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Canadian Science Advisory Secretariat (CSAS)

Research Document 2026/060

Newfoundland and Labrador Region

Stock Assessment and Application of Management Procedure for Atlantic Cod (*Gadus morhua*) Stock in NAFO Subdivision 3Ps in 2023

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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.

Published by:

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

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



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ISSN 1919-5044

ISBN 978-1-100-00269-9 Cat. No. Fs70-5/2026-060E-PDF

Correct citation for this publication:

Varkey, D.A., Wheeland, L.J., Kumar, R., Regular, P., Hatefi, F., Rideout, R., and Skanes, K. 2026. Stock Assessment and Application of Management Procedure for Atlantic Cod (*Gadus morhua*) Stock in NAFO Subdivision 3Ps in 2023. DFO Can. Sci. Advis. Sec. Res. Doc. 2026/060. iv + 34 p.

Aussi disponible en français :

Varkey, D.A., Wheeland, L.J., Kumar, R., Regular, P., Hatefi, F., Rideout, R., et Skanes, K. 2026. Évaluation du stock et application d'une procédure de gestion pour le stock de morue de l'Atlantique (*Gadus morhua*) dans la sous-division 3Ps de l'OPANO en 2023. Secr. can. des avis sci. du MPO. Doc. de rech. 2026/060. iv + 35 p.

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ABSTRACT

The status of the cod stock in the Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps was assessed during a Fisheries and Oceans Canada (DFO) Regional Peer Review Process meeting held November 6–10, 2023. This document supports the conclusions and advice presented in the Science Advisory Report (SAR), and should be considered alongside the other documents output from this meeting. An integrated state space model was used to assess the status of the stock and estimate fishing mortality. This model incorporates catch (1959–2022), time varying natural mortality informed by trends in cod condition, and includes abundance indices from bottom trawl surveys conducted by Canada (1983–2005, 2007–19, 2022), France (1978–91), and industry (Groundfish Enterprise Allocation Council [GEAC], 1998–2005), and standardized catch rate indices from the Sentinel gillnet and line-trawl surveys (1995–2022). Spawning Stock Biomass (SSB) at January 1, 2024 was estimated to be 35.5 kt (27.1 kt–46.8 kt). The stock is in the Critical Zone (54% of Blim [38–60%]) as defined by the DFO Precautionary Approach (PA) Framework. The probability of being below Blim is >99.9%. The estimated fishing mortality rate (ages 5–8) has declined to 0.02 in 2023. Natural mortality was estimated to be 0.35 (ages 5–8) in 2022, an increase from the previous assessment. Although the estimated fishing mortality rate has decreased, the elevated natural mortality diminishes the prospects for short-term rebuilding of the stock. Recruitment (age 2) estimates have been below the long term average since the mid-1990s. As per the management procedure adopted for this stock, the maximum Total Allowable Catch (TAC) is based on a fishing mortality (F) equal 0.065 when the stock is in critical zone; this corresponds to a maximum TAC of 1550 t for 2024–25. In the short term projections, the probability of stock growth is low and there is a probability >99% that the stock will remain below Blim between 2025 and the beginning of 2027.

INTRODUCTION

This document outlines the results of the 2023 analytical assessment of Atlantic Cod (*Gadus morhua*) stock in North Atlantic Fisheries Organization (NAFO) Subdivision (Subdiv.) 3Ps, based on an integrated age-structured population model called 'Hybrid'. The assessment model incorporates scientific data from bottom trawl surveys (Canada, 1983–2022; France, 1978–92); an industry association Groundfish Enterprise Allocation Council (GEAC) (1997–2007), the inshore Sentinel gillnet and line trawl Survey (1995–2022), and commercial landings data and catch-at-age data. Natural mortality estimates in the model are informed by a cod condition-based index of mortality (M_c). Figure **Error! Reference source not found.** is a summarized presentation of the timeline of all data contributing to the assessment. Greater detail on all input data can be found in Wheeland et al. (2025).

The 3Ps cod stock is located in southern Newfoundland in the NAFO subdivision 3Ps. Owing to the location of the St. Pierre and Miquelon territories of France, the stock is jointly managed by Canada and France. In 2019, amendments to the Fisheries Act introduced Fish Stock Provisions (FSP) to support sustainable management of fish stocks and rebuilding of depleted stocks. Given the ecological and economic importance of the 3Ps cod stock in the region, it was designated as one of the 30 major stocks under the FSP. As the stock was in the critical zone, efforts were directed towards developing a rebuilding plan, and simulation work undertaken during this process led to the adoption of a management procedure (MP) to provide advice on maximum Total Allowable Catch (TAC) for the stock (DFO 2024, Varkey et al. 2026).

INPUT DATA

FISHERIES LANDINGS

Fishery records for the stock date back to the late 1950s and the fishery ranged from 50,000 to 80,000 t in the 1960s, 30,000 to 60,000 t in 1970–80s, followed by a rapid decline in 1990s. A moratorium was imposed on the stock from August 1993 to 1996. The fishery reopened in 1997 with a TAC close to 10,000 t. The TAC increased to 30,000 t by 1999. The stock has declined since and the TAC levels gradually declined. For the 2022–23 management year, the TAC was 1,304 t. Landings data are included in a table (Table **Error! Reference source not found.**) but more details about the fishery and landings information from 1959–2022 is outlined in the associated document (Wheeland et al. 2025) and references therein. The censored likelihood fit for landings uses lower and upper bounds to account for uncertainty in the landings data (Figure **Error! Reference source not found.**) similar to the approach adopted for fitting landings information for the northern cod assessment (Cadigan 2015). In the current assessment, mark-recapture data were used to estimate recreational fishery catches (see Wheeland et al. 2025). Given decreases in TAC, recent average estimated recreational catches accounted for >10% of total annual landings and would not be captured by the previously adopted catch bounds. Catch bounds in the assessment model were therefore increased from 1.1 to 1.3 for years 2020 onward.

Catch-at-age (1959–2022)

Since the previous assessment in 2021, two additional years of catch-at-age (2021 and 2022) information are included in this assessment (Table A2).

CAN-RV Spring Survey (1983–2022)

Canadian research vessel (“CAN RV”) bottom trawl surveys have been conducted in Subdiv. 3Ps since 1972, however surveys from 1972 to 1982 had limited coverage (Wheeland et al. 2025). The 2021 survey was the last year when data were collected using research vessel Canadian Coast Guard Ship (CCGS) *Alfred Needler*. The 2022 survey was conducted by the research vessel CCGS *John Cabot*, and based on the analysis of data collected from comparative fishing (Wheeland and Trueman 2024), the assessment model uses the cod survey index data at 1:1 correspondence between these two vessels, and with earlier data collected by the CCGS *Teleost* and CCGS *Wilfred Templeman*. There was no survey of Subdiv. 3Ps in 2023. Abundance at age (mean number per tow) from the research vessel (RV) survey (Table **Error! Reference source not found.**) is a key input in the Hybrid model. The CAN-RV Spring survey data are also used for computation of maturity at age (Table A4) and beginning of the year stock weights-at-age (Table A5). The stock weights are calculated based on a mixed effects model (Cadigan 2023) applied to the mean-weights at age from the CAN-RV survey.

Fisheries resource assessment of the 3Ps region (ERHAPS) trawl survey (1978–91)

France conducted a bottom trawl research survey in Subdiv. 3Ps during February-March of 1978 to 1992 (Bishop et al. 1993). The ERHAPS survey used the same stratification scheme as the Canadian survey. However, only the offshore strata were sampled. A Lofoten otter trawl was used during daylight hours to conduct 30 minute tows. Further, data for unsampled strata were estimated from a multiplicative model based on the results of the Canadian survey for the same strata. The vessel changed in 1992. Since data from the two vessels could not be converted, data from 1978 to 1991 were used in the assessment model and data from 1992 were excluded (Table A6).

GEAC Trawl Survey (1998–2005)

An industry-led bottom trawl survey was conducted from 1997 to 2005 and in 2007 (see McClintock 2011 and references therein). This survey also used the stratification scheme of the Canadian and French surveys. An Engel trawl was used, although it did not have a cod-end liner. Tows were 30 minute duration. The 1997 and 2007 data were excluded from the model because of coverage and vessel issues (Table A7).

Sentinel Gill Net and Line Trawl (1995–2022)

Fixed-gear Sentinel surveys have been conducted at sites along the south coast of Newfoundland from St. Bride’s to Burgeo from 1995 through 2022. The Sentinel survey for 2023 was still ongoing at the time of the assessment; hence, data for 2023 are incomplete and not included in the modelling reported below. Sentinel methods and results are detailed in Kumar et al. 2026 and references therein. Standardized catch rates at age are input in the assessment model from fixed sites in the 5 ½” gillnet (Table A8) and the line-trawl (Table A9) series.

Condition-based M-index (1978–2022)

Biological sampling data from both the CAN-RV spring survey and Sentinel gillnet and line-trawl surveys are utilized to generate an index of natural mortality (M) derived from proportion of cod in poor condition (see Regular et al. (2022) for more detail on index calculation). This condition-based index of M is available from 1978 to 2023 (Table A10). For the years 1959 to 1977, the average of the first five years of the index is used.

Hybrid assessment model description

The assessment model, Hybrid, (Varkey et al. 2022) has been used to assess the stock since 2019. The Hybrid model is named as such because it uses a variety of features from SAM (Nielsen and Berg 2014) (mainly the use of random effects for modelling N and F matrices) and the Northern Cod Assessment Model (Cadigan 2015), mainly the inclusion of expert opinion on reliability of landings time series through the use of censored likelihood. The model has the following main features:

1. includes all the available surveys (Canadian RV survey, French ERHAPS, industry trawl survey, and gillnet and line-trawl Sentinel surveys);
2. two types of commercial data—fisheries catch-at-age where the age composition is fit using continuation ratio logits, and fisheries landings which are fit using a censored likelihood;
3. multivariate normal (MVN) random walk for fishing mortality (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. the model starts in 1959 which is the first year for which landings data are available.

The time-varying natural mortality is modelled as a function of a scaled fish condition-based mortality index; at previous assessments, the trend used was the normalized condition based index (see Varkey et al. (2022), equation 1). From this assessment onwards, the log of the condition index is normalized (equation 2) and applied in the function (equation 3).

$$X_y = \frac{Mc_y - \mu_{Mc}}{\sigma_{Mc}} \quad (1)$$

$$X_y = \frac{\log(Mc_y) - \mu_{\log(Mc)}}{\sigma_{\log(Mc)}} \quad (2)$$

$$M_{a,y} = M_{base} e^{mpar_a \cdot X_y} \quad (3)$$

RESULTS

MODEL FITS AND DIAGNOSTICS

From the previous assessment, there is one additional year of CAN-RV survey and two additional years of sentinel data. Similar to the model fits at the previous assessment, model predictions of recruits (age 2 fish) in the RV survey are below the observed indices (Figure B1). The sentinel line trawl for both additional years 2021 and 2022 for ages 3 to 6 are lower than the corresponding indices in 2020, and these are the main factors negatively affecting the RV fit for ages 2 and 3. The model fits the younger age indices from the Sentinel surveys more closely than it fits the indices in the RV survey (Figures B2 and B3). The indices for age groups 4 to 6, the CAN-RV indices are slightly higher than the index in 2021, and the fits are better. For ages 7 and above, where two consecutive years of data are available, the index in 2022 is at par or lower than the value in 2021, however most of these values are above the levels from 2015–19. The Sentinel line-trawl indices in recent years have also shown large increases for the older ages. For example, at the previous assessment, the sentinel line-trawl indices showed time series highs for ages 8, 9 and 10. The 2021 and 2022 indices for ages 8 and 9 show a decline. The model predictions follow the increase from 2015, but show recent declines for ages 9 and 10. In summary, the stock trends reported by the model are influenced by both the RV survey

and the sentinel survey, however, for the trends in the recent years, the increase in the indices for the older ages in the sentinel seem to be having a greater influence.

The error plots for the RV data do not indicate major year or age effects but there do appear to be recent cohort effects (Figure B4). Recent cohort effects are noted in the sentinel survey fits as well (Figures B5 and B6). The error plots for the Sentinel gillnet series show clear year effects in the early part of the time series (Figure B5); this coincides with the early phase of the Sentinel program which was initiated while the fishery was in a moratorium. When the fishery reopened, there was a TAC of 10, 20, and 30 kt in 1997, 1998, and 1999, respectively. Model fits and error plots for the French and GEAC surveys are shown in Figures B7–B10.

MODEL OUTPUTS

Model results indicate that Spawning Stock Biomass (SSB) declined from the beginning of the time series from levels higher than 200 kt in the early 1960s to values near the Limit Reference Point (LRP) by the mid-1970s (Figure 3). Subsequently, SSB increased and was estimated to be above 100 kt over 1981 to 1988, followed by a continuous decline to less than 40 kt in 1993. The estimated SSB was below the LRP from 1991 to 1994. Following the start of the moratorium (1993), estimated SSB increased, but by 1999 had started declining again. From about 2001 to 2006, SSB was relatively stable at values below the LRP. SSB decreased in the mid-2000s, and has been stable at a low level (near 30 kt) since 2009. The SSB estimated for the beginning of year 2023 was 34.1 kt (95% confidence interval (CI) = 27.4 to 42.7 kt). With a projected catch of 1304 t for 2023, the SSB in the beginning of year 2024 will be 35.5 kt (95% CI = 27.1 to 46.8 kt). Combining positive and negative effects between different age groups, the model shows a small upward trend in stock status.

Recruitment estimates (Figure 4) peaked in 1965–66 at approximately 200 million age 2 fish, then generally declined until the late 1970s when there were about 50 million age 2 cod in the population. During most of the 1980s, recruitment was variable between 70 and 150 million fish. From 1993 onward, recruitment was generally low at values around 25 to 40 million fish with particularly low values (~9 million) during 2016–17. Recruitment levels have increased since, reaching near 21 million (95% CI = 9.2 to 48 kt) in 2022. Since the CAN-RV survey could not be completed in 2023, a more recent estimate of recruitment is not available. As noted earlier from the fits to CAN-RV survey data for age-2 fish, the model tends to under-estimate recruitment.

The assessment model provides estimates of both fishing mortality (F) and natural mortality (M). The estimated average fishing mortality rate for ages five to eight generally increased from 1959 (F = 0.23) to the mid-1970s (peaked at 0.4 in 1975) leading up to the extension of jurisdiction in 1977. Following this high, the F levels declined rapidly to approximately 0.27 and remained at similar values until the mid-1980s (Figure 5). Fishing mortality estimates generally increased again until the moratorium. Average F was near zero (<0.02) during the moratorium (1994–97) when removals were only from bycatch. The estimated average fishing mortality rate for ages 5–8 has generally declined from 0.15 in 2017 to 0.02, (95% CI = 0.02 to 0.03) in 2023. Ages 5–8 are typically the dominant ages in the fishery. However, as noted in the 2021 assessment, the catch-at-age for 2020 was dominated by age 9s (~45% by weight) reflecting the dominance of a single year class (2011) in the population and the fishery. At this assessment, the data showed a reduction in the dominance of the 2011 year class in the fishery, and a resultant shift in the selectivity pattern showing greater presence of fish aged 5 to 8.

Generally, M estimates were consistent, near 0.33 from 1959 to 1980, followed by a decline to 0.27 through the early 2000s. M subsequently increased and reached a time series high at 0.40 in 2019 (Figure 6). M in 2022 is estimated to be 0.35, (95% CI = 0.32 to 0.37). With the revision

to the estimation of M, the *mpar* parameter was revised upwards from 0.13 to 0.15 (Table 1) indicating a slightly stronger dependence on fish condition.

RETROSPECTIVE ANALYSES

The two new values for the Sentinel index for the older ages 8 and 9 were lower in 2021 and 2022 compared to the value in 2020. Further, compared to the previous assessment, there is revision to the sentinel indices and the inclusion of log of condition based index for M. These changes together lead to a small revision in the trends for the stock (Figure 7). At the 2021 assessment, it was assumed that the TAC of 1,346 t would be caught. The F estimates in 2021 have revised downward (Figure 8) and part of the reason for the revision downwards in F estimates for years 2021 are that landings (826 t) were smaller than the TAC. Retrospective revision in M estimation is small (Figure 9).

PROJECTIONS AND APPLICATION OF MP

For model projection years, the quantities such as recruitment, stock weights-at-age, condition based index for M, and catch weights are based on averages of the last three years from the assessment. Maturity-at-age was based on projected maturity for years 2024–27 from the cohort-based maturity model. Catch for 2023 was assumed to be equal to the TAC (1,304 t). Process error in projections were simulated from 2024 onwards based on the process error standard deviations estimated in the model. Projections were conducted based on the adopted MP for the stock which specifies an $F = 0.065$ when the stock is in the critical zone. A scenario of no removals was presented for comparison. There is high probability that the stock will remain in the critical zone during the short term projection period (Table 2).

The trajectory of the projections under the adopted MP was compared with the expected progress under the rebuilding plan. The rebuilding plan stipulates a check of whether the median SSB estimates from the assessment model and projections fall within the 75 percent probability envelope from the rebuilding projections under prevailing productivity conditions. This check (Figure 10) showed considerable overlap with the rebuilding plan projections, but also showed that the median values for all short-term projection years under the MP were below the median values from the rebuilding plan projections.

SOURCES OF UNCERTAINTY

The 2018 Sentinel line-trawl indices were at time series lows for ages 3 to 5 while the 2019 indices were comparatively much higher for several age groups. The increase in index, especially of older ages in the index led to the revision of the trajectories for several years for these cohorts. At this assessment, indices for ages 8 and 9 trended downward. Although this index covers only a small portion of the stock, it shows good internal consistency and for this reason, the model is sensitive to the Sentinel index. The model under-estimates the index for the young ages in the DFO-RV survey in the post-2010 period, mainly because the model fits the younger age indices from the Sentinel surveys more closely than it fits the indices in the RV survey for the younger ages. Although, the model fits well to all other ages (6–14+) in the DFO-RV survey and the catch-at-age, this issue is a source of uncertainty that requires further research.

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TABLES

Table 1: Parameter estimates from the assessment model.

Parameter names	Age	Value	Parameter names	Age	Value
mpar	2 to 5	0.0000	q_Sentinel_LT	3	0.0324
mpar	6 plus	0.1515	q_Sentinel_LT	4	0.1353
q_DFO_RV_IO	2	0.1709	q_Sentinel_LT	5	0.2539
q_DFO_RV_IO	3	0.3718	q_Sentinel_LT	6	0.3196
q_DFO_RV_IO	4	0.3766	q_Sentinel_LT	7	0.3611
q_DFO_RV_IO	5	0.3125	q_Sentinel_LT	8	0.3912
q_DFO_RV_IO	6	0.2971	q_Sentinel_LT	9	0.3460
q_DFO_RV_IO	7	0.2778	q_Sentinel_LT	10	0.3130
q_DFO_RV_IO	8 plus	0.2744	rhoF_postmoratorium	all	0.9889
q_DFO_RV_OFF	2	0.0429	rhoF_premoratorium	all	0.9711
q_DFO_RV_OFF	3	0.0743	std_CRL	2	2.5743
q_DFO_RV_OFF	4	0.0932	std_CRL	3	0.6705
q_DFO_RV_OFF	5	0.1559	std_CRL	5 to 8	0.2016
q_DFO_RV_OFF	6	0.2102	std_CRL	9 plus	0.6732
q_DFO_RV_OFF	7	0.2412	std_f_pre_moratorium	2	0.7479
q_DFO_RV_OFF	8	0.3117	std_f_pre_moratorium	3	0.0930
q_DFO_RV_OFF	9	0.3149	std_f_pre_moratorium	4	0.0695
q_DFO_RV_OFF	10	0.3113	std_f_pre_moratorium	5	0.0551
q_DFO_RV_OFF	11	0.3202	std_f_pre_moratorium	6	0.1205
q_DFO_RV_OFF	12	0.2994	std_f_pre_moratorium	7	0.2130
q_DFO_RV_OFF	13	0.3092	std_f_pre_moratorium	8	0.2101
q_DFO_RV_OFF	14	0.2992	std_f_pre_moratorium	9	0.3502
q_ERHAPS	2	0.0470	std_f_post_moratorium	2	0.6199
q_ERHAPS	3	0.0702	std_f_post_moratorium	3	0.7416
q_ERHAPS	4	0.1013	std_f_post_moratorium	4	0.8260
q_ERHAPS	5	0.1705	std_f_post_moratorium	5	0.6126
q_ERHAPS	6	0.2398	std_f_post_moratorium	6	0.5787
q_ERHAPS	7 plus	0.2740	std_f_post_moratorium	7	0.6139
q_GEAC	2	0.0063	std_f_post_moratorium	8	0.6000
q_GEAC	3	0.0783	std_f_post_moratorium	9	0.6499
q_GEAC	4	0.2417	std_index_DFO_RV_IO	all	0.8758
q_GEAC	5	0.3508	std_index_DFO_RV_OFF	all	0.6850
q_GEAC	6	0.4643	std_index_ERHAPS	all	0.7304
q_GEAC	7 plus	0.6936	std_index_GEAC	all	1.1866
q_Sentinel_GN	4	0.0037	std_index_Sentinel_GN	all	0.6809
q_Sentinel_GN	5	0.0473	std_index_Sentinel_LT		0.3977
q_Sentinel_GN	6	0.1846	std_process_error	all	0.2247

Parameter names	Age	Value	Parameter names	Age	Value
q_Sentinel_GN	7	0.3035	std_recruitment	all	0.3555
q_Sentinel_GN	8	0.3591			
q_Sentinel_GN	9	0.3577			
q_Sentinel_GN	10	0.2901			

Table 1: Risk of projected SSB being below the LRP under the adopted MP and under $F = 0$ over 2025–27.

F	Year	SSB/ B_{LIM}	SSB (‘000 t)	SSB Low (‘000 t)	SSB High (‘000 t)	Catch (t)	P(SSB _y > SSB ₂₀₂₄)	P(SSB _y > LRP)
MP	2024	0.54	35.5	27.1	46.8	1.550	NA	<0.1%
MP	2025	0.56	36.7	27.3	49.7	1.547	59%	<0.1%
MP	2026	0.58	38.1	27.6	53.8	1.597	67%	<0.1%
MP	2027	0.59	38.9	27.4	57.4	1.628	69%	<0.1%
F=0	2024	0.54	35.5	27.1	46.8	0.001	NA	<0.1%
F=0	2025	0.58	38.5	28.5	52.2	0.001	70%	<0.1%
F=0	2026	0.63	41.5	30.0	58.6	0.001	82%	<0.1%
F=0	2027	0.66	43.6	30.6	63.8	0.001	87%	1.70%

FIGURES

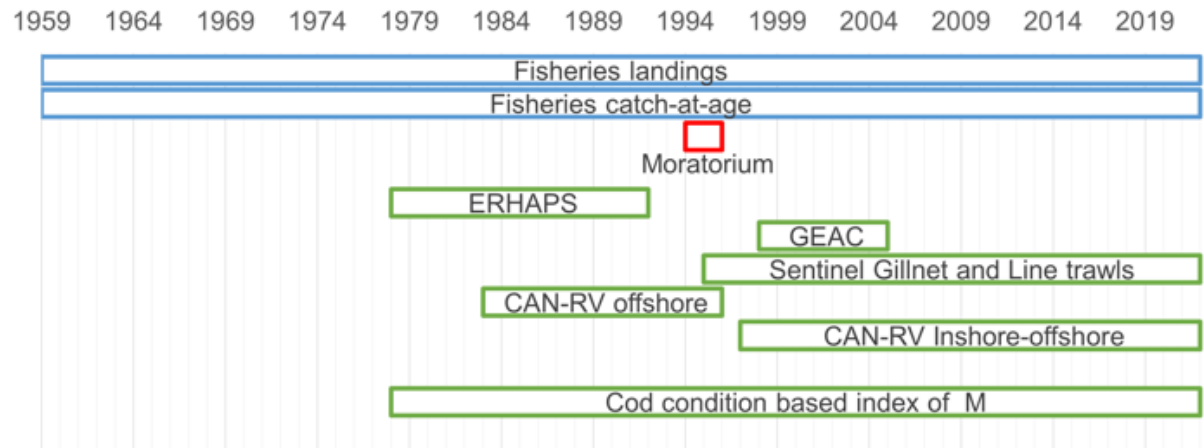


Figure 1: Timeline of data sources for the assessment.

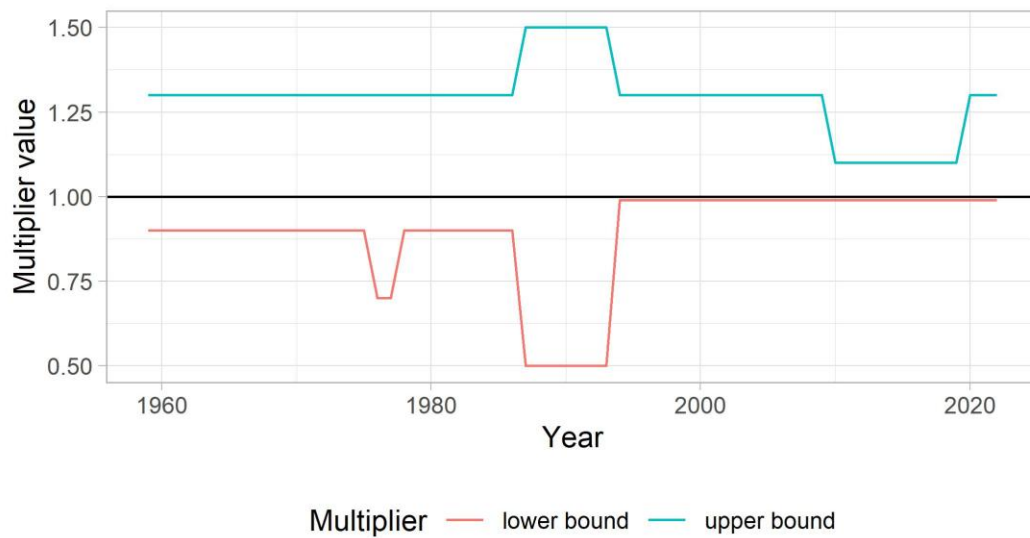


Figure 2: Lower and upper bounds for the landings estimation using censored likelihood.

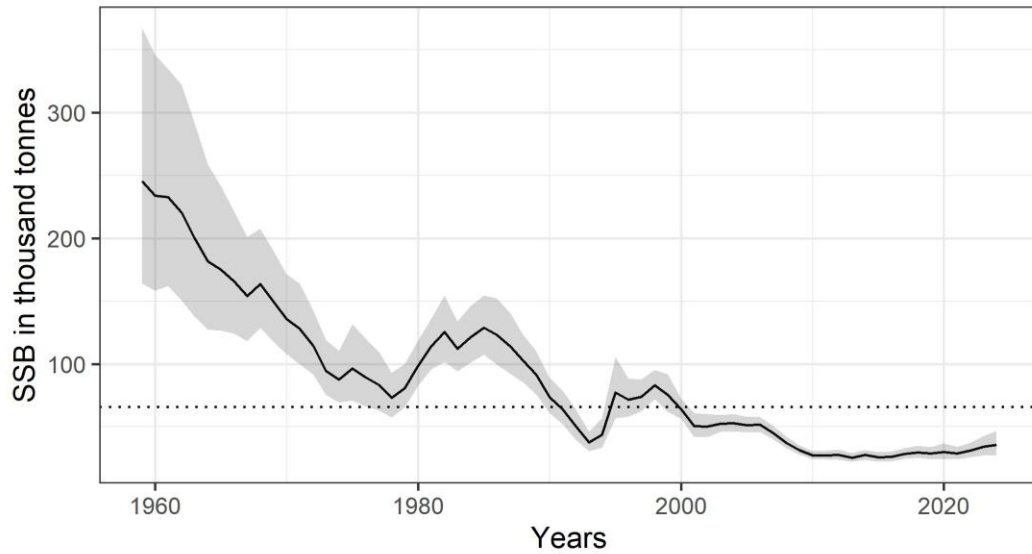


Figure 3: Estimates of SSB (median estimate with 95% confidence interval) for the period 1959 to 2022. Dashed line indicates *Blim*. This reference point represents the boundary between the Critical and Cautious Zones of DFO's Precautionary Approach framework.

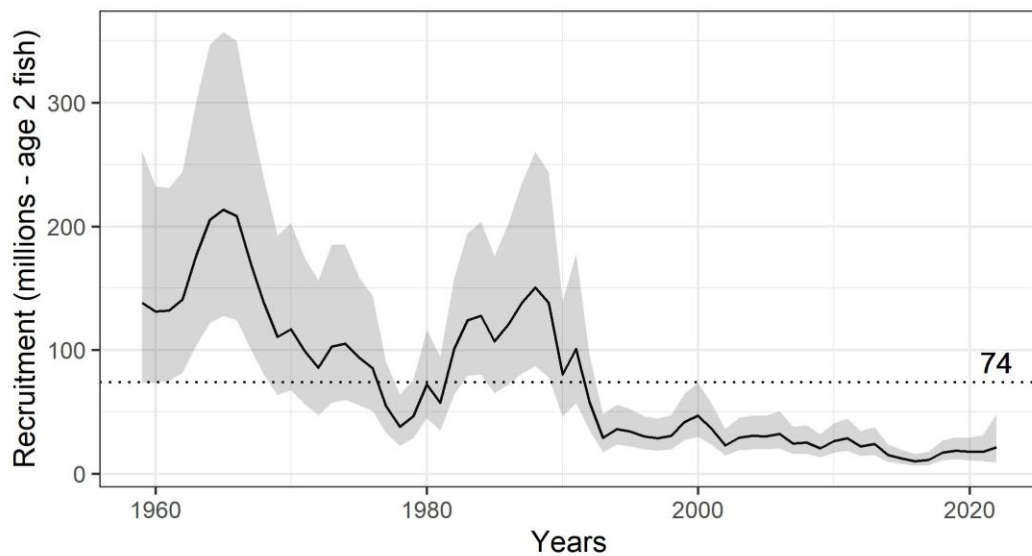


Figure 4: Estimates of recruitment for the period 1959 to 2021. The dotted line represents the time-series average of 74 million fish.

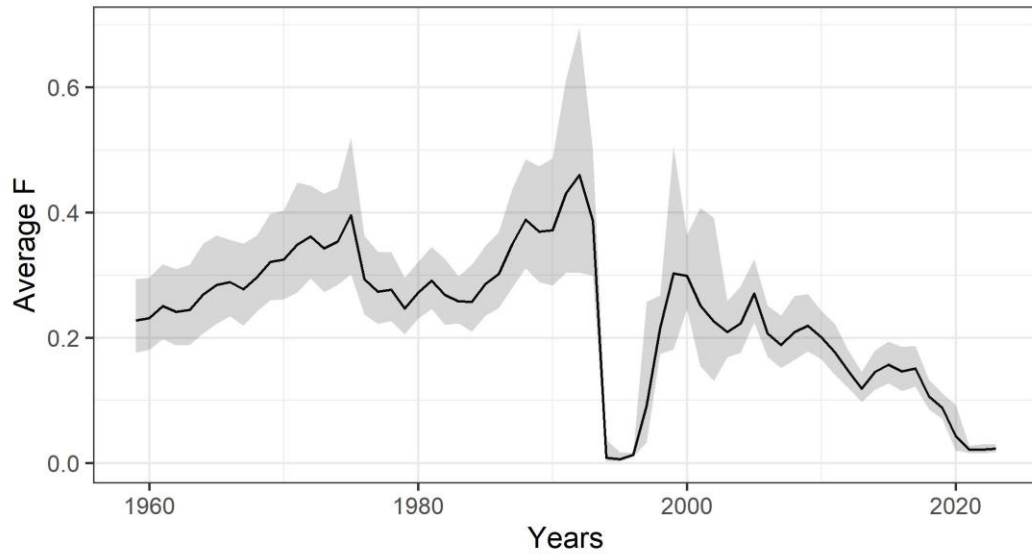


Figure 5: Average F (ages 5 to 9) estimates for 3Ps cod between 1959 and 2021.

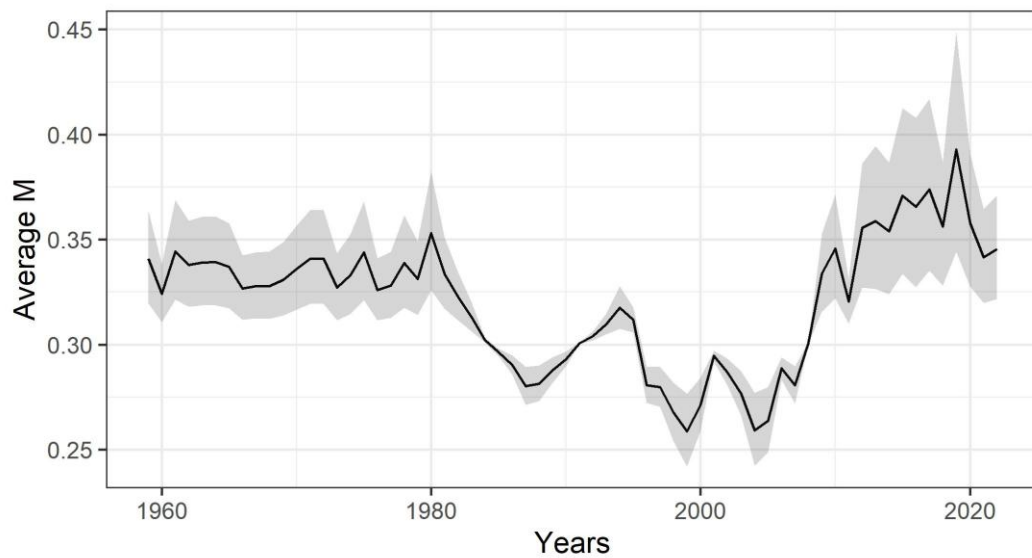


Figure 6: Natural mortality (Average M , ages 5 to 9) of 3Ps cod between 1959 and 2021. M is set at a base level of $M=0.3$ and scaled within the model based on the index of condition.

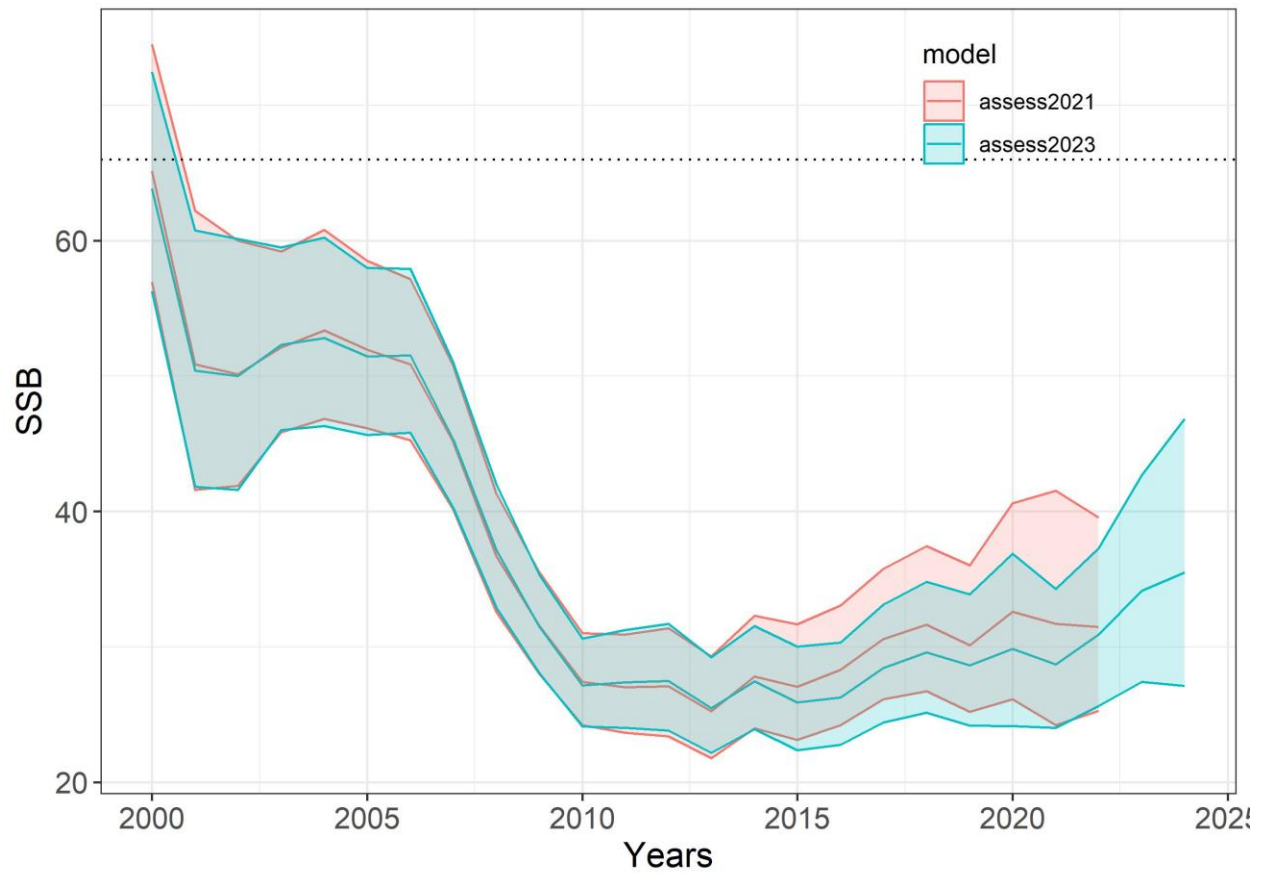


Figure 7: Assessment retro for Spawning Stock Biomass (SSB in thousand tonnes).

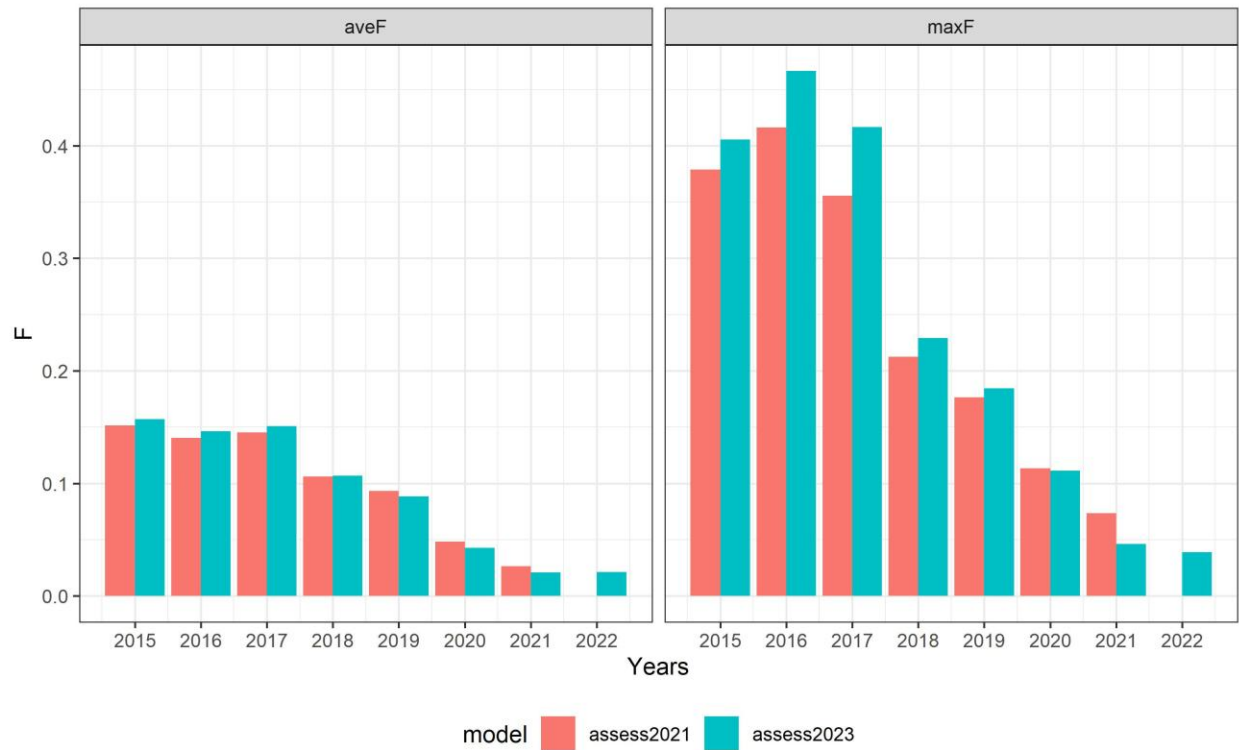


Figure 8: Assessment retro for average F and the F for fully selected ages.

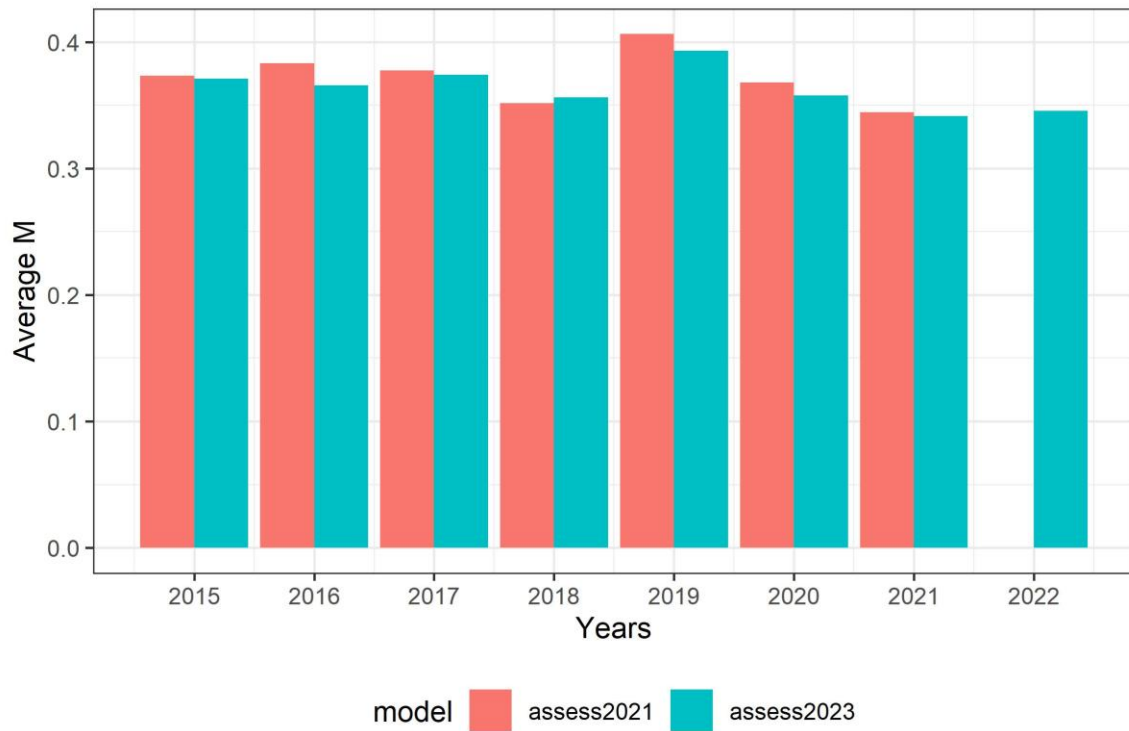


Figure 9: Assessment retro for average M .

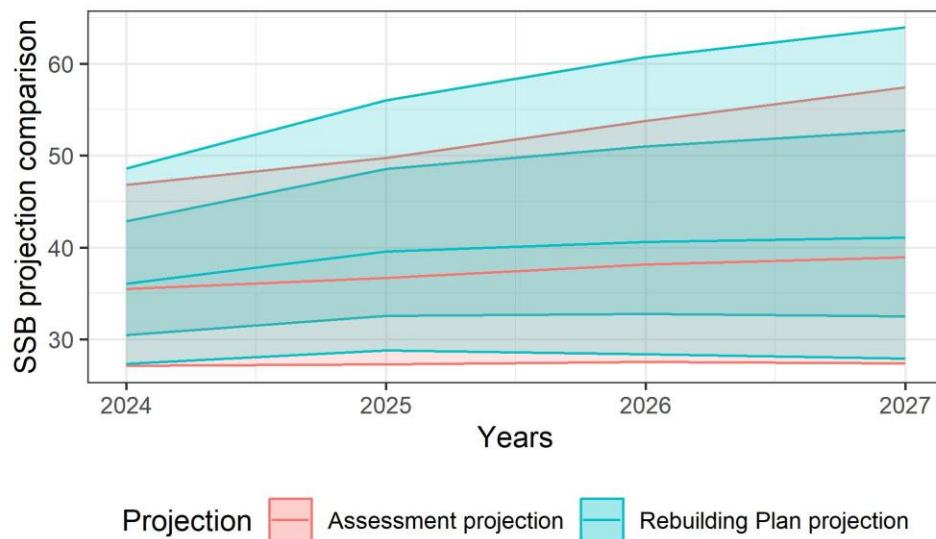


Figure 10: Comparison of projections from the current assessment (solid red line with 95% confidence intervals) with expected growth under the rebuilding plan (solid blue line with 75% and 95% confidence intervals shown).

APPENDIX A - TABLES

*Table A2: Total landings and lower and upper bounds (in tonnes). Lower and upper bounds were determined based on multipliers specified for different time periods in the fishery (**Error! Reference source not found.**).*

Year	Landings (t)	Lower Bound	Upper Bound
1959	60,170	54,153	78,221
1960	77,285	69,557	100,471
1961	86,824	78,142	112,871
1962	55,239	49,715	718,11
1963	51,821	46,639	67,367
1964	56,567	50,910	73,537
1965	51,853	46,668	67,409
1966	66,207	59,586	86,069
1967	62,774	56,497	81,606
1968	77,556	69,800	100,823
1969	63,799	57,419	82,939
1970	76,858	69,172	99,915
1971	62,448	56,203	81,182
1972	44,213	39,792	57,477
1973	52,641	47,377	68,433
1974	46,712	42,041	60,726
1975	35,373	31,836	45,985
1976	37,133	25,993	48,273
1977	32,245	22,572	41,919
1978	27,221	24,499	35,387
1979	33,006	29,705	42,908
1980	37,568	33,811	48,838
1981	38,892	35,003	50,560
1982	33,902	30,512	44,073
1983	38,451	34,606	49,986
1984	36,950	33,255	48,035
1985	51,367	46,230	66,777
1986	57,990	52,191	75,387
1987	59,204	29,602	88,806
1988	43,382	21,691	65,073
1989	39,540	19,770	59,310
1990	41,405	20,703	62,108
1991	43,589	21,795	65,384
1992	35,895	17,948	53,843
1993	15,216	7,608	22,824
1994	661	654	859
1995	821	813	1,067
1996	1,057	1,046	1,374
1997	9,420	9,326	12,246

Year	Landings (t)	Lower Bound	Upper Bound
1998	20,156	19,955	26,203
1999	27,997	27,717	36,397
2000	25,100	24,849	32,630
2001	16,546	16,380	21,509
2002	15,319	15,166	19,915
2003	15,260	15,108	19,838
2004	14,414	14,270	18,738
2005	14,776	14,628	19,208
2006	13,157	13,026	17,105
2007	12,959	12,829	16,847
2008	11,773	11,655	15,305
2009	9,762	9,664	12,691
2010	8,299	8,216	9,129
2011	6,876	6,807	7,563
2012	5,087	5,036	5,596
2013	4,366	4,322	4,803
2014	6,887	6,818	7,576
2015	6,460	6,395	7,106
2016	7,246	7,173	7,970
2017	6,641	6,574	7,305
2018	4,737	4,690	5,211
2019	3,528	3,493	3,881
2020	2,228	2,206	2,451
2021	826	818	1074
2022	909	900	1182

Table A2: Catch Numbers at age.

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	0	1001	13940	7525	7265	4875	942	1252	1260	631	545	44	1
1960	0	567	5496	23704	6714	3476	3484	1020	827	406	407	283	110
1961	0	450	5586	10357	15960	3616	4680	1849	1376	446	265	560	91
1962	0	1245	6749	9003	4533	5715	1367	791	571	187	140	135	389
1963	0	961	4499	7091	5275	2527	3030	898	292	143	99	107	284
1964	0	1906	5785	5635	5179	2945	1881	1891	652	339	329	54	233
1965	12	2314	9636	5799	3609	3254	2055	1218	1033	327	68	122	165
1966	0	949	13662	13065	4621	5119	1586	1833	1039	517	389	32	75
1967	0	2871	10913	12900	6392	2349	1364	604	316	380	95	149	55
1968	55	1143	12602	13135	5853	3572	1308	549	425	222	111	5	506
1969	0	774	7098	11585	7178	4554	1757	792	717	61	120	67	220
1970	0	756	8114	12916	9763	6374	2456	730	214	178	77	121	181
1971	0	2884	6444	8574	7266	8218	3131	1275	541	85	125	62	57
1972	0	731	4944	4591	3552	4603	2636	833	463	205	117	48	45
1973	0	945	4707	11386	4010	4022	2201	2019	515	172	110	14	29
1974	56	3025	8265	7080	4780	2457	1625	1053	490	241	63	42	79

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+
1975	0	675	3301	2557	4655	5357	874	778	233	169	51	20	26
1976	0	443	4161	7601	3178	2251	796	222	84	47	29	13	20
1977	0	552	7718	7976	4409	1008	308	276	108	48	57	26	30
1978	1	216	4474	5347	3004	1509	513	253	318	77	58	35	58
1979	1	130	1669	12064	4567	1839	720	252	49	36	4	3	9
1980	0	188	1597	4846	7864	3447	1080	366	107	77	43	13	69
1981	0	1074	3616	2745	3914	5210	1663	576	190	142	127	22	56
1982	8	190	4447	4337	1757	3063	3560	672	208	54	16	7	14
1983	9	754	2733	9536	3008	1471	1050	1256	293	109	49	21	20
1984	5	359	4241	4984	4852	1695	533	436	354	47	25	6	11
1985	0	160	2839	7950	5406	4994	1624	606	654	267	98	18	26
1986	55	1442	8677	8914	9077	3822	2204	832	306	198	78	46	54
1987	0	636	2517	7779	7902	6605	1823	1298	466	141	131	144	136
1988	3	375	3474	3455	7380	4912	1448	619	423	229	119	79	100
1989	23	1104	6967	4991	2056	2393	1606	960	528	314	110	57	67
1990	0	1241	5902	6370	3463	1843	1705	1239	749	129	109	34	110
1991	4	425	7592	5925	3873	1615	756	875	784	333	181	197	221
1992	7	1370	3087	6052	4004	1339	449	206	251	211	177	119	438
1993	0	278	3712	2035	3156	1334	401	89	38	52	13	14	5
1994	0	1	30	152	72	79	41	19	2	2	0	0	0
1995	0	0	0	39	102	34	26	5	0	0	0	0	0
1996	0	2	16	19	77	117	38	13	8	1	0	0	0
1997	1	14	455	1345	602	769	922	254	113	124	7	13	1
1998	0	83	298	964	1605	946	1512	1371	233	110	55	16	3
1999	0	49	677	1333	2139	2479	1155	901	849	203	127	23	14
2000	0	23	408	828	1539	1573	1696	589	507	977	133	45	45
2001	1	76	576	844	1162	1172	796	720	269	186	199	25	17
2002	1	112	591	1416	1283	1009	788	451	372	112	79	81	11
2003	1	18	363	1051	2063	1278	644	353	277	156	58	46	84
2004	4	66	144	714	1826	1855	665	281	165	82	44	14	39
2005	0	70	427	634	1106	1653	1236	598	157	114	45	25	39
2006	0	47	279	927	992	911	1155	727	324	95	40	24	29
2007	3	63	279	756	1122	875	540	575	485	178	54	42	42
2008	0	9	212	642	1314	1069	653	351	329	208	110	27	38
2009	0	20	131	914	1037	841	469	223	102	93	66	45	28
2010	0	8	404	590	1301	741	399	208	80	24	68	34	20
2011	1	28	152	922	912	893	362	169	64	27	21	8	15
2012	0	10	80	202	723	646	398	143	64	22	32	4	11
2013	0	10	166	458	393	495	361	149	56	22	16	4	8
2014	0	6	59	785	796	367	564	218	132	28	32	5	3
2015	0	2	289	298	893	610	262	303	72	32	7	3	4
2016	0	2	78	912	649	797	385	102	128	38	21	10	3
2017	0	0	18	262	1408	512	472	211	74	46	11	18	7
2018	0	2	27	102	425	1033	316	111	49	15	5	1	2
2019	0	6	28	69	151	262	595	209	103	54	14	6	6
2020	0	1	9	29	89	100	124	337	41	30	14	3	2
2021	0	0	7	48	167	41	29	51	37	21	4	2	7

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+
2022	0	1	14	46	99	93	50	33	20	28	1	3	0

Table A3: CAN-RV survey.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14+
1983	10.01	6.52	1.14	3.72	1.62	0.48	0.89	1.61	0.75	0.36	0.14	0.06	0.20
1984	5.40	2.33	1.55	0.63	2.11	0.77	0.37	0.46	0.71	0.18	0.14	0.06	0.11
1985	7.74	14.88	12.56	9.96	3.28	2.66	0.79	0.48	0.42	0.42	0.49	0.21	0.29
1986	6.62	5.65	6.48	7.95	6.33	2.13	1.47	0.84	0.29	0.24	0.29	0.17	0.24
1987	8.48	5.67	4.97	13.82	8.31	3.35	1.29	0.69	0.28	0.23	0.16	0.17	0.42
1988	9.13	5.93	2.96	2.84	6.50	5.84	3.65	1.49	0.84	0.74	0.35	0.16	0.38
1989	6.50	4.66	3.17	1.51	1.16	2.15	1.21	0.67	0.37	0.41	0.13	0.11	0.29
1990	1.48	9.82	14.49	10.89	5.67	3.84	3.13	1.15	0.71	0.32	0.16	0.12	0.19
1991	27.69	5.03	10.00	11.24	5.75	2.84	1.58	1.19	0.74	0.56	0.22	0.11	0.18
1992	1.80	6.95	2.11	4.15	2.03	1.03	0.53	0.26	0.24	0.08	0.04	0.01	0.04
1993	0.00	1.99	4.04	1.49	1.35	0.47	0.10	0.04	0.03	0.04	0.01	0.00	0.02
1994	1.63	1.46	4.31	6.10	1.73	1.62	0.50	0.08	0.04	0.03	0.02	0.01	0.02
1995	0.31	1.16	1.67	13.08	19.65	4.40	5.75	2.19	0.25	0.20	0.01	0.07	0.03
1996	1.08	3.67	3.62	1.32	2.69	2.91	0.54	0.46	0.09	0.09	0.02	0.00	0.00
1997	1.68	2.44	1.01	0.46	0.25	0.26	0.21	0.12	0.04	0.01	0.00	0.00	0.00
1998	1.28	6.28	7.40	4.91	3.53	1.73	2.19	2.43	0.38	0.26	0.06	0.03	0.00
1999	3.05	2.52	2.26	2.41	2.12	1.54	0.39	0.68	0.52	0.07	0.02	0.02	0.01
2000	3.84	6.66	3.52	2.24	1.75	1.11	0.80	0.31	0.28	0.46	0.11	0.00	0.01
2001	2.88	11.44	10.58	3.71	1.74	1.08	0.66	0.60	0.32	0.43	0.80	0.10	0.11
2002	1.53	3.72	7.08	4.95	2.58	1.73	0.85	0.45	0.31	0.07	0.11	0.16	0.01
2003	2.62	2.24	3.67	5.88	3.51	1.34	0.63	0.28	0.16	0.17	0.04	0.09	0.02
2004	2.24	2.50	1.85	1.93	3.49	3.61	1.08	0.68	0.57	0.67	0.13	0.09	0.08
2005	1.63	7.32	7.27	3.49	2.08	1.52	1.20	0.41	0.09	0.15	0.06	0.03	0.24
2007	2.34	5.33	3.26	2.11	1.14	0.76	0.35	0.56	0.37	0.12	0.10	0.07	0.07
2008	4.09	4.30	3.27	1.99	1.22	0.50	0.34	0.12	0.14	0.08	0.04	0.02	0.02
2009	2.47	8.64	5.81	4.91	2.65	1.53	0.84	0.18	0.15	0.18	0.32	0.12	0.04
2010	2.76	7.75	13.95	5.87	3.53	1.27	0.25	0.08	0.03	0.03	0.07	0.01	0.01
2011	4.63	6.37	2.56	5.46	2.04	1.42	0.49	0.09	0.08	0.00	0.02	0.01	0.01
2012	3.99	11.21	6.37	3.34	3.39	1.76	0.94	0.16	0.25	0.01	0.04	0.00	0.04
2013	19.94	12.11	16.14	5.83	4.04	2.72	2.06	0.48	0.24	0.06	0.01	0.00	0.01
2014	5.21	11.03	4.54	2.23	1.11	0.41	0.83	0.42	0.06	0.00	0.01	0.00	0.01
2015	4.90	8.47	10.97	2.87	1.17	0.92	0.31	0.43	0.06	0.01	0.00	0.00	0.00
2016	2.58	5.98	4.62	4.71	2.00	0.69	0.22	0.12	0.14	0.01	0.00	0.00	0.00
2017	3.22	4.34	3.99	3.57	2.62	0.62	0.38	0.09	0.04	0.05	0.00	0.00	0.00
2018	5.40	4.56	2.59	1.73	2.22	2.29	0.23	0.19	0.17	0.13	0.01	0.00	0.00
2019	6.73	6.77	4.32	2.00	1.20	0.90	0.31	0.13	0.04	0.04	0.00	0.01	0.00
2021	9.69	5.15	2.88	1.23	1.04	0.45	0.63	0.34	0.26	0.12	0.03	0.00	0.01
2022	10.56	10.37	3.50	1.62	1.12	0.37	0.33	0.18	0.19	0.11	0.01	0.02	0.00

Table A4: Proportion mature at age.

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	0.001	0.004	0.014	0.068	0.194	0.470	0.757	0.914	0.972	0.991	0.997	0.999	1.000
1960	0.000	0.003	0.015	0.061	0.180	0.470	0.757	0.914	0.972	0.991	0.997	0.999	1.000
1961	0.000	0.000	0.011	0.054	0.227	0.400	0.757	0.914	0.972	0.991	0.997	0.999	1.000
1962	0.001	0.001	0.001	0.046	0.174	0.569	0.669	0.914	0.972	0.991	0.997	0.999	1.000
1963	0.000	0.004	0.010	0.011	0.173	0.441	0.856	0.860	0.972	0.991	0.997	0.999	1.000
1964	0.001	0.003	0.018	0.078	0.110	0.474	0.747	0.964	0.949	0.991	0.997	0.999	1.000
1965	0.000	0.005	0.018	0.091	0.413	0.574	0.795	0.917	0.992	0.983	0.997	0.999	1.000
1966	0.000	0.003	0.025	0.104	0.349	0.853	0.937	0.944	0.976	0.998	0.994	0.999	1.000
1967	0.000	0.001	0.016	0.126	0.428	0.741	0.980	0.994	0.986	0.994	1.000	0.998	1.000
1968	0.001	0.000	0.007	0.085	0.444	0.829	0.938	0.997	0.999	0.997	0.998	1.000	0.999
1969	0.001	0.004	0.001	0.044	0.342	0.816	0.969	0.988	1.000	1.000	0.999	1.000	1.000
1970	0.000	0.007	0.021	0.013	0.240	0.750	0.961	0.995	0.998	1.000	1.000	1.000	1.000
1971	0.001	0.001	0.034	0.090	0.129	0.684	0.949	0.993	0.999	1.000	1.000	1.000	1.000
1972	0.003	0.005	0.010	0.162	0.317	0.625	0.937	0.992	0.999	1.000	1.000	1.000	1.000
1973	0.005	0.014	0.026	0.078	0.510	0.686	0.949	0.990	0.999	1.000	1.000	1.000	1.000
1974	0.002	0.020	0.060	0.124	0.420	0.849	0.912	0.995	0.999	1.000	1.000	1.000	1.000
1975	0.002	0.009	0.070	0.227	0.432	0.860	0.968	0.980	1.000	1.000	1.000	1.000	1.000
1976	0.000	0.007	0.037	0.218	0.575	0.804	0.981	0.994	0.996	1.000	1.000	1.000	1.000
1977	0.000	0.001	0.028	0.136	0.508	0.862	0.957	0.998	0.999	0.999	1.000	1.000	1.000
1978	0.003	0.003	0.006	0.110	0.392	0.793	0.966	0.992	1.000	1.000	1.000	1.000	1.000
1979	0.000	0.011	0.018	0.042	0.345	0.726	0.934	0.992	0.998	1.000	1.000	1.000	1.000
1980	0.001	0.000	0.040	0.096	0.244	0.692	0.916	0.981	0.998	1.000	1.000	1.000	1.000
1981	0.012	0.005	0.005	0.139	0.388	0.706	0.906	0.978	0.995	1.000	1.000	1.000	1.000
1982	0.001	0.034	0.028	0.056	0.385	0.790	0.947	0.976	0.995	0.999	1.000	1.000	1.000
1983	0.000	0.006	0.089	0.145	0.420	0.708	0.957	0.992	0.994	0.999	1.000	1.000	1.000
1984	0.000	0.001	0.024	0.214	0.505	0.899	0.904	0.993	0.999	0.999	1.000	1.000	1.000
1985	0.000	0.001	0.007	0.093	0.433	0.860	0.991	0.973	0.999	1.000	1.000	1.000	1.000
1986	0.000	0.002	0.005	0.037	0.299	0.681	0.973	0.999	0.993	1.000	1.000	1.000	1.000
1987	0.000	0.001	0.013	0.037	0.178	0.640	0.857	0.995	1.000	0.998	1.000	1.000	1.000
1988	0.000	0.000	0.011	0.082	0.223	0.554	0.881	0.944	0.999	1.000	1.000	1.000	1.000
1989	0.001	0.002	0.005	0.095	0.372	0.681	0.876	0.969	0.979	1.000	1.000	1.000	1.000
1990	0.000	0.006	0.023	0.073	0.493	0.797	0.941	0.976	0.992	0.992	1.000	1.000	1.000
1991	0.002	0.003	0.052	0.240	0.540	0.901	0.963	0.992	0.996	0.998	0.997	1.000	1.000
1992	0.004	0.016	0.051	0.341	0.807	0.946	0.988	0.994	0.999	0.999	1.000	0.999	1.000
1993	0.000	0.021	0.096	0.461	0.831	0.982	0.996	0.999	0.999	1.000	1.000	1.000	1.000
1994	0.000	0.003	0.114	0.411	0.932	0.979	0.999	1.000	1.000	1.000	1.000	1.000	1.000
1995	0.002	0.006	0.039	0.434	0.821	0.995	0.998	1.000	1.000	1.000	1.000	1.000	1.000
1996	0.007	0.015	0.069	0.330	0.821	0.968	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.004	0.034	0.092	0.502	0.856	0.965	0.995	1.000	1.000	1.000	1.000	1.000	1.000
1998	0.003	0.022	0.149	0.403	0.931	0.986	0.994	0.999	1.000	1.000	1.000	1.000	1.000
1999	0.000	0.016	0.103	0.465	0.818	0.995	0.999	0.999	1.000	1.000	1.000	1.000	1.000
2000	0.003	0.004	0.085	0.375	0.812	0.968	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.004	0.025	0.074	0.345	0.758	0.955	0.995	1.000	1.000	1.000	1.000	1.000	1.000
2002	0.003	0.026	0.159	0.635	0.751	0.942	0.991	0.999	1.000	1.000	1.000	1.000	1.000
2003	0.008	0.019	0.144	0.583	0.974	0.945	0.988	0.998	1.000	1.000	1.000	1.000	1.000

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+
2004	0.004	0.044	0.104	0.516	0.911	0.999	0.990	0.998	1.000	1.000	1.000	1.000	1.000
2005	0.003	0.021	0.213	0.408	0.870	0.987	1.000	0.998	1.000	1.000	1.000	1.000	1.000
2006	0.005	0.014	0.105	0.610	0.804	0.977	0.998	1.000	1.000	1.000	1.000	1.000	1.000
2007	0.002	0.021	0.064	0.385	0.901	0.960	0.996	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.006	0.011	0.086	0.250	0.770	0.981	0.993	0.999	1.000	1.000	1.000	1.000	1.000
2009	0.014	0.034	0.069	0.297	0.619	0.947	0.997	0.999	1.000	1.000	1.000	1.000	1.000
2010	0.007	0.061	0.169	0.323	0.654	0.888	0.990	0.999	1.000	1.000	1.000	1.000	1.000
2011	0.002	0.036	0.233	0.538	0.754	0.894	0.975	0.998	1.000	1.000	1.000	1.000	1.000
2012	0.002	0.019	0.170	0.589	0.869	0.951	0.974	0.995	1.000	1.000	1.000	1.000	1.000
2013	0.001	0.017	0.138	0.528	0.871	0.974	0.992	0.994	0.999	1.000	1.000	1.000	1.000
2014	0.003	0.005	0.109	0.573	0.859	0.969	0.995	0.999	0.999	1.000	1.000	1.000	1.000
2015	0.001	0.017	0.057	0.469	0.918	0.971	0.993	0.999	1.000	1.000	1.000	1.000	1.000
2016	0.002	0.011	0.084	0.398	0.865	0.989	0.995	0.999	1.000	1.000	1.000	1.000	1.000
2017	0.000	0.013	0.074	0.320	0.878	0.979	0.999	0.999	1.000	1.000	1.000	1.000	1.000
2018	0.001	0.002	0.089	0.374	0.708	0.988	0.997	1.000	1.000	1.000	1.000	1.000	1.000
2019	0.001	0.009	0.026	0.409	0.816	0.926	0.999	1.000	1.000	1.000	1.000	1.000	1.000
2020	0.001	0.009	0.063	0.273	0.831	0.970	0.985	1.000	1.000	1.000	1.000	1.000	1.000
2021	0.001	0.009	0.063	0.352	0.842	0.972	0.996	0.997	1.000	1.000	1.000	1.000	1.000
2022	0.001	0.009	0.063	0.352	0.830	0.987	0.996	0.999	0.999	1.000	1.000	1.000	1.000

Table A5: Stock weights (kg) at age.

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	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1960	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1961	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1962	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1963	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1964	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1965	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1966	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1967	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1968	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1969	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1970	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1971	0.09	0.29	0.68	1.25	1.82	2.47	3.21	4.23	5.45	6.76	8.65	10.08	15.12
1972	0.10	0.29	0.63	1.14	1.63	2.21	3.06	4.28	5.60	6.80	8.46	9.69	14.66
1973	0.09	0.29	0.62	1.10	1.61	2.18	2.79	3.84	5.21	6.51	8.12	9.31	14.08
1974	0.09	0.30	0.68	1.19	1.72	2.37	3.01	3.84	5.13	6.64	8.50	9.73	14.57
1975	0.09	0.31	0.73	1.37	1.95	2.65	3.42	4.33	5.35	6.80	9.01	10.55	15.60
1976	0.09	0.29	0.74	1.44	2.20	2.94	3.77	4.87	5.97	7.04	9.16	11.11	16.69
1977	0.09	0.26	0.64	1.34	2.11	3.04	3.84	4.92	6.16	7.22	8.74	10.45	16.58
1978	0.08	0.25	0.56	1.09	1.86	2.79	3.78	4.77	5.93	7.10	8.57	9.55	15.61
1979	0.08	0.26	0.60	1.08	1.76	2.83	3.96	5.34	6.52	7.72	9.49	10.50	16.16
1980	0.09	0.27	0.63	1.18	1.73	2.66	3.99	5.53	7.20	8.36	10.15	11.46	16.74
1981	0.08	0.28	0.62	1.14	1.73	2.38	3.37	4.99	6.69	8.30	9.91	11.10	16.06
1982	0.08	0.27	0.65	1.18	1.77	2.51	3.21	4.51	6.46	8.26	10.53	11.57	16.39

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14+
1983	0.08	0.25	0.60	1.16	1.71	2.38	3.16	4.00	5.46	7.49	9.86	11.60	15.99
1984	0.07	0.24	0.58	1.12	1.76	2.40	3.14	4.14	5.10	6.65	9.38	11.38	16.38
1985	0.07	0.23	0.56	1.05	1.67	2.45	3.15	4.11	5.26	6.20	8.34	10.83	16.60
1986	0.07	0.22	0.53	1.01	1.55	2.30	3.17	4.08	5.16	6.31	7.67	9.50	16.35
1987	0.07	0.22	0.50	0.94	1.48	2.12	2.95	4.06	5.04	6.06	7.64	8.55	15.31
1988	0.07	0.23	0.52	0.90	1.42	2.07	2.76	3.85	5.09	5.99	7.44	8.63	14.33
1989	0.07	0.22	0.54	0.97	1.41	2.05	2.80	3.77	5.04	6.33	7.69	8.76	14.12
1990	0.07	0.20	0.48	0.90	1.32	1.76	2.40	3.31	4.29	5.45	7.09	7.93	12.50
1991	0.07	0.21	0.44	0.81	1.27	1.72	2.16	2.98	3.97	4.88	6.43	7.70	11.66
1992	0.07	0.24	0.50	0.81	1.26	1.83	2.35	3.02	4.04	5.10	6.50	7.87	12.28
1993	0.07	0.24	0.57	0.91	1.23	1.78	2.47	3.26	4.06	5.15	6.74	7.89	12.74
1994	0.07	0.22	0.52	0.96	1.24	1.57	2.16	3.08	3.95	4.67	6.15	7.39	11.98
1995	0.07	0.22	0.50	0.91	1.40	1.69	2.03	2.88	3.97	4.82	5.88	7.09	11.80
1996	0.08	0.23	0.50	0.86	1.33	1.91	2.20	2.74	3.76	4.89	6.13	6.84	11.64
1997	0.08	0.25	0.55	0.92	1.33	1.93	2.66	3.18	3.80	4.91	6.61	7.54	11.98
1998	0.08	0.25	0.57	1.00	1.41	1.91	2.66	3.80	4.36	4.92	6.57	8.03	12.41
1999	0.09	0.27	0.59	1.06	1.53	2.02	2.64	3.81	5.21	5.65	6.59	7.99	12.97
2000	0.09	0.28	0.58	1.00	1.49	2.02	2.57	3.48	4.79	6.22	6.98	7.40	12.45
2001	0.08	0.27	0.60	1.00	1.42	1.97	2.59	3.40	4.38	5.72	7.66	7.81	11.82
2002	0.08	0.26	0.60	1.05	1.45	1.91	2.56	3.46	4.30	5.26	7.08	8.61	11.58
2003	0.08	0.24	0.56	1.06	1.51	1.95	2.48	3.41	4.35	5.16	6.51	7.96	11.76
2004	0.08	0.26	0.56	1.02	1.60	2.15	2.66	3.49	4.56	5.58	6.82	7.82	12.34
2005	0.08	0.27	0.60	1.01	1.55	2.27	2.94	3.78	4.73	5.96	7.50	8.33	12.93
2006	0.08	0.25	0.57	1.02	1.43	2.05	2.90	3.91	4.79	5.77	7.46	8.55	12.77
2007	0.07	0.23	0.54	0.97	1.44	1.90	2.63	3.88	4.97	5.86	7.24	8.52	12.75
2008	0.07	0.20	0.47	0.88	1.31	1.82	2.30	3.32	4.63	5.71	6.91	7.79	12.04
2009	0.07	0.22	0.46	0.84	1.33	1.85	2.46	3.23	4.40	5.91	7.44	8.18	12.27
2010	0.08	0.23	0.51	0.84	1.28	1.89	2.52	3.48	4.33	5.69	7.82	8.94	12.79
2011	0.08	0.25	0.50	0.85	1.15	1.64	2.32	3.23	4.22	5.09	6.86	8.58	12.43
2012	0.07	0.25	0.53	0.84	1.20	1.51	2.09	3.08	4.06	5.15	6.37	7.81	12.47
2013	0.07	0.21	0.52	0.86	1.11	1.49	1.81	2.62	3.67	4.72	6.15	6.93	11.69
2014	0.07	0.21	0.46	0.89	1.21	1.49	1.93	2.46	3.38	4.60	6.06	7.17	11.50
2015	0.07	0.21	0.47	0.77	1.26	1.62	1.93	2.62	3.18	4.23	5.92	7.07	11.45
2016	0.07	0.20	0.44	0.77	1.06	1.65	2.06	2.57	3.32	3.91	5.34	6.79	11.18
2017	0.07	0.20	0.42	0.72	1.06	1.39	2.10	2.76	3.26	4.08	4.93	6.13	10.85
2018	0.07	0.22	0.45	0.72	1.05	1.46	1.87	2.95	3.66	4.19	5.39	5.90	10.75
2019	0.07	0.21	0.45	0.71	0.95	1.32	1.78	2.40	3.59	4.34	5.12	5.98	9.87
2020	0.06	0.21	0.45	0.75	1.00	1.28	1.72	2.43	3.10	4.48	5.57	5.96	9.66
2021	0.06	0.19	0.45	0.76	1.06	1.34	1.66	2.33	3.12	3.85	5.73	6.46	9.49
2022	0.07	0.19	0.42	0.76	1.08	1.43	1.75	2.26	3.02	3.91	4.96	6.71	9.65

Table A6: ERHAPS survey by the Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER).

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+
1978	0.62	1.32	2.60	1.73	1.01	0.75	0.44	0.25	0.19	0.02	0.03	0.01	0.03
1979	0.46	0.41	2.21	7.73	3.47	1.93	1.02	0.40	0.23	0.31	0.10	0.11	0.23

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+
1980	5.47	1.27	0.37	1.98	3.35	1.23	0.50	0.21	0.16	0.13	0.08	0.08	0.13
1981	0.14	3.78	3.81	3.96	5.74	4.35	1.23	0.92	0.36	0.12	0.11	0.05	0.10
1982	9.21	1.50	6.38	6.12	4.65	3.49	4.07	1.21	0.67	0.32	0.12	0.16	0.08
1983	8.31	4.16	2.29	5.55	4.70	3.50	2.13	1.60	0.58	0.19	0.15	0.06	0.05
1984	9.43	6.22	12.27	7.12	15.45	4.55	1.73	2.52	1.80	0.50	0.13	0.11	0.10
1985	4.38	11.56	5.96	3.14	0.85	1.56	0.91	0.62	0.69	0.87	1.05	0.10	0.18
1986	6.93	4.03	14.55	25.35	20.74	8.73	6.67	3.69	0.76	0.56	0.69	0.21	0.31
1987	16.29	9.09	2.24	6.56	9.87	6.57	2.33	1.53	0.75	0.16	0.28	0.12	0.23
1988	11.69	11.71	7.25	2.85	5.14	3.69	1.26	0.61	0.28	0.28	0.13	0.12	0.26
1989	18.89	12.25	6.27	4.44	2.66	3.39	1.55	0.77	0.21	0.10	0.05	0.05	0.06
1990	2.39	18.26	20.11	7.66	2.46	0.73	1.00	0.44	0.26	0.11	0.09	0.03	0.06
1991	12.14	7.08	12.96	12.68	7.56	2.42	1.07	0.91	0.62	0.06	0.15	0.03	0.03

Table A7: GEAC survey.

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+
1998	0.06	0.40	1.76	2.32	1.81	0.35	1.64	3.40	0.40	0.04	0.13	0.22	0.04
1999	0.34	1.14	1.71	2.83	3.58	3.27	0.51	1.43	1.36	0.17	0.10	0.02	0.00
2000	1.64	7.24	2.86	3.35	5.18	5.89	3.99	1.14	5.83	7.14	0.79	0.11	0.17
2001	0.21	12.47	26.74	3.75	2.14	1.62	1.34	0.96	0.10	0.44	0.58	0.08	0.10
2002	0.00	1.26	16.88	18.47	2.90	1.39	1.18	0.91	0.46	0.09	0.27	0.30	0.00
2003	0.22	0.41	2.46	8.34	9.28	1.32	0.73	1.32	0.48	0.24	0.00	0.16	0.18
2004	0.08	0.68	0.80	1.07	2.98	1.18	0.15	0.12	0.18	0.13	0.05	0.00	0.20
2005	0.05	1.74	1.15	0.43	0.31	0.74	0.50	0.08	0.04	0.09	0.04	0.00	0.00

Table A8: Sentinel Gillnet standardized catch rates.

Year	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1995	0.0755	3.9468	8.5693	5.2138	2.4371	0.3702	0.1456
1996	0.2742	2.6384	12.1100	9.8872	2.8270	0.8431	0.0678
1997	0.2407	5.1254	5.1201	9.0898	7.3047	1.0790	0.5977
1998	0.0535	1.0927	7.3457	3.2500	2.5445	1.5384	0.2802
1999	0.0025	0.7732	1.2399	1.8390	0.6618	0.2159	0.2090
2000	0.0201	0.2878	0.7629	0.6291	0.9770	0.3112	0.0937
2001	0.1542	0.3977	0.8577	0.6710	0.3788	0.3652	0.1732
2002	0.0363	0.4913	0.7914	0.7551	0.3250	0.1510	0.1663
2003	0.0688	0.2307	0.9999	0.4817	0.1700	0.0891	0.0324
2004	0.0380	0.2202	0.8161	0.8047	0.3910	0.1404	0.0266
2005	0.0256	0.1352	0.5554	0.6468	0.3800	0.2887	0.0512
2006	0.0960	0.2945	0.5261	0.4831	0.5096	0.2515	0.1257
2007	0.0510	0.3839	1.0138	0.7108	0.4019	0.2489	0.1740
2008	0.0944	0.2432	1.0730	0.8870	0.4292	0.2032	0.0830
2009	0.0092	0.2532	0.6194	1.1015	0.2166	0.1709	0.0549
2010	0.0605	0.3493	0.7960	0.6482	0.3392	0.1075	0.1780
2011	0.0062	0.0934	0.3050	0.5571	0.2241	0.1774	0.0187

Year	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
2012	0.0394	0.1365	0.4733	0.5067	0.3884	0.1244	0.0728
2013	0.0651	0.4594	0.9993	0.4173	0.4671	0.2871	0.0230
2014	0.0368	0.4265	0.4632	0.2941	0.4779	0.2243	0.1029
2015	0.0612	0.0902	0.4867	0.4029	0.1611	0.1450	0.0612
2016	0.0036	0.2692	0.3554	0.4057	0.3051	0.2692	0.0718
2017	0.0704	0.2231	0.7279	0.3640	0.6223	0.1409	0.0763
2018	0.0328	0.1496	0.4598	1.4741	0.4816	0.2773	0.0693
2019	0.0063	0.0595	0.3478	0.6017	1.4446	0.3165	0.3134
2020	0.0257	0.4667	0.4538	0.3315	0.3476	0.7531	0.2414
2021	0.1037	0.7944	1.3594	0.9800	0.6388	0.6415	0.3412
2022	0.0839	0.4367	1.0065	1.5184	0.4946	0.3384	0.2516

Table A9: Sentinel line-trawl standardized catch rates.

Year	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1995	0.7516	1.4403	5.0852	7.3212	1.9354	1.7861	0.3891	0.1091
1996	0.8161	3.0687	2.8760	4.5640	4.6596	1.3513	0.7499	0.1647
1997	0.5890	2.3011	2.4434	1.5898	1.6722	2.3286	0.2795	0.1697
1998	0.7507	1.6993	2.4688	1.6522	0.6659	0.9549	1.1716	0.2356
1999	0.9260	2.0981	2.5200	1.6058	0.7150	0.5626	0.3985	0.1641
2000	1.5089	2.5752	2.3141	1.9877	0.9757	0.6892	0.2684	0.1197
2001	1.8919	3.3002	2.4468	1.4523	0.7857	0.4469	0.2509	0.0586
2002	1.4739	3.0438	2.7696	0.9617	0.5832	0.1921	0.0919	0.0710
2003	0.2542	3.7114	4.2309	2.1994	0.8975	0.3647	0.0973	0.0508
2004	0.9779	1.0244	3.7910	2.0232	1.0755	0.3554	0.1649	0.0348
2005	0.7690	2.1123	1.3648	1.3747	1.2014	0.4571	0.1964	0.0792
2006	1.0064	1.9143	2.6076	1.9750	1.3814	1.3517	0.4317	0.1592
2007	0.9271	1.9539	1.6996	1.4468	0.9524	0.5043	0.4818	0.1938
2008	0.4381	2.8736	2.5646	1.8596	0.8631	0.5628	0.2858	0.2292
2009	0.4965	1.6039	2.9008	1.5291	0.6080	0.3636	0.1130	0.0855
2010	0.2643	1.6107	1.3664	1.4030	0.6649	0.1629	0.0682	0.0515
2011	0.7985	1.0962	2.4998	1.8656	1.1542	0.4795	0.1334	0.0290
2012	0.7983	1.5220	1.5451	1.5271	1.4499	0.5460	0.2446	0.0258
2013	0.2728	1.4938	1.5117	0.9772	0.6955	0.6820	0.1878	0.0716
2014	0.4360	0.4661	1.6754	1.3145	0.6315	0.5284	0.3265	0.0967
2015	0.1139	0.9468	1.1344	1.2237	1.0965	0.3394	0.3082	0.1184
2016	0.1705	0.7343	1.8409	1.1797	1.0370	0.4594	0.1114	0.1740
2017	0.1295	0.7347	1.6761	2.2041	0.8617	0.3686	0.1444	0.0672
2018	0.0422	0.3794	0.8560	1.3327	1.3910	0.6193	0.1945	0.0973
2019	0.2721	0.8286	0.8069	1.5026	1.8828	1.5397	0.4390	0.1237
2020	0.3561	1.2142	1.7367	1.5882	1.7085	1.6215	1.5036	0.5789
2021	0.2785	0.7193	1.3227	1.1254	0.8122	0.7039	0.6033	0.3867
2022	0.1362	0.6549	1.1931	1.1088	1.2644	0.5836	0.2723	0.6030

Table A10: Condition index for M.

Year	Ages 2-14+	Year	Ages 2-14+
1959	-0.9213	1995	-1.1835
1960	-0.9213	1996	-1.4769
1961	-0.9213	1997	-1.5949
1962	-0.9213	1998	-1.6902
1963	-0.9213	1999	-1.805
1964	-0.9213	2000	-1.6258
1965	-0.9213	2001	-1.3756
1966	-0.9213	2002	-1.5274
1967	-0.9213	2003	-1.6255
1968	-0.9213	2004	-1.7837
1969	-0.9213	2005	-1.6958
1970	-0.9213	2006	-1.4538
1971	-0.9213	2007	-1.5629
1972	-0.9213	2008	-1.3005
1973	-0.9213	2009	-0.8925
1974	-0.9213	2010	-0.8602
1975	-0.9213	2011	-1.0589
1976	-0.9213	2012	-0.851
1977	-0.9213	2013	-0.6633
1978	-0.8129	2014	-0.679
1979	-0.84	2015	-0.7058
1980	-0.8629	2016	-0.4991
1981	-1.0426	2017	-0.7381
1982	-1.0783	2018	-0.8913
1983	-1.0836	2019	-0.6454
1984	-1.2852	2020	-0.7796
1985	-1.3581	2021	-0.8852
1986	-1.4324	2022	-0.8735
1987	-1.559	2023	-1.104
1988	-1.4871		
1989	-1.4748		
1990	-1.4183		
1991	-1.2979		
1992	-1.2407		
1993	-1.2024		
1994	-0.9627		

APPENDIX B - MODEL DIAGNOSTICS

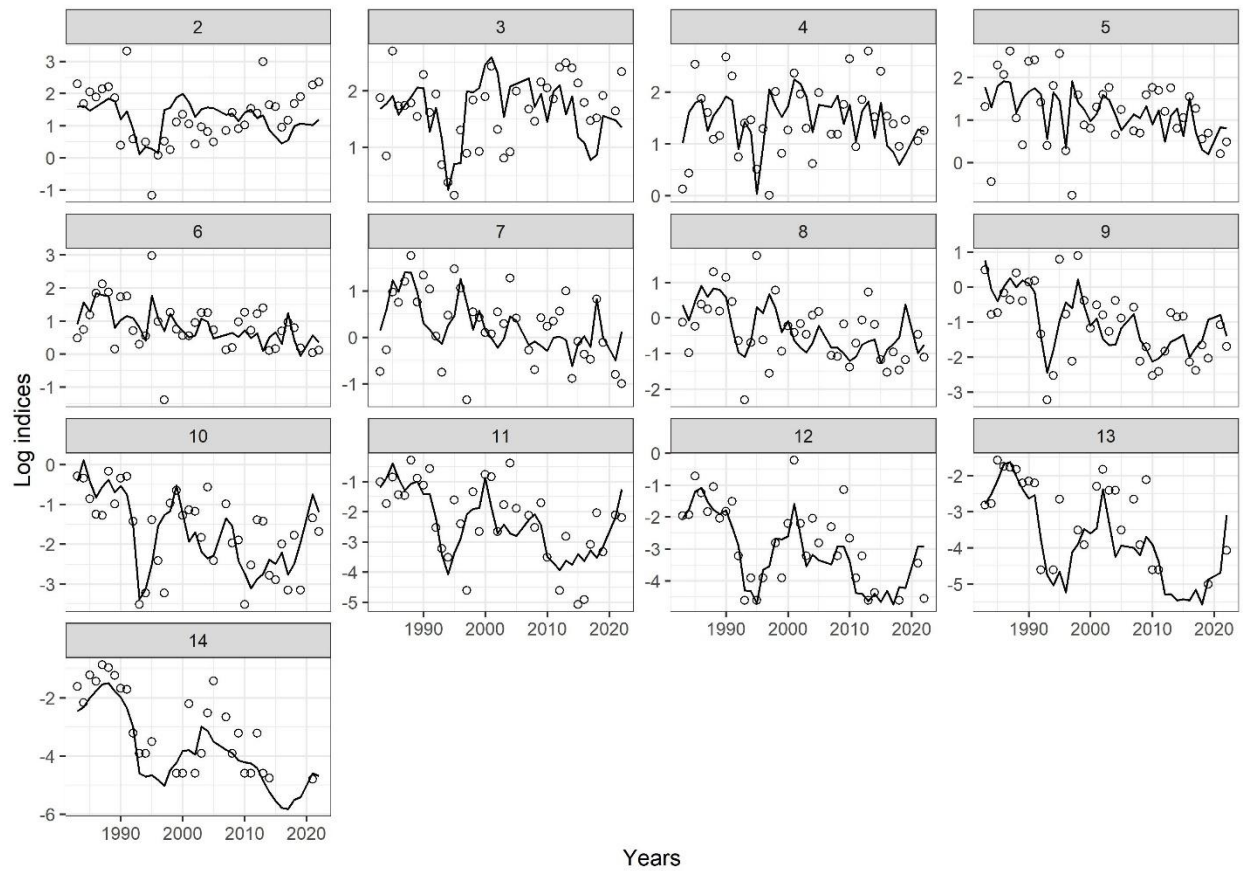


Figure B1: Model fits at age to the DFO Spring RV survey in NAFO Subdiv. 3Ps.

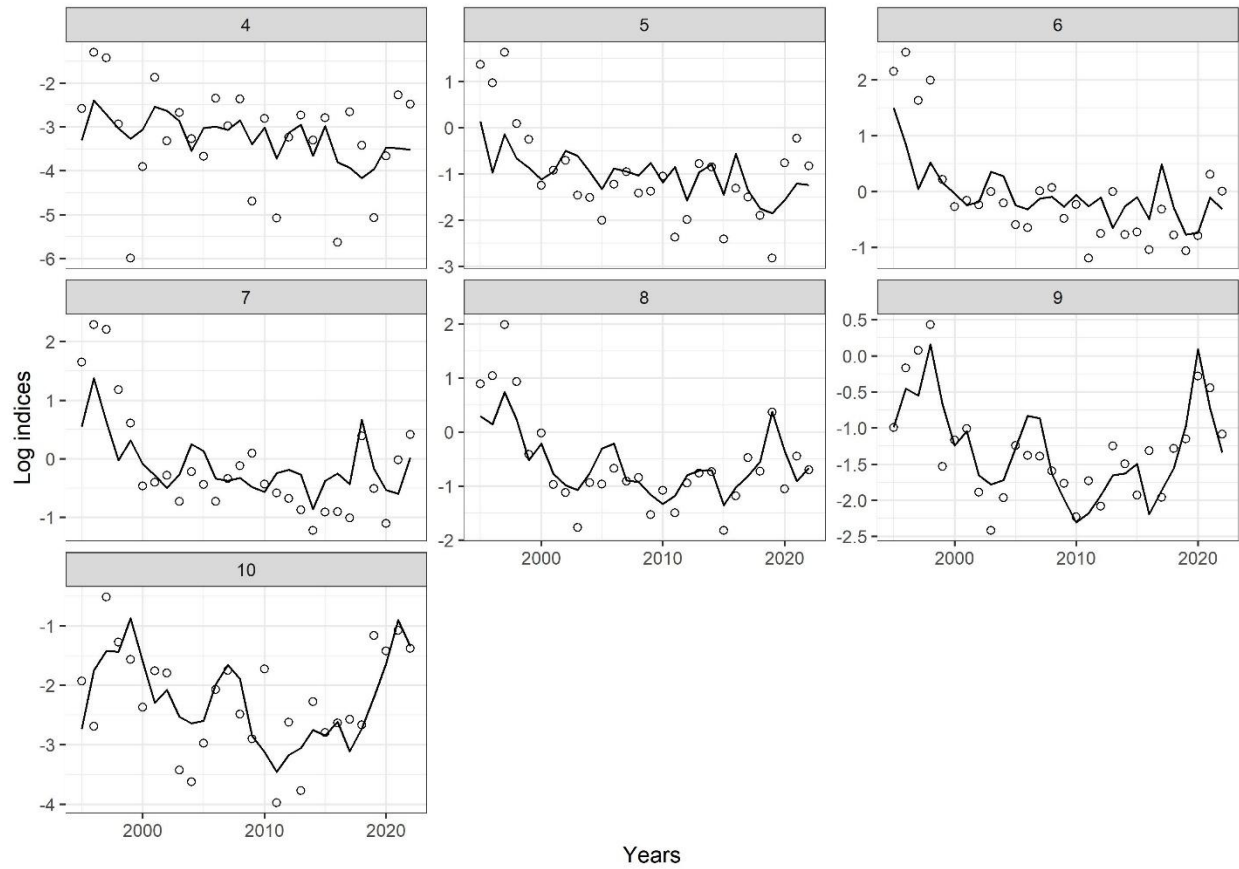


Figure B2: Model fits at age to the Sentinel GN index.

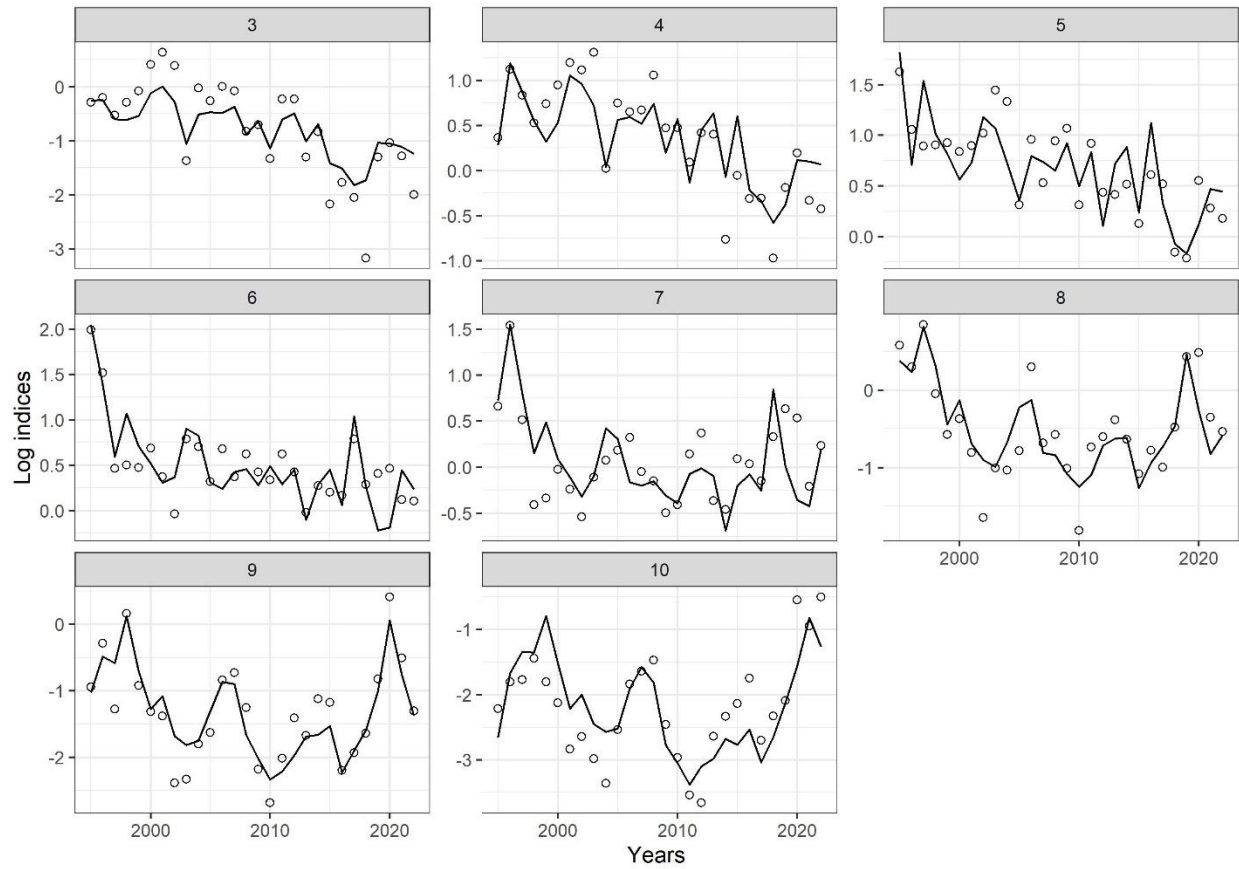


Figure B3: Model fits at age to the Sentinel line-trawl index.

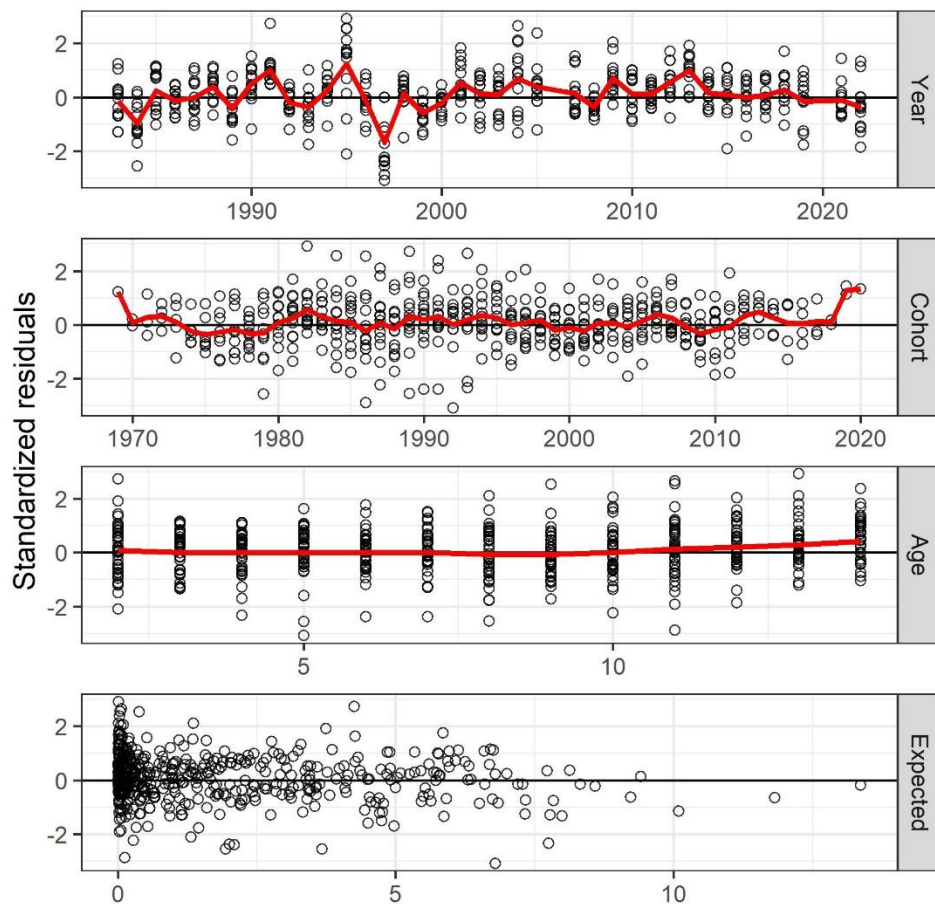


Figure B4: Standardized residuals of indices obtained from the DFO RV survey are plotted against year, cohort, age, and predicted log-index for the three divisions. A solid line representing the mean is drawn on each plot.

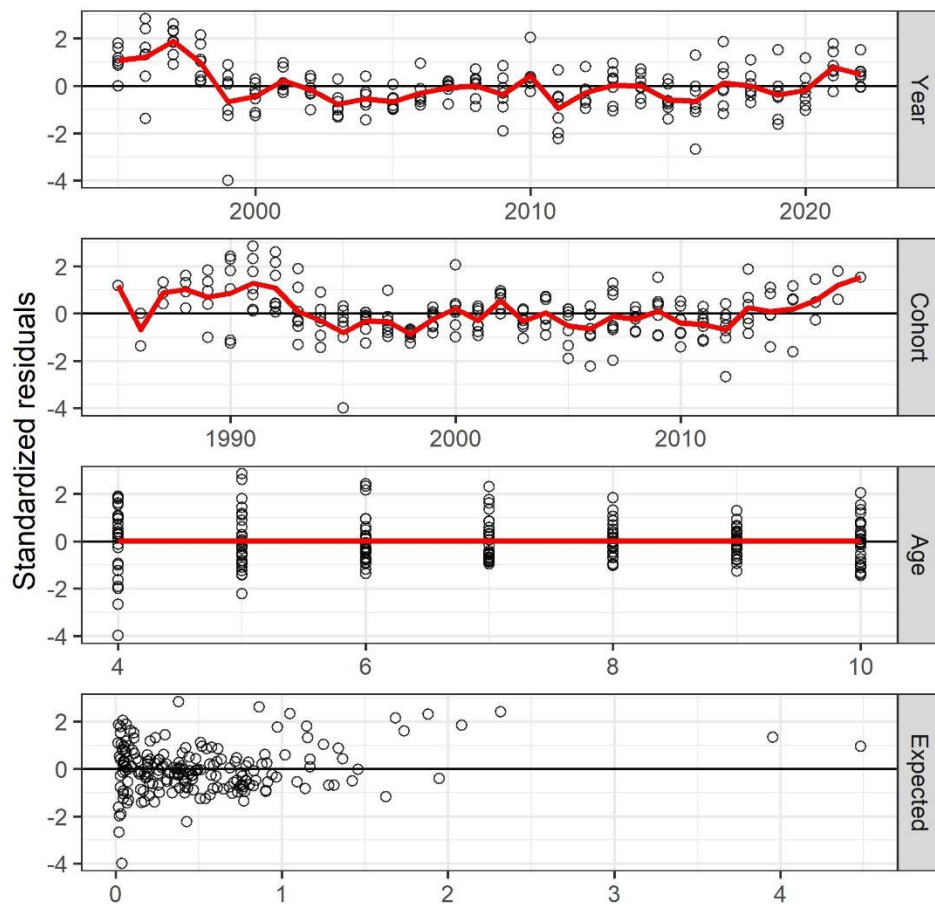


Figure B5: Standardized residuals of indices obtained from the Sentinel gillnet survey are plotted against year, cohort, age, and predicted log-index for the three divisions. A solid line representing the mean is drawn on each plot.

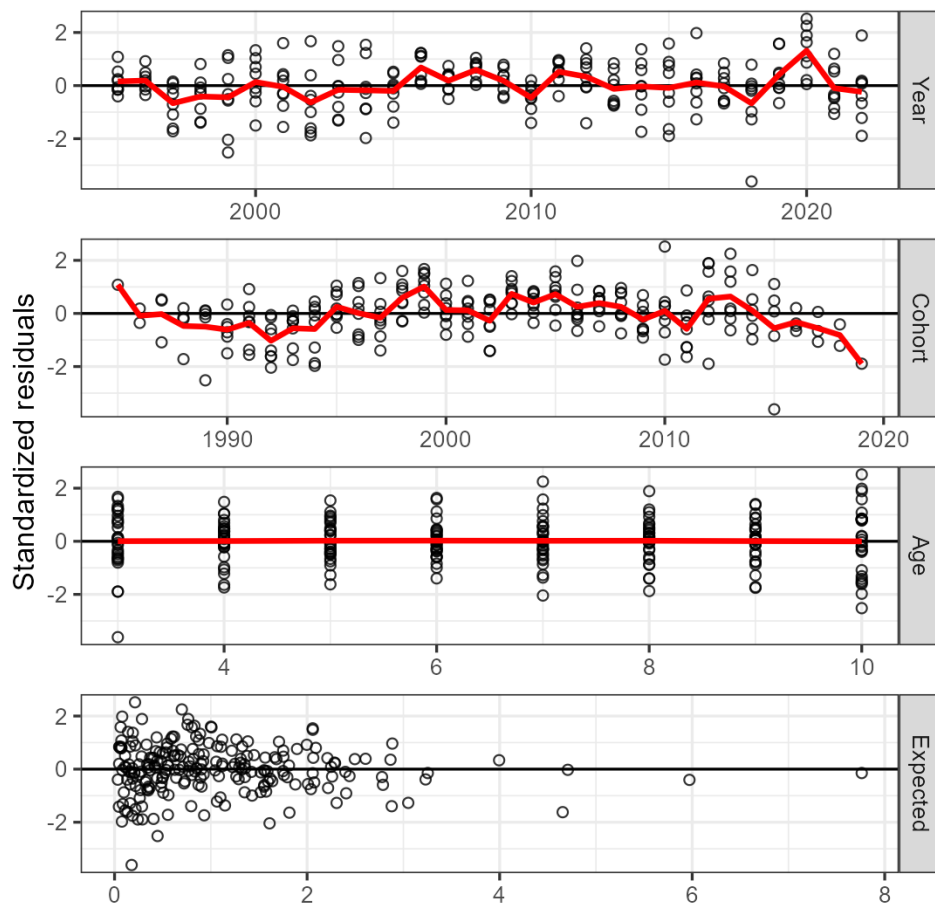


Figure B6: Standardized residuals of indices obtained from the Sentinel line-trawl survey are plotted against year, cohort, age, and predicted log-index for the three divisions. A solid line representing the mean is drawn on each plot.

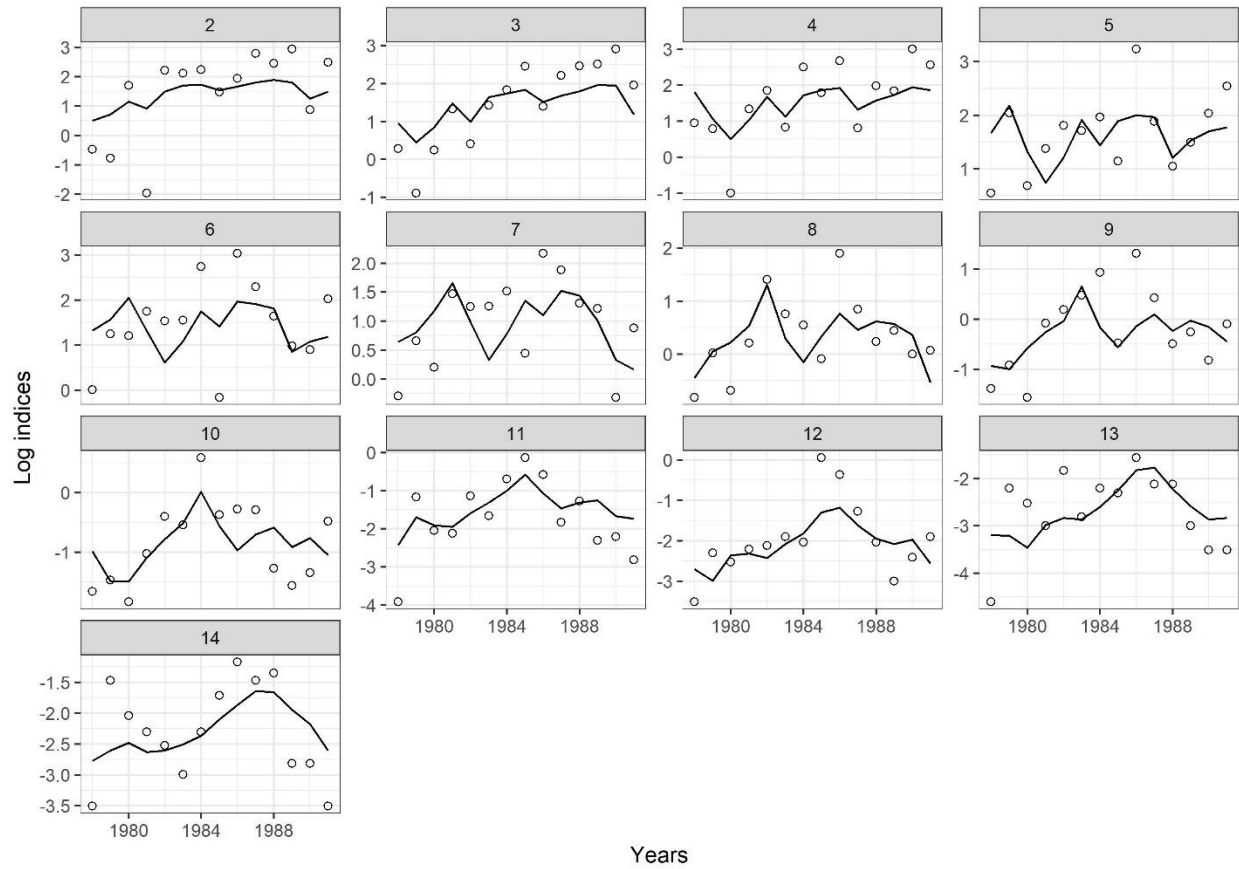


Figure B7: Model fits at age to the French EHRAPS survey.

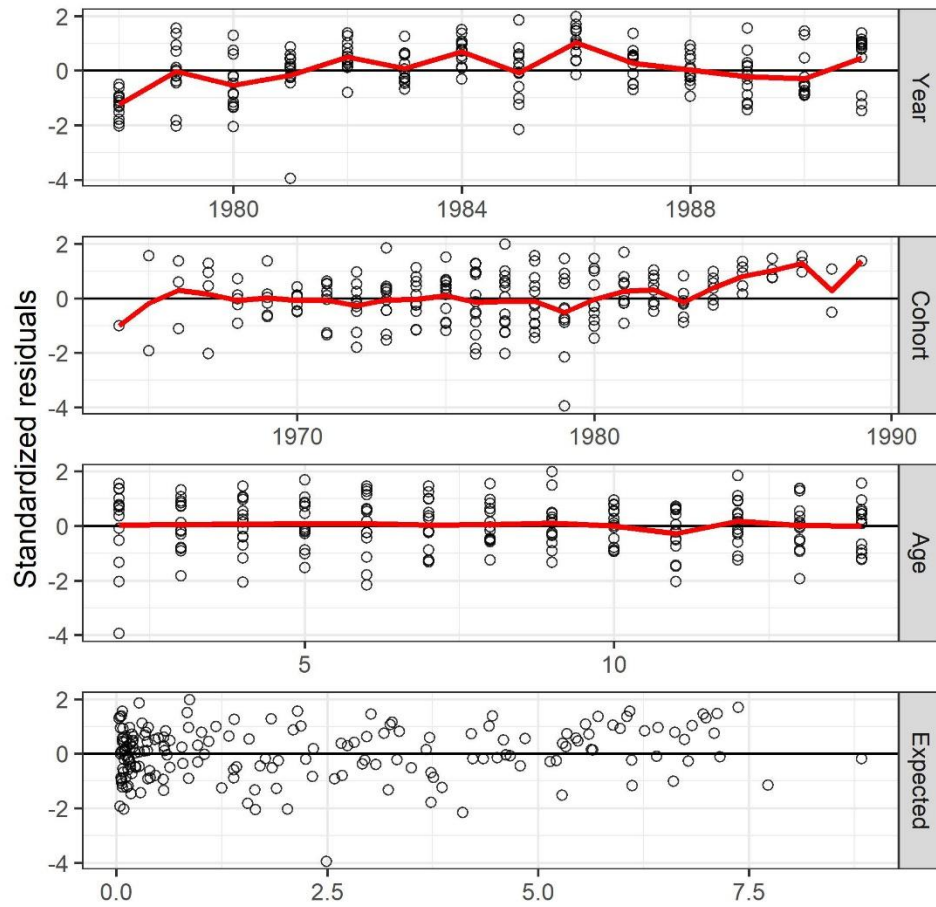


Figure B8: Standardized residuals of indices obtained from the ERHAPS survey are plotted against year, cohort, age, and predicted log-index for the three divisions. A solid line representing the mean is drawn on each plot.

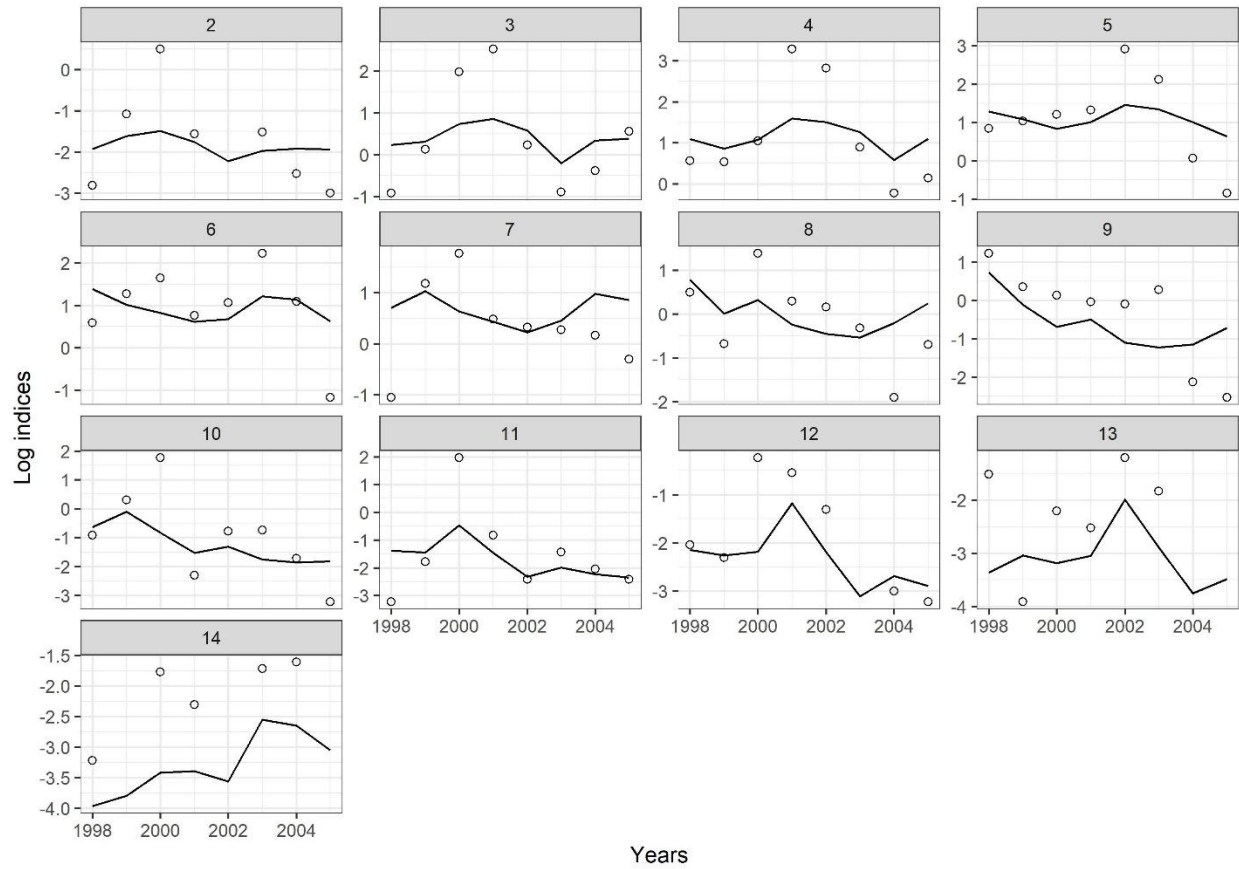


Figure B9: Model fits at age to the GEAC survey.

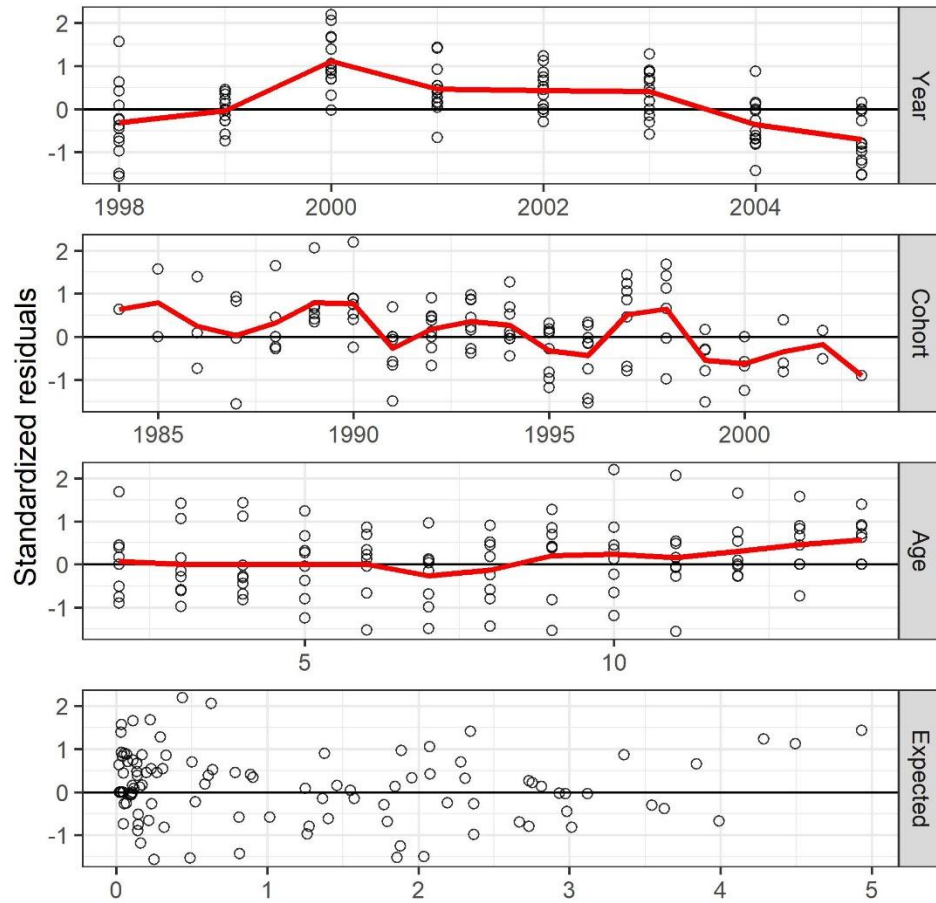


Figure B10: Standardized residuals of indices obtained from the GEAC survey are plotted against year, cohort, age, and predicted log-index for the three divisions. A solid line representing the mean is drawn on each plot.