or lower. For example, it is uncertain if the catches by foreign fleets were reported accurately before the implementation of the Canadian Exclusive Economic Zone in 1977. Similarly, there is considerable uncertainty during the period of quota negotiation between Canada and France (1987–89). Although the stock was under moratorium during 1993–96, there is uncertainty about bycatch levels in these years. Information from interviews with current and retired fish harvesters (Carruthers and Ings pers. comm.) suggested that discarding and depredation could have led to underreporting after the fishery reopened in 1997 to early 2000s. The ensuing discussion at the framework meeting was used to determine agreed-upon updated lower and upper bounds for landings, which reflect the current understanding of uncertainty in the data (Figure 11).

MODEL OUTPUTS

Model results indicated that SSB declined from the beginning of the time-series in 1959 (196 kt) to values near the LRP by the mid-1970s (Figure 12). Subsequently, SSB increased and was estimated to be above 100 kt over 1980–88, but this period was followed by a continuous decline to less than 40 kt in 1993. The SSB was below the LRP from 1991 to 1994. During the first two years (1993–95) of the moratorium, SSB increased; then stabilized at about 80 kt over 1995–99. During the early 2000s, SSB was also relatively stable, but at values just below the LRP. The SSB decreased further since the early 2000s. The SSB for beginning of year 2020 was 26 kt. With the projected catch of 2,702 t for calendar year 2020, the SSB in the beginning of year 2021 will be 24.8 kt (38% of the LRP).

Recruitment peaked in 1965–66 at approximately 200 million age 2 fish, then generally declined until the mid-to late 1970s when there were about 50 million age 2 cod in the population (Figure 13). During most of the 1980s, recruitment varied between 70–150 million fish. From 1993 onward, recruitment was generally low, at around 25–40 million fish, with particularly low values (8–9 million) during 2016–17. In 2018 and 2019, recruitment levels increased to 17 and 20 million, respectively.

The assessment model provides estimates of both *F* and *M*. The estimated *F* for ages 5–8 generally increased from 1959 (*F*=0.27) to the mid-1970s (peaked at 0.42 in 1975) leading up to the extension of Canada's jurisdiction in 1977, then declined rapidly to approximately 0.3 and remained at similar values until the mid-1980s (Figure 14). Then, *F* estimates generally increased again until the moratorium in 1993. Average *F* was near zero (<0.02) during the moratorium (1993–97) when removals were only from bycatch. The estimated average *F* for the dominant ages in the fishery (i.e., 5–8) has generally declined from 0.16 in 2015 to 0.1 in 2019. For year 2020, the assumed catch is 2,702 t. Using this value in the first year of projection, the estimated *F* is 0.07 for 2020. Generally, *M* was between 0.27 and 0.35 during the 1980–2010 period, but subsequently increased considerably; the *M* estimates in the last four years were among the highest values in the time-series (Figure 15). *M* for ages 5–8 was estimated to be 0.43 (0.35–0.52) in 2019. The time varying trend in *M* was flat for ages 2–5 and followed the condition-based index for older ages (6+).

SENSITIVITY ANALYSIS

CONDITION THRESHOLD FOR NATURAL MORTALITY, *M*

As described in equation 10, estimates of *M* are based on an index of natural mortality (*Mc*). This *Mc* index was calculated using observations of fish condition from the spring DFO-RV surveys and the Sentinel surveys, where the proportion of observations below a threshold of 0.85 in relative fish condition (*Kr*) are converted to an instantaneous rate of mortality. While the 0.85 threshold is based on laboratory studies, the critical threshold experienced by wild fish may be higher or lower (Regular in press[3]). Sensitivity analyses were therefore carried out at a higher threshold (*Kr* = 0.9) and at a lower threshold (*Kr* = 0.8). At the higher threshold, a larger proportion of fish fall below it and, consequently, the mortality index increases. Conversely, lowering the condition threshold to 0.8 means fewer fish will fall into that category, so the mortality index decreases.

This sensitivity analysis was used to evaluate whether the stock status and mortality estimates from the model are sensitive to the condition threshold used in the calculation of the index, M_c. The absolute values of M_c were quite different at the different thresholds; however, when the indices were standardized, the trends were very similar (Figure 16). As noted previously, *M* was estimated separately for ages 2–5 and for ages 6+, and the time varying trend in *M* was flat for ages 2–5, but followed the condition-based index for ages 6+. For ages 2–5, the estimated *mpar* values were close to zero. For ages 6+, the *mpar* estimates were 0.132 (for the assessment model based on the condition threshold *Kr*=0.85), 0.127 (for *Kr*=0.8), and 0.12 (for *Kr*=0.9). After normalizing the indices, the estimated *M* trends for both the age groups were similar across the sensitivity analysis trials (Figure 17).

MODEL PROJECTIONS

The model was projected forward with the following assumptions:

1. Catch weights-at-age, stock weights-at-age, selectivity, condition-based *M* indices, and recruitment were averaged from their respective values for 2017–19
2. Maturity was based on the projected maturity for 2020–23, from the cohort-based maturity model
3. Catch for 2020 was assumed to be 2,702 t

Projections of the stock to 2023 were conducted assuming fishery removals to be within ±60% of current values, a catch of 2,702 t for 2020, and no catch in 2021 and 2022. Under these scenarios, there is a high probability (>99%) that the stock will remain below B_{lim} between 2021 and the beginning of 2023 (Table 10). To obtain a positive trajectory from the projected SSB for beginning of year 2021–23 (Table 10), a 20% increase in removals results in a 52% probability of growth and a 50% reduction in removal results in a 75% probability of growth. At zero removals, the probability for positive growth of the stock from 2021 is 88% (i.e., no scenario produces 95% probability).

OTHER DATA SOURCES

In addition to the DFO-RV survey indices, other sources of information were considered in the assessment to provide perspectives on stock status. These sources include data from the Sentinel survey (1995–2019), science logbooks for vessels <35 feet (1997–2019), logbooks from vessels >35 feet (1998–2019), and at sea observer sampling. Information from tagging experiments in Placentia Bay (and more recently Fortune Bay) was also available. Any differences in trends between these additional data sources and the DFO-RV survey are difficult to reconcile, but may be attributed to differences in survey/project design, seasonal changes in stock distribution, differing selectivity of various gear types, and/or the degree to which the various data sources track only certain subareas/components versus the entire distribution of the stock.

SCIENCE LOGBOOKS (<35 FEET SECTOR)

In 1997, a science logbook was introduced to record catch and effort data for vessels <35 feet in the re-opened fishery. Return of this logbook at season's end is mandatory (L. Slaney, Resource Management Branch, DFO, pers. comm.). Prior to the moratorium, the only data for vessels <35 feet came from purchase slips, which provided limited information on catch and no information on effort. Since the moratorium, catch information came from estimated weights and/or measured weights from the dockside monitoring program. Catch rates have the potential to provide a relative index of temporal and spatial patterns of fish density, which may relate to the overall biomass of the stock. Prior to the fall assessment meeting, there were about 199,000 records in the database. As with the Sentinel program, we considered data to 2019 only, and excluded the current (in-progress) year. The number of annual logbook records has declined over time, even over multi-year periods having a common TAC. In addition, the percentage of the total cod catch for the <35 ft sector represented in the logbooks has generally decreased over time, from about 70% in 1997 to about 30% in 2019. The number of vessels in the logbook series has also decreased over time (Tables 11–12).

A catch rate index was derived with data from the inshore fishery. An initial screening of this data was conducted, and observations were not used in the analysis if:

1. the amount of gear or location was not reported (or reported as offshore / outside of 3Psa, 3Psb or 3Psc),
2. more than 30 gillnets were used, or
3. <100 or >4,000 hooks were used on a line trawl.

Upper limits for the amount of gear were applied to eliminate outlying records and exclude <1% of the available data for each gear type. As observed in previous assessments, preliminary examination of the logbook data indicated that soak time for gillnets was most commonly 24 hours, with 48 hours being the next most common time period. In comparison, line trawls were generally in the water for a much shorter period of time, typically 2 hours, with very few sets more than 12 hours.

The screening criteria described above resulted in a substantial fraction of <35 ft catch not being available for analysis. For example, in 2019, only 23% of the <35 ft gillnet catch and 9% of the <35 ft line trawl catch were included in the CPUE standardization. These values were lower than usual, and reflected both the low reporting rate and an increasing portion of logbook records with invalid entries for the location fished. Locations were considered invalid when logbook entries did not include a fishing location as shown on the map included in the logbook (i.e., “Area Listings” 29–37). Where most of these invalid locations occurred, the location fished was reported, as either “10” or “11”, which correspond to “species fishing areas” (e.g., Lobster Fishing Area 10) that are relatively large and include more than one of the necessary “Area Listings”. Therefore, it was not possible to resolve these entries to the finer-scale areas indicated in the logbook, and, consequently, a considerable portion of the catch and effort data from smaller vessels was excluded by our selection criteria.

As in previous assessments, effort was treated as simply the number of gillnets, or hooks for line trawls (1,000s), deployed in each set of the gear; soak times were not adjusted as the relationship between soak time, gear saturation, and fish density is not known. Catches from science logbooks were expressed in terms of weight (whereas those from the Sentinel fishery were expressed in terms of numbers); commercial catches were generally landed as head on gutted and recorded in pounds; these were converted to whole weight (in kg) by multiplying by a gutted-to-whole weight conversion factor (i.e., 1.2) and converting pounds to kilograms (by multiplying by 2.203).

The frequency distribution of catches per set was skewed to the right for both gears (not shown). For gillnets, catches per net were typically around 15 kg with a long tail on the distribution extending to about 75–100 kg per net. The distribution of catches for line trawls was similarly skewed, with median catches of about 180 kg/1,000 hooks; but extending out to 500–600 kg/1,000 hooks.

The catch from Subdiv. 3Ps was divided into cells defined by gear type (gillnet or line trawl), location (numbered 29–37, as described above) and year (1997–2019). Initially, unstandardized CPUEs were computed and examined; in this preliminary analysis, plots of median annual catch rate for gillnets and line trawl were examined for each year and location. Catch rates for gillnets tended to be higher in areas 29–32 (Placentia Bay and south of Burin Peninsula) than elsewhere. Gillnet catch rates in 2019 were low or average at all locations except on the Burin Peninsula, where one high CPUE value had a large impact on the annual estimate (Figure 18). Most of the line trawl data came from areas west of the Burin Peninsula, and the results in areas 29–33 were based on low sample sizes and showed more annual variability (Figure 19). In 2019, line trawl catch rates were relatively high at the head of Placentia Bay and on the western side, but low elsewhere except at Francois-Burgeo.

Prior to modeling, the data were aggregated within each gear year month location cell, and the aggregated data were weighted by their associated cell counts. CPUE data were standardized to remove site (fishing area) and seasonal (month, year) effects. A Generalized Linear Model with a log link and Gamma distribution was used to estimate year and month within location and there was no intercept. Effort was used as an offset. Sets with effort and no catch were considered valid entries in the model.

For the present assessment, the model adequately fitted data from gillnets and line trawls and two standardized annual catch rate indices were produced, one for each gear type. All effects included in the model were significant.

Standardized gillnet catch rates declined over 1998–2000 and have subsequently been low and stable at approximately 20 kg/net, but the 2019 catch rate estimate was the lowest in the time-series (Figure 20). For line trawls, temporal patterns differed from those of gillnets, with much inter-annual variation since 2000. After peaking in 2006, line trawl catch rates generally declined to 2010, and remained near the time-series average in 2014 (Figure 21). The catch rates estimated for 2016–19 were the lowest in the time-series, but were based on a low number of logbook returns.

The observed trends in commercial catch rate indices for the inshore fishery were influenced by many factors. There have been substantial annual changes in the management plans in the post moratorium period (Brattey et al. 2003). In addition, gillnets and line trawls can at times be deployed to target local aggregations. For inshore fisheries, catch rates can also be strongly influenced by annual variability in the extent and timing of inshore (as well as long-shore) cod migration patterns. Similarly, the changes in management regulations, particularly the switch from a competitive fishery to Individual Quotas (IQs) and, for some vessels, the need to fish cod as bycatch to maximize financial return, can have a strong influence on catch rates irrespective of stock size (DFO 2006). Consequently, inshore commercial catch rate data must be interpreted with caution. Despite these issues, the initial declines in gillnet and line trawl catch rates following the re-opening of the fishery in 1997 were cause for concern. The remarkable consistency in gillnet catch rates since 1998, despite the changes in resource abundance and management regulations, has not yet been explained. The recent decrease in modeled catch rates for line trawls since 2015 is also difficult to explain, but may be related to the low sample sizes. Also, the age structure of the inshore line trawl catch differed from all the other gears and indicates that the 2011 cohort was not as well represented in line trawls as it was in other gear types.

LOGBOOKS (>35 FT SECTOR)

Standardized catch rate indices for gillnets and otter trawls were updated for vessels >35 ft based on logbook data. This logbook series was administered with follow up by DFO staff when logbooks were not returned promptly. Return rates, calculated as the proportion of landings represented by logbooks to sector landings, were considerably higher than those for the <35 ft sector.

For gillnets, data were screened to select deployments between 12–24 hours and a minimum of five data entries was arbitrarily set for including cells (year, area, quarter) in models. The number of vessels in the logbook database, which were subsequently used in the catch rate model, decreased by half over the time-series, with only 51 vessels reporting in 2019. This decline was due to a reduction in the number of vessels participating in the fishery over time. The amount of gillnet landings covered by the logbooks was more than 55% over the last decade (Table 13). The model standardized catch rates to account for spatial and seasonal effects. Results indicated that catch rates were higher in magnitude (Figure 22) than those from vessels <35 ft (Figure 20), but the pattern over time was similar. Catch rates in the >35 ft fleet initially (1998–2000) declined by about half and then remained stable to 2017. In 2018, catch rates from the >35 ft fleet were higher than any other observed since 2000. In 2019, catch rates were again similar to those from 2000–17.

A standardized index for the otter trawl fleet was developed with data screened to exclude tows less than 15 minutes and longer than 10 hours. As most of the fishery occurs during fall and winter, only tows conducted between October and March were retained for analyses and a minimum of five entries per cell (year, area, quarter) was included in modeling. CPUE was calculated as catch weight per hour of towing. However, due to privacy concerns and the need to be consistent with policy interpretation, the catch rate analyses for otter trawlers was not presented.

Attempts to standardize catch rates from line trawls revealed diagnostic issues (normality violations) with the models tested and further exploration would be required to develop a catch rate series for the >35 ft sector. Data screening for line trawls removed deployments longer than

24 hours, as sets of longer duration were infrequent and not consistent with the known fishing procedures in the area. Also, only line trawls with a minimum of 150 hooks were retained in the analyses, to reduce the potential number of mistakes in effort recordings. Standardization was attempted across years, areas, and seasons. However, significant interactions between areas and quarters complicated the analyses, indicating that seasonal catch rates differ among unit areas.

OBSERVER SAMPLING

Information collected at sea by observers on Canadian vessels fishing for cod (1997–2019) were reviewed for the potential to create standardized catch rate indices for gillnets, line trawls and otter trawls. Preliminary analyses of the line trawl effort data in 2018 revealed issues associated with changes in recording protocols over time that have not been resolved. Therefore, no standardized estimates of catch rates by line trawls were developed based on observer data. Also, there was insufficient data to develop a standardized catch rate index for the otter trawl fleet.

To develop a standardized catch rate index for gillnets based on observer sampling, data were screened to remove deployments longer than five days. Data exploration indicated substantial variations in observer coverage over time and among unit areas, and the proportion of the landings observed was low (<2%) during most years (Table 14). Standardization accounted for area and seasonal effects. Generally, the results of standardizing the gillnet data were broadly consistent with those from both logbook series up to 2017. Catch rates declined by about half over 1998–2000 and remained relatively stable up to 2017 but, during 2018, increased to the highest in the time-series (Figure 23). Information from number of sets available for estimation of standardised catch rates has varied considerably over time (Table 15). Catch rates during 2019 were lower, similar to those observed during 2016 and 2017.

TAGGING EXPERIMENTS

The geographical coverage of cod tagging since 2007 was largely limited to areas of Fortune Bay and Placentia Bay, and it is uncertain how results from these inshore areas relate to the stock as a whole. The number of cod tagged has varied annually and by area; tagging was conducted annually in 3Psc (Placentia Bay) during 2007–15, as well as in 2017 and 2019–20; in 3Psb (Fortune Bay) in 2007, during 2012–20; and in 3Psa in 2007, 2013 and, 2017 and 2019 (Table 16). Although exploitation rates based on cod tagging in these inshore areas may not be applicable to other areas, or to the whole stock, these inshore regions accounted for a significant portion (~50%) of the overall annual landings from the stock since 2007. In 2019, dedicated efforts were made to expand the areas where cod were tagged, so tagging was conducted in all three inshore areas (3Psa, 3Psb, 3Psc).

The general pattern of tag returns remained unchanged; most of the fish tagged in 3Ps were harvested in 3Ps (Table 17). Recent tagging suggested that exploitation of 3Ps cod in neighbouring stock areas (Div. 3KL) is minimal, presenting no major issue for management. No new information was available to evaluate mixing in the western portion of the stock (from Subdiv. 3Pn or Div. 4RS). The timing of tagging experiments with respect to the annual commercial fishery complicated analysis aimed at developing exploitation rates, although analytical work is underway to try to address these challenges.

In 2018, part of an array of acoustic receivers was placed in upper Placentia Bay. In 2019, this array was expanded to all waters leading to the upper reaches of Placentia Bay. In 2019, 65 cod were implanted with acoustic tags in upper Placentia Bay; 43 of these fish have been detected by those receivers since then. This telemetry information will help to determine the timing and movements of cod that use Placentia Bay and nearby areas.

The ratio of catch to tag returns from the commercial fishery was used to estimate total removals for the recreational harvest in Subdiv. 3Ps. Harvesters do not return the tags from all the fish that are captured; consequently, reporting rates have to be estimated using a high-reward tagging scheme. Analyses indicated that removals by the recreational harvest comprised a relatively small component of the total removals in Subdiv. 3Ps.

CONCLUSIONS AND ADVICE

The stock was assessed using an integrated state space model, which incorporated landings and catch-at-age (1959–2019), time varying natural mortality informed by trends in cod condition, and included abundance indices from research surveys using bottom trawls conducted by Canada (1983–2005, 2007–19), France (1978–91), industry (GEAC, 1998–2005), as well as standardized catch rates from the Sentinel gillnet and line trawl surveys (1995–2019). There was no 2020 Canadian bottom trawl survey.

SSB at January 1, 2021 is projected to be 25 kt (18 kt–35 kt) with an assumed catch of 2,702 t in 2020. The stock is in the Critical Zone (38% of the LRP [27–53%]) as defined by the DFO PA Framework. The probability of being below the LRP is >99.9%. The stock has been below the LRP since the early 2000s.

The estimated fishing mortality rate (ages 5–8) declined from 0.16 in 2015 to 0.11 in 2019. With an assumed catch of 2,702 t in 2020, *F* is projected to be 0.07 (0.05–0.09) in 2020. Estimated *M* for ages 5–8 increased during the last decade, reaching 0.43 (0.35–0.52) in 2019. Recruitment (age 2) estimates up to 2019, have been below the long-term average since the mid-1990s.

Projection of the stock to 2023 was conducted assuming fishery removals to be within +/-60% of an assumed catch of 2,702 t for 2020, and with no catch. Under these scenarios, there is a >99% probability that the stock will remain below the LRP between 2021 and the beginning of 2023. The probability of stock growth to 2023 ranges between 39% and 78% across catch scenarios (+/-60% of current levels) and is 88% when there are no removals. Natural mortality plays an important role in projections for this stock. If natural mortality rates are appreciably different from those used, projected outcomes will differ from values reported above.

Bottom temperatures in Subdiv. 3Ps remained above normal between 2009 and 2019, but no data were available for 2020. No zooplankton data were available for 2019 and 2020. Satellite imagery indicates that the timing and magnitude of the spring phytoplankton bloom were normal in 2020, after two consecutive years of early onset and above-normal production. Ongoing warming trends, together with an increased dominance of warm water fishes, indicate that this ecosystem continues to experience structural changes. Reduced condition is indicative of diminished productivity in 3Ps cod.

Consistency with the DFO decision-making framework incorporating the PA requires that removals from all sources must be kept at the lowest possible level until the stock clears the critical zone.

SOURCES OF UNCERTAINTY

Advice for the upcoming fishing season was based on a one year projection to 1 January 2021, which added uncertainty to the assessment results. Typically, model estimates (rather than projections) are available for January 1 of the upcoming fishing season. Although the assessment model performs well in retrospective testing, model projections require assumptions about future biological states, which were estimated to be similar to recent observations (three year averages) in projection scenarios. If future conditions vary greatly from these assumptions, results will differ. Uncertainty was also increased by the lack of bottom trawl data from 2020, as the spring DFO-RV survey was cancelled due to the global pandemic. This data series is known to interact with Sentinel line trawl data within the model; thus, model results can be subject to additional influence from this line trawl data in the absence of DFO-RV survey data. Upward revisions to recent (e.g., 1 January 2020) SSB estimates in the current assessment were evidence of the impact of adding one, but not the other, data series to the model in the terminal year. Preliminary data suggested that adequate sampling was conducted by the Sentinel program during 2020, which should be available for the 2021 assessment. Therefore, the addition of data from the 2021 spring DFO-RV survey and the 2020 Sentinel sampling may revise recent SSB estimates downward in the next assessment.

The 2018 Sentinel line trawl indices were at time-series lows for ages 3–5, while the 2019 indices for several age groups were comparatively much higher. Inclusion of the 2019 Sentinel data led to an upward revision of stock status. Although this index covers only a small portion of the stock, it shows good internal consistency. For this reason, the assessment model is sensitive to the Sentinel line trawl index. Conversely, the DFO-RV survey covers most of the stock area, but has comparatively less internal consistency. This issue requires further research in the context of gaining a better understanding of how data from the various sources interact within the assessment model.

The accepted population model for the stock includes Sentinel data, but the model underestimated the index for the young ages (2–3, especially) in the DFO-RV survey in the post-2010 period. However, the model fits well to all other ages (6–14+) in the DFO-RV survey and all ages in other surveys, as well as the catch-at-age. Model performance is greatly reduced when the Sentinel data are excluded, as evidenced by strong retrospective patterns over the past five years. As with the issue above, further research in the context of gaining a better understanding of how data from the various sources interact within the model.

Although the DFO-RV survey of Subdiv. 3Ps includes coverage of 45 index strata, the majority of the survey indices for cod are typically influenced by catches from only a small number of those strata. High estimates in some of these strata are a result of a single large survey tow in particular years. For example, a large catch of cod in a single survey tow in stratum 309 on Burgeo Bank in 2016 had a major influence on survey indices (60% of the biomass index). The presence of single large catches in survey tows caused increased uncertainty in the data, which is not accounted for in the assessment model.

Burgeo Bank is a known seasonal mixing area for cod from Subdiv. 3Ps and from the Northern Gulf of St. Lawrence. In 1993, the timing of the DFO-RV survey was changed to start in April of each year, in order to minimize the impact of migratory Northern Gulf fish on the assessment of 3Ps cod. However, at least one published study suggests that a non-trivial portion of cod in the Burgeo Bank area (i.e., western 3Ps) in April is of Northern Gulf origin (Méthot et al. 2005). The potential presence of non-3Ps cod in this area at the time of the DFO-RV survey combined with the fact that a large portion of survey indices have come from the Burgeo Bank area in recent years suggests the potential for overestimation of survey results.

Survey indices are at times influenced by “year-effects” - an atypical survey result that can be caused by a number of factors (e.g., environmental conditions, movement, degree of aggregation) which may be unrelated to absolute stock size. There are strong indications that the 2013 survey may have been influenced by a year-effect that resulted in a large spike in the survey indices for that year. The 2013 DFO-RV survey estimated that the abundance of multiple cohorts increased compared to observations of these same cohorts at one age younger in 2012.

Since the number of fish in a cohort cannot increase after it is fully recruited to the survey gear (without immigration), such results are usually considered clear evidence for a year- effect. Year-effects in the survey data have the potential to mask trends in the data for several years and contribute to retrospective patterns.

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TABLES

Table 1. Reported landings of cod (t) from NAFO Subdiv. 3Ps by country and for fixed and mobile gear sectors. Landings are presented by calendar year but note that, since 2000, the TAC has been established for April 1–March 31. Catch estimates for 2019 are incomplete since the fishing year was in progress at the time of the assessment. See Healey et al. (2014) for pre-1980 data.

Year	Canada NL (Mobile)	Canada NL (Fixed)[2]	Canada Mainland (All gears)	France SPM (Inshore)	France SPM (Offshore)	France Metro (All gears)	Others (All gears)	Total	TAC
1980	2,809	29,427	715	214	1,722	2,681	-	37,568	28,000
1981	2,696	26,068	2,321	333	3,768	3,706	-	38,892	30,000
1982	2,639	21,351	2,948	1,009	3,771	2,184	-	33,902	33,000
1983	2,100	23,915	2,580	843	4,775	4,238	-	38,451	33,000
1984	895	22,865	1,969	777	6,773	3,671	-	36,950	33,000
1985	4,529	24,854	3,476	642	9,422	8,444	-	51,367	41,000
1986	5,218	24,821	1,963	389	13,653	11,939	7	57,990	41,000
1987	4,133	26,735	2,517	551	15,303	9,965	-	59,204	41,000
1988	3,662	19,742	2,308	282	10,011	7,373	4	43,382	41,000
1989	3,098	23,208	2,361	339	9,642	892	-	39,540	35,400
1990	3,266	20,128	3,082	158	14,771	-	-	41,405	35,400
1991	3,916	21,778	2,106	204	15,585	-	-	43,589	35,400
1992	4,468	19,025	2,238	2	10,162	-	-	35,895	35,400
1993	1,987	11,878	1,351	-	-	-	-	15,216	20,000
1994	82	493	86	-	-	-	-	661	0
1995	26	676	60	59	-	-	-	821	0
1996	60	836	118	43	-	-	-	1,057	0
1997	108	7,594	79	448	1,191	-	-	9,420	10,000
1998	2,543	13,609	885	609	2,511	-	-	20,156	20,000
1999	3,059	21,156	614	621	2,548	-	-	27,997	30,000
2000	3,436	16,247	740	870	3,807	-	-	25,100	20,000
2001	2,152	11,187	856	675	1,675	-	-	16,546	15,000

Year	Canada NL (Mobile)	Canada NL (Fixed)[2]	Canada Mainland (All gears)	France SPM (Inshore)	France SPM (Offshore)	France Metro (All gears)	Others (All gears)	Total	TAC
2002	1,326	11,292	499	579	1,623	-	-	15,319	15,000
2003	1,869	10,600	412	734	1,645	-	-	15,260	15,000
2004	1,595	9,450	790	465	2,113	-	-	14,414	15,000
2005	1,863	9,537	818	617	1,941	-	-	14,776	15,000
2006	1,011	9,590	675	555	1,326	-	-	13,157	13,000
2007	1,339	9,303	294	520	1,503	-	-	12,959	13,000
2008	982	8,654	377	467	1,293	-	-	11,773	13,000
2009	1,733	5,870	193	282	1,684	-	-	9,762	11,500
2010	1,419	5,244	196	76	1,364	-	-	8,299	11,500
2011	1,392	4,046	300	456	682	-	-	6,876	11,500
2012	658	3,596	277	265	291	-	-	5,087	11,500
2013	378	2,680	174	366	768	-	-	4,366	11,500
2014	614	4,199	637	279	1,158	-	-	6,887	13,225
2015	1415	3,706	175	440	724	-	-	6,460	13,490
2016	1,930	3,343	239	324	1,360	-	-	7,196	13,043
2017	1,387	4,413	239	51	552	-	-	6,641	6,500
2018	387	4,108	80	21	126	-	-	4,722	5,980
2019[1]	580	2,817	61	26	45	-	-	3,529	5,980

[1]Provisional catches

[2]1996–2006 includes recreational and Sentinel catch. 2007–19 does not include recreational catch.

Table 2. Reported fixed gear catches of cod (t) from NAFO Subdiv. 3Ps by gear type (includes non-Canadian and recreational catch). See Healey et al. (2014) for pre-1980 data.

Year	Gillnet	Longline	Handline	Trap	Total
1980	5,493	19,331	2,545	2,077	29,446
1981	4,998	20,540	1,142	948	27,628
1982	6,283	13,574	1,597	1,929	23,383
1983	6,144	12,722	2,540	3,643	25,049
1984	7,275	9,580	2,943	3,271	23,069
1985	7,086	10,596	1,832	5,674	25,188
1986	8,668	11,014	1,634	4,073	25,389
1987	9,304	11,807	1,628	4,931	27,670
1988	6,433	10,175	1,469	2,449	20,526
1989	5,997	10,758	1,657	5,996	24,408
1990	6,948	8,792	2,217	3,788	21,745
1991	6,791	10,304	1,832	4,068	22,995
1992	5,314	10,315	1,330	3,397	20,356
1993	3,975	3,783	1,204	3,557	12,519
1994	90	0	381	0	471
1995	383	182	0	5	570
1996	467	158	137	10	772
1997	3,760	1,158	1,172	1,167	7,258
1998	10,116	2,914	308	92	13,430
1999	17,976	3,714	503	45	22,237
2000	14,218	3,100	186	56	17,561
2001	7,377	2,833	2,089	57	12,357
2002	7,827	2,309	775	119	11,030
2003	8,313	2,044	546	35	10,937
2004	7,910	2,167	415	15	10,508
2005	8,112	2,016	626	6	10,760
2006	7,590	2,698	314	2	10,603
2007[2]	7,287	2,374	445	11	10,116
2008[2]	6,636	2,482	341	21	9,480
2009[2]	4,052	1,644	612	36	6,344
2010[2]	4,013	1,182	296	2	5,493
2011[2]	2,910	882	221	19	4,032
2012[2]	3,089	670	192	10	3,961
2013[2]	1,939	457	270	14	2,680
2014[2]	2,760	1,066	331	38	4,195
2015[2]	3,065	326	299	9	3,699
2016[2]	2,779	283	268	10	3,340
2017[2]	3,658	352	359	23	4,392
2018[2]	3,547	254	257	0	4,057
2019[12]	2,299	285	209	0	2,792

Year	Gillnet	Longline	Handline	Trap	Total
2020[123]	931	133	70	0	1,134

[1]Provisional
[2]Excluding recreational catch
[3]As of October 2, 2019

Table 3. Reported Canadian (NL + Mar Regions) monthly landings (t) of cod per unit area in Subdiv. 3Ps.

Year	Month	Inshore			Offshore					Total
		3Psa	3Psb	3Psc	3Psd	3Pse	3Psf	3Psg	3Psh	
2017	Jan	128.9	129.6	159.4	0.9	15.2	15.3	20.5	530.1	1,000.0
2017	Feb	41.9	106.0	67.1	4.3	0.0	0.0	110.3	344.8	674.3
2017	Mar	23.7	0.0	1.8	19.5	0.0	0.5	0.4	100.8	146.6
2017	Apr	0.0	0.0	0.1	0.0	0.0	0.0	0.0	5.1	5.2
2017	May	19.4	58.6	47.2	0.5	0.2	0.0	0.3	0.5	126.8
2017	Jun	47.1	123.0	444.5	0.2	1.1	0.0	0.0	0.0	615.9
2017	Jul	8.7	57.5	989.2	0.9	0.0	3.1	0.4	3.9	1,063.6
2017	Aug	9.7	30.2	208.9	0.7	0.3	1.0	0.7	0.0	251.4
2017	Sep	6.6	17.2	139.4	10.3	25.7	131.8	15.8	2.9	349.7
2017	Oct	4.7	26.4	307.6	10.7	143.5	80.4	25.8	1.5	600.6
2017	Nov	4.9	58.8	304.6	4.4	59.0	12.4	1.0	27.5	472.7
2017	Dec	23.0	188.8	143.7	0.0	0.0	24.0	110.9	141.8	632.2
2017	**Total**	**318.7**	**796.0**	**2,813.3**	**52.4**	**245.1**	**268.6**	**286.0**	**1,159.0**	**5,939.0**
2018	Jan	56.5	94.4	75.7	0.0	6.6	0.0	47.1	129.3	409.7
2018	Feb	22.7	70.4	8.1	4.7	0.5	0.0	5.7	56.4	168.5
2018	Mar	6.2	0.0	0.0	18.9	0.0	0.0	6.0	59.5	90.5
2018	Apr	0.0	0.0	0.0	0.1	0.0	0.0	0.2	3.5	3.8
2018	May	19.6	36.8	50.3	1.3	0.0	0.0	0.5	3.3	111.9
2018	Jun	38.5	77.3	416.0	1.2	0.9	1.9	0.6	11.0	547.4
2018	Jul	8.3	51.2	785.4	24.8	0.0	14.7	0.9	15.7	901.1
2018	Aug	4.2	27.8	206.4	1.0	14.4	19.2	5.0	2.1	280.2
2018	Sep	4.3	29.0	138.5	2.6	69.7	10.0	51.1	0.8	306.0
2018	Oct	2.5	21.3	240.7	0.1	18.4	44.2	14.9	0.3	342.5
2018	Nov	9.2	53.7	551.5	7.2	25.6	30.5	0.3	0.1	678.1
2018	Dec	38.0	375.5	229.2	1.7	9.6	0.0	60.8	20.3	735.0
2018	**Total**	**210.2**	**837.4**	**2,701.9**	**63.7**	**145.8**	**120.6**	**193.1**	**302.1**	**4,574.7**
2019	Jan	3.9	15.1	42.1	1.5	0.0	0.0	176.7	237.0	476.3
2019	Feb	0.0	0.0	0.0	8.2	0.0	0.0	11.7	82.8	102.7
2019	Mar	0.9	0.0	0.0	9.0	0.0	0.0	10.2	50.2	70.2
2019	Apr	6.7	0.0	0.8	0.0	0.0	0.0	2.8	2.0	12.3
2019	May	22.1	67.5	37.1	0.5	0.0	0.0	0.2	4.4	131.7
2019	Jun	25.6	77.1	447.7	1.3	0.1	10.4	10.2	2.3	573.7
2019	Jul	3.3	41.6	621.8	0.8	0.1	2.8	0.1	3.0	673.4
2019	Aug	4.0	16.1	131.3	6.5	0.0	4.9	13.3	0.0	176.2
2019	Sep	7.1	19.9	73.0	0.0	8.5	25.7	11.9	0.0	146.1

Year	Month	Inshore			Offshore					Total
		3Psa	3Psb	3Psc	3Psd	3Pse	3Psf	3Psg	3Psh	
2019	Oct	8.9	40.2	322.1	2.8	21.7	119.3	3.6	0.6	519.3
2019	Nov	3.7	34.4	273.5	0.1	0.0	0.0	0.0	0.0	311.6
2019	Dec	8.9	87.8	128.2	0.0	0.0	0.3	5.5	33.0	263.6
2019	**Total**	**94.1**	**399.8**	**2,077.6**	**30.6**	**30.4**	**163.4**	**246.1**	**415.3**	**3,457.3**
2020	Jan	26.8	58.3	121.4	0.0	0.1	0.0	27.9	139.7	374.3
2020	Feb	4.2	4.2	20.4	4.7	0.0	0.0	12.1	43.8	89.4
2020	Mar	4.2	0.4	0.0	4.6	0.0	0.0	3.4	11.2	23.9
2020	Apr	0.0	0.2	0.0	0.0	0.0	0.0	0.8	5.6	6.6
2020	May	10.6	7.9	2.1	0.1	0.0	0.0	0.1	0.0	20.8
2020	Jun	23.4	46.4	314.4	0.0	0.0	0.3	0.0	0.0	384.4
2020	Jul	9.6	36.2	368.0	0.1	0.0	0.0	0.0	0.4	414.3
2020	Aug	1.1	12.3	29.7	0.3	0.0	0.0	0.0	0.0	43.4
2020	Sep	1.4	13.4	45.6	0.0	0.0	0.0	0.0	0.0	60.5
2020	Oct	-	-	-	-	-	-	-	-	-
2020	Nov	-	-	-	-	-	-	-	-	-
2020	Dec	-	-	-	-	-	-	-	-	-
2020	**Total**	**81.5**	**179.3**	**901.5**	**9.7**	**0.1**	**0.3**	**44.2**	**200.9**	**1,417.6**

*French catch (2017 = 602 t, 2018 = 118 t, 2019 =70 t) excluded since unit area not available.

Table 4. Summary of biological sampling conducted on NAFO Subdiv. 3Ps cod landings during 2019.

-		Landings		Number of	
Gear	Reported (t)	Sampled (t)	Unsampled (%)	Length frequencies	Otoliths
Inshore	-	-	-	-	-
Handline	209	82	61	508	78
Gillnet	2,076	1,861	10	9,437	1,267
Line trawl	281	118	58	1,541	570
Offshore	-	-	-	-	-
Gillnet	250	3	99	224	55
Line trawl	35	2	94	56	3
Otter trawl	654	375	43	3,258	483

Table 5. Estimates of average weight, average length and the total numbers and weight of Subdiv. 3Ps cod catch from Canadian and french landings during 2019 (excluding recreational catch).

Age	Average Weight (kg)	Average Length (cm)	Total Catch (numbers)	Total Catch std error	Total Catch CV	Total Catch Weight (t)*
1	-	-	-	-	-	-
2	0.086	22	5	0	0.01	0.00043
3	0.849	45.461	5,703	1.45	0.25	4.841847
4	1.071	49.057	28,138	3.57	0.13	30.135798
5	1.432	53.682	68,940	6.29	0.09	98.72208

Age	Average Weight (kg)	Average Length (cm)	Total Catch (numbers)	Total Catch std error	Total Catch CV	Total Catch Weight (t)*
6	1.737	57.483	151,288	10.97	0.07	262.787256
7	2.011	60.29	261,984	14.71	0.06	526.849824
8	2.294	62.821	594,997	18.62	0.03	1364.923118
9	2.361	62.77	209,021	14.04	0.07	493.498581
10	3.086	67.651	102,859	8.57	0.08	317.422874
11	2.902	65.996	53,654	6.45	0.12	155.703908
12	3.468	69.134	13,786	3.16	0.23	47.809848
13	7.89	92.271	5,811	0.94	0.16	45.84879
14	4.388	74.642	4,438	1.81	0.41	19.473944
15	8.797	96.014	1,267	0.36	0.28	11.145799
16	5.358	83.825	434	0.24	0.54	2.325372
17	-	0	0	0	0	0
18	6.22	88	346	0.23	0.67	2.15212
19	-	-	-	-	-	-
20	-	-	-	-	-	-

*Sum of products (SOP) in catch-at-age calculation = 0.96. Refer to Gavaris and Gavaris (1983) for more detail.

Table 6. Numbers-at-age (000s) for the commercial cod fishery in NAFO Subdiv. 3Ps from 1959–2019 (ages 3–14 shown). Recreational catches were excluded for 2007 onward (see text).

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1959	1,001	13,940	7,525	7,265	4,875	942	1,252	1,260	631	545	44	1
1960	567	5,496	23,704	6,714	3,476	3,484	1,020	827	406	407	283	110
1961	450	5,586	10,357	15,960	3,616	4,680	1,849	1,376	446	265	560	91
1962	1,245	6,749	9,003	4,533	5,715	1,367	791	571	187	140	135	389
1963	961	4,499	7,091	5,275	2,527	3,030	898	292	143	99	107	284
1964	1,906	5,785	5,635	5,179	2,945	1,881	1,891	652	339	329	54	233
1965	2,314	9,636	5,799	3,609	3,254	2,055	1,218	1,033	327	68	122	165
1966	949	13,662	13,065	4,621	5,119	1,586	1,833	1,039	517	389	32	75
1967	2,871	10,913	12,900	6,392	2,349	1,364	604	316	380	95	149	55
1968	1,143	12,602	13,135	5,853	3,572	1,308	549	425	222	111	5	506
1969	774	7,098	11,585	7,178	4,554	1,757	792	717	61	120	67	220
1970	756	8,114	12,916	9,763	6,374	2,456	730	214	178	77	121	181
1971	2,884	6,444	8,574	7,266	8,218	3,131	1,275	541	85	125	62	57
1972	731	4,944	4,591	3,552	4,603	2,636	833	463	205	117	48	45
1973	945	4,707	11,386	4,010	4,022	2,201	2,019	515	172	110	14	29
1974	3,025	8,265	7,080	4,780	2,457	1,625	1,053	490	241	63	42	22
1975	675	3,301	2,557	4,655	5,357	874	778	233	169	51	20	4
1976	443	4,161	7,601	3,178	2,251	796	222	84	47	29	13	3
1977	552	7,718	7,976	4,409	1,008	308	276	108	48	57	26	12
1978	216	4,474	5,347	3,004	1,509	513	253	318	77	58	35	17
1979	130	1,669	12,064	4,567	1,839	720	252	49	36	4	3	4
1980	188	1,597	4,846	7,864	3,447	1,080	366	107	77	43	13	41
1981	1,074	3,616	2,745	3,914	5,210	1,663	576	190	142	127	22	6
1982	190	4,447	4,337	1,757	3,063	3,560	672	208	54	16	7	6
1983	754	2,733	9,536	3,008	1,471	1,050	1,256	293	109	49	21	6
1984	359	4,241	4,984	4,852	1,695	533	436	354	47	25	6	2
1985	160	2,839	7,950	5,406	4,994	1,624	606	654	267	98	18	8
1986	1,442	8,677	8,914	9,077	3,822	2,204	832	306	198	78	46	21

Year	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	375	3,474	3,455	7,380	4,912	1,448	619	423	229	119	79	62
1988	1,104	6,967	4,991	2,056	2,393	1,606	960	528	314	110	57	22
1989	1,241	5,902	6,370	3,463	1,843	1,705	1,239	749	129	109	34	21
1990	425	7,592	5,925	3,873	1,615	756	875	784	333	181	197	84
1991	1,370	3,087	6,052	4,004	1,339	449	206	251	211	177	119	127
1992	278	3,712	2,035	3,156	1,334	401	89	38	52	13	14	5
1993	1	30	152	72	79	41	19	2	2	0	0	0
1994	0	0	39	102	34	26	5	0	0	0	0	0
1995	2	16	19	77	117	38	13	8	1	0	0	0
1996	14	455	1345	602	769	922	254	113	124	7	13	0
1997	83	298	964	1,605	946	1,512	1,371	233	110	55	16	3
1998	49	677	1,333	2,139	2,479	1,155	901	849	203	127	23	10
1999	23	408	828	1,539	1,573	1,696	589	507	977	133	45	28
2000	76	576	844	1,162	1,172	796	720	269	186	199	25	11
2001	112	591	1,416	1,283	1,009	788	451	372	112	79	81	8
2002	18	363	1,051	2,063	1,278	644	353	277	156	58	46	73
2003	66	144	714	1,826	1,855	665	281	165	82	44	14	18
2004	70	427	634	1,106	1,653	1,236	598	157	114	45	25	6
2005	47	279	927	992	911	1,155	727	324	95	40	24	7
2006	63	279	756	1,122	875	540	575	485	178	54	42	18
2007	9	212	642	1,314	1,069	653	351	329	208	110	27	12
2008	20	131	914	1,037	841	469	223	102	93	66	45	12
2009	8	404	590	1,301	741	399	208	80	24	68	34	9
2010	28	152	922	912	893	362	169	64	27	21	8	6
2011	10	80	202	723	646	398	143	64	22	32	4	9
2012	10	166	458	393	495	361	149	56	22	16	4	7
2013	6	59	785	796	367	564	218	132	28	32	5	2
2014	2	289	298	893	610	262	303	72	32	7	3	0
2015	2	78	912	649	797	385	102	128	38	21	10	2
2016	0	18	262	1,408	512	472	211	74	46	11	19	4

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
2017	2	27	102	425	1,033	316	111	49	15	5	1	1
2018	7	28	103	431	1,043	312	110	49	15	5	1	1
2019	6	28	69	151	262	595	207	103	54	14	6	4

Table 7a. Mean annual weights-at-age (kg) for cod calculated from lengths-at-age based on samples from commercial fisheries (including recreational fisheries and Sentinel surveys, where available) in NAFO Subdiv. 3Ps in 1959–2019. The weights-at-age from 1976 are extrapolated back to 1959.

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1959	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1960	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1961	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1962	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1963	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1964	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1965	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1966	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1967	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1968	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1969	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1970	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1971	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1972	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1973	0.28	0.69	1.08	1.68	2.4	3.21	4.1	5.08	6.03	7	8.05	9.16
1974	0.399	0.624	1.064	1.813	2.429	3.349	3.927	4.832	5.438	7.558	9.337	8.466
1975	0.543	0.827	1.281	1.75	2.355	3.182	3.509	5.381	4.971	6.417	10.185	10.185
1976	0.537	1.005	1.455	2.284	3.032	4.267	5.439	7.395	7.426	9.873	11.45	16.628
1977	0.606	0.684	1.367	1.992	2.765	3.703	4.684	5.452	6.701	6.741	9.225	11.753
1978	0.545	0.763	1.111	2.03	2.888	3.929	4.612	6.058	7.233	6.981	9.747	10.954
1979	0.422	0.668	1.056	1.692	2.694	3.776	4.125	5.942	7.65	10.423	10.032	10.987
1980	0.511	0.776	1.147	1.715	2.357	3.561	5.474	7.193	7.219	9.872	9.566	8.527

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1981	0.516	0.877	1.366	1.839	2.303	3.359	4.893	6.991	7.52	10.414	8.871	12.302
1982	0.462	0.809	1.171	1.82	2.396	2.819	3.756	4.853	6.814	8.394	8.805	11.688
1983	0.583	0.853	1.472	2.019	2.525	3.099	3.523	4.952	6.486	7.968	10.613	12.076
1984	0.671	1.201	1.485	2.105	2.741	4.26	5.369	6.314	8.081	10.55	7.704	8.682
1985	0.588	0.821	1.2	1.783	2.626	3.373	5.149	5.941	6.74	7.94	11.32	7.876
1986	0.532	0.691	1.15	1.744	2.327	3.075	4.96	6.132	6.293	7.489	9.41	12.003
1987	0.472	0.701	1.251	1.707	2.27	3.248	4.299	5.523	6.867	7.072	7.73	10.514
1988	0.63	0.799	1.016	1.637	2.169	3.122	4.256	5.976	6.885	7.342	8.277	9.126
1989	0.559	0.79	1.166	1.709	2.441	3.531	4.58	6.081	6.529	7.448	7.889	8.98
1990	0.543	0.753	1.346	1.932	2.562	2.958	3.923	3.959	6.185	7.509	7.836	7.231
1991	0.435	0.7	1.135	1.877	2.608	3.234	4.382	5.15	6.894	8.143	8.065	10.071
1992	0.459	0.665	1.023	1.658	2.514	3.251	4.665	7.621	7.861	9.296	11.49	13.43
1993	0.417	0.848	1.344	1.945	2.08	2.652	3.701	4.286	7.307	6.585	7.378	7.435
1994	0.417	0.848	1.344	1.945	2.08	2.652	3.701	4.286	7.307	6.585	7.378	7.435
1995	0.4965	0.681	1.966	2.21	2.499	2.434	2.513	-	-	-	-	-
1996	0.576	0.878	1.383	1.879	2.389	2.709	3.862	4.374	8.354	6.57	10.112	13.097
1997	0.519	0.984	1.153	1.417	2.285	3.233	3.903	3.863	4.585	9.272	5.847	12.044
1998	0.598	0.984	1.736	1.982	2.361	3.158	4.087	3.994	4.439	4.458	5.717	5.459
1999	0.789	0.924	1.543	2.263	2.52	2.784	3.822	5.389	4.985	5.333	6.041	7.166
2000	0.442	1.23	1.219	1.949	2.763	2.808	3.337	4.858	6.799	6.719	6.717	8.679
2001	0.722	1.063	1.478	1.964	2.579	3.379	3.347	3.538	5.472	8.75	7.591	8.118
2002	0.586	1.053	1.531	1.972	2.289	3.013	4.023	3.627	3.751	6.198	9.153	7.133
2003	0.673	0.971	1.531	2.067	2.316	2.621	3.836	4.581	4.066	5.251	7.968	10.317
2004	0.619	0.996	1.409	2.091	2.479	2.709	2.901	4.45	6.298	5.331	6.88	8.703
2005	0.681	0.967	1.381	1.832	2.438	2.87	3.165	3.37	4.944	6.296	6.136	8.697
2006	0.643	1.012	1.53	1.898	2.175	2.732	3.405	3.89	3.213	5.147	7.014	7.387
2007	0.642	1.085	1.517	1.991	2.3	2.556	3.535	4.912	5.425	4.765	6.897	8.299
2008	0.912	0.961	1.349	1.949	2.202	2.522	2.717	4.073	5.214	5.041	5.257	8.153
2009	0.722	0.952	1.446	1.933	2.385	2.506	2.423	3.257	5.567	7.026	8.189	8.303
2010	0.805	1.128	1.334	1.966	2.161	2.523	2.605	2.85	5.562	7.751	9.753	10.329

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
2011	0.845	1.017	1.355	1.574	2.125	2.386	2.745	2.598	2.769	2.864	4.728	7.567
2012	0.836	0.965	1.418	1.982	2.019	2.206	2.82	3.305	3.559	2.665	2.849	2.897
2013	0.819	1.149	1.487	1.732	2.034	2.067	2.56	2.733	2.926	3.104	2.364	2.583
2014	0.93	1.03	1.832	2.046	2.097	2.731	2.49	3.281	3.826	2.644	4.532	4.873
2015	0.766	1.144	1.532	2.067	2.416	2.727	2.991	3.116	3.997	5.79	5.072	-
2016	0.837	1.184	1.506	1.787	2.261	2.385	2.958	3.575	4.038	4.749	4.14	7.625
2017	0.481	0.852	1.338	1.816	1.932	2.361	2.528	2.396	3.937	4.07	3.654	3.158
2018	0.688	1.414	1.549	1.904	2.148	2.336	3.286	3.151	3.624	5.37	5.806	6.422
2019	0.849	1.071	1.432	1.737	2.011	2.294	2.361	3.086	2.902	3.468	7.89	4.388

Table 7b. Beginning of the year weights-at-age (stock weights in kg) for cod in NAFO Subdiv. 3Ps, modeled from the weights-at-age derived from the Canadian DFO-RV survey.

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1959	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1960	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1961	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1962	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1963	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1964	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1965	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1966	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1967	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1968	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1969	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1970	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1971	0.295	0.685	1.239	1.822	2.463	3.225	4.228	5.495	6.771	8.526	9.988	11.696
1972	0.291	0.642	1.135	1.647	2.235	3.085	4.260	5.623	6.827	8.398	9.693	11.414
1973	0.286	0.624	1.090	1.601	2.155	2.799	3.805	5.172	6.429	7.952	9.199	10.854
1974	0.295	0.676	1.176	1.712	2.337	3.008	3.847	5.147	6.574	8.293	9.600	11.274

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1975	0.308	0.734	1.355	1.949	2.636	3.428	4.339	5.448	6.836	8.838	10.402	12.095
1976	0.297	0.753	1.441	2.201	2.949	3.807	4.892	6.085	7.190	9.152	11.045	12.844
1977	0.268	0.651	1.322	2.105	3.010	3.861	4.944	6.242	7.321	8.799	10.494	12.539
1978	0.249	0.560	1.075	1.827	2.722	3.719	4.732	5.956	7.107	8.506	9.605	11.796
1979	0.261	0.603	1.073	1.757	2.790	3.951	5.313	6.610	7.821	9.484	10.623	12.690
1980	0.275	0.635	1.170	1.757	2.676	4.009	5.545	7.276	8.500	10.219	11.600	13.466
1981	0.275	0.624	1.128	1.724	2.377	3.385	4.927	6.673	8.255	9.826	11.106	12.852
1982	0.274	0.657	1.179	1.779	2.504	3.248	4.520	6.468	8.255	10.380	11.591	13.319
1983	0.250	0.607	1.146	1.703	2.369	3.150	4.009	5.493	7.435	9.679	11.462	12.855
1984	0.244	0.581	1.106	1.746	2.392	3.151	4.120	5.165	6.699	9.235	11.287	12.835
1985	0.232	0.562	1.043	1.669	2.428	3.164	4.113	5.302	6.297	8.327	10.782	12.521
1986	0.219	0.531	0.996	1.552	2.284	3.163	4.079	5.222	6.365	7.715	9.592	11.948
1987	0.221	0.505	0.935	1.477	2.110	2.946	4.030	5.079	6.105	7.593	8.648	11.229
1988	0.224	0.518	0.902	1.417	2.051	2.776	3.830	5.097	6.012	7.392	8.635	10.727
1989	0.225	0.546	0.971	1.431	2.060	2.831	3.800	5.110	6.364	7.681	8.837	10.809
1990	0.201	0.482	0.884	1.313	1.762	2.401	3.281	4.304	5.425	6.944	7.884	9.579
1991	0.206	0.445	0.799	1.248	1.697	2.167	2.955	3.953	4.856	6.289	7.567	8.902
1992	0.241	0.503	0.817	1.264	1.815	2.359	3.038	4.078	5.123	6.465	7.854	9.336
1993	0.242	0.573	0.912	1.259	1.796	2.478	3.272	4.164	5.246	6.755	7.991	9.723
1994	0.220	0.520	0.938	1.244	1.580	2.161	3.038	3.971	4.735	6.125	7.409	9.015
1995	0.223	0.501	0.903	1.379	1.686	2.056	2.864	3.968	4.826	5.891	7.126	8.793
1996	0.231	0.503	0.857	1.316	1.866	2.207	2.755	3.780	4.866	6.057	6.900	8.722
1997	0.249	0.551	0.922	1.343	1.917	2.632	3.185	3.896	4.963	6.527	7.553	9.204
1998	0.256	0.577	0.995	1.414	1.923	2.674	3.759	4.439	5.051	6.576	8.031	9.525
1999	0.273	0.597	1.056	1.539	2.040	2.705	3.839	5.248	5.779	6.721	8.113	9.850
2000	0.274	0.588	1.000	1.484	2.014	2.606	3.521	4.854	6.217	7.008	7.577	9.584
2001	0.270	0.596	0.994	1.423	1.965	2.605	3.423	4.471	5.766	7.537	7.890	9.561
2002	0.256	0.600	1.035	1.450	1.921	2.579	3.446	4.356	5.323	6.995	8.482	9.378
2003	0.246	0.566	1.038	1.502	1.947	2.501	3.383	4.353	5.167	6.450	7.875	9.070

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
2004	0.261	0.566	1.023	1.596	2.143	2.697	3.510	4.590	5.574	6.761	7.842	9.435
2005	0.268	0.600	1.023	1.573	2.276	2.976	3.826	4.850	6.024	7.469	8.415	10.115
2006	0.252	0.572	1.007	1.454	2.078	2.932	3.924	4.902	5.888	7.442	8.590	10.083
2007	0.228	0.540	0.958	1.439	1.930	2.690	3.890	5.049	5.973	7.293	8.588	10.024
2008	0.201	0.469	0.857	1.299	1.803	2.343	3.328	4.639	5.710	6.871	7.832	9.349
2009	0.221	0.470	0.838	1.327	1.854	2.484	3.286	4.487	5.918	7.358	8.225	9.722
2010	0.236	0.521	0.846	1.306	1.905	2.577	3.520	4.487	5.820	7.769	8.977	10.294
2011	0.243	0.505	0.846	1.170	1.656	2.342	3.233	4.270	5.195	6.840	8.516	9.672
2012	0.248	0.534	0.844	1.209	1.539	2.126	3.074	4.112	5.191	6.407	7.861	9.386
2013	0.210	0.511	0.834	1.117	1.478	1.848	2.618	3.678	4.712	6.047	6.966	8.703
2014	0.211	0.462	0.858	1.200	1.494	1.951	2.500	3.439	4.608	5.981	7.140	8.670
2015	0.209	0.469	0.772	1.238	1.610	1.975	2.637	3.284	4.301	5.844	7.057	8.588
2016	0.204	0.449	0.758	1.079	1.616	2.078	2.612	3.392	4.014	5.339	6.757	8.228
2017	0.203	0.439	0.723	1.061	1.415	2.095	2.759	3.365	4.143	4.984	6.176	7.833
2018	0.217	0.463	0.752	1.081	1.493	1.970	2.979	3.786	4.361	5.452	6.096	7.990
2019	0.204	0.454	0.723	1.019	1.381	1.890	2.545	3.730	4.501	5.287	6.162	7.619
2020	0.210	0.471	0.790	1.098	1.459	1.950	2.701	3.509	4.847	5.932	6.478	7.985
2021	0.212	0.483	0.822	1.196	1.562	2.041	2.758	3.692	4.520	6.336	7.215	8.383
2022	0.217	0.487	0.844	1.241	1.693	2.169	2.861	3.742	4.720	5.868	7.658	8.517

Table 8. Details of annual DFO-RV surveys of NAFO Subdiv. 3Ps.

Year	Vessel	Start Date	End Date	Days	Sets	Sets w/ Cod	% w/ Cod
1983	AN 9	23-Apr-83	8-May-83	15	164	117	0.71
1984	AN 26	10-Apr-84	17-Apr-84	7	93	59	0.63
1985	WT 26	8-Mar-85	25-Mar-85	17	109	78	0.72
1986	WT 45	6-Mar-86	23-Mar-86	17	136	88	0.65
1987	WT 55–56	13-Feb-87	22-Mar-87	37	130	95	0.73
1988	WT 68	27-Jan-88	14-Feb-88	18	146	106	0.73

Year	Vessel	Start Date	End Date	Days	Sets	Sets w/ Cod	% w/ Cod
1989	WT 81	1-Feb-89	16-Feb-89	15	146	90	0.62
1990	WT 91	1-Feb-90	19-Feb-90	18	108	66	0.61
1991	WT 103	2-Feb-91	20-Feb-91	18	158	104	0.66
1992	WT 118	6-Feb-92	24-Feb-92	18	137	63	0.46
1993.1 (Jan)	WT 133	6-Feb-93	23-Feb-93	17	136	52	0.38
1993.4 (April)	WT 135	2-Apr-93	20-Apr-93	18	130	63	0.48
1994	WT 150–151	6-Apr-94	26-Apr-94	20	166	73	0.44
1995	WT 166–167	04-Apr-95	28-Apr-95	24	161	65	0.40
1996	WT 186–187	10-Apr-96	01-May-96	22	148	105	0.71
1997	WT 202–203	02-Apr-97	23-Apr-97	22	158	104	0.66
1998	WT 219–220	10-Apr-98	05-May-98	25	177	113	0.64
1999	WT 236–237	13-Apr-99	06-May-99	23	175	128	0.73
2000	WT 313–315	08-Apr-00	11-May-00	34	171	136	0.80
2001	WT 364–365, Tel 351	07-Apr-01	29-Apr-01	23	173	134	0.77
2002	WT 418–419	05-Apr-02	27-Apr-02	21	177	117	0.66
2003	WT 476–477	05-Apr-03	02-May-03	23	176	117	0.66
2004	WT 523, WT 546, Tel 522	11-Apr-04	11-May-04	30	177	107	0.60
2005	WT 617–618, AN 656	17-Apr-05	09-May-05	22	178	134	0.75
2006	WT 688	13-Apr-06	18-Apr-06	5.1	48	43	-
2007	WT 757–759	04-Apr-07	02-May-07	29	178	135	0.76
2008	WT 824–827	10-Apr-08	23-May-08	44	169	115	0.68
2009	AN 902–904	08-Apr-09	13-May-09	35	175	137	0.78
2010	AN 930–932	08-Apr-10	08-May-10	31	177	132	0.75
2011	AN 401–403	07-Apr-11	08-May-11	32	174	131	0.75
2012	AN 415–417	31-Mar-12	26-Apr-12	27	177	137	0.77
2013	AN 430–432	26-Mar-13	23-Apr-13	29	179	133	0.74

Year	Vessel	Start Date	End Date	Days	Sets	Sets w/ Cod	% w/ Cod
2014	AN 445–446, Tel 130	05-Apr-14	10-May-14	36	156	105	0.67
2015	AN 450–452	11-Apr-15	10-May-15	30	173	116	0.67
2016	Tel 157,158,169	02-Apr-16	01-May-16	30	157	110	0.70
2017	AN 476–478	06-Apr-17	08-May-17	33	179	121	0.68
2018	AN 494–496	28-Apr-18	27-May-18	30	167	115	0.69
2019	AN 506–508	30-Mar-19	4-May-19	35	169	106	0.63

Table 9. Summary of additional data contributing to the 2020 assessment of 3Ps cod, compared to the previous assessment in 2019.

Data	Assessment 2019	Assessment 2020
DFO-RV Spring survey	1983–2019	1983–2019 (no 2020 survey)
ERHAPS	1978–1991	1978–1991
Sentinel Gillnet and Line trawl	1995–2018	1995–2019
GEAC	1998–2005	1998–2005
Fisheries landings	1959–2019 (preliminary estimate for 2019)	1959–2019 (preliminary estimate for 2020 used in model projections)
Fisheries catch-at-age	1959–2019 (preliminary estimate for 2019)	1959–2019 (not estimated for 2020)
M-index based on fish condition	1978–2019	1978–2019 (additional data for 2016, 2017, 2019)

Table 10. Risk of projected SSB being below B_{lim} under 14 scenarios of catch removals (catch at status quo, ±10 to 60% status quo and no removals) over 2021–23. Status quo catch was assumed to be 2,702 t. B_y represents SSB in projection year.

Catch Multiplier	Projected Catch	Probability of growing out of the critical zone $P(B_y>B_{lim})$		Probability of growth from current levels $P(B_y>\text{projected }B2021)$	
		2022	2023	2022	2023
1.6	4,323	<0.1%	<0.1%	40%	39%
1.5	4,053	<0.1%	<0.1%	43%	42%
1.4	3,783	<0.1%	<0.1%	44%	45%
1.3	3,513	<0.1%	<0.1%	47%	49%
1.2	3,242	<0.1%	<0.1%	49%	52%
1.1	2,972	<0.1%	<0.1%	51%	55%
1	2,702	<0.1%	<0.1%	53%	58%
0.9	2,432	<0.1%	<0.1%	55%	62%
0.8	2,162	<0.1%	<0.1%	57%	65%
0.7	1,891	<0.1%	<0.1%	59%	67%
0.6	1,621	<0.1%	<0.1%	62%	72%
0.5	1,351	<0.1%	<0.1%	65%	75%
0.4	1,081	<0.1%	<0.1%	66%	78%
0.001	*	<0.1%	<0.1%	75%	88%

Table 11. Number of vessels <35 feet reporting on gillnets in logbooks from NAFO Subdiv. 3Ps.

Year	Location									Total
	29	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	
1997	48	90	54	43	49	139	38	62	23	546
1998	77	174	90	86	50	137	48	73	36	771
1999	115	276	81	79	58	152	62	110	51	984
2000	91	279	63	78	29	108	42	66	26	782
2001	24	128	37	31	26	83	47	64	27	467
2002	26	68	34	51	21	85	54	57	35	431
2003	27	53	31	45	16	92	47	60	22	393
2004	23	48	24	39	18	74	35	59	19	339
2005	18	54	21	27	15	55	37	47	22	296
2006	17	44	23	17	14	54	26	42	14	251
2007	20	37	27	17	12	48	13	26	12	212
2008	28	22	19	26	5	38	13	36	11	198
2009	15	21	18	16	5	24	12	25	8	144
2010	11	22	17	15	2	20	6	17	4	114
2011	10	10	9	9	2	29	6	22	9	106
2012	14	21	13	15	5	21	5	13	7	114
2013	13	21	11	10	0	18	4	13	1	91
2014	15	22	14	10	2	14	3	14	2	96
2015	7	11	9	3	1	8	1	15	4	59
2016	8	4	7	4	0	6	4	12	2	47
2017	8	6	7	4	2	3	6	9	2	47
2018	5	7	5	3	1	7	2	8	2	40
2019	13	6	8	2	2	10	2	4	2	49
Total	633	1,424	622	630	335	1,225	513	854	341	6,577

Table 12. Number of vessels <35 feet reporting on line trawls in logbooks from NAFO Subdiv. 3Ps.

Year	Location									Total
	29	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	
1997	23	45	27	24	25	47	51	48	55	345
1998	19	32	48	58	28	66	54	63	56	424
1999	14	15	27	33	29	66	66	55	62	367
2000	23	43	16	15	14	51	44	43	42	291
2001	7	21	8	16	12	65	39	53	37	258
2002	3	29	10	6	20	56	41	49	34	248
2003	4	20	2	7	14	62	37	40	25	211
2004	1	13	4	6	16	52	34	45	31	202
2005	6	12	9	11	6	37	25	36	29	171
2006	1	9	9	5	9	41	31	37	27	169
2007	2	9	3	3	4	55	15	28	17	136
2008	2	7	7	6	5	44	18	32	21	142

Year	Location									Total
	29	30	31	32	33	34	35	36	37	
2009	0	16	7	5	4	38	14	24	19	127
2010	2	10	2	4	3	23	8	20	19	91
2011	0	3	3	4	4	25	7	17	16	79
2012	2	10	3	5	4	24	3	8	17	76
2013	1	9	1	3	0	13	1	8	8	44
2014	3	5	0	2	2	7	1	9	7	36
2015	0	5	1	2	1	5	0	10	5	29
2016	0	0	1	0	0	5	5	7	5	23
2017	1	5	0	0	5	2	7	14	3	37
2018	0	1	1	1	3	3	3	9	3	24
2019	0	1	1	0	2	3	6	4	1	18
Total	114	320	190	216	210	790	510	659	539	3,548

Table 13. Estimated catch rates for gillnets and summaries of data provided in logbooks for vessels >35 feet, from NAFO Subdiv. 3Ps.

Quota Year	Estimated CPUE (t/net)	Standard Error	Number of Sets	Number of Vessels	Landings (t)		
					Logbooks	Reported	% of Reported
1998	112	3.50	1,048	128	2,495	4,237	59
1999	85	1.82	2,893	168	4,966	8,213	60
2000	71	1.81	1,734	148	2,088	4,456	47
2001	42	1.11	1,701	131	1,044	2,309	45
2002	53	1.60	1,154	115	1,085	2,600	42
2003	55	1.63	1,212	134	1,277	2,772	46
2004	53	1.49	1,367	127	1,112	2,437	46
2005	40	1.07	1,526	133	1,230	2,446	50
2006	50	1.36	1,393	134	1,439	2,564	56
2007	50	1.26	1,642	151	1,722	2,456	70
2008	48	1.24	1,599	137	1,598	2,278	70
2009	46	1.39	1,126	119	1,068	1,642	65
2010	50	1.74	805	89	902	1,469	61
2011	48	1.67	788	92	1,114	1,412	79
2012	49	2.16	466	69	792	1,235	64
2013	56	2.76	364	49	443	681	65
2014	60	2.30	632	63	969	1,397	69
2015	50	1.80	718	58	1,217	1,813	67
2016	42	1.34	943	62	1,101	1,662	66
2017	55	2.02	723	55	851	1,522	56
2018	77	2.86	716	49	961	1,728	56
2019	53	1.91	773	51	687	1,078	64

Table 14. Standardized catch rates for gillnets based on at sea sampling by observers in NAFO Subdiv. 3Ps. Number for sets and proportion of landings observed are also provided.

Quota Year	CPUE	Standard Error	Number of		Observed Catch (t)	Landings (t)	% Observed
			Trips	Sets			
1997	71.65	6.75	19	111	59.3	3,760	1.58
1998	79.80	4.76	22	350	281.7	10,102	2.79
1999	39.01	1.97	32	425	158.5	20,469	0.77
2000	31.80	1.78	20	395	131.1	10,891	1.2
2001	-	-	0	0	0	6,159	0
2002	61.29	20.25	3	8	-	-	-
2003	32.50	1.68	40	432	131.2	8,055	1.63
2004	34.78	1.79	34	457	146.7	7,353	2
2005	22.86	1.32	23	363	50.9	6,898	0.74
2006	23.62	1.68	23	217	44.9	6,877	0.65
2007	28.72	1.79	19	285	77.9	6,678	1.17
2008	31.33	1.85	30	304	58.9	6,264	0.94
2009	31.91	2.38	13	179	48.6	3,602	1.35
2010	21.72	1.56	10	212	13.9	3,709	0.37
2011	23.25	2.30	9	94	23.7	2,994	0.79
2012	15.20	2.05	5	49	9.2	2,741	0.34
2013	28.26	9.92	1	7	-	-	0.01
2014	50.81	10.35	3	21	-	-	0.67
2015	38.63	5.02	8	53	31.4	3,066	1.02
2016	20.84	1.99	7	110	13.0	3,047	0.43
2017	20.80	3.67	6	28	-	-	0.22
2018	125.89	28.48	5	17	16.6	3,334	0.50
2019	26.12	3.80	7	43	19.4	2,395	0.81

NOTE: Landings not presented for less than 5 vessels.

Table 15. Information from number of sets available for estimation of standardised catch rates from observer sampling of gillnets.

Year	Total sets	Year	Total sets
1997	111	2011	94
1998	350	2012	49
1999	425	2013	7
2000	395	2014	21
2001	-	2015	53
2002	8	2016	109
2003	432	2017	28
2004	457	2018	17
2005	363	2019	43
2006	217	-	-
2007	285	-	-

Year	Total sets	Year	Total sets
2008	304	-	-
2009	179	-	-
2010	212	-	-

Table 16. Annual number of cod tagged in NAFO Subdiv. 3Ps during 2007–20 by tag type (i.e., low or high reward) and by statistical unit area.

Release Year	Low Reward ($10)	High Reward ($100)	Total Tagged in 3Psa	Total Tagged in 3Psb	Total Tagged in 3Psc	Total Tagged in 3Ps
2007	3,410	480	840	1019	2,031	3,890
2008	315	80	-	-	395	395
2009	2,006	504	-	-	2,510	2,510
2010	817	205	-	-	1,022	1,022
2011	767	196	-	-	963	963
2012	1,869	471	-	743	1,597	2,340
2013	3,153	798	554	557	2,840	3,951
2014	789	200	-	416	573	989
2015	994	256	-	514	736	1,250
2016	401	101	-	502	-	502
2017	1,467	373	100	1136	574	1,840
2018	283	76	-	359	-	359
2019	1,927	466	168	929	1296	2,393
2020	1,077	271	-*	-*	-*	1,348

*Not available at time of assessment.

Table 17. Annual number of cod tags returned from NAFO Subdiv. 3Ps during 2007–17 by tag type (i.e., low or high reward).

Recapture Year	Low Reward ($10)	High Reward ($100)	Total Returned
2007	333	67	400
2008	262	58	320
2009	245	70	315
2010	210	74	284
2011	95	35	130
2012	146	42	188
2013	179	67	246
2014	195	73	268
2015	176	63	239
2016	130	64	194
2017	186	71	257

FIGURES

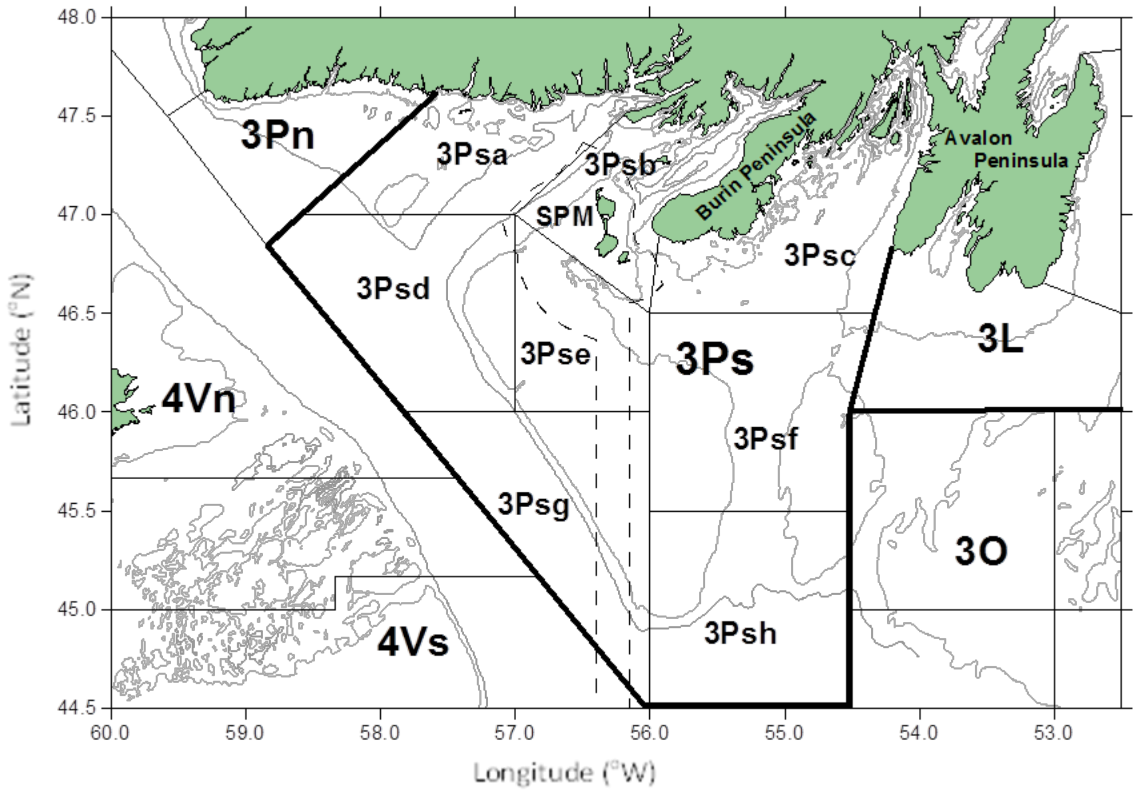

Figure 1. NAFO Subdiv. 3Ps management zone showing the economic zone around the French islands of St. Pierre et Miquelon (SPM, dashed line), the 100 m and 250 m depth contours (grey lines) and the boundaries of the statistical unit areas (solid lines).

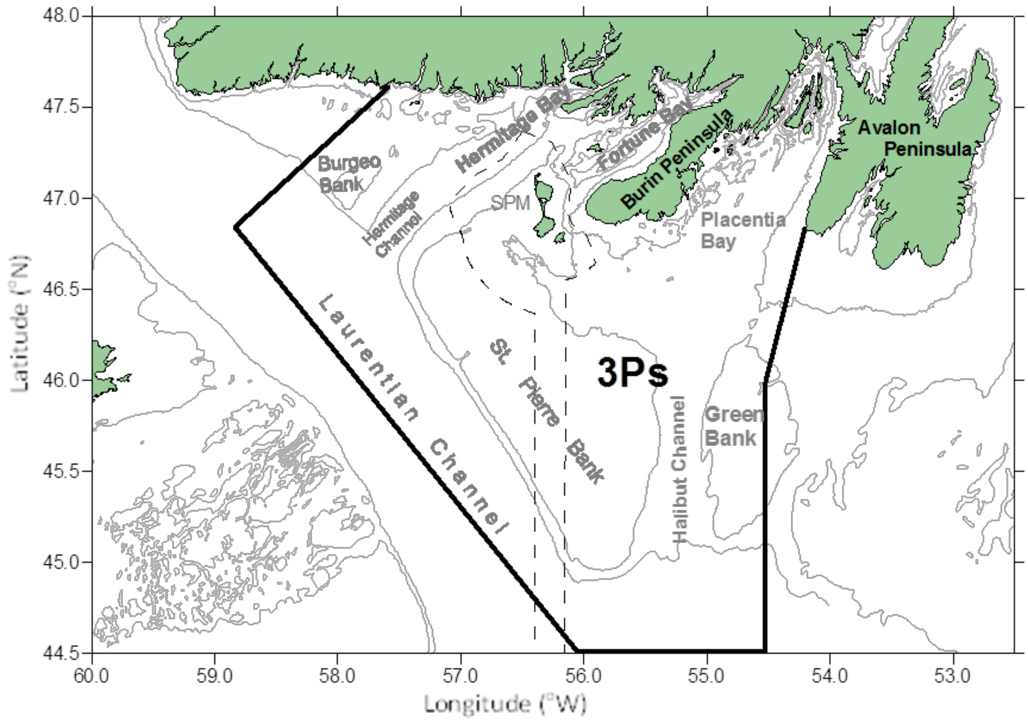

Figure 2. NAFO Subdiv. 3Ps management zone showing the economic zone around the French islands of St. Pierre and Miquelon (SPM, dashed line), the 100 m and 250 m depth contours (grey lines) and the main fishing areas.

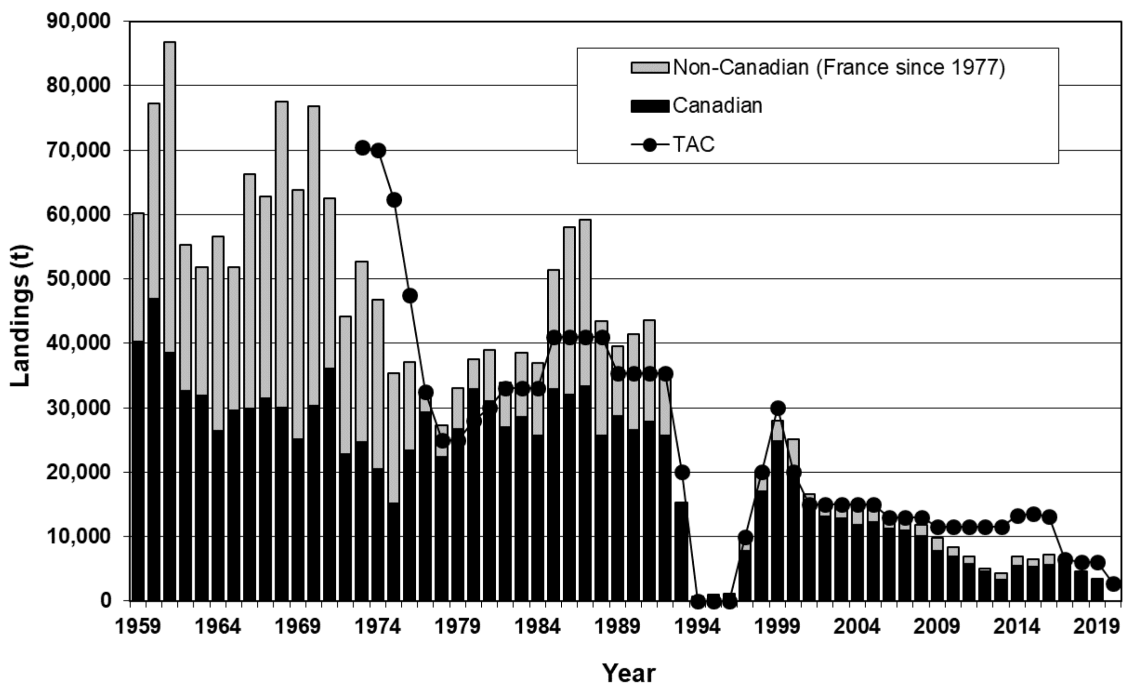

Figure 3a. Reported landings of cod by Canadian and non-Canadian vessels in NAFO Subdiv. 3Ps. Note that the 2020 fishery was still in progress at the time of the current assessment.

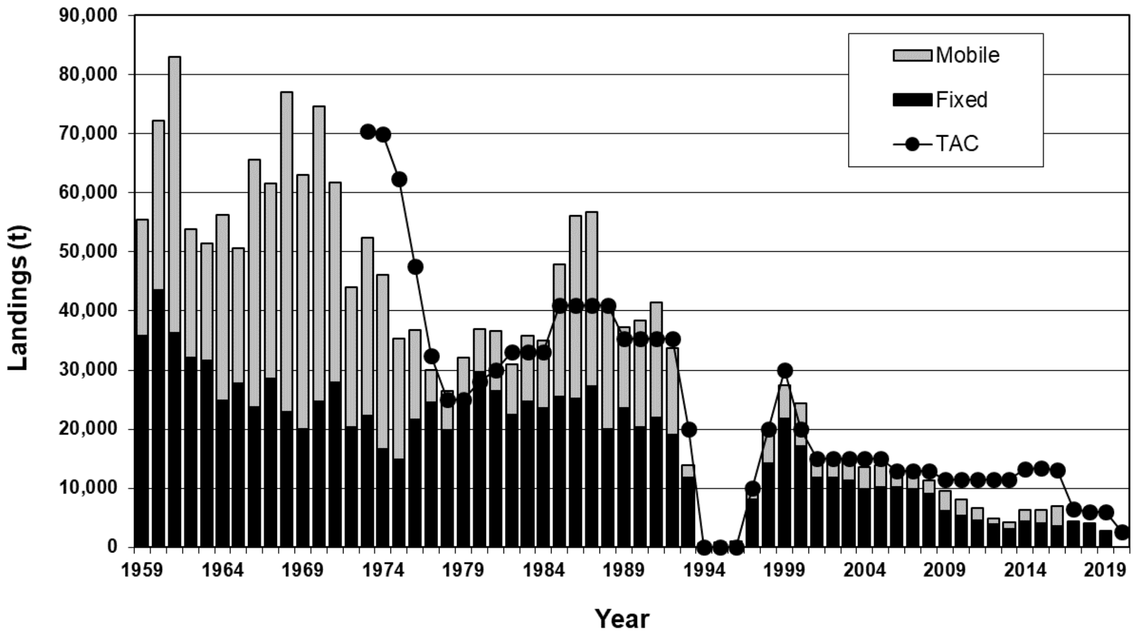

Figure 3b. Reported landings of cod by fixed and mobile gears in NAFO Subdiv. 3Ps. Note that the 2020 fishery was still in progress at the time of the current assessment.

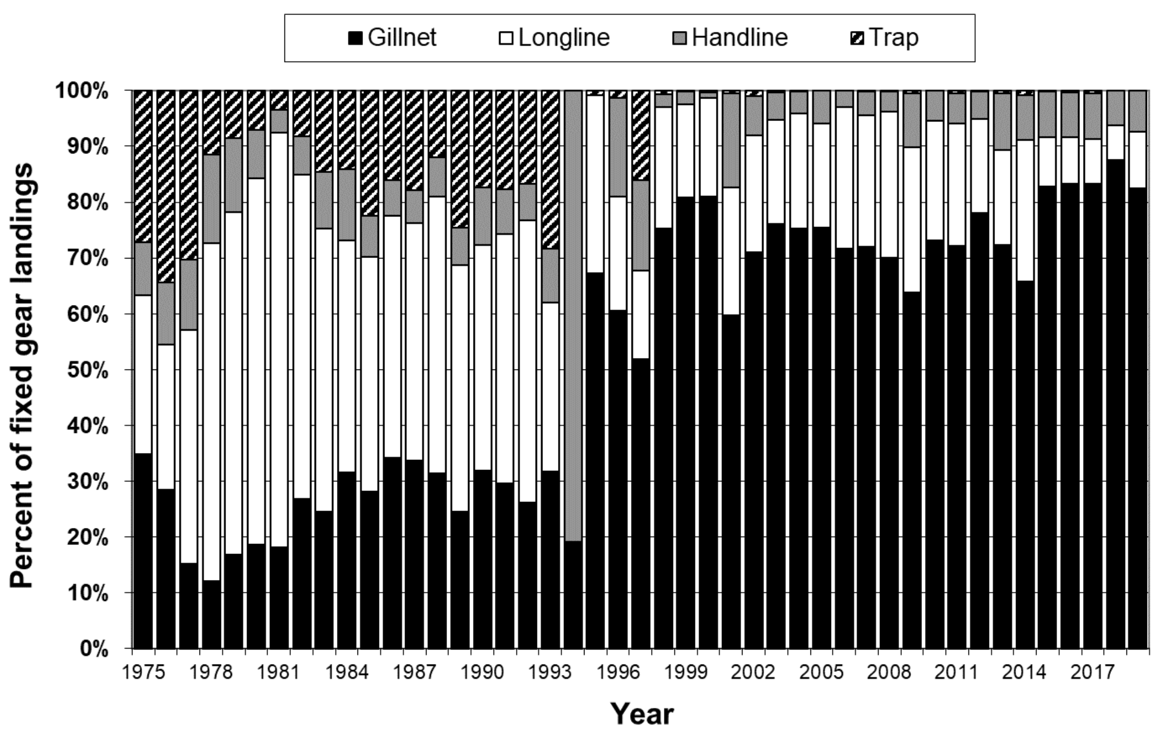

Figure 4. Percent of total fixed gear landings by the four main fixed gears used in the cod fishery in NAFO Subdiv. 3Ps. The fishery was under a moratorium during 1994–96 and values for those years are based on Sentinel and by-catch landings of <800 t.

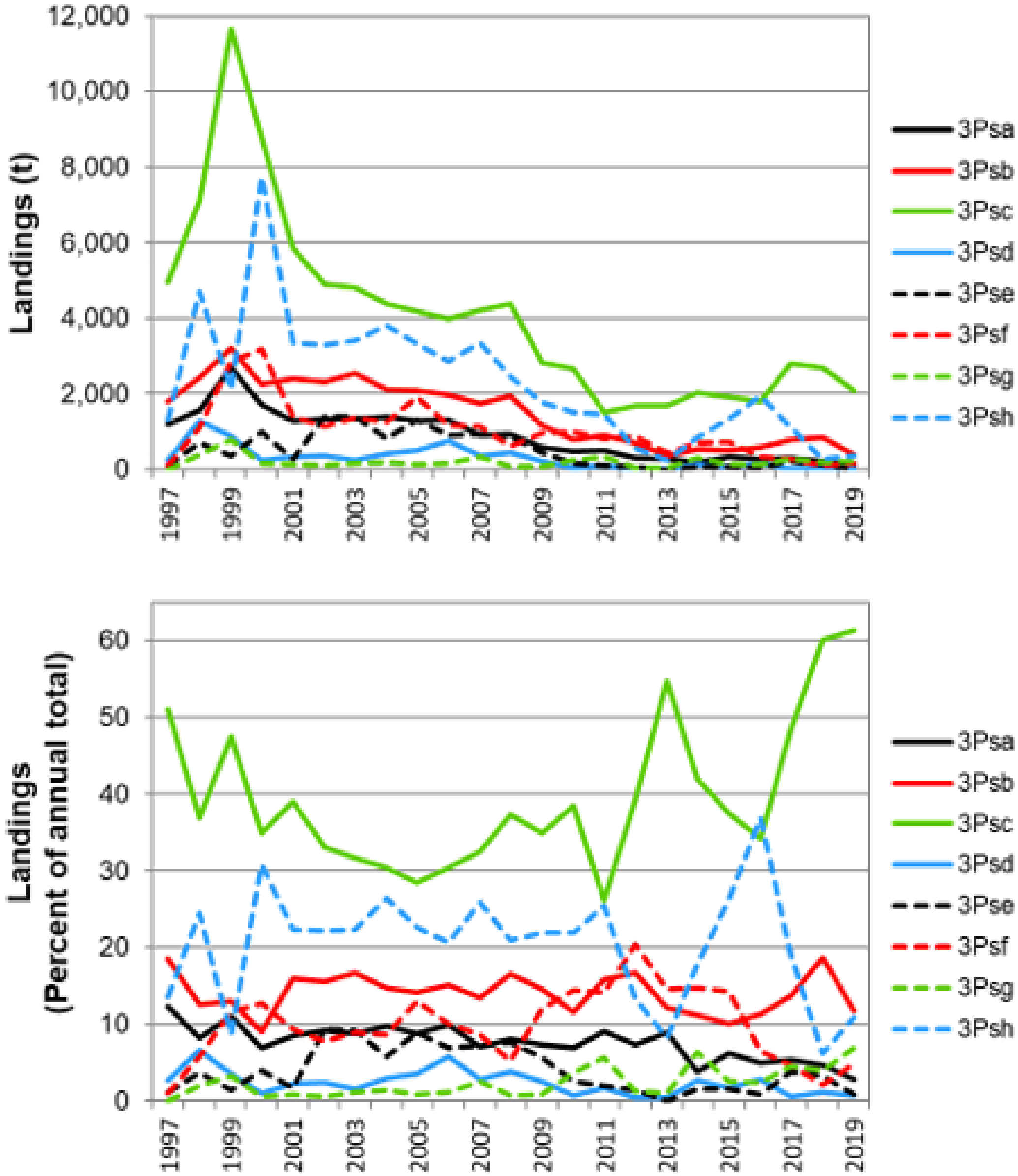

Figure 5. Breakdown of recent Canadian annual landings of NAFO Subdiv. 3Ps cod by statistical unit areas. Both landings (upper panel) and percent of total landings (lower panel) are presented. Unit area is not available for SPM landings. Refer to Figure 1 for locations of unit areas.

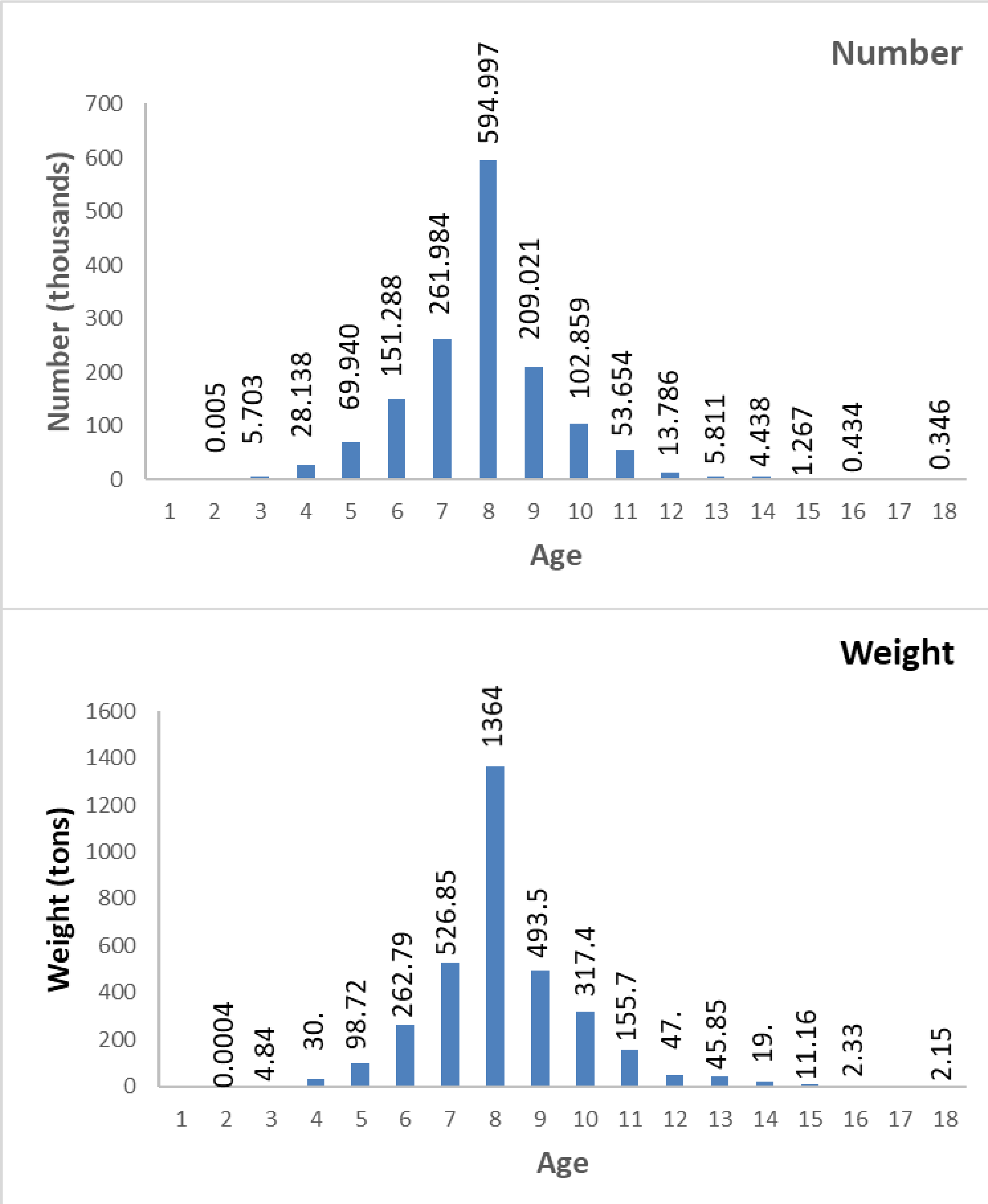

Figure 6. Catch numbers and weight-at-age for NAFO Subdiv. 3Ps cod from commercial fisheries and Sentinel sampling in 2019.

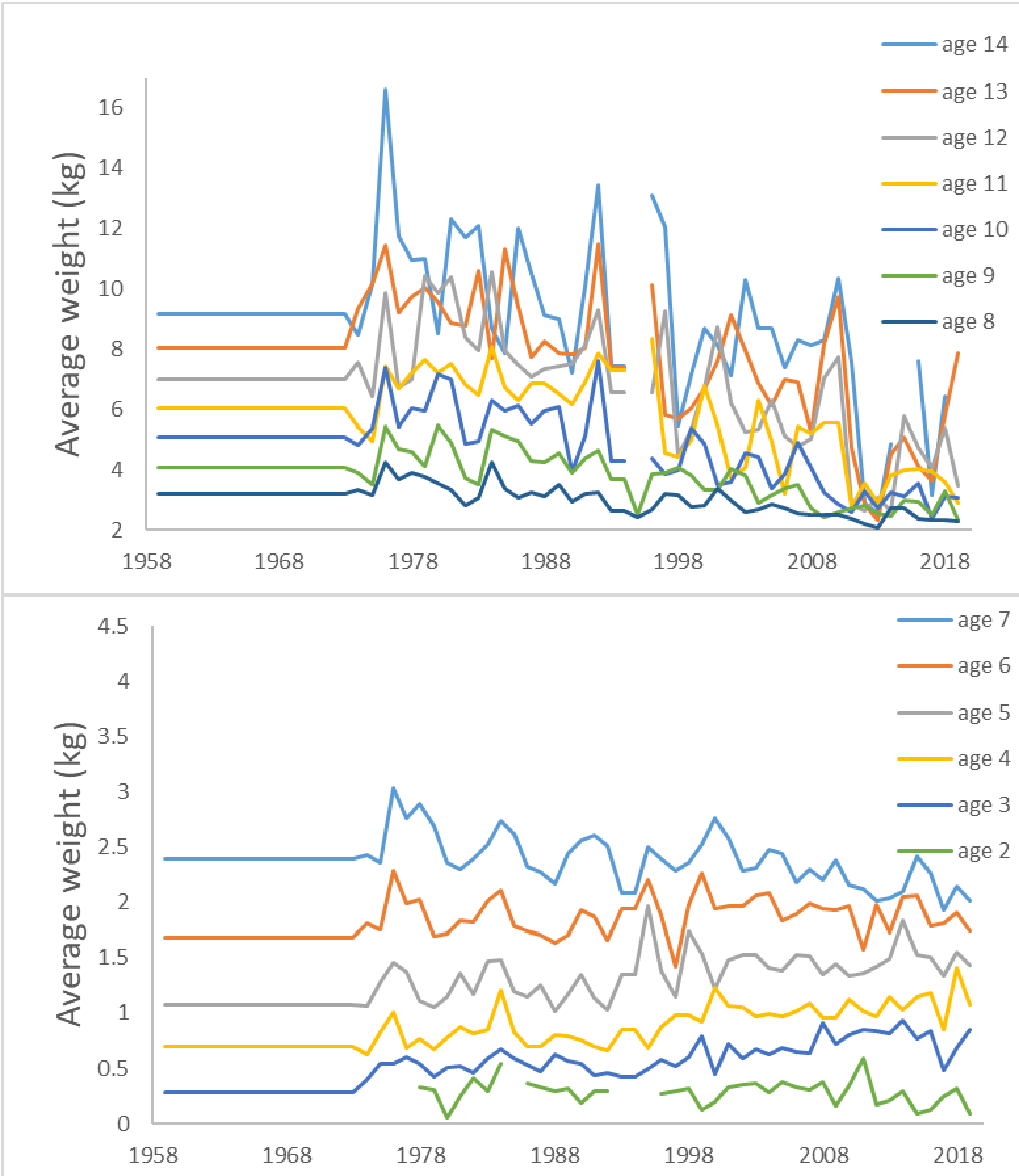

Figure 7. Mean weights-at-age calculated from mean lengths-at-age (lower panel: ages 2–7; upper panel: ages 8–14) from the commercial catch of cod in NAFO Subdiv. 3Ps during 1959–2019.

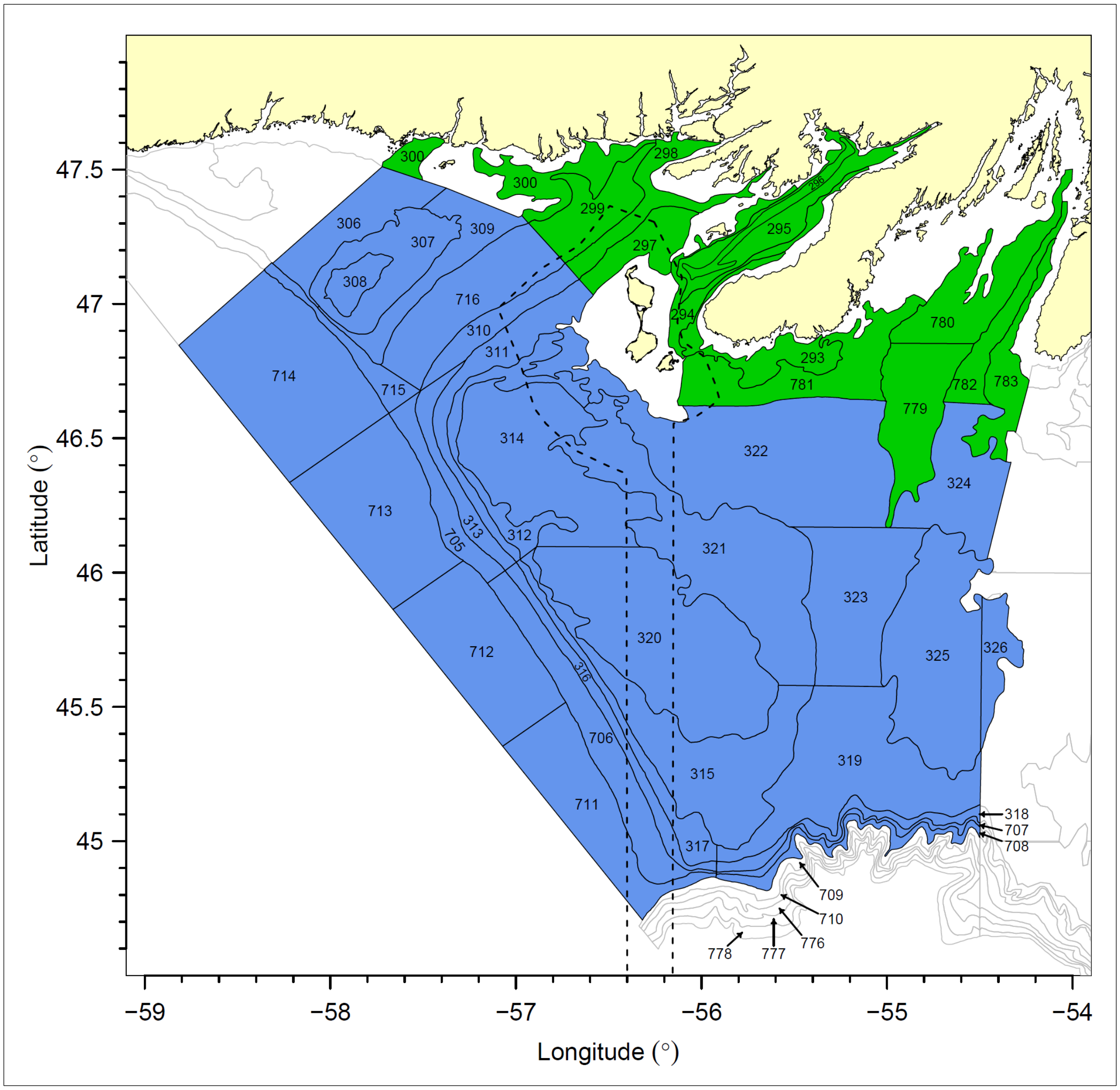

Figure 8. Stratum area boundaries and area surveyed during the DFO-RV bottom trawl survey of NAFO Subdiv. 3Ps. Offshore strata are shaded blue. Inshore strata were added in 1994 (strata 779–783) and 1997 (strata 293–300) and are shaded green. The dashed line represents the boundary of the French economic zone.

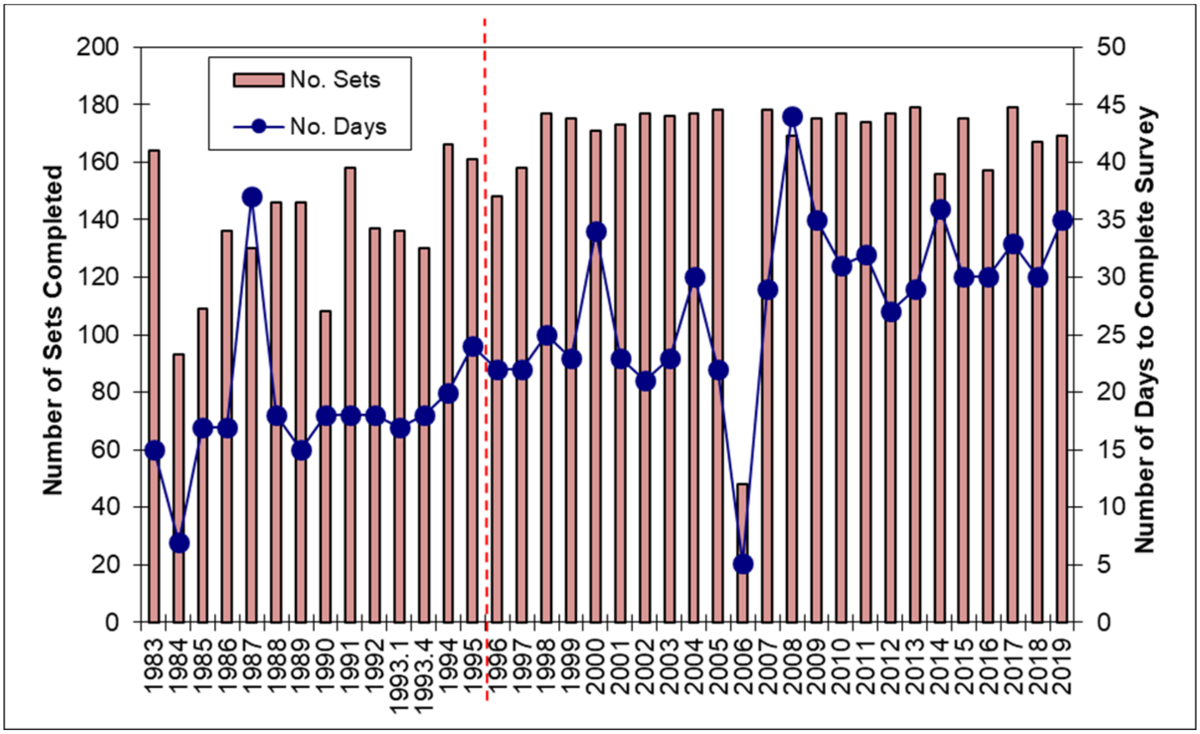

Figure 9. Number of sets completed during DFO-RV surveys of NAFO Subdiv. 3Ps, and the number of days required to complete these sets. Survey coverage was expanded to present levels (i.e., covering all inshore and offshore index strata) in 1997. Red vertical line indicates the break between the "offshore" and "inshore and offshore" series following survey area expansion.

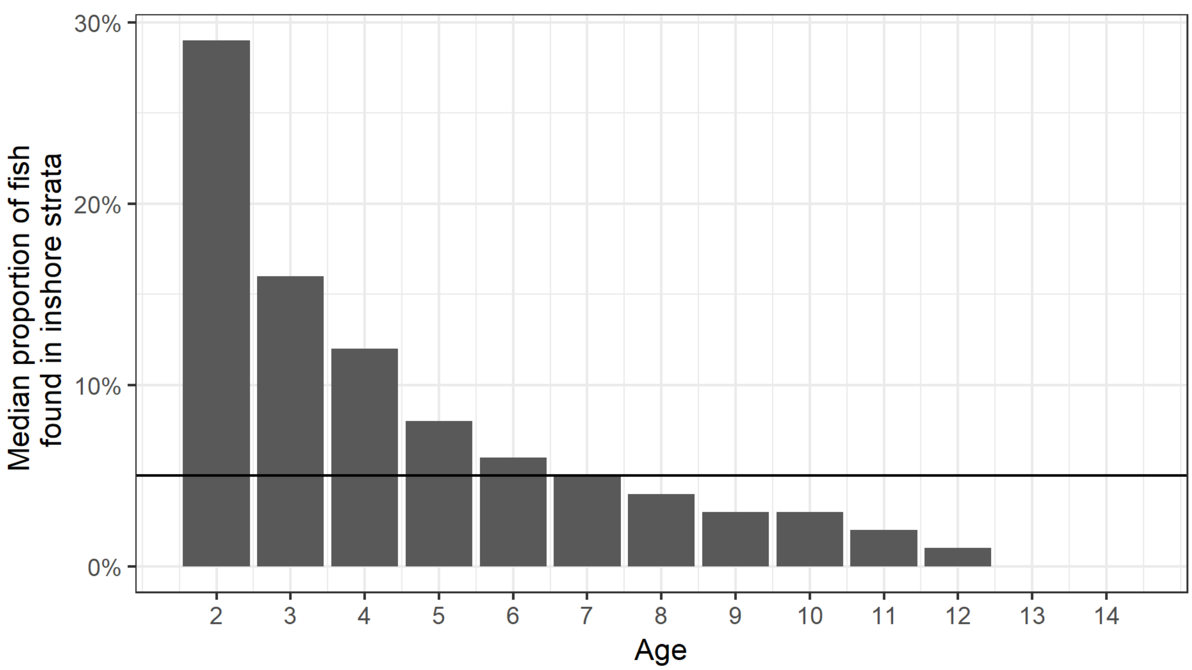

Figure 10. Proportion of cod by age in the inshore versus combined inshore-offshore area in the DFO-RV surveys of NAFO Subdiv. 3Ps from 1997–2018. The offset for q was applied to ages 8 and older. The horizontal line indicates 5%, which was used as a cut-off for ages to apply this offset.

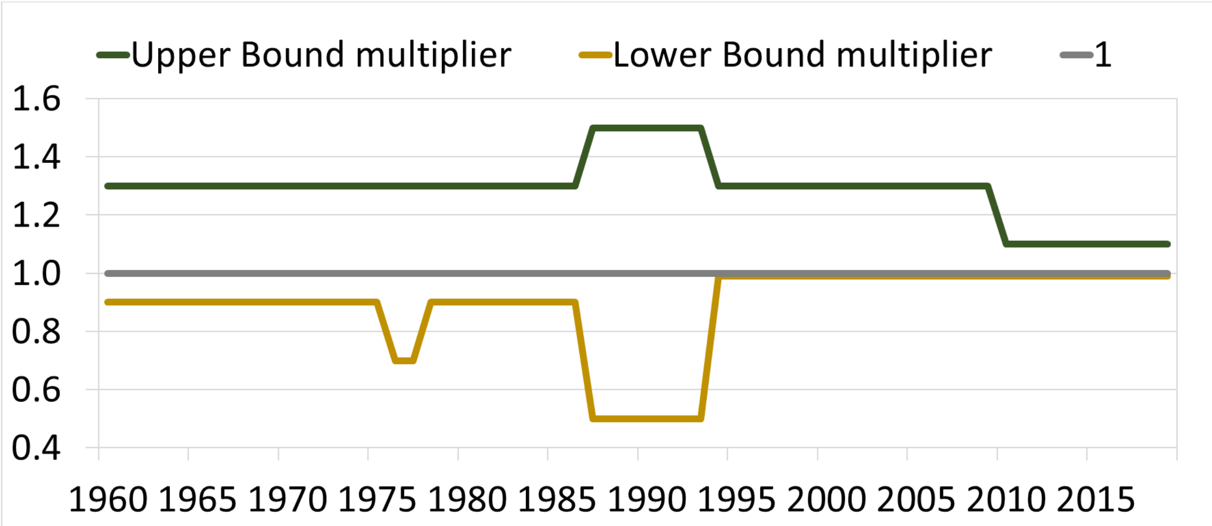

Figure 11. Landings bounds decided at the Framework meeting for NAFO Subdiv. 3Ps cod in October 2019.

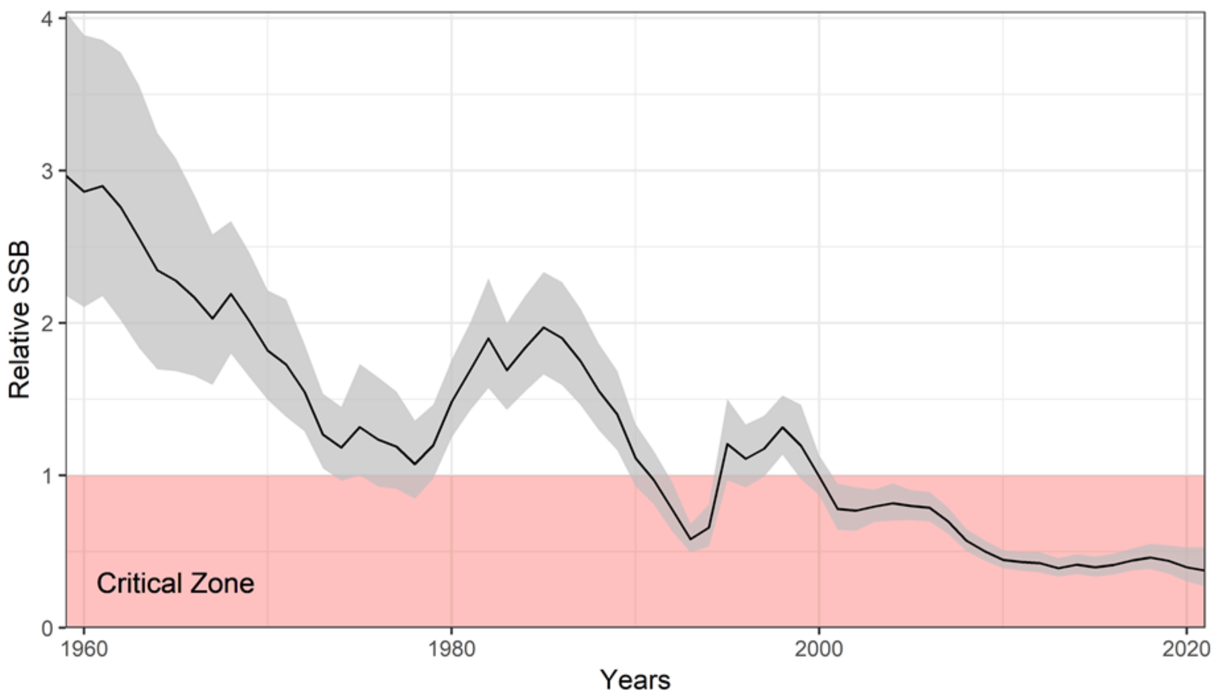

Figure 12. Estimates of SSB for NAFO Subdiv. 3Ps cod, relative to the B_{lim} value (median estimate with 95% confidence interval), 1959–2020. This reference point represents the boundary between the critical and cautious zones of DFO's Precautionary Approach framework.

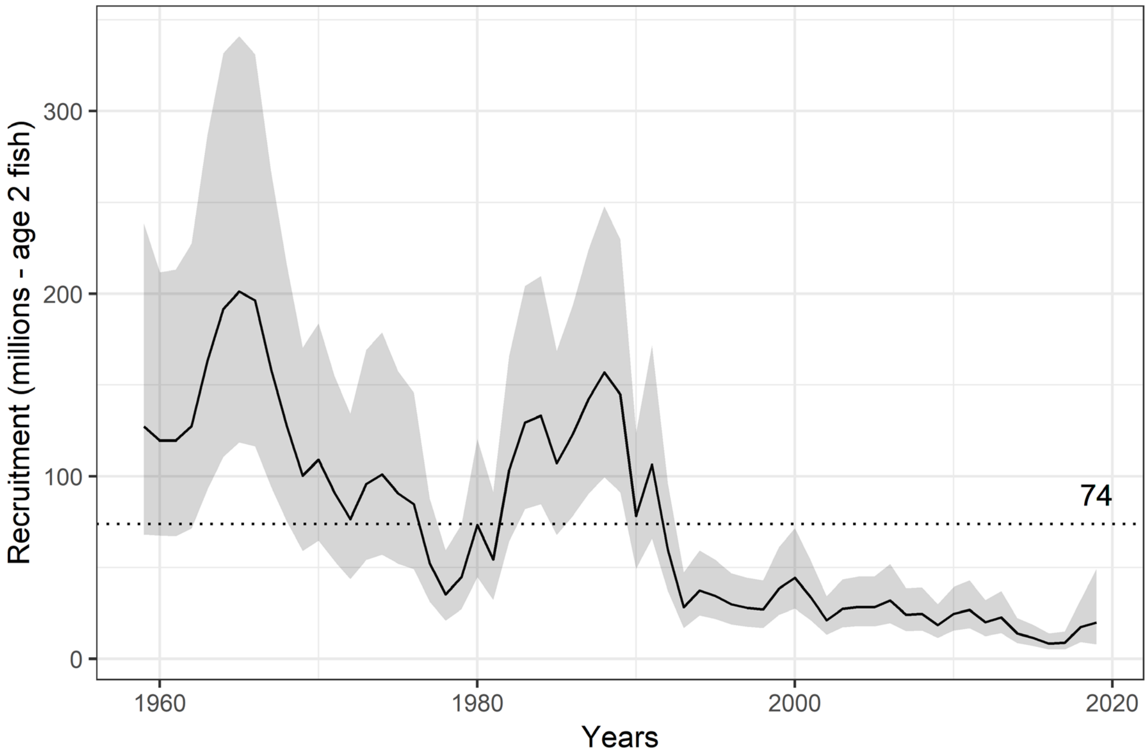

Figure 13. Estimates of recruitment for NAFO Subdiv. 3Ps cod, 1959–2019. Values for year 2020 and 2021 are projections based on average recruitment from 2017–19.

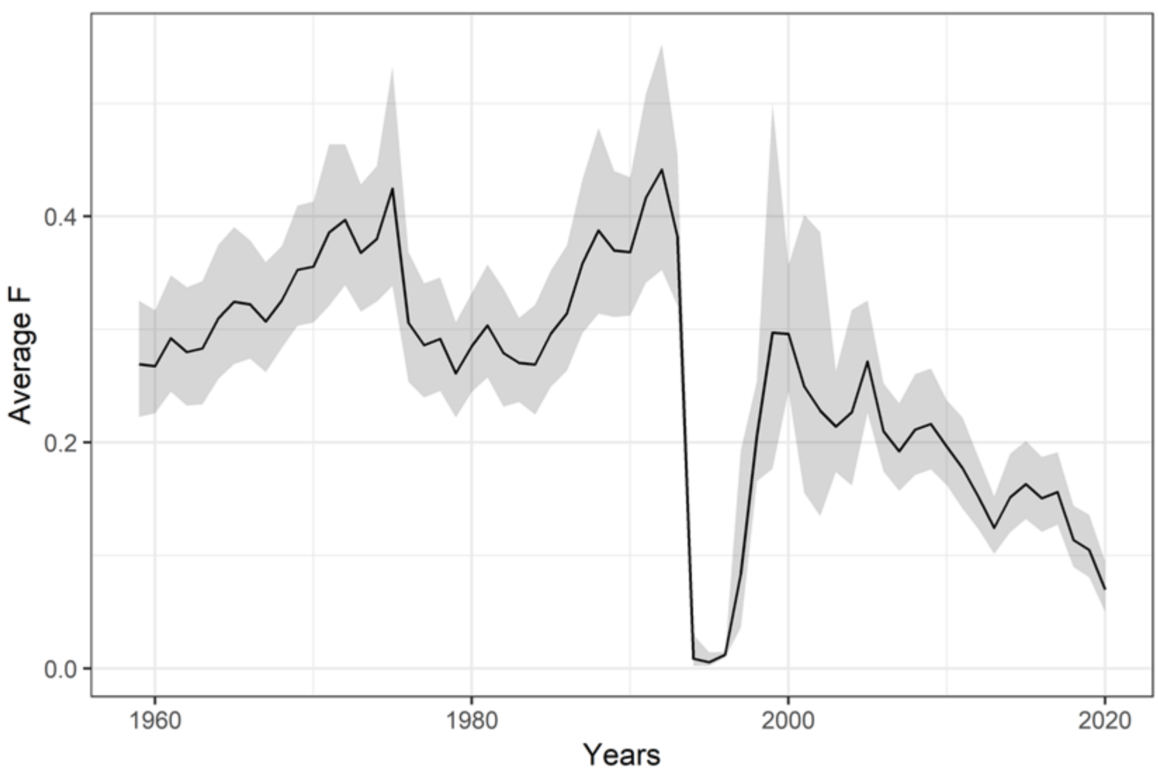

Figure 14. Average F (ages 5–8) estimates for NAFO Subdiv. 3Ps cod, 1959–2019.

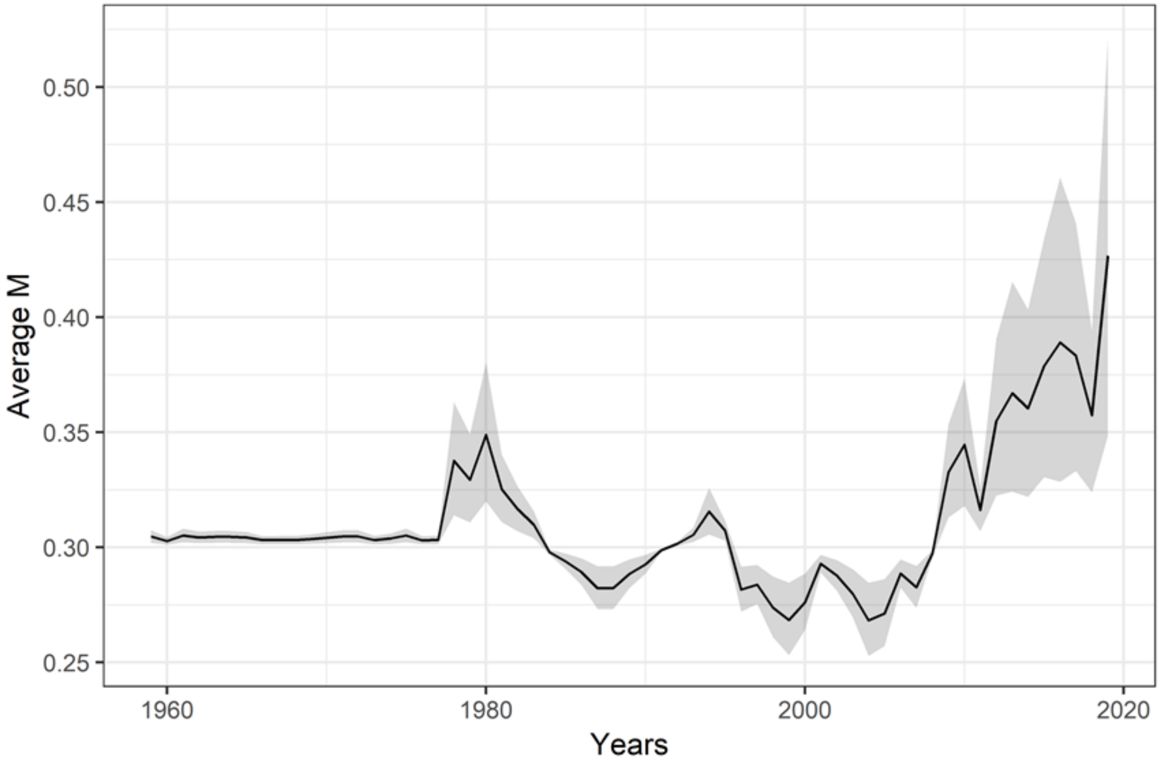

Figure 15. Natural mortality of NAFO Subdiv. 3Ps cod based on fish condition, 1959–2019.

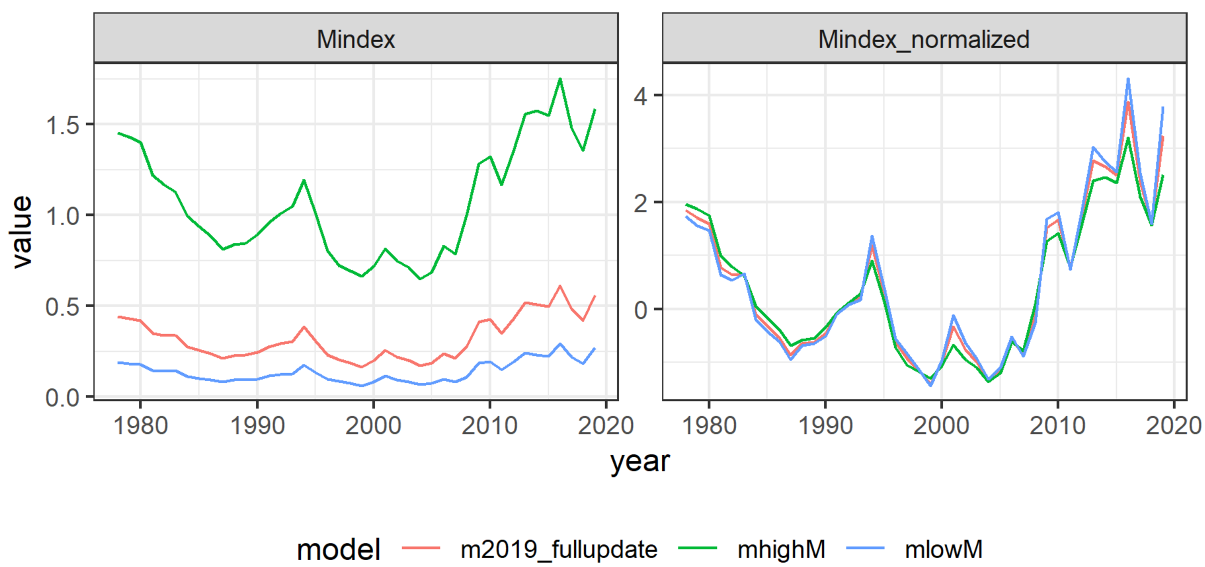

Figure 16. Trend of fish condition-based index of natural mortality (Mc) at three different thresholds for relative condition: Kr=0.85 (assessment model-red), 0.8 (lowM-blue), 0.9 (highM-green) (left panel) and corresponding normalized indices (right panel).

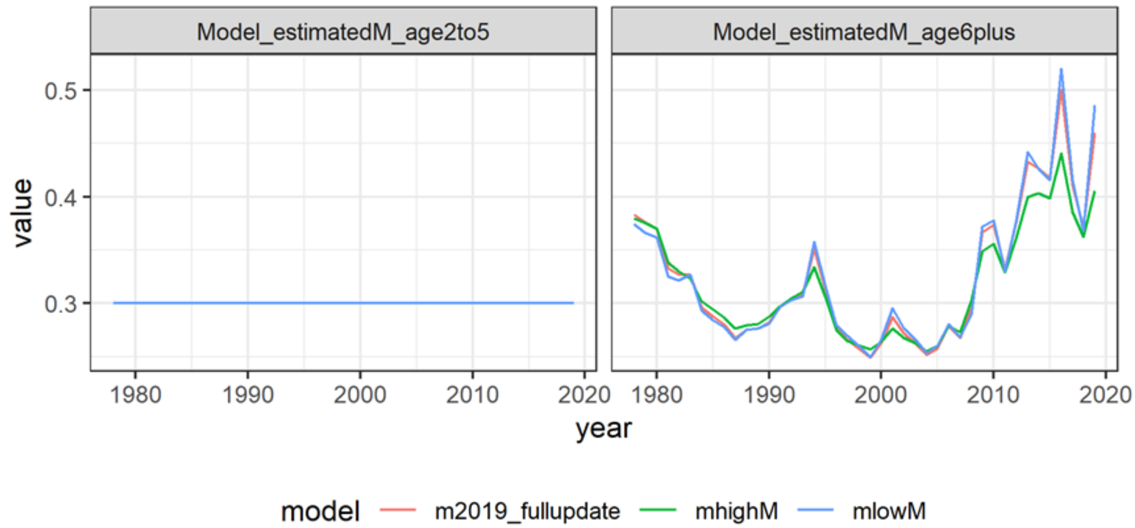

Figure 17. Estimated M across the sensitivity trials based on fish condition-based index, calculated at different thresholds of relative condition: Kr=0.85 (assessment model-red), 0.8 (low M-blue), 0.9 (high M-green) for age groups 2–5 (left panel) and ages 6 and above (right panel).

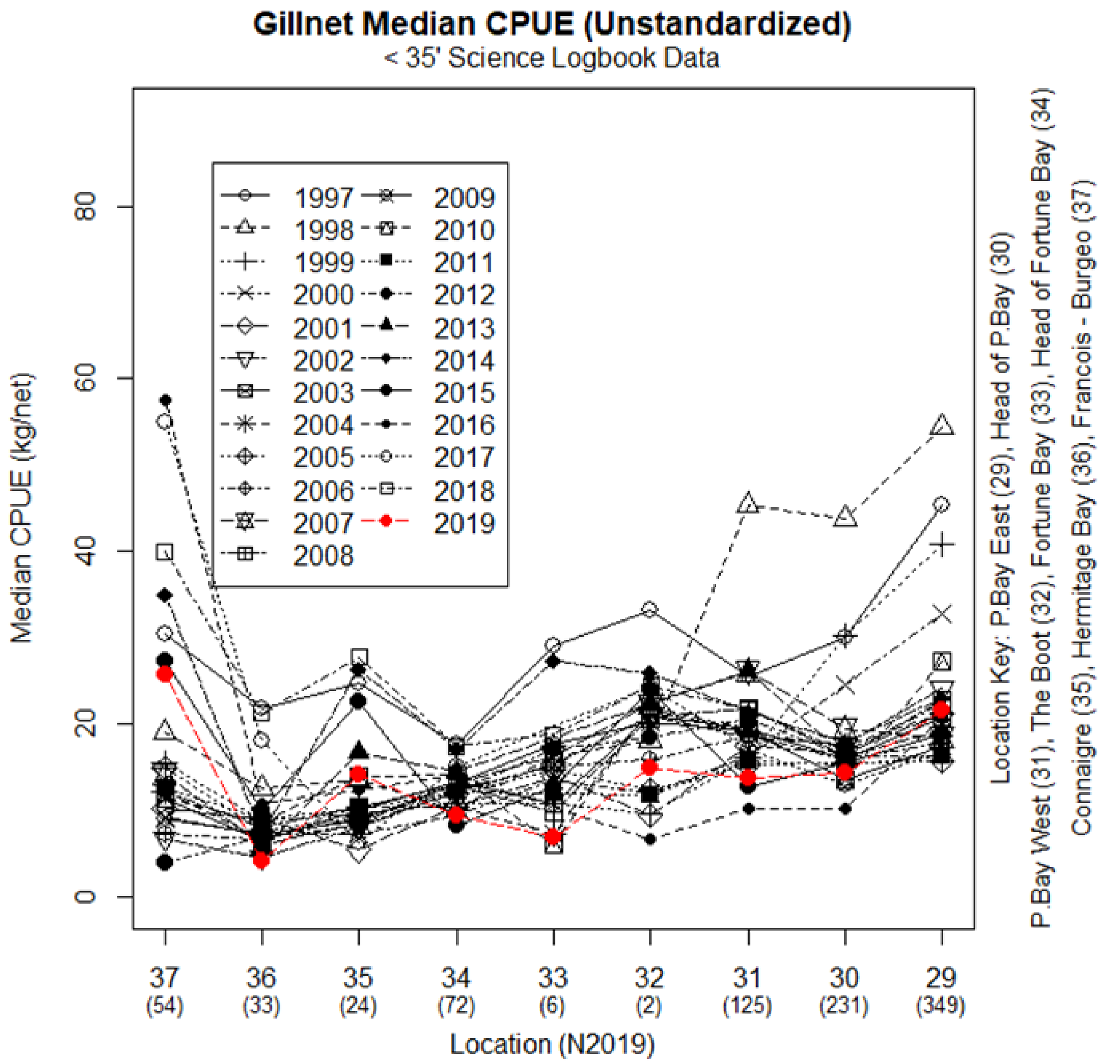

Figure 18. Unstandardized catch rates of NAFO Subdiv. 3Ps cod in gillnets, based on data reported in logbooks for vessels <35 feet.

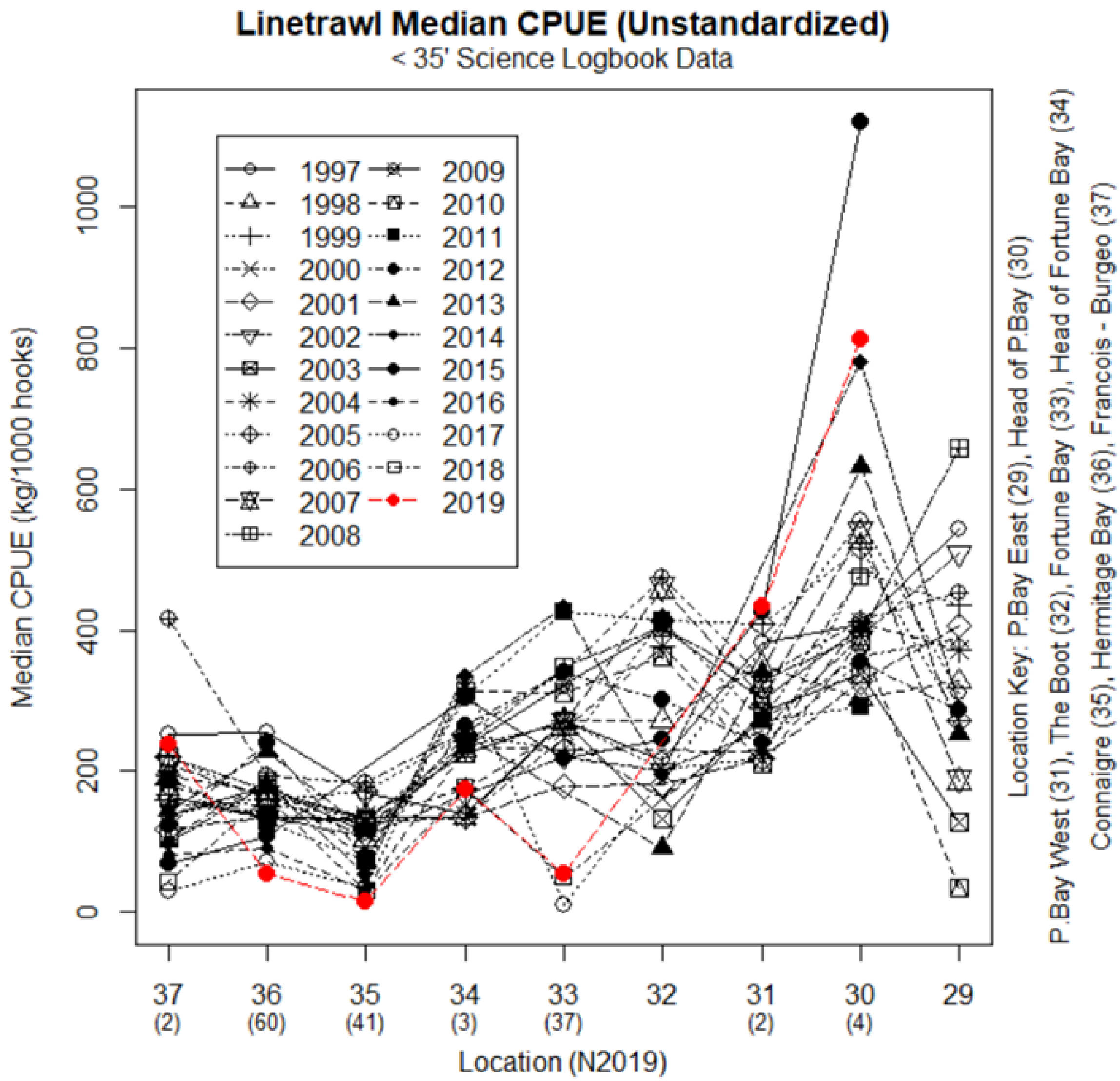

Figure 19. Unstandardized catch rates of NAFO Subdiv. 3Ps cod in line trawls, based on data reported in logbooks for vessels <35 feet.

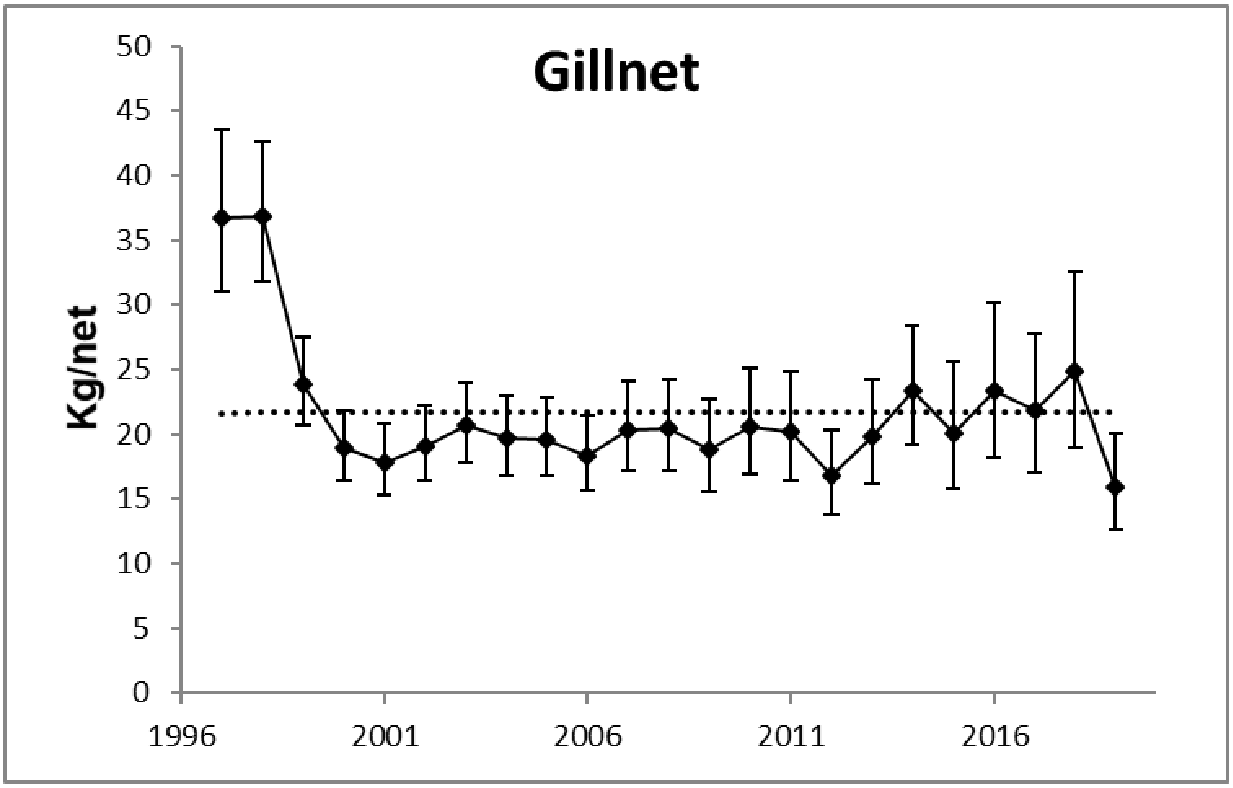

Figure 20. Standardized catch rates of NAFO Subdiv. 3Ps cod (plus 95% confidence intervals) for gillnets, based on data reported in logbooks for vessels <35 feet, 1997–2019. Horizontal line represents the time-series average.

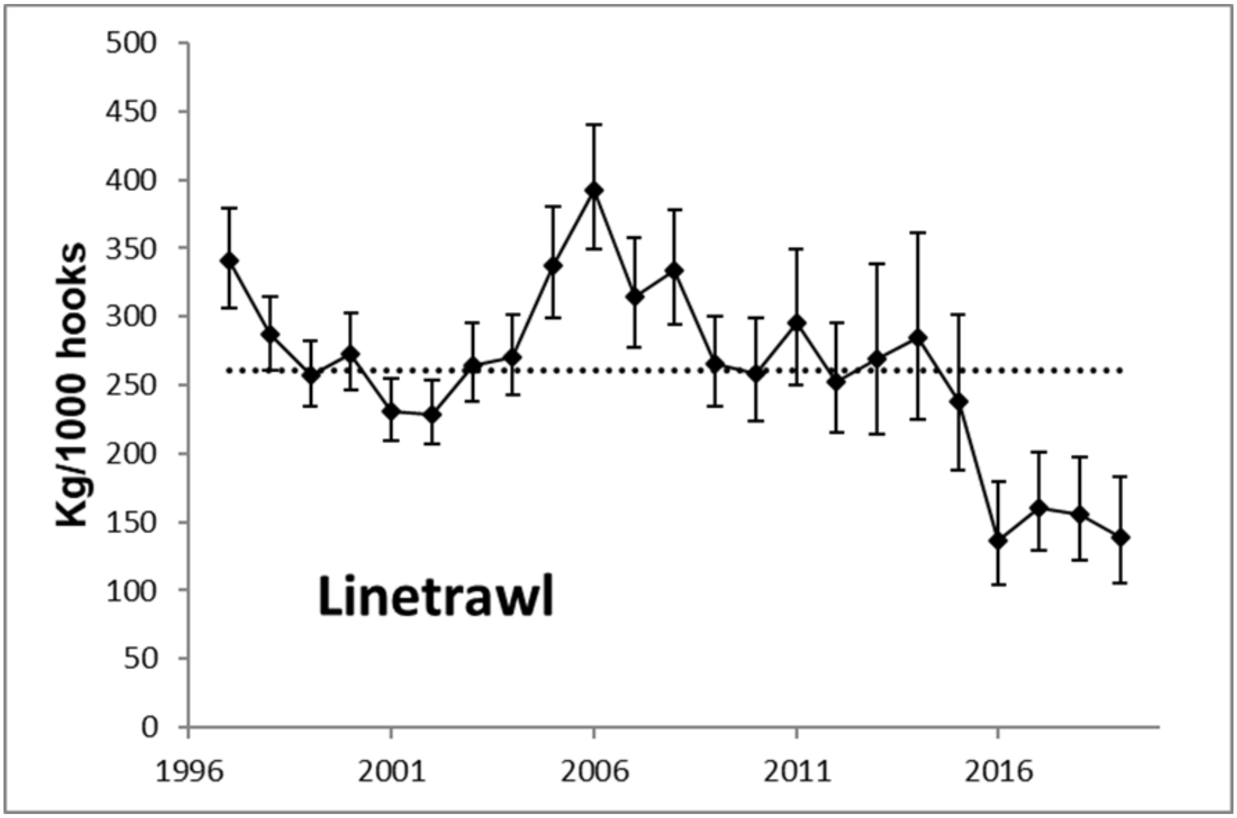

Figure 21. Standardized catch rates of NAFO Subdiv. 3Ps cod (plus 95% confidence intervals) for line trawls as reported in logbooks for vessels <35 feet, 1997–2019. Horizontal line represents the time-series average.

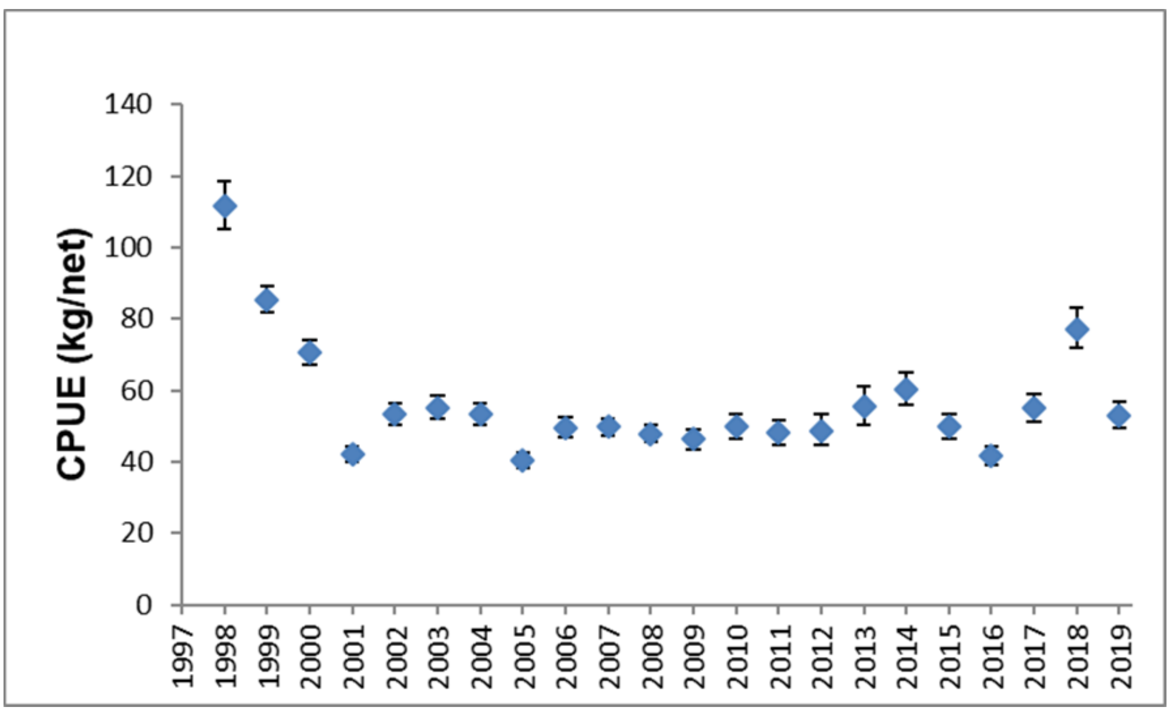

Figure 22. Standardized catch rates of NAFO Subdiv. 3Ps cod (with 95% confidence intervals) for gillnets, based on data from logbooks from vessels >35 feet, 1998–2019.

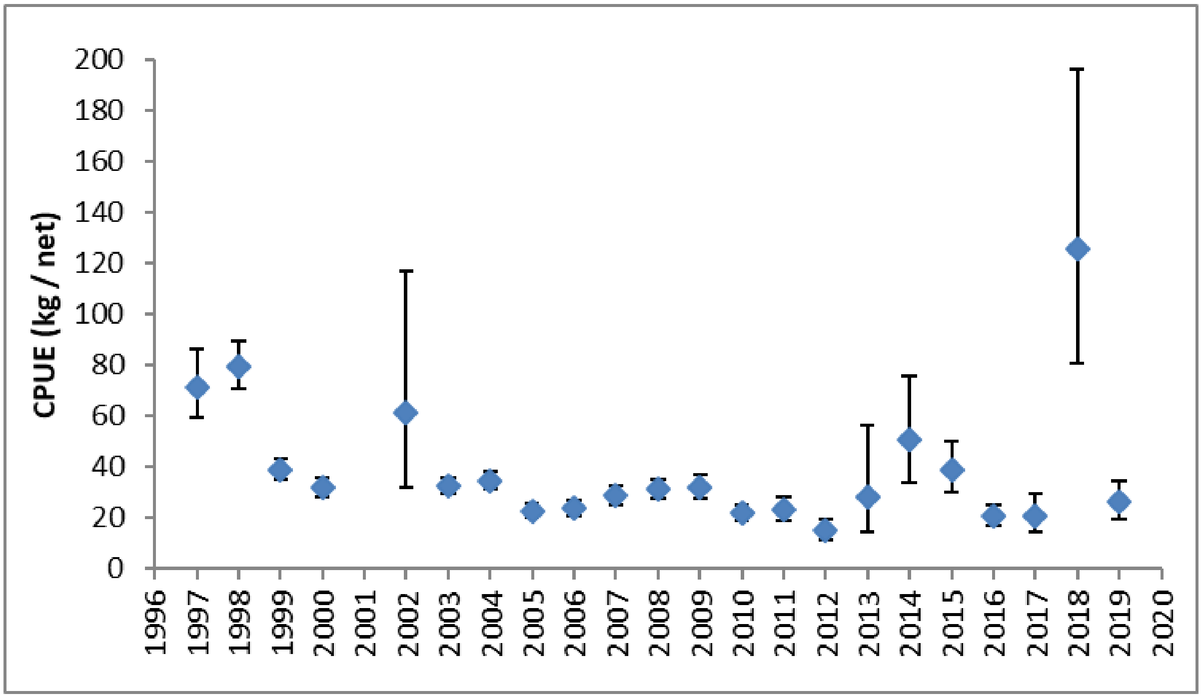

Figure 23. Standardized catch rates of NAFO Subdiv. 3Ps cod (plus 95% confidence intervals) for gillnets, based on at sea sampling by observers, 1996–2019. Information from number of sets available annually is shown in Table 15.

APPENDIX A – MODEL OUTPUTS

This appendix presents key outputs from the assessment.

Table A1. Estimated SSB (in thousand tonnes).

Year	SSB	Low	High
1959	196	144	267
1960	189	139	257
1961	191	144	255
1962	182	133	249
1963	169	121	235
1964	155	112	214
1965	150	111	203
1966	143	109	188
1967	134	105	170
1968	145	119	176
1969	133	109	163
1970	120	99	146
1971	114	91	142
1972	102	85	123
1973	84	69	101
1974	78	64	96
1975	87	66	114
1976	82	61	108
1977	79	60	102
1978	71	56	90
1979	79	65	97
1980	98	82	116
1981	111	94	132
1982	125	104	151
1983	112	94	132
1984	121	102	144
1985	130	110	154
1986	125	105	150
1987	116	97	138
1988	103	86	123
1989	92	77	111
1990	74	61	88
1991	64	54	77
1992	51	42	63
1993	38	33	45
1994	43	35	53
1995	80	64	99
1996	73	61	88

Year	SSB	Low	High
1997	78	65	92
1998	87	75	101
1999	79	64	97
2000	65	57	75
2001	52	43	62
2002	51	42	61
2003	52	46	60
2004	54	47	63
2005	53	47	60
2006	52	46	59
2007	46	41	52
2008	38	33	43
2009	33	29	38
2010	29	26	34
2011	29	25	33
2012	28	24	33
2013	26	22	30
2014	27	23	32
2015	26	22	31
2016	27	23	32
2017	29	25	34
2018	30	26	36
2019	29	24	36
2020	26	20	35
2021	25	18	35

Table A2. Estimated recruits (in million).

Year	Recruits	Low	High
1959	127	68	239
1960	120	67	212
1961	120	67	213
1962	127	71	227
1963	163	93	287
1964	192	111	332
1965	201	119	341
1966	196	116	331
1967	159	94	267
1968	127	75	216
1969	100	59	170
1970	109	65	184
1971	91	54	155
1972	77	44	134

Year	Recruits	Low	High
1973	96	54	169
1974	101	57	179
1975	91	52	158
1976	85	49	146
1977	52	31	88
1978	35	21	60
1979	45	27	74
1980	73	45	120
1981	54	32	91
1982	103	64	166
1983	129	82	204
1984	133	85	210
1985	107	68	169
1986	123	78	193
1987	142	90	224
1988	157	99	248
1989	145	91	230
1990	78	49	124
1991	106	66	172
1992	60	37	96
1993	28	17	47
1994	38	24	59
1995	34	22	54
1996	30	19	47
1997	28	18	44
1998	27	17	43
1999	39	24	61
2000	44	28	72
2001	34	21	54
2002	21	13	34
2003	27	17	43
2004	28	18	45
2005	28	18	45
2006	32	20	52
2007	24	15	39
2008	25	15	39
2009	19	11	30
2010	25	15	39
2011	27	17	43
2012	20	12	32
2013	23	14	37
2014	14	9	22

Year	Recruits	Low	High
2015	12	7	19
2016	8	5	14
2017	9	5	15
2018	17	9	32
2019	20	8	49

Table A3. Estimated average fishing (F), natural (M), and total (Z) mortality for ages 5–9.

Year	Average *F*	Average *M*	Average *Z*
1959	0.27	0.31	0.57
1960	0.27	0.30	0.57
1961	0.29	0.31	0.60
1962	0.28	0.30	0.58
1963	0.28	0.31	0.59
1964	0.31	0.31	0.62
1965	0.33	0.30	0.63
1966	0.32	0.30	0.63
1967	0.31	0.30	0.61
1968	0.33	0.30	0.63
1969	0.35	0.30	0.66
1970	0.36	0.30	0.66
1971	0.39	0.31	0.69
1972	0.40	0.31	0.70
1973	0.37	0.30	0.67
1974	0.38	0.30	0.68
1975	0.43	0.31	0.73
1976	0.31	0.30	0.61
1977	0.29	0.30	0.59
1978	0.29	0.34	0.63
1979	0.26	0.33	0.59
1980	0.29	0.35	0.63
1981	0.30	0.33	0.63
1982	0.28	0.32	0.60
1983	0.27	0.31	0.58
1984	0.27	0.30	0.57
1985	0.30	0.29	0.59
1986	0.31	0.29	0.60
1987	0.36	0.28	0.64
1988	0.39	0.28	0.67
1989	0.37	0.29	0.66
1990	0.37	0.29	0.66
1991	0.42	0.30	0.72
1992	0.44	0.30	0.74

Year	Average *F*	Average *M*	Average *Z*
1993	0.38	0.31	0.69
1994	0.01	0.32	0.32
1995	0.01	0.31	0.31
1996	0.01	0.28	0.29
1997	0.08	0.28	0.37
1998	0.21	0.27	0.48
1999	0.30	0.27	0.57
2000	0.30	0.28	0.57
2001	0.25	0.29	0.54
2002	0.23	0.29	0.52
2003	0.21	0.28	0.49
2004	0.23	0.27	0.50
2005	0.27	0.27	0.54
2006	0.21	0.29	0.50
2007	0.19	0.28	0.48
2008	0.21	0.30	0.51
2009	0.22	0.33	0.55
2010	0.20	0.35	0.54
2011	0.18	0.32	0.49
2012	0.15	0.36	0.51
2013	0.12	0.37	0.49
2014	0.15	0.36	0.51
2015	0.16	0.38	0.54
2016	0.15	0.39	0.54
2017	0.16	0.38	0.54
2018	0.11	0.36	0.47
2019	0.11	0.43	0.53

Table A4. Estimated numbers-at-age (in millions).

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+
1959	127.39	100.18	173.24	45.84	38.64	27.83	5.63	7.57	5.80	5.77	3.13	0.49	0.01
1960	119.52	96.72	71.73	117.33	29.30	19.86	15.75	3.74	4.19	3.04	3.54	1.60	0.31
1961	119.57	87.15	76.04	46.99	65.08	14.77	14.10	7.87	2.41	2.27	1.66	2.41	1.00
1962	127.44	87.32	67.76	54.71	27.28	34.15	8.60	6.12	3.99	1.27	1.20	0.91	2.07
1963	163.10	89.56	59.40	46.48	31.26	15.65	18.13	5.68	2.97	2.14	0.70	0.69	1.78
1964	191.60	125.33	59.89	36.31	27.19	15.79	9.20	9.01	4.03	1.56	1.32	0.39	1.41
1965	201.18	149.15	89.86	35.30	20.90	13.67	9.03	5.15	3.98	2.65	0.73	0.70	0.96
1966	196.34	145.72	109.53	57.25	18.32	14.08	5.47	4.67	2.85	1.60	1.83	0.36	0.81
1967	158.84	157.48	112.17	68.87	31.22	10.35	6.57	2.64	2.15	1.40	0.58	1.17	0.61
1968	127.41	120.06	117.00	77.31	33.33	15.44	5.60	3.49	1.37	1.14	0.68	0.22	1.51
1969	100.38	89.55	90.09	74.51	38.87	17.76	6.86	2.67	1.91	0.63	0.58	0.33	0.88
1970	109.08	67.91	62.54	59.69	41.13	20.32	8.34	2.99	1.08	0.83	0.30	0.26	0.51
1971	91.15	89.24	45.77	37.39	28.61	22.25	8.99	3.65	1.54	0.51	0.41	0.15	0.32
1972	76.52	68.43	65.70	26.97	18.23	15.28	9.96	3.78	1.60	0.75	0.26	0.19	0.21
1973	95.76	50.45	50.16	43.97	13.70	9.90	6.06	4.53	1.70	0.69	0.37	0.12	0.19
1974	100.99	76.36	31.75	33.38	21.02	6.72	4.57	2.63	1.83	0.73	0.29	0.16	0.16
1975	90.68	74.77	54.27	16.30	17.60	13.23	2.71	1.88	1.06	0.75	0.30	0.13	0.14
1976	84.70	67.64	55.37	35.65	11.20	7.52	4.32	1.16	0.78	0.47	0.33	0.14	0.14
1977	52.34	73.22	51.84	37.42	19.53	5.13	2.45	2.56	0.66	0.45	0.29	0.20	0.17
1978	35.31	38.55	64.55	33.64	17.34	7.91	2.66	1.63	1.58	0.37	0.28	0.17	0.26
1979	44.75	22.86	30.66	56.27	22.07	9.18	4.30	1.50	0.91	0.75	0.20	0.16	0.30
1980	73.41	34.82	17.18	23.97	35.70	13.39	5.16	2.28	0.92	0.61	0.39	0.13	0.35
1981	54.39	66.74	29.72	13.39	17.18	21.39	7.03	3.16	1.36	0.59	0.41	0.21	0.30
1982	103.28	40.10	57.07	21.52	8.45	11.11	15.36	3.90	1.86	0.82	0.36	0.24	0.30
1983	129.49	79.81	32.67	43.88	13.75	5.81	5.52	7.94	2.45	1.10	0.51	0.24	0.33
1984	133.26	89.55	59.92	27.44	26.55	9.05	3.55	3.44	4.15	1.48	0.66	0.30	0.38
1985	106.99	100.11	70.88	42.87	19.46	16.28	5.88	2.37	2.38	2.32	1.12	0.43	0.51
1986	122.96	69.37	75.72	49.33	34.51	12.99	9.15	3.64	1.60	1.44	1.26	0.67	0.64

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+
1987	142.30	83.21	40.44	47.82	32.74	20.13	6.77	4.66	2.11	0.98	0.84	0.72	0.82
1988	156.97	93.70	53.34	21.98	29.86	18.47	7.83	3.37	2.36	1.15	0.61	0.46	0.80
1989	144.84	111.72	61.91	31.19	11.27	11.85	7.62	4.18	1.75	1.25	0.54	0.33	0.61
1990	78.25	110.69	77.67	36.87	14.48	6.15	6.20	3.79	2.07	0.83	0.62	0.25	0.51
1991	106.46	49.22	72.18	40.35	16.61	5.53	2.69	3.15	1.76	0.88	0.39	0.30	0.37
1992	59.71	76.68	27.41	35.33	15.83	4.66	1.39	0.94	0.85	0.41	0.23	0.09	0.21
1993	28.33	47.34	50.26	13.24	13.48	4.78	1.43	0.36	0.15	0.13	0.06	0.04	0.04
1994	37.57	19.26	40.73	36.88	8.14	6.12	1.86	0.65	0.17	0.06	0.05	0.02	0.04
1995	34.44	31.72	12.89	31.04	33.23	7.80	4.82	1.37	0.30	0.12	0.03	0.03	0.04
1996	29.79	31.22	33.20	10.59	16.62	17.07	4.08	2.24	0.77	0.20	0.10	0.02	0.03
1997	27.96	21.43	23.04	27.83	8.01	8.82	8.23	2.31	1.17	0.53	0.12	0.07	0.03
1998	27.00	21.54	16.44	15.55	13.86	5.32	6.26	5.60	1.41	0.66	0.31	0.09	0.05
1999	38.52	19.57	14.89	12.58	9.66	8.27	3.31	2.80	2.82	0.72	0.32	0.14	0.07
2000	44.43	31.58	14.95	9.67	7.80	5.36	4.56	1.63	1.35	1.99	0.35	0.13	0.10
2001	33.79	36.23	25.32	10.74	6.58	4.55	2.65	2.01	0.72	0.72	0.96	0.15	0.10
2002	21.21	27.18	22.61	16.92	6.89	3.74	2.25	1.20	0.91	0.33	0.36	0.44	0.09
2003	27.40	13.23	17.79	14.38	11.24	4.37	1.85	0.98	0.60	0.43	0.14	0.17	0.24
2004	28.40	21.93	9.74	10.29	10.09	7.04	2.36	0.91	0.47	0.34	0.20	0.07	0.20
2005	28.30	22.32	15.63	7.49	6.12	6.23	3.73	1.47	0.48	0.30	0.17	0.09	0.14
2006	31.95	22.43	15.68	11.55	5.81	3.79	3.89	2.15	0.86	0.26	0.16	0.09	0.11
2007	24.23	26.83	15.01	10.73	6.98	3.69	1.97	2.12	1.17	0.48	0.14	0.09	0.10
2008	24.63	16.48	19.15	9.66	7.53	4.17	2.09	1.06	1.01	0.58	0.26	0.07	0.10
2009	18.53	20.07	11.71	13.40	6.89	4.02	1.90	0.91	0.46	0.44	0.27	0.13	0.08
2010	24.66	11.46	16.09	8.75	8.34	3.46	1.55	0.66	0.36	0.16	0.17	0.10	0.08
2011	26.76	19.95	7.64	11.88	6.33	4.36	1.58	0.70	0.26	0.13	0.07	0.06	0.07
2012	20.04	21.72	13.90	5.37	7.20	4.28	2.11	0.74	0.33	0.11	0.07	0.03	0.06
2013	22.83	12.79	16.40	10.34	4.28	3.96	2.28	0.96	0.31	0.15	0.06	0.03	0.04
2014	13.95	18.40	8.10	12.27	6.52	2.29	2.48	1.08	0.43	0.12	0.07	0.02	0.03
2015	11.58	8.81	16.24	6.26	7.77	3.75	1.27	1.21	0.39	0.16	0.05	0.02	0.02
2016	8.41	8.44	6.98	15.60	5.62	4.79	2.05	0.69	0.54	0.13	0.07	0.02	0.02

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+
2017	8.81	5.30	6.44	6.33	13.36	3.50	2.40	1.00	0.33	0.18	0.04	0.03	0.02
2018	17.34	5.06	4.18	4.09	5.45	9.04	2.51	1.12	0.49	0.15	0.07	0.02	0.02
2019	19.86	14.65	4.75	3.33	3.29	3.67	5.62	1.87	0.81	0.29	0.08	0.04	0.02