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Updated state-space model for American plaice (*Hippoglossoides platessoides*) in Div. 3LNO

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Abstract

This work presents an update of the state-space model (SSM) developed for American plaice in NAFO Divisions 3LNO. The original model was developed in 2020 and had the goal of addressing uncertainties in the landings data and reducing the problem of retrospective patterns. The primary purpose of this update is to include more recent data for years 2018-2020 and to assess model fit and diagnostics. Overall, the updated SSM fit the data well with no patterns in the survey and landings residuals. Additionally, there are no major trends in the retrospective plots. As in the previous model formulation, model diagnostics suggest that the natural mortality rate assumption should be reconsidered for the stock.

Introduction

This document presents an update of the state-space model for American plaice from **Perreault et al.** (**2020**) that includes updated data for years 2018-2020. The methodology remains unchanged.

Methods

The model formulation is identical to the model described in **Perreault et al.** (**2020**) and a summary of the formulation is detailed in Appendix A. The updated data used in the model are listed in Appendix B, and we refer to **Wheeland et al.** (**2018**) for details on data collection.

Results

Overall, trends in population estimates (Fig. 1) are similar to those estimated from the 2020 state-space model (SSM), with average fishing mortality rates (aveF) estimated below the current fishing mortality reference point ($F_{lim} = 0.31$) and spawning stock biomass (ssb) estimated below the current biomass reference point ($B_{lim} = 50$). Model predicted landings are within the landings bounds (Fig. 3) in the most recent years. As in the 2020 SSM, survey catchabilities are very high at older ages (Fig. 4), with the largest estimates for the fall survey at approximately 8.0. Overall, the model fits the data well with no major patterns in the survey residuals (Fig. 5) or the continuation ratio logit residuals (Fig. 6). For ages 1-5 the process errors are close to zero until the mid-90's, with no noticeable trends in process errors at the older ages (Figs. 7 and 8). The retrospective plots (Figs. 9 and 10) indicate that aveF is slightly underestimated and ssb slightly overestimated as years of data are removed from the model. As in the 2020 SSM, the natural mortality (M) profile plot (Fig. 11) has the best model fit (i.e., lowest negative log-likelihood) when M is increased by 0.30 at all ages and years. The self-simulation study lower 2.75% and upper 97.5% intervals showed a consistent positive bias in aveF and a negative bias in ssb in the later years of the study.

Discussion

As discussed in **Perreault et al.** (**2020**), the state-space model provides a better quantification of the uncertainty in the landings data, and improves the retrospective problem (see, e.g. **Wheeland et al.** (**2018**)). Additionally, state-space models partition the uncertainty into process error and observation error, which may be a more realistic formulation than traditional virtual population analysis that treats the underlying population processes as deterministic.

Further work is needed to better understand some model output and diagnostics. Specifically:

- the survey catchability estimates are unreasonably high; further discussion and research is needed to better understand what may be driving the high estimates.
- model diagnostics provide strong evidence that the natural mortality assumption should be reconsidered for the stock (i.e., lower negative log-likelihood when M is increased at all ages and years).
- self-test simulation runs produce biases in both aveF and ssb estimates, most notably in the later years. This is not unique to the 3LNO American plaice SSM, however further research is needed to better understand the source of the bias.

Conclusion

While this SSM represents a significant advancement in the modelling of American plaice in Div. 3LNO, further work is required before this can be considered for implementation as an assessment model for this stock.

References

KRISTENSEN, K., Nielsen, A., Berg, C. W., Skaug, H. J., and Bell, B. (2016). TMB: Automatic differentiation and Laplace approximation. Journal of Statistical Software, 70(5), 1–21.

MORGAN, M., and Brodie, W. (2001). An exploration of virtual population analyses for divisions 3LNO American plaice. NAFO, NAFO SCR Doc, 1(4).

PERREAULT, A. M., Wheeland, L. J., Morgan, M. J., & Cadigan, N. G. (2020). A state-space stock assessment model for American plaice on the Grand Bank of Newfoundland. J. Northw. Atl. Fish. Sci, 51, 45-104.

WHEELAND, L.J., Dwyer, K., Morgan, M.J., Rideout, R., and R. Rogers. (2018). Assessment of American Plaice in Div. 3LNO. NAFO SCR Doc. 18/039, 77p.

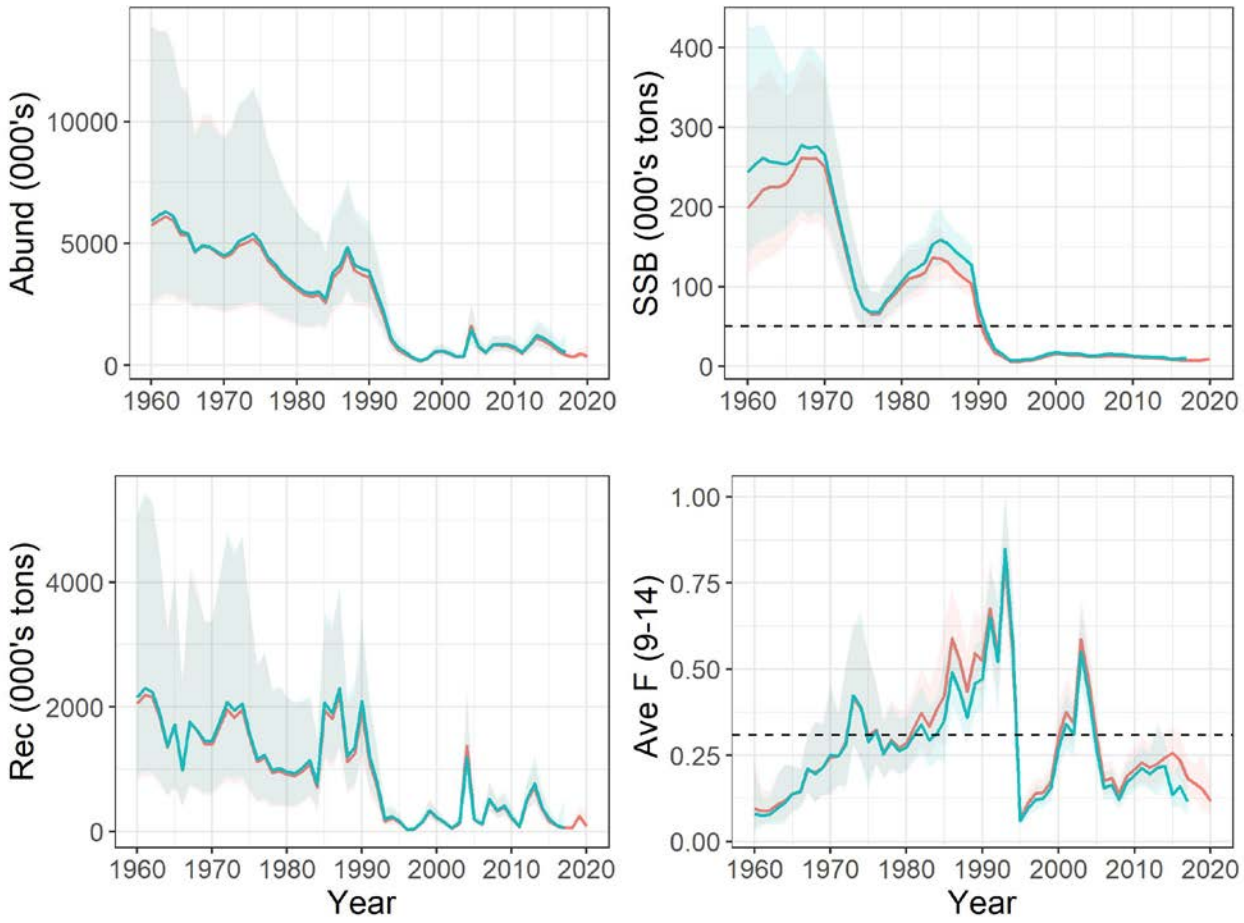

Figure 1. Estimated population abundance (Abund), spawning stock biomass (SSB), average fishing mortality rates (ages 9-14; AveF) and recruitment (Rec) for the new SSM (pink line) and 2020 SSM (blue line). The shaded colored regions represent the corresponding 95% confidence intervals. The dashed horizontal line represents Flim = 0.31 in the aveF plot and Blim = 50 in the SSB plot.

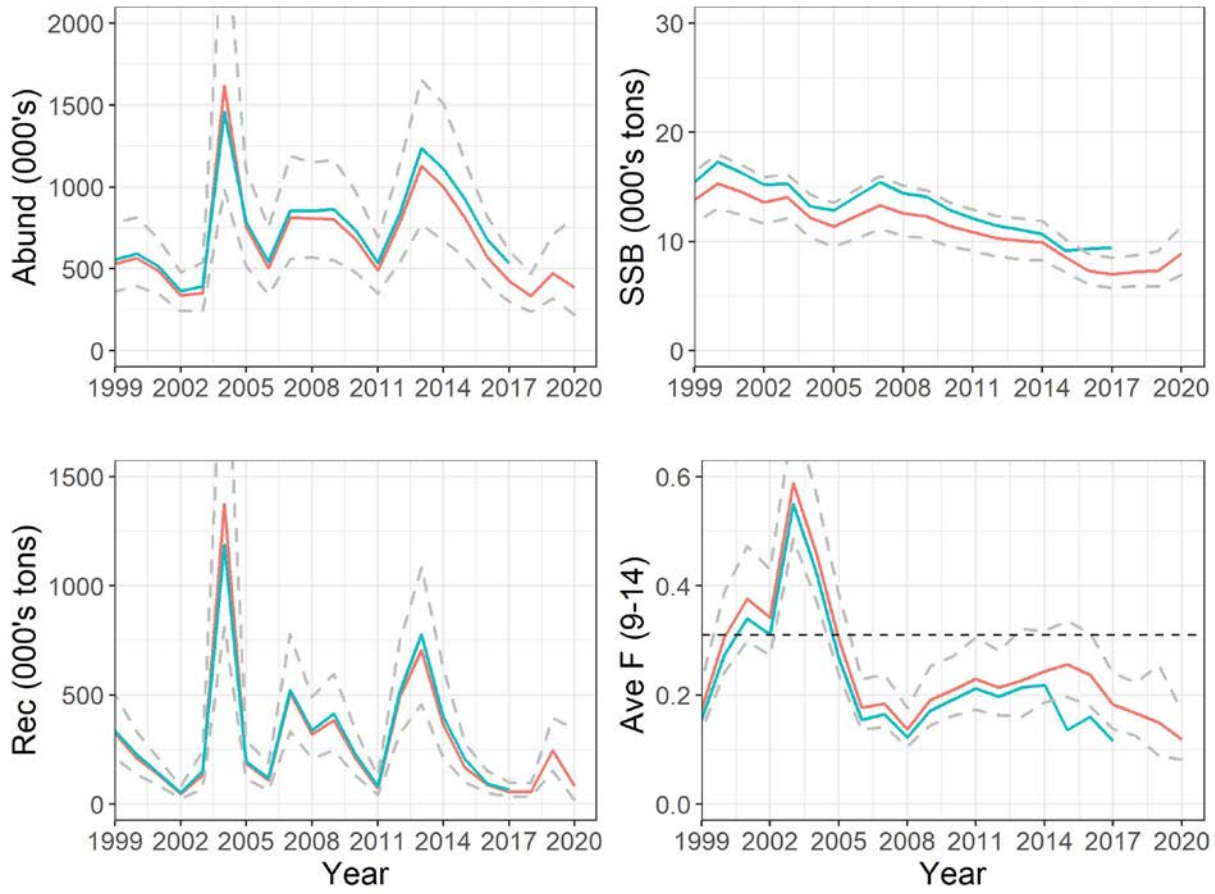

Figure 2. Zoomed-in estimated population abundance (Abund), spawning stock biomass (SSB), average fishing mortality rates (ages 9-14; AveF) and recruitment (Rec) for the new SSM (pink line) and 2020 SSM (blue line). The dashed grey lines represent the 95% confidence interval for the new SSM. The dashed horizontal line represents Flim = 0.31 in the aveF plot.

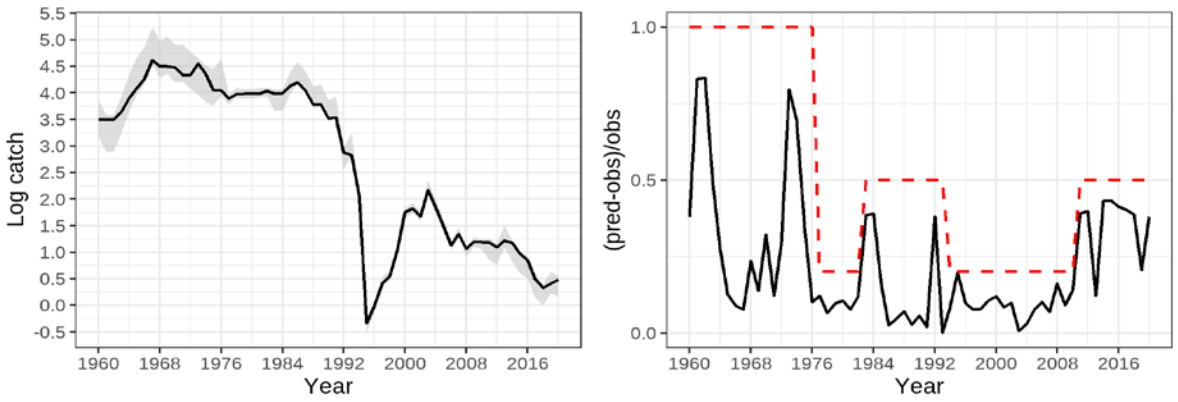

Figure 3. Left SSM estimated log catch numbers at ages 5-15+ (solid line), the shaded grey region represents the region between the log lower catch bounds and upper catch bounds. Right: SSM estimated landings ratio (i.e., predicted - observed/observed). The dashed red line is the fixed upper bounds.

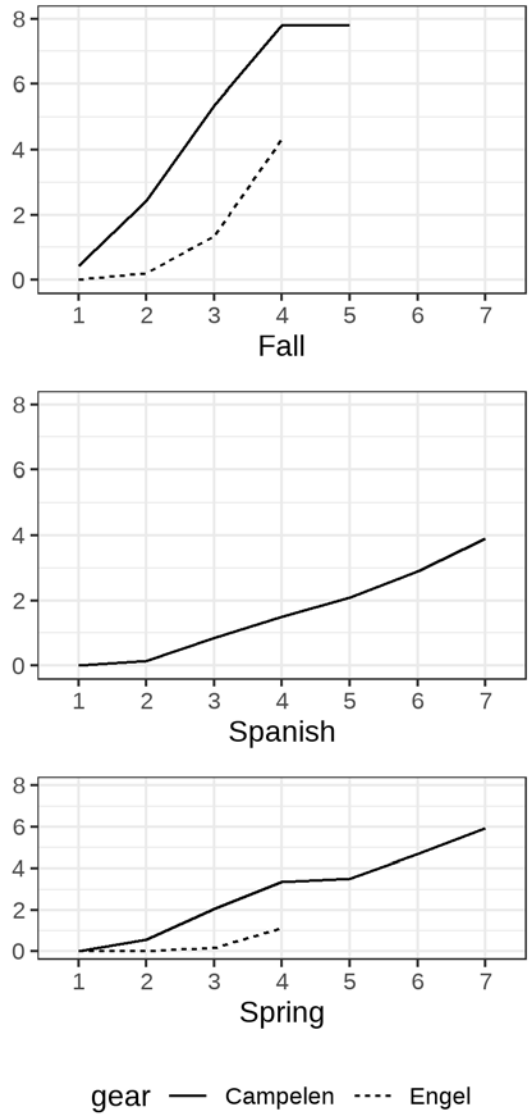

Figure 4. Survey catchability patterns for the fall, spring and Spanish surveys, with a separate catchability parameter estimated for the Engel and Campelen gear types for the spring and fall surveys for ages 1-4. Catchabiltiy for ages 7+ is fixed at the value for age 7.

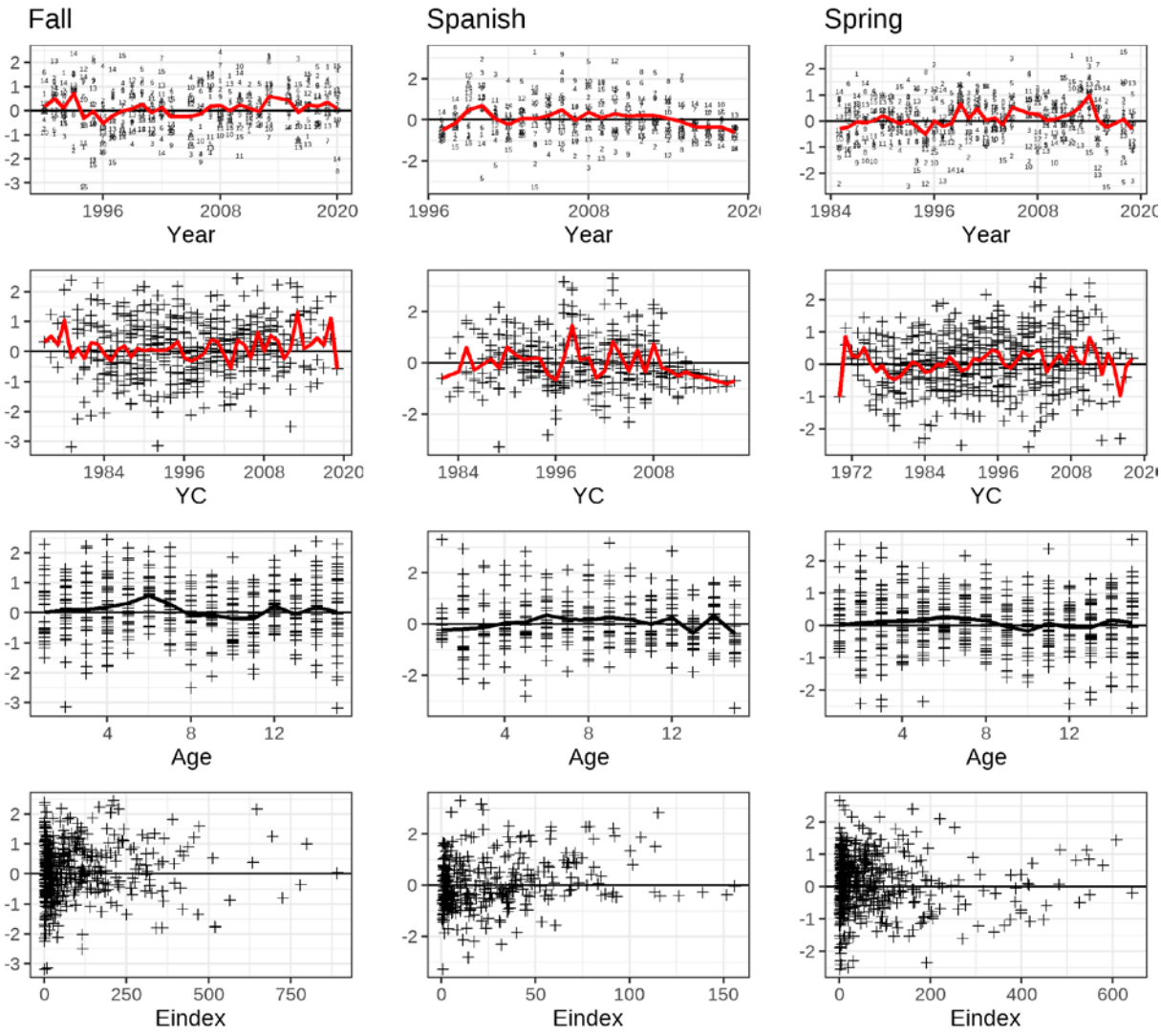

Figure 5. Fall, Spring and Spanish survey index residuals for the SSM.

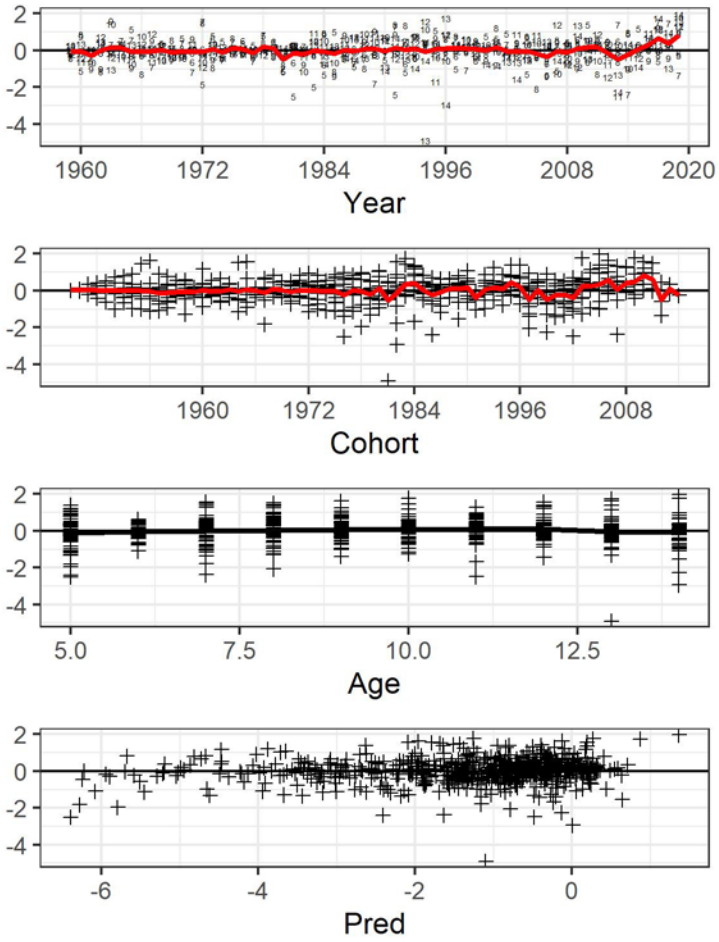

Figure 6. Continuation ratio-logit residuals for the SSM.

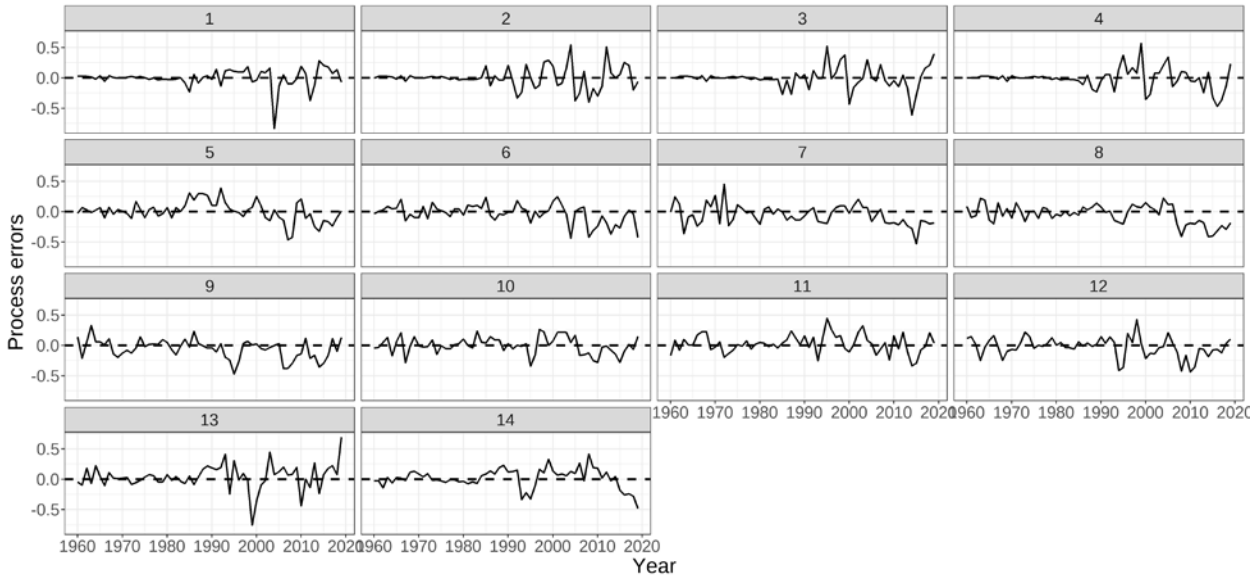

Figure 7. SSM estimated process errors for ages 1-14 for years 1960-2019.

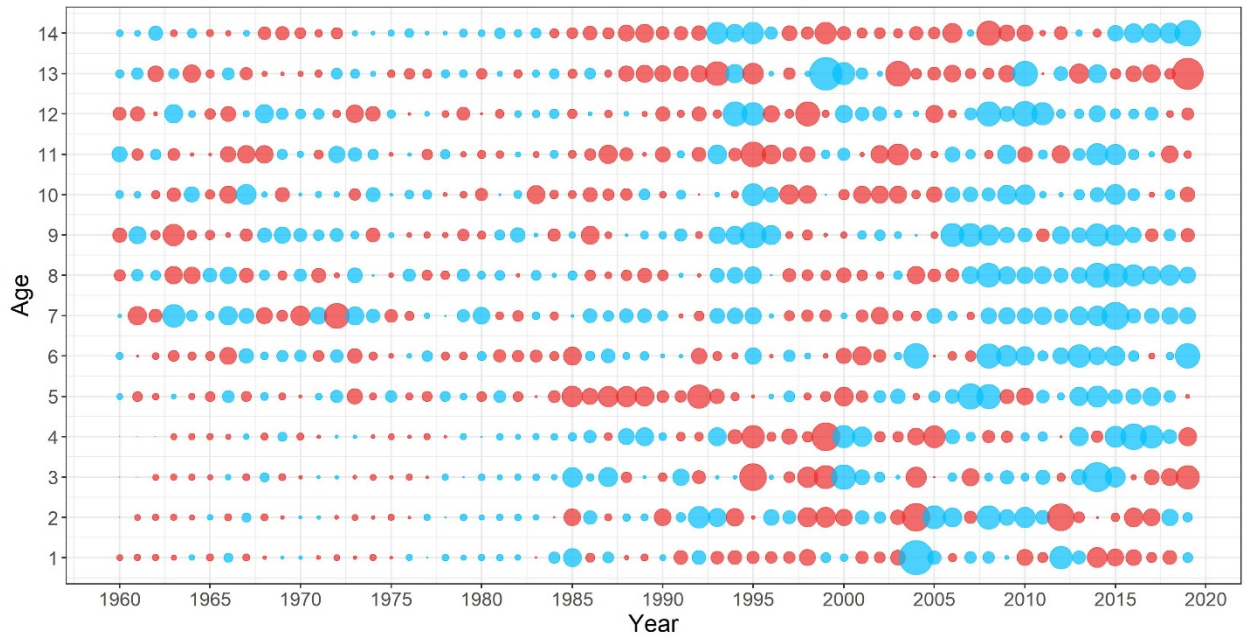

Figure 8. Bubble plot of SSM estimated process errors for ages 1-14 for years 1960-2019. The size of the bubble is proportional to the absolute value; red bubbles are positive and blue bubbles are negative.

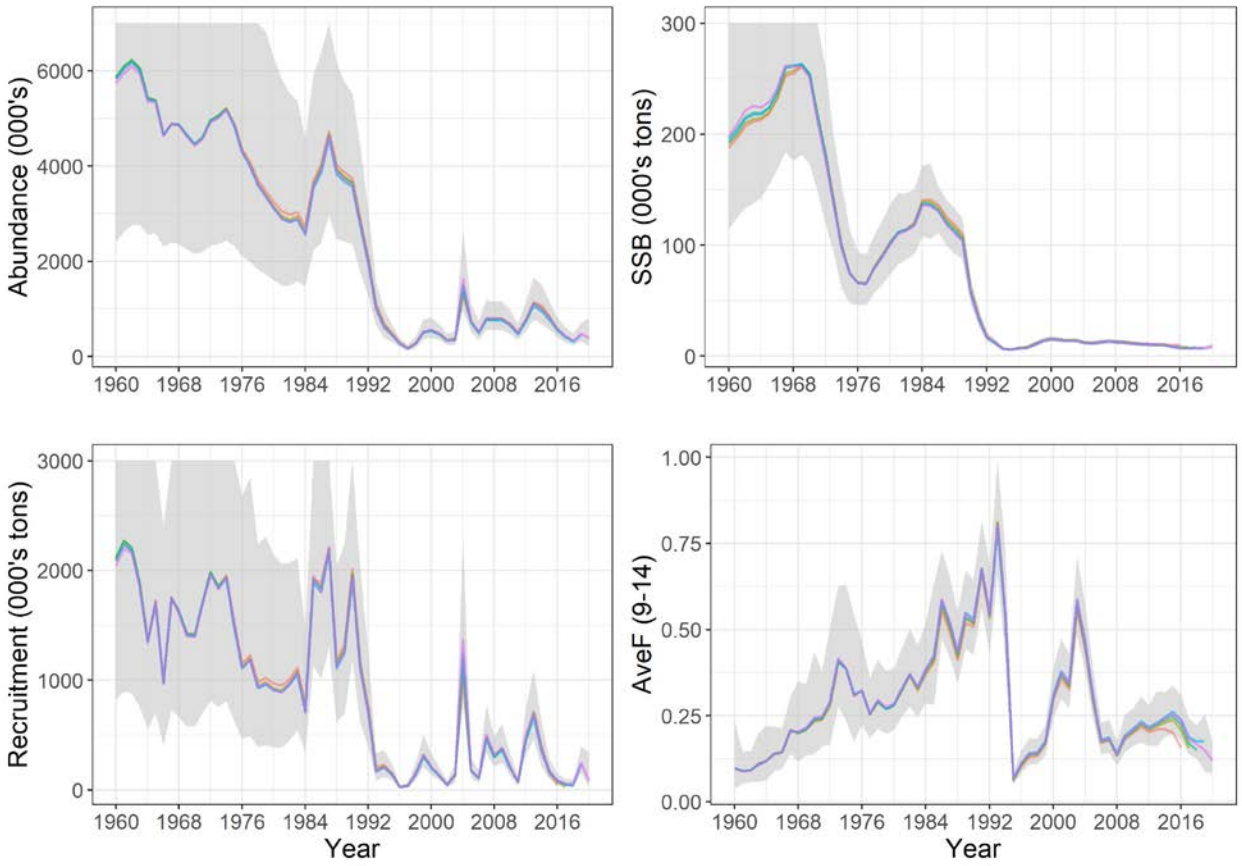

Figure 9. SSM retrospective estimates from 2016-2020 for total abundance, spawning stock biomass (ssb), average fishing mortality rates (ages 9-14; AveF) and recruitment for years 1960-2020. The colored lines represent a separate retrospective run and the shaded grey region is the 95% confidence interval for the new SSM (i.e., the full model).

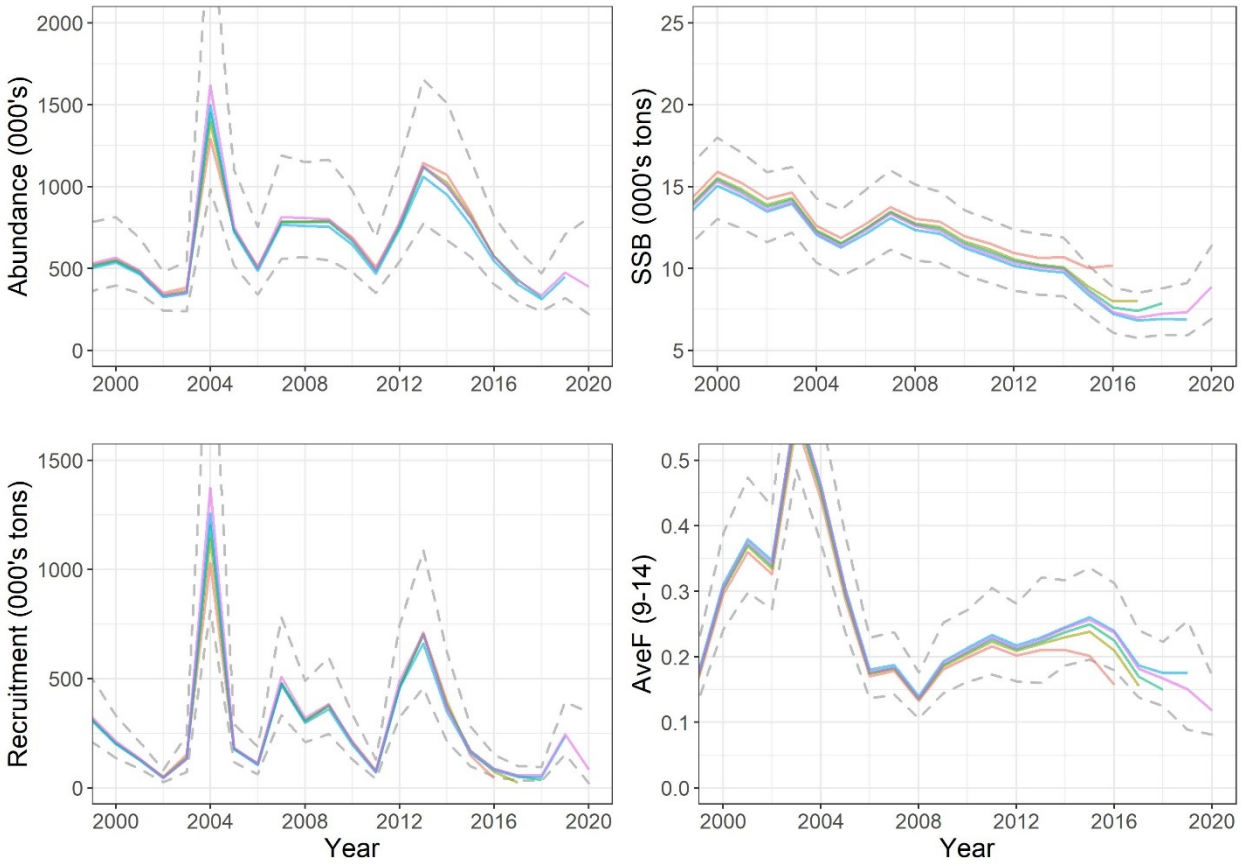

Figure 10. SSM retrospective estimates from 2016-2020 for total abundance, spawning stock biomass (ssb), average fishing mortality rates (ages 9-14; AveF) and recruitment for years 2000-2020. The colored lines represent a separate retrospective run and dashed lines represent the 95% confidence interval for the new SSM (i.e., the full model).

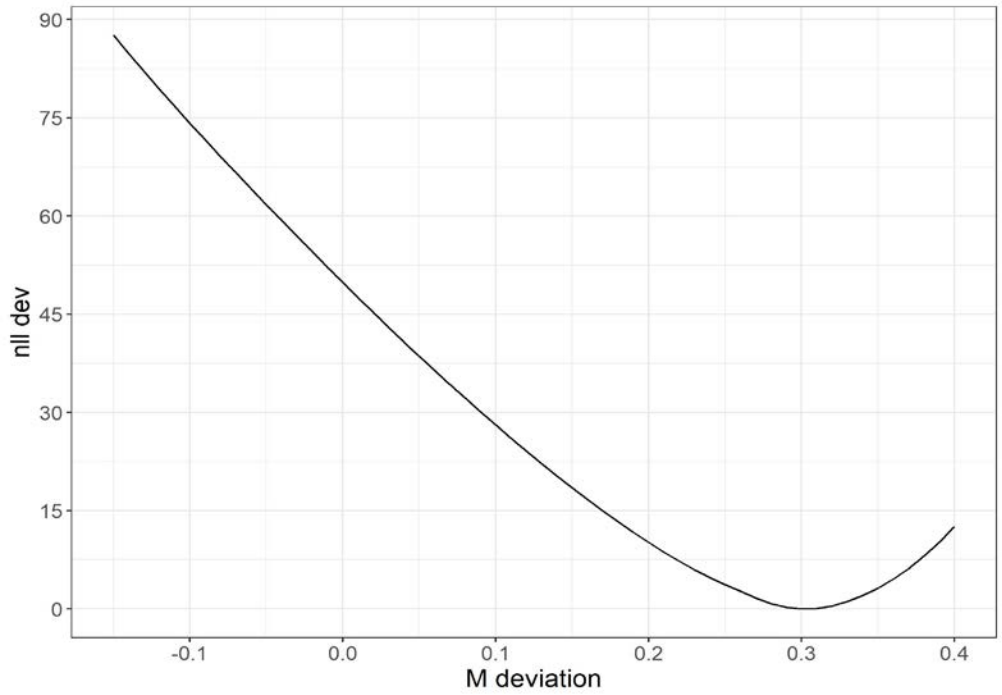

Figure 11. Profile plots for various natural mortality (M) deviations for the SSM.

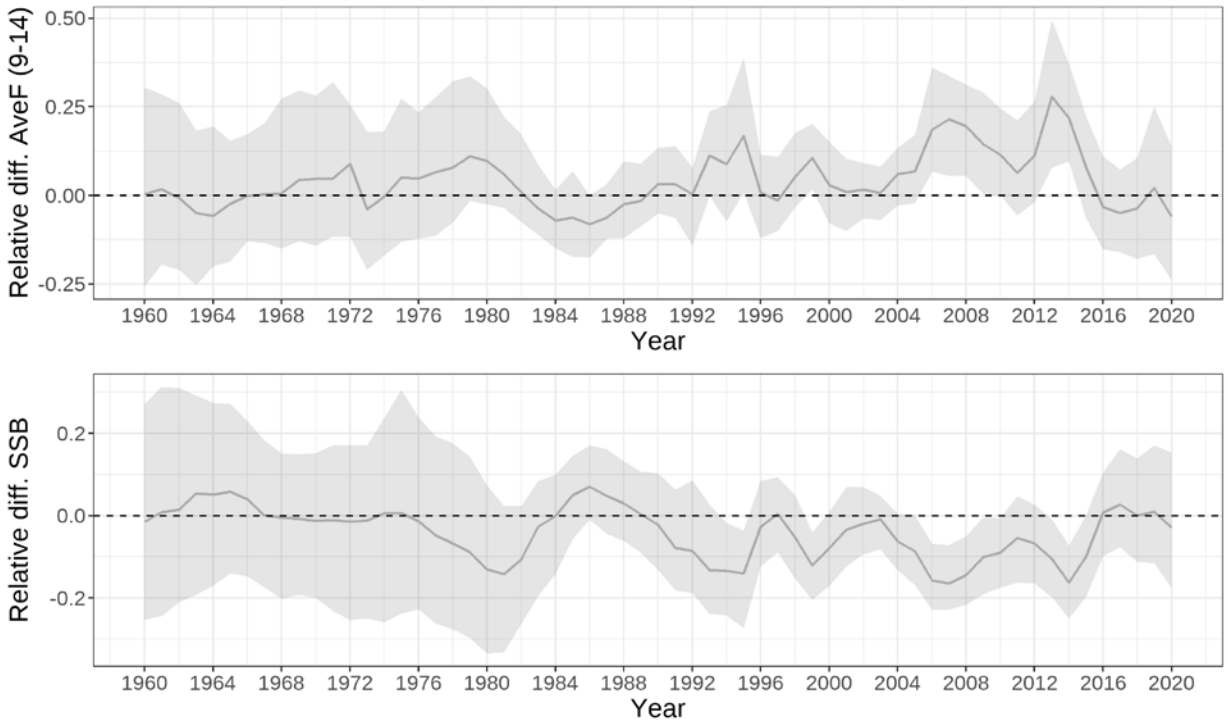

Figure 12. Relative difference from self-test sample for spawning stock biomass (SSB) and average fishing mortality rates for ages 9-14 (aveF). The solid grey line is the median of the estimates and shaded grey regions represent the lower 2.75% and upper 97.5% bounds.

Table 1. Some state-space model parameter estimates (est) and standard errors (se).

name	est	se
cv_index_Fall_1	0.67	0.12
cv_index_Fall_2-11	0.29	0.02
cv_index_Fall_12-15	0.50	0.05
cv_index_Span_1	1.44	0.39
cv_index_Span_2-7	0.85	0.10
cv_index_Span_8-15	0.52	0.06
cv_index_Sprg_1	1.24	0.30
cv_index_Sprg_2	0.64	0.10
cv_index_Sprg_3-13	0.36	0.03
cv_index_Sprg_14-15	0.54	0.07
std_log_R	0.73	0.09
F_mean_F_5_pre	0.01	0.02
F_mean_F_5_post	0.00	0.00
F_mean_F_6_pre	0.91	0.68
F_mean_F_6_post	0.12	0.10
std_log_F_5	2.65	1.23
std_log_F_6+	2.03	0.35
std_pe	0.23	0.01
std_crl_5-6	0.61	0.07
std_crl_90-99	0.97	0.09
std_crl_7-11	0.36	0.03
std_crl_12-14	0.31	0.04
ar_index_age_Fall	0.54	0.05
ar_index_age_Spanish	0.73	0.04
ar_index_age_Spring	0.83	0.03
ar_logF_age	0.90	0.04
ar_logF_year6+	0.98	0.01
ar_logF_year5	0.97	0.03
ar_logRec	0.30	0.14

Appendix A: SSM Formulation

Process equations

We treat the abundance at all ages and fishing mortality deviations as random effects. The process equations describing the abundance at age a in year y are,

$$\log(N_{y,a}) = \begin{cases} \mu_{Rj} + \delta_{R_y}, & \text{if } a = 1 \\ \log(N_{y-1,a-1}) - Z_{y-1,a-1} + \gamma_{y,a}, & \text{if } 1 < a < A^+ \\ \log(N_{y-1,A^+-1}\exp^{-Z_{y-1,A^+-1}} + N_{y-1,A^+}\exp^{-Z_{y-1,A^+}}) + \gamma_{y,A^+}, & \text{if } a = A^+ \end{cases}$$

where the total mortality rate is $Z_{y,a} = M_{y,a} + F_{y,a}$, the sum of the natural mortality rate, $M_{y,a}$ and the fishing mortality rate $F_{y,a}$. Here, $M_{y,a}$ is assumed to be known and fixed at 0.50 for ages 1-3, 0.30 for age 4 and 0.20 for all ages 5 and above, except during 1989 to 1996, where it is fixed at 0.53 for all ages 5 and above, 0.83 for ages 1-3 and 0.63 for age 4 as per **Morgan and Brodie** (**2001**). A^+ represents the plus group for ages 15^+. Numbers at the first age are modeled as deviations δ_{R_y} from a fixed mean effect μ_{Rj} for $j = 1,2$, where j represents a separate μ_{Rj} pre/post 1993 to account for large differences in recruitment between the two time periods. The δ_{R_y} that are closer together in years are expected to be more similar in time,

$$\delta_{R_y} \sim N(0, \Sigma_R),$$

where $\Sigma_{Ry,\tilde{y}} = \phi_R^{|y-\tilde{y}|}\sigma_R\tilde{\sigma}_R$ and σ_R and ϕ_R are the AR(1) standard deviation and correlation fixed effect parameters to estimate, with $-1 \leq \phi_R \leq 1$. The $F_{y,a}$ for ages 5 and 6^+ are treated separately since age 5 fish were not actively targeted in the earliest years of the fishery. Age 5 fish are modeled similarly to recruits: $F_{y,5} = \mu_{F_{5,j}} + \delta_{F_{y,5}}$, where $\mu_{F_{5,j}}$ are the fixed effect mean fishing mortality rates for $j = 1,2$, for j pre/post 1995 to account for the closure of the commercial fishery. The $\delta_{F_{y,5}}$ are treated as from an AR(1) process across years with σ_{F_5} and $\phi_{F_{Y5}}$ the AR(1) standard deviation and year correlation fixed effect parameters to estimate. For age 6^+ fish, fishing mortality rates are assumed to increase with age,

$$F_{y,a} = \begin{cases} \mu_{F_{a,j}} + \delta_{F_{y,a}}, & \text{if } a = 6 \\ F_{y,a-1} + \delta_{F_{y,a}}, & \text{if } 6 < a \leq A^+ \end{cases}$$

where $\mu_{F_{a,j}}$ is the mean fishing mortality rate for age 6 fish, for $j = 1,2$ split pre/post 1995. The $\delta_{F_{y,a}}$ are freely estimated for age 6, constrained to be positive for ages 7+, and are modeled as auto-correlated over ages and years since F deviations should be more similar for fish that are closer together in ages and years,

$$\text{Cov}(\delta_{F_{y,a}}, \delta_{F_{y-j,a-k}}) = \frac{\sigma_{F_{6^+}}^2 \phi_{F_{A6^+}}^{|a-\tilde{a}|} \phi_{F_{Y6^+}}^{|y-\tilde{y}|}}{(1-\phi_{F_{A6^+}}^2)(1-\phi_{F_{Y6^+}}^2)},$$

where $\sigma_{F_{6^+}}$, $\phi_{F_{Y6^+}}$ and $\phi_{F_{A6^+}}$ are the AR(1) standard deviation, year and age correlation fixed effect parameters to estimate, respectively, with $-1 \leq \phi_{F_{Y6^+}}, \phi_{F_{A6^+}} \leq 1$.

Observation equations

The observation equations relate the survey and commercial catch data to the population processes. The available data are research vessel survey indices, commercial landed weights (landings) and their age compositions (described below), which we define as I, W, and X, respectively. The survey indices are modeled as

$$I_{s,y,a} = q_{s,a}N_{y,a}\exp^{-f_s Z_{y,a}},$$

where $q_{s,a}$ is the survey catchability and f represents the fraction of the year that the survey takes place. The $q_{s,a}$ are assumed to increase with age,

$$q_{s,a} = \begin{cases} \delta_{s,a}, & \text{if } a = 1 \\ q_{s,a-1} + \delta_{s,a}, & \text{if } 1 < a \leq 7 \\ q_{s,7}, & \text{if } 7 < a \leq A^{+}, \end{cases}$$

where the $\delta_{q_{s,a}}$ are freely estimated for age 1 and constrained to be positive for ages 1+. The $q_{s,a}$ at ages 8^{+} are fixed at the $q_{s,a}$ for age 7, selected via a thorough model fitting process (**Perreault et al., 2020**). We assume that survey indices have additive multivariate normal measurement errors with constant coefficient of variation, i.e. $\sigma_{s,a} = cv_{s,a}I_{os,y,a}$ where $I_{os,y,a}$ is the observed index for survey at age in year and $\sigma_{s,a}$ is the standard deviation. The $cv_{s,a}$ are aggregated into age groups for ages 1, 2-11, 12-15 for the fall survey, 1,2,3-13,14-15 for the spring survey, and 1,2-8, 8-15 for the Spanish survey.

To account for similarities in survey indices that are closer together in age, we assume AR(1) correlations independent for each survey. The conditional negative log-likelihood for the survey s indices is,

$$l(\theta, u; I) = -\log\{f_{MVN}(I_{os,y}; I_{s,y}, \Sigma_{Is})\},$$

where f_{MVN} is the multivariate normal density function and Σ_{Is} is the covariance matrix for survey with elements calculated from $\Sigma_{Isa,\tilde{a}} = \phi_s^{|a-\tilde{a}|}\sigma_{s,a}\sigma_{s,\tilde{a}}$ with $-1 \leq \phi_s \leq 1$, where ϕ_s is the AR(1) fixed effect correlation parameter to estimate.

The catch age composition data are fit using the continuation ratio logit (crl) transformation (see **Perreault et al. (2020)** for details). Let $X_{y,a}$ be the crl's derived from the model Baranov catch equation $C_{y,a} = N_{y,a}\{1 - \exp(-Z_{y,a})F_{y,a}/Z_{y,a}\}$ and $X_{oy,a}$ be the sampled (i.e. observed) catch proportions crl's. The observation model is based on assuming that the model crl residuals follow a multivariate normal distribution with residuals closer together in ages more similar than those that are further apart. The conditional negative log-likelihood for the crl age composition data is,

$$l(\theta, u; X) = -\log\{f_{MVN}(X_{oy}; X_y, \Sigma_X)\}$$

where Σ_X is the covariance matrix with elements calculated from $\Sigma_{Xa,\tilde{a}} = \phi_C^{|a-\tilde{a}|}\sigma_{Cj,a}\sigma_{Cj,\tilde{a}}$ with $\phi_C = 0.90$ and $\sigma_{Cj,a}$ grouped for ages 5-6 and 7-11 for $j = 1,2$, pre/post 1993.

A censored likelihood approach was used to account for uncertainties in reported landings in which the landings bounds are treated as the only information about landings. The lower landings bounds are assumed to be the reported landings (RL) and the upper landings bounds are fixed at 2×RL for years 1960-1976, 1.5×RL for years 1983-1993 and 2011-2017, and 1.2×RL for years 1977-1982 and 1994-2010. Let B_{ly} and B_{uy} denote the lower and upper landings bounds and σ_L = 0.05, then the conditional negative log-likelihood for the landings is,

$$l(\theta, u; W) = -\sum_{y=1}^{Y} \log\left[\phi\left\{\frac{\log(B_{uy}/W_y)}{\sigma_L}\right\} - \phi\left\{\frac{\log(B_{ly}/W_y)}{\sigma_L}\right\}\right],$$

where ϕ in the cumulative distribution function for a N(0,1) random variable.

Parameter estimation

In state-space stock assessment models there are both fixed effect parameters $\theta \in \mathbb{R}^q$ and random effects $u \in \mathbb{R}^m$. Estimation of the fixed effect parameters is based on the marginal negative log-likelihood $l(\theta; D)$ where the random effects are integrated out. Let D represent the set of all data used in the model and let $l(\theta; u, D)$ denote the joint negative log-likelihood of θ and u. The marginal negative log-likelihood is,

$$l(\theta; D) = \log\left[\int_{R^m} \exp\{l(\theta; u, D)\}\, \partial u\right].$$

This integral is difficult to calculate directly, so we use the TMB package (**Kristensen et al., 2016**) in R which provides the Laplace approximation for the marginal negative log-likelihood. TMB provides the user with the objective and gradient functions of $l(\theta; D)$ which greatly improve parameter estimation in derivative-based optimizers that are used to find the maximum likelihood estimate $(MLE; \hat{\theta})$ for θ. We use the nlminb package in R for this purpose.

Appendix B: Data used in the SSM

Table B1. Estimated proportion mature-at-age for Div. 3LNO American plaice.

Year	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
1960	0.0	0.0	0.0	0.0	0.1	0.2	0.6	0.8	0.9	1.0	1.0
1961	0.0	0.0	0.0	0.0	0.1	0.3	0.6	0.8	0.9	1.0	1.0
1962	0.0	0.0	0.0	0.0	0.1	0.2	0.6	0.8	0.9	1.0	1.0
1963	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.9	1.0	1.0	1.0
1964	0.0	0.0	0.0	0.1	0.1	0.3	0.6	0.7	0.9	1.0	1.0
1965	0.0	0.0	0.0	0.1	0.2	0.2	0.6	0.8	0.9	1.0	1.0
1966	0.0	0.0	0.0	0.0	0.2	0.5	0.5	0.8	0.9	1.0	1.0
1967	0.0	0.0	0.0	0.1	0.1	0.4	0.7	0.7	0.9	1.0	1.0
1968	0.0	0.0	0.1	0.1	0.2	0.4	0.6	0.9	0.9	1.0	1.0
1969	0.0	0.0	0.0	0.2	0.3	0.5	0.7	0.8	1.0	0.9	1.0
1970	0.0	0.0	0.0	0.1	0.4	0.6	0.8	0.9	0.9	1.0	1.0
1971	0.0	0.0	0.0	0.1	0.2	0.6	0.8	0.9	1.0	1.0	1.0
1972	0.0	0.0	0.0	0.1	0.2	0.4	0.8	0.9	1.0	1.0	1.0
1973	0.0	0.0	0.0	0.0	0.2	0.3	0.6	0.9	1.0	1.0	1.0
1974	0.0	0.0	0.0	0.0	0.1	0.3	0.6	0.8	1.0	1.0	1.0
1975	0.0	0.0	0.0	0.0	0.1	0.2	0.6	0.8	0.9	1.0	1.0
1976	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.8	0.9	1.0	1.0
1977	0.0	0.0	0.0	0.1	0.1	0.4	0.6	0.8	0.9	1.0	1.0
1978	0.0	0.0	0.0	0.1	0.2	0.4	0.7	0.8	0.9	1.0	1.0
1979	0.0	0.0	0.0	0.1	0.2	0.5	0.7	0.9	0.9	1.0	1.0
1980	0.0	0.0	0.0	0.1	0.2	0.5	0.8	0.9	1.0	1.0	1.0
1981	0.0	0.0	0.0	0.0	0.2	0.4	0.8	0.9	1.0	1.0	1.0
1982	0.0	0.0	0.0	0.1	0.2	0.5	0.7	0.9	1.0	1.0	1.0
1983	0.0	0.0	0.0	0.1	0.4	0.6	0.8	0.9	1.0	1.0	1.0
1984	0.0	0.0	0.0	0.2	0.5	0.8	0.9	0.9	1.0	1.0	1.0
1985	0.0	0.0	0.1	0.2	0.6	0.8	1.0	1.0	1.0	1.0	1.0
1986	0.0	0.0	0.0	0.3	0.7	0.9	1.0	1.0	1.0	1.0	1.0
1987	0.0	0.0	0.1	0.4	0.8	1.0	1.0	1.0	1.0	1.0	1.0
1988	0.0	0.0	0.1	0.4	0.9	1.0	1.0	1.0	1.0	1.0	1.0
1989	0.0	0.0	0.1	0.5	0.8	1.0	1.0	1.0	1.0	1.0	1.0
1990	0.0	0.0	0.0	0.3	0.8	1.0	1.0	1.0	1.0	1.0	1.0
1991	0.0	0.0	0.0	0.2	0.6	1.0	1.0	1.0	1.0	1.0	1.0
1992	0.0	0.0	0.1	0.2	0.6	0.9	1.0	1.0	1.0	1.0	1.0
1993	0.0	0.0	0.1	0.2	0.6	0.9	1.0	1.0	1.0	1.0	1.0
1994	0.0	0.0	0.1	0.3	0.6	0.9	1.0	1.0	1.0	1.0	1.0
1995	0.1	0.1	0.2	0.4	0.6	0.9	1.0	1.0	1.0	1.0	1.0
1996	0.0	0.2	0.3	0.6	0.8	0.8	1.0	1.0	1.0	1.0	1.0
1997	0.0	0.0	0.3	0.7	0.9	1.0	0.9	1.0	1.0	1.0	1.0
1998	0.0	0.0	0.2	0.6	0.9	1.0	1.0	1.0	1.0	1.0	1.0
1999	0.0	0.1	0.1	0.5	0.8	1.0	1.0	1.0	1.0	1.0	1.0
2000	0.0	0.1	0.2	0.5	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2001	0.0	0.0	0.2	0.5	0.8	0.9	1.0	1.0	1.0	1.0	1.0

Year	Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
2002	0.0	0.1	0.2	0.6	0.8	1.0	1.0	1.0	1.0	1.0	1.0
2003	0.1	0.2	0.4	0.6	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2004	0.0	0.2	0.4	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0
2005	0.1	0.1	0.4	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0
2006	0.0	0.1	0.2	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0
2007	0.0	0.1	0.3	0.4	0.8	1.0	1.0	1.0	1.0	1.0	1.0
2008	0.0	0.1	0.2	0.5	0.7	0.9	1.0	1.0	1.0	1.0	1.0
2009	0.0	0.1	0.2	0.5	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2010	0.0	0.1	0.3	0.5	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2011	0.0	0.1	0.3	0.6	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2012	0.0	0.0	0.2	0.5	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2013	0.0	0.0	0.1	0.4	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2014	0.0	0.0	0.2	0.4	0.7	0.9	1.0	1.0	1.0	1.0	1.0
2015	0.0	0.1	0.2	0.5	0.7	0.9	1.0	1.0	1.0	1.0	1.0
2016	0.0	0.1	0.3	0.6	0.8	0.9	1.0	1.0	1.0	1.0	1.0
2017	0.0	0.1	0.3	0.7	0.9	0.9	1.0	1.0	1.0	1.0	1.0
2018	0.0	0.1	0.3	0.7	0.9	1.0	1.0	1.0	1.0	1.0	1.0
2019	0.0	0.1	0.3	0.6	0.9	1.0	1.0	1.0	1.0	1.0	1.0
2020	0.0	0.1	0.3	0.7	0.8	1.0	1.0	1.0	1.0	1.0	1.0

Table B2. Estimated catch weights-at-age (kg) for Div. 3LNO American plaice.

Year	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14	age15
1960	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	0.9	1.2	1.3
1961	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	0.9	1.2	1.4
1962	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	0.9	1.2	1.4
1963	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.2	1.5
1964	0.2	0.3	0.4	0.5	0.5	0.6	0.8	0.9	0.9	1.2	1.6
1965	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.9	1.3	1.7
1966	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.0	1.0	1.3	1.7
1967	0.2	0.3	0.4	0.5	0.6	0.8	0.8	1.0	1.1	1.4	1.9
1968	0.2	0.3	0.3	0.4	0.6	0.7	0.9	1.0	1.1	1.4	1.9
1969	0.2	0.3	0.3	0.4	0.6	0.7	0.8	1.0	1.0	1.4	1.9
1970	0.2	0.3	0.3	0.4	0.5	0.7	0.8	0.8	1.0	1.2	1.6
1971	0.2	0.3	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.1	1.6
1972	0.2	0.3	0.4	0.5	0.5	0.6	0.8	0.9	0.9	1.2	1.6
1973	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.2	1.3	1.8
1974	0.2	0.3	0.3	0.4	0.6	0.7	0.9	1.1	1.4	1.6	2.2
1975	0.2	0.3	0.3	0.4	0.6	0.7	0.9	1.1	1.3	1.5	2.1
1976	0.2	0.3	0.3	0.4	0.6	0.7	0.8	1.0	1.1	1.3	1.9
1977	0.2	0.3	0.4	0.4	0.6	0.7	0.9	1.0	1.2	1.4	2.0
1978	0.2	0.3	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.4	1.9
1979	0.2	0.3	0.4	0.5	0.6	0.6	0.7	0.9	1.2	1.7	2.0
1980	0.2	0.3	0.4	0.5	0.5	0.6	0.6	0.7	1.0	1.4	1.8
1981	0.2	0.4	0.4	0.5	0.5	0.5	0.6	0.7	0.8	1.0	1.5
1982	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	1.0	1.3	1.8
1983	0.3	0.4	0.5	0.6	0.7	0.7	0.7	0.8	1.0	1.2	1.8
1984	0.3	0.3	0.4	0.5	0.6	0.6	0.7	0.9	1.1	1.4	2.2
1985	0.2	0.3	0.4	0.5	0.5	0.7	0.8	1.1	1.5	1.9	2.6
1986	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.3	1.7	2.3
1987	0.2	0.3	0.4	0.4	0.5	0.7	0.8	1.1	1.4	1.7	2.4
1988	0.2	0.3	0.3	0.4	0.5	0.6	0.8	1.0	1.4	1.7	2.5
1989	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.1	1.4	1.8	2.5
1990	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.2	1.6	2.0	2.3
1991	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.3	1.8	2.2	2.5
1992	0.2	0.3	0.4	0.4	0.5	0.7	0.9	1.2	1.5	1.8	2.5
1993	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.2	1.4	2.2
1994	0.1	0.2	0.3	0.4	0.5	0.8	0.9	1.1	1.5	1.7	2.2
1995	0.2	0.2	0.3	0.4	0.7	1.0	1.6	1.7	1.5	2.3	1.9
1996	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.6	2.9	2.4
1997	0.2	0.2	0.3	0.5	0.7	0.8	1.0	1.3	1.8	2.3	2.3
1998	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.2	1.7	1.7
1999	0.2	0.3	0.3	0.4	0.5	0.6	0.7	1.0	1.2	1.5	1.9
2000	0.2	0.3	0.4	0.4	0.5	0.7	0.8	1.1	1.4	1.6	2.0

Year	age5	age6	age7	age8	age9	age10	age11	age12	age13	age14	age15
2001	0.2	0.3	0.4	0.5	0.5	0.6	0.8	1.0	1.2	1.4	2.0
2002	0.2	0.3	0.4	0.5	0.5	0.6	0.8	1.1	1.2	1.6	2.1
2003	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.1	1.3	1.6	2.2
2004	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.3	1.8	2.4
2005	0.2	0.3	0.5	0.6	0.7	0.8	0.9	1.1	1.4	1.6	2.1
2006	0.2	0.3	0.4	0.5	0.6	0.7	1.0	1.1	1.3	1.7	2.2
2007	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.2	1.3	1.5	1.8
2008	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.3	1.4	1.6	1.8
2009	0.2	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.3	1.5	1.8
2010	0.2	0.3	0.4	0.5	0.6	0.7	0.8	1.0	1.1	1.4	1.8
2011	0.2	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1.2	1.4	2.0
2012	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.1	1.3	1.9
2013	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.3	2.0
2014	0.2	0.2	0.3	0.4	0.4	0.6	0.7	0.8	1.0	1.1	1.9
2015	0.1	0.2	0.3	0.3	0.4	0.5	0.7	0.8	1.0	1.1	1.6
2016	0.2	0.3	0.3	0.5	0.6	0.6	0.8	0.9	1.1	1.3	1.8
2017	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.2	1.1	1.7
2018	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.8	1.3
2019	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.7	0.9	1.0	1.3
2020	0.1	0.3	0.3	0.5	0.5	0.6	0.7	0.8	1.1	1.4	1.7

Table B3. Estimated catch-at-age for Div. 3LNO American plaice.

Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
44.7	318.8	841.8	1,365.9	1,738.3	2,280.0	2,540.0	3,473.6	2,752.5	2,564.7	4,588.8
28.1	200.4	531.2	1,230.9	2,463.9	3,174.2	2,467.1	2,272.0	3,894.1	2,579.4	5,102.7
62.4	445.1	657.2	1,096.1	1,184.5	1,669.1	2,432.4	2,697.6	2,409.5	3,276.8	5,958.8
144.3	1,029.7	1,866.4	1,434.1	1,546.8	2,237.6	3,104.3	4,174.8	3,896.9	3,851.9	5,622.8
268.6	1,916.7	4,997.5	3,253.4	6,174.5	8,768.6	6,960.2	6,149.8	3,245.9	3,033.6	5,552.8
475.5	3,157.0	7,234.8	9,305.9	7,048.0	7,562.9	5,731.6	5,790.8	5,214.6	4,333.2	6,510.2
1,759.8	6,271.7	10,036.6	11,132.5	9,516.7	7,266.3	7,106.4	5,667.6	5,731.0	5,009.8	8,475.7
433.9	3,345.3	10,834.8	7,647.2	9,504.5	13,713.2	13,672.7	14,564.6	9,495.5	6,572.1	13,247.8
275.8	2,342.3	4,139.2	9,785.9	11,210.5	11,631.0	7,735.4	13,842.2	8,778.0	6,339.2	8,419.3
690.3	2,453.1	7,875.0	14,186.6	18,181.9	12,778.9	12,735.3	10,396.6	7,053.8	5,305.1	7,666.2
115.9	2,172.2	2,554.1	10,006.8	13,536.7	11,286.1	11,179.1	8,248.5	5,556.4	4,661.3	9,285.0
1,135.9	1,749.6	8,411.7	10,457.6	15,504.1	14,164.8	10,993.1	9,026.5	5,195.2	3,720.6	7,130.5
578.2	2,573.8	2,367.8	7,696.8	11,301.7	12,765.9	12,718.0	10,706.0	6,783.8	4,354.0	7,033.1
46.4	1,079.1	6,329.1	10,518.1	13,016.7	10,042.3	9,980.4	6,762.3	6,589.6	3,733.8	7,013.8
354.0	5,955.0	10,475.0	10,069.0	7,768.0	9,004.0	7,086.0	4,596.0	3,809.0	2,278.0	2,164.0
883.0	3,128.0	7,220.0	9,433.0	9,234.0	7,903.0	5,701.0	4,732.0	3,788.0	2,617.0	2,933.0
837.0	3,907.0	8,781.0	19,363.0	16,597.0	12,338.0	8,323.0	5,156.0	3,024.0	2,309.0	2,241.0
974.0	6,723.0	8,743.0	11,730.0	13,559.0	11,157.0	6,520.0	4,257.0	2,369.0	1,493.0	1,625.0
1,558.0	4,467.0	9,195.0	10,397.0	12,743.0	13,881.0	9,938.0	6,823.0	3,655.0	2,239.0	2,440.0
1,257.0	6,551.0	13,532.0	18,747.0	14,977.0	12,506.0	8,791.0	3,775.0	1,843.0	714.0	580.0
263.0	2,977.0	9,531.0	12,578.0	14,111.0	14,212.0	11,288.0	8,088.0	3,732.0	1,565.0	1,022.0
154.0	554.0	2,248.0	4,786.0	7,921.0	11,425.0	13,565.0	11,872.0	8,693.0	5,591.0	4,697.0
27.0	314.0	1,814.0	4,799.0	8,946.0	12,836.0	15,801.0	14,489.0	7,942.0	4,224.0	2,943.0
119.0	991.0	3,053.0	5,797.0	8,343.0	7,707.0	8,493.0	7,517.0	4,588.0	2,480.0	1,771.0
48.0	397.0	1,516.0	3,311.0	5,853.0	9,958.0	12,887.0	8,964.0	5,072.0	2,515.0	1,602.0
296.0	788.0	2,362.0	5,652.0	10,694.0	15,741.0	14,528.0	9,233.0	4,108.0	1,969.0	1,792.0
4,407.0	9,707.0	12,556.0	12,530.0	13,372.0	13,874.0	14,246.0	10,376.0	5,947.0	2,637.0	2,155.0
2,237.0	4,941.0	7,691.0	10,893.0	15,867.0	17,640.0	11,404.0	6,986.0	3,076.0	1,303.0	1,046.0
2,908.0	3,213.0	4,853.0	7,269.0	10,123.0	10,325.0	9,260.0	6,040.0	2,692.0	1,156.0	962.0
12,745.0	11,553.0	11,432.0	9,652.0	14,180.0	12,387.0	8,405.0	4,972.0	2,029.0	1,027.0	715.0
15,134.0	7,694.0	4,489.0	4,604.0	8,666.0	8,666.0	6,452.0	3,633.0	1,702.0	945.0	548.0
6,103.0	12,152.0	7,846.0	9,331.0	7,856.0	6,589.0	4,394.0	2,294.0	811.0	364.0	484.0
148.0	1,023.0	2,591.0	3,395.0	3,618.0	2,154.0	1,507.0	875.0	576.0	513.0	579.0
1,172.4	3,712.9	8,820.9	11,590.5	5,720.0	3,376.9	1,853.1	1,002.5	526.9	354.7	526.8
4,316.3	3,837.1	5,426.1	4,459.7	2,777.0	736.9	475.6	162.8	120.9	54.7	27.7
99.2	313.9	453.2	333.0	203.3	65.5	13.6	4.1	0.1	0.1	0.4
180.9	742.8	975.0	452.7	211.1	51.9	10.4	8.1	2.3	1.0	1.3
19.4	134.9	543.7	719.4	409.4	149.3	93.5	56.8	26.2	1.4	1.4
10.6	54.8	272.7	767.1	804.9	455.5	278.5	117.3	69.0	49.2	18.3
26.0	174.5	268.4	579.2	1,029.9	1,079.4	627.4	278.1	125.6	39.6	38.3
15.2	226.3	726.8	915.1	1,442.7	1,532.7	979.1	429.1	195.2	43.9	116.6
111.0	331.5	1,139.1	1,413.3	1,583.8	1,595.5	1,403.9	665.1	232.4	86.1	109.1
312.2	308.3	609.9	1,488.3	1,431.7	1,082.1	1,059.3	605.2	203.5	62.4	60.6
1,212.4	983.0	1,104.7	1,707.9	1,993.6	1,201.8	999.9	879.7	358.2	156.5	131.8
346.2	1,898.8	1,215.9	967.5	1,086.1	1,013.6	739.9	591.1	320.1	201.4	124.4
58.6	289.0	999.0	842.9	778.7	579.7	536.2	341.9	260.0	178.0	250.4
76.1	228.4	637.2	558.5	469.0	354.4	311.7	252.7	210.7	154.5	238.8
53.9	73.3	375.1	627.6	738.8	366.3	283.3	249.6	247.8	247.3	564.6
82.3	136.2	292.8	722.4	736.4	511.0	226.9	198.8	111.5	101.3	227.8

Age5	Age6	Age7	Age8	Age9	Age10	Age11	Age12	Age13	Age14	Age15
189.3	689.5	544.6	691.0	787.2	645.5	472.2	214.3	88.4	87.3	356.0
126.1	687.0	882.4	555.1	483.1	579.1	408.6	295.5	155.7	88.7	289.9
724.1	795.2	1,003.7	963.5	439.2	369.0	272.0	254.1	79.6	31.9	111.5
285.4	762.7	841.6	710.9	732.8	369.9	239.1	221.4	143.3	70.5	115.0
332.8	635.5	1,139.4	1,069.4	923.5	721.4	355.8	243.3	140.3	90.6	192.0
72.5	371.4	759.7	936.9	692.5	519.4	285.2	176.3	121.7	90.7	200.6
61.6	171.6	269.9	369.3	312.3	225.3	200.0	145.0	88.1	62.6	134.4
120.3	268.2	461.5	635.9	476.2	406.6	237.7	152.8	86.0	43.3	51.6
55.5	96.7	250.1	377.5	282.0	275.3	259.0	150.7	88.3	56.6	30.9
18.2	91.4	245.9	264.4	290.1	306.5	215.4	163.9	66.7	43.6	17.2
18.3	192.6	462.2	349.3	213.1	232.6	221.4	164.6	65.1	27.2	19.3
6.9	40.5	93.3	211.8	153.0	212.7	224.9	165.1	100.7	50.1	5.1

Table B4. Nominal catches (t) of American plaice in NAFO Divisions 3LNO.

Year	Land
1960	24,000
1961	18,000
1962	18,000
1963	26,000
1964	39,000
1965	53,000
1966	65,000
1967	94,000
1968	73,000
1969	79,000
1970	67,000
1971	68,000
1972	59,000
1973	53,000
1974	46,000
1975	43,000
1976	52,000
1977	44,000
1978	50,000
1979	49,000
1980	49,000
1981	50,000
1982	51,000
1983	39,000
1984	39,000
1985	54,000
1986	65,000
1987	55,000
1988	41,000
1989	43,000
1990	32,000
1991	34,000
1992	13,000
1993	17,000
1994	7,400
1995	600
1996	900
1997	1,407
1998	1,618
1999	2,565
2000	5,176

Year	Land
2001	5,739
2002	4,870
2003	8,727
2004	6,158
2005	4,110
2006	2,828
2007	3,606
2008	2,515
2009	3,015
2010	2,898
2011	2,363
2012	2,148
2013	3,016
2014	2,265
2015	1,842
2016	1,664
2017	1,172
2018	1,002
2019	1,248
2020	1,175

Table B5. Abundance index (millions) at age for American plaice in Divsisions 3LNO from the Canadian Fall RV survey.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1990	11.4	53.1	186.1	705.4	853.0	642.8	369.6	191.7	124.5	55.2	29.2	17.4	12.1	9.3	6.3
1991	1.6	98.8	264.5	449.8	724.4	578.8	249.4	116.3	81.8	44.3	25.9	13.9	12.2	7.0	3.9
1992	5.8	81.4	217.7	258.3	368.0	499.4	226.0	76.6	35.7	17.7	8.4	6.8	3.3	3.2	2.0
1993	0.0	10.1	116.0	497.9	360.5	372.1	316.6	104.1	33.0	15.3	6.8	5.1	3.1	2.4	2.2
1994	0.0	0.0	19.5	103.7	190.3	151.0	134.9	89.2	28.6	7.8	2.7	1.7	0.9	1.2	0.0
1995	38.2	125.8	60.5	110.7	296.0	337.7	154.0	62.5	40.2	10.8	1.9	1.3	0.5	0.3	0.0
1996	3.1	82.9	121.9	215.4	204.5	171.0	80.4	20.9	8.7	3.1	1.7	0.5	0.1	0.1	0.0
1997	3.3	19.7	103.7	152.0	157.3	168.3	128.8	56.6	23.9	7.0	2.9	1.2	0.8	0.6	0.1
1998	24.4	26.6	17.0	116.2	117.5	121.1	109.2	82.6	65.4	18.6	7.4	3.5	2.0	0.8	0.8
1999	153.6	170.2	71.8	23.7	92.5	93.4	79.6	98.9	72.7	33.7	18.9	12.3	4.9	1.1	1.5
2000	90.1	329.6	415.5	122.9	73.7	132.0	115.6	83.8	61.8	48.9	25.4	7.1	3.1	0.8	1.0
2001	45.8	184.0	302.5	117.2	54.5	67.5	98.5	62.5	48.7	26.9	26.2	12.1	2.8	1.1	0.8
2002	10.8	149.8	223.5	295.4	105.6	42.4	72.9	75.9	41.1	26.8	27.0	15.8	7.9	1.0	1.6
2003	17.7	47.3	176.6	274.1	325.1	85.4	49.1	35.0	19.0	12.3	11.0	6.3	1.8	0.8	0.7
2004															
2005	70.0	485.2	165.5	114.1	170.5	197.0	132.1	38.1	13.9	13.3	7.3	5.1	4.9	3.3	1.0
2006	17.9	137.1	265.6	106.9	74.3	141.1	138.3	108.8	26.3	9.2	10.5	9.9	5.6	3.6	4.4
2007	204.1	141.5	177.6	328.5	118.1	68.0	128.4	121.2	74.1	24.4	9.1	8.6	2.7	4.9	7.0
2008	170.0	619.2	193.2	356.2	515.6	146.4	117.5	103.6	69.1	28.2	8.3	4.7	2.6	2.7	3.3
2009	219.8	319.9	463.8	173.0	229.2	230.7	78.4	52.2	41.6	21.3	14.4	3.7	3.1	2.4	4.4
2010	87.9	433.8	394.6	523.5	199.8	255.1	135.1	46.7	28.2	36.6	11.7	4.6	3.4	3.0	4.4
2011	9.6	272.2	335.8	308.8	286.5	184.8	145.1	91.3	29.3	17.0	14.3	10.1	3.7	1.2	3.9
2012	94.1	65.8	296.1	286.7	285.9	235.1	112.3	67.2	49.6	19.9	10.9	7.7	4.4	1.5	2.2
2013	516.1	420.4	286.2	451.3	381.9	348.9	158.3	85.3	42.1	20.3	13.4	10.7	6.4	2.3	4.1
2014															
2015	62.7	622.0	1,151.5	286.8	178.8	172.2	130.2	78.7	42.4	22.5	15.0	7.7	3.8	1.4	2.4
2016	5.6	133.0	875.6	815.9	155.5	120.7	87.6	39.9	29.2	15.6	5.4	3.8	0.6	1.0	1.7
2017	4.9	108.9	462.3	1,047.2	379.3	135.1	84.6	54.3	29.4	18.8	9.8	6.0	1.4	1.5	1.7
2018	10.3	74.2	164.6	368.4	538.2	330.4	107.4	51.8	38.2	21.9	13.3	6.1	1.8	2.1	1.3
2019	158.4	82.4	73.2	296.3	378.0	457.2	163.6	67.6	29.4	19.8	13.5	9.6	3.2	2.0	2.1
2020	14.9	219.8	93.4	154.4	311.8	296.1	186.8	53.0	27.9	17.5	17.2	12.9	7.7	1.4	1.6

Table B6. Abundance index (millions) at age for American plaice in Divsisions 3LNO from the Canadian Spring RV survey.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1985	0.3	2.2	49.4	165.3	274.1	455.6	583.6	382.6	204.2	138.7	83.9	45.0	22.6	13.9	5.1
1986	0.0	4.3	31.1	109.8	256.4	561.3	577.4	307.6	194.1	98.6	46.2	34.6	21.8	8.9	6.6
1987	0.5	27.2	100.7	221.9	460.6	748.2	657.4	399.1	185.0	101.4	41.9	33.9	20.0	11.2	7.3
1988	0.0	8.4	79.4	191.3	368.6	616.6	543.9	315.0	217.9	85.3	48.6	32.5	18.7	12.0	7.3
1989	0.0	6.2	86.6	445.3	336.5	552.5	470.8	274.0	187.8	74.7	39.9	27.1	16.8	9.7	7.6
1990	0.3	9.3	44.3	346.8	618.6	377.9	371.0	200.3	130.5	77.5	32.4	21.4	14.3	8.8	8.1
1991	0.0	1.8	28.5	84.1	398.1	364.2	180.2	112.9	67.5	35.2	22.3	13.4	7.2	5.5	4.7
1992	0.0	4.5	33.2	59.6	110.3	190.1	150.9	63.4	34.1	17.5	9.5	5.4	3.3	1.8	2.7
1993	0.0	2.4	9.1	120.5	139.5	178.7	160.2	89.5	32.3	16.1	7.3	4.2	2.2	1.2	1.5
1994	0.0	0.0	2.5	21.1	99.2	106.0	85.4	43.3	20.0	5.4	4.0	1.4	1.2	1.0	0.3
1995	0.0	0.0	2.0	10.8	41.9	57.5	59.9	49.9	27.5	8.3	2.3	0.5	0.1	0.0	0.0
1996	0.3	46.3	99.5	125.6	133.5	130.4	97.1	39.5	16.2	4.5	1.9	2.2	0.5	0.3	0.2
1997	0.1	6.5	40.4	55.1	65.3	84.4	79.3	48.7	18.9	6.0	2.7	1.8	0.6	0.2	0.1
1998	0.5	10.3	11.0	54.1	70.9	69.5	76.5	78.7	47.5	19.4	9.8	3.2	1.6	0.4	0.1
1999	8.4	42.5	35.1	22.5	66.7	104.5	104.9	111.5	107.3	65.3	30.5	13.0	6.5	1.9	2.1
2000	4.8	54.6	149.3	72.5	35.0	67.0	78.0	64.6	59.2	47.2	27.9	9.5	4.0	0.9	1.3
2001	5.2	101.0	275.9	113.0	28.9	36.4	73.9	62.4	58.4	45.0	34.6	16.0	5.5	2.8	2.4
2002	0.3	37.9	98.7	150.6	56.5	41.3	51.9	53.8	38.3	24.4	20.0	12.6	4.0	2.0	1.1
2003	0.2	7.9	74.6	95.1	188.2	72.5	46.1	49.7	40.0	18.1	13.8	11.5	4.5	2.2	1.2
2004	7.0	17.7	29.2	77.8	96.5	161.9	51.3	29.3	19.9	15.6	9.2	8.2	4.5	2.7	0.4
2005	5.1	131.2	223.2	78.5	149.7	163.8	143.9	55.1	31.9	16.5	13.7	8.2	6.2	4.7	3.6
2006															
2007	16.9	27.8	66.9	320.2	193.9	89.6	144.5	115.5	82.6	16.8	10.9	5.1	4.4	3.8	5.3
2008	10.7	132.9	98.2	101.7	239.0	116.5	92.0	117.0	70.1	42.6	14.8	7.3	3.8	3.3	3.6
2009	7.0	111.0	188.0	79.4	75.2	129.8	45.7	35.0	38.9	26.5	16.8	6.4	1.7	2.0	6.1
2010	3.6	125.2	165.6	191.2	85.4	146.9	138.2	40.6	28.1	18.4	12.1	8.9	3.3	1.2	4.5
2011	0.0	79.1	207.7	209.5	189.3	116.5	97.0	66.7	20.6	13.2	10.9	10.5	3.1	1.0	5.2
2012	33.3	44.1	193.8	234.1	159.1	173.3	114.5	71.4	46.9	22.8	12.0	7.1	4.5	2.1	4.2
2013	18.9	164.3	126.9	267.1	219.7	187.0	182.7	98.2	53.4	33.1	17.6	12.1	5.1	3.1	3.7
2014	8.5	303.0	392.7	127.0	175.9	196.8	140.5	121.5	67.1	37.6	27.1	12.2	8.0	7.2	4.7
2015	0.6	153.9	434.9	158.1	72.8	73.0	123.8	54.8	37.2	20.7	11.6	3.7	0.9	0.7	2.0
2016	1.8	76.3	285.1	315.4	75.3	46.8	41.9	30.4	16.4	12.0	6.2	3.7	2.0	1.5	0.5
2017															
2018	1.3	21.8	100.9	260.5	148.5	100.8	66.0	45.2	20.7	20.7	10.7	5.7	2.0	0.7	1.4
2019	5.0	16.5	16.0	39.4	99.1	148.7	106.2	28.8	13.9	10.6	6.3	3.7	3.0	0.8	0.9
2020															

Table B7. Abundance index (millions) at age for American plaice in Divsisions 3LNO from the Spanish RV survey.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1997	0.0	0.1	2.0	4.8	6.1	19.9	25.7	13.7	4.5	1.3	0.5	0.4	0.1	0.1	0.1
1998	0.0	0.1	0.4	5.9	8.6	14.2	30.0	48.5	33.8	13.7	5.4	2.0	0.9	1.0	0.2
1999	0.0	21.8	14.4	4.1	12.9	37.9	32.1	42.5	60.5	50.1	20.5	9.2	5.0	1.9	1.3
2000	0.0	50.5	189.3	67.8	11.0	19.6	49.7	39.5	51.9	47.0	29.1	13.6	6.4	1.0	2.2
2001	1.8	25.5	256.8	78.1	4.8	11.4	30.6	28.5	27.2	20.4	21.2	8.3	2.3	1.0	0.6
2002	0.0	10.8	25.0	165.3	38.4	11.4	10.0	18.8	14.3	8.9	10.7	7.4	1.8	1.0	0.3
2003	0.6	4.2	35.4	58.0	235.2	56.4	22.5	16.9	19.4	8.1	8.5	10.4	3.9	1.7	0.6
2004	56.6	20.5	13.1	35.0	76.8	204.7	47.1	12.8	11.2	11.9	6.4	7.9	4.4	3.8	0.3
2005	1.7	76.2	130.1	17.1	40.6	91.5	121.1	42.4	17.8	6.1	4.4	4.3	3.3	2.4	1.6
2006	0.1	13.8	161.7	217.7	105.8	85.8	92.8	78.7	57.9	25.6	11.9	6.5	3.5	2.3	1.4
2007	4.9	1.2	10.6	158.8	97.6	33.6	61.1	45.1	56.8	10.9	3.8	3.1	2.2	2.3	2.1
2008	3.8	65.2	10.7	33.8	282.6	122.0	37.0	75.1	38.9	32.6	8.9	4.7	1.7	2.4	3.8
2009	2.6	3.5	31.0	6.7	50.5	97.2	35.1	19.6	17.2	23.1	20.5	8.0	1.5	1.1	5.0
2010	0.3	42.0	28.1	67.8	43.5	108.9	141.0	29.7	13.7	9.6	9.4	11.1	3.5	1.3	5.3
2011	0.1	6.4	84.2	70.9	116.8	137.2	128.1	82.4	14.8	10.0	8.8	6.4	2.2	0.9	2.8
2012	0.7	0.3	4.0	58.4	71.4	168.0	125.2	84.5	49.5	17.6	7.0	5.1	2.7	1.6	1.8
2013	2.5	0.7	1.1	12.2	132.6	160.5	182.8	64.8	41.9	21.8	8.2	5.2	2.6	1.3	1.8
2014	0.3	2.7	14.1	9.6	9.7	60.9	67.5	74.6	42.3	22.4	14.9	3.6	1.7	1.9	1.3
2015	0.4	6.4	60.6	19.6	13.9	77.1	157.5	39.0	27.8	11.0	6.0	2.1	0.7	0.4	1.1
2016	0.0	0.0	4.8	19.8	6.9	11.3	29.7	22.4	11.2	7.7	3.4	2.0	0.6	0.7	0.4
2017	0.0	0.0	2.1	12.0	6.4	10.2	23.7	16.2	8.6	5.2	2.8	2.1	0.8	0.9	0.3
2018	0.0	0.1	1.1	4.0	16.5	34.4	38.6	22.6	9.2	11.0	5.1	2.1	0.7	0.2	0.4
2019	0.0	0.2	0.2	0.9	4.4	8.0	10.7	3.4	3.2	3.0	1.4	0.7	1.1	0.1	0.2

Table B8. Estimated stock weights-at-age for Div. 3LNO American plaice.

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1960	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.1	1.4	1.7	2.0
1961	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.1	1.4	1.7	2.0
1962	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.1	1.4	1.7	2.0
1963	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.1	1.4	1.7	2.0
1964	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	0.9	1.1	1.4	1.7	2.0
1965	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	0.9	1.1	1.4	1.7	2.0
1966	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.0
1967	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.0
1968	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.7	2.0
1969	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.6	0.8	1.1	1.4	1.7	2.0
1970	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.8	1.0	1.3	1.7	2.0
1971	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.4	0.5	0.7	1.1	1.3	1.6	2.0
1972	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.3	1.6	1.9
1973	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.7	1.9
1974	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.4	2.0
1975	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.5	1.8
1976	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.6	1.9
1977	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.5	2.0
1978	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.6	1.9
1979	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.5	0.7	1.0	1.2	1.6	2.0
1980	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.3	1.6	2.0
1981	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.4	0.5	0.7	1.0	1.2	1.6	2.0
1982	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.7	1.0	1.3	1.6	2.0
1983	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.3	1.7	2.1
1984	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.3	1.7	2.1
1985	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.1	1.3	1.7	2.1
1986	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.4	1.7	2.1
1987	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.4	1.8	2.1
1988	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.4	1.8	2.1
1989	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.8	2.1
1990	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.7	2.1
1991	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.2	1.4	1.7	2.1
1992	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	0.9	1.1	1.4	1.8	2.1
1993	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.1
1994	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.4	0.6	0.8	1.1	1.4	1.7	2.0
1995	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.8	1.0	1.3	1.6	2.0
1996	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.7	1.0	1.3	1.6	2.0
1997	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.2	1.6	1.9
1998	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.2	1.5	1.9
1999	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.7	1.0	1.1	1.5	1.8
2000	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.7	0.9	1.2	1.4	1.8

year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2001	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.7	0.9	1.1	1.4	1.7
2002	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.1	1.4	1.7
2003	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.7	0.8	1.0	1.3	1.6
2004	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.7	0.8	1.0	1.2	1.5
2005	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.2	1.4
2006	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.7	0.9	1.1	1.2	1.4
2007	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.8	0.9	1.0	1.3	1.4
2008	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.8	0.9	1.1	1.2	1.4
2009	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.7	1.0	1.1	1.3	1.4
2010	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.1	1.3	1.5
2011	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.3	1.5
2012	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.5
2013	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2
2014	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.2
2015	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.1
2016	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.8	1.0	1.1
2017	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.5	0.6	0.8	0.9	0.9	1.1
2018	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.0	1.0
2019	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.7	0.8	1.0	1.1
2020	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.3	0.4	0.6	0.8	0.9	1.1

Colophon

This version of the document was generated on 2021-06-01 14:36:54 using the R markdown template for SCR documents from **NAFOdown**.

The computational environment that was used to generate this version is as follows:

```
#> - Session info -------------------------------------------------------
-----------
#>  setting  value
#>  version  R version 4.1.0 (2021-05-18)
#>  os       Windows 10 x64
#>  system   x86_64, mingw32
#>  ui       RTerm
#>  language (EN)
#>  collate  English_United States.1252
#>  ctype    English_United States.1252
#>  tz       America/St_Johns
#>  date     2021-06-01
#>
#> - Packages -----------------------------------------------------------
-----------
#>  ! package     * version    date       lib
#>    APAM2021      0.0.0.9000 2021-05-31 [1]
#>    assertthat    0.2.1      2019-03-21 [1]
#>    backports     1.2.1      2020-12-09 [1]
#>    base64enc     0.1-3      2015-07-28 [1]
#>    bookdown      0.22       2021-04-22 [1]
#>    broom         0.7.6      2021-04-05 [1]
#>    cachem        1.0.5      2021-05-15 [1]
#>    callr         3.7.0      2021-04-20 [1]
#>    cellranger    1.1.0      2016-07-27 [1]
#>    cli           2.5.0      2021-04-26 [1]
#>    colorspace    2.0-1      2021-05-04 [1]
#>    cowplot       1.1.1      2020-12-30 [1]
#>    crayon        1.4.1      2021-02-08 [1]
#>    data.table    1.14.0     2021-02-21 [1]
#>    DBI           1.1.1      2021-01-15 [1]
#>    dbplyr        2.1.1      2021-04-06 [1]
#>    desc          1.3.0      2021-03-05 [1]
#>    devtools      2.4.1      2021-05-05 [1]
#>    digest        0.6.27     2020-10-24 [1]
#>    dplyr       * 1.0.6      2021-05-05 [1]
#>    ellipsis      0.3.2      2021-04-29 [1]
#>    evaluate      0.14       2019-05-28 [1]
#>    fansi         0.5.0      2021-05-25 [1]
#>    farver        2.1.0      2021-02-28 [1]
#>    fastmap       1.1.0      2021-01-25 [1]
#>    flextable   * 0.6.6      2021-05-17 [1]
#>    forcats     * 0.5.1      2021-01-27 [1]
#>    fs            1.5.0      2020-07-31 [1]
#>    gdtools       0.2.3      2021-01-06 [1]
```

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#>    generics      0.1.0      2020-10-31 [1]
#>    ggplot2     * 3.3.3      2020-12-30 [1]
#>    ggthemes      4.2.4      2021-01-20 [1]
#>    glue          1.4.2      2020-08-27 [1]
#>    gtable        0.3.0      2019-03-25 [1]
#>    haven         2.4.1      2021-04-23 [1]
#>    highr         0.9        2021-04-16 [1]
#>    hms           1.1.0      2021-05-17 [1]
#>    htmltools     0.5.1.1    2021-01-22 [1]
#>    httr          1.4.2      2020-07-20 [1]
#>    jsonlite      1.7.2      2020-12-09 [1]
#>    knitr         1.33       2021-04-24 [1]
#>    labeling      0.4.2      2020-10-20 [1]
#>    lattice       0.20-44    2021-05-02 [2]
#>    lifecycle     1.0.0      2021-02-15 [1]
#>    lubridate     1.7.10     2021-02-26 [1]
#>    magrittr      2.0.1      2020-11-17 [1]
#>    Matrix        1.3-3      2021-05-04 [2]
#>    memoise       2.0.0      2021-01-26 [1]
#>    modelr        0.1.8      2020-05-19 [1]
#>    munsell       0.5.0      2018-06-12 [1]
#>    NAFOdown    * 0.0.1.9000 2021-05-29 [1]
#>    officer       0.3.18     2021-04-02 [1]
#>    patchwork   * 1.1.1      2020-12-17 [1]
#>    pillar        1.6.1      2021-05-16 [1]
#>    pkgbuild      1.2.0      2020-12-15 [1]
#>    pkgconfig     2.0.3      2019-09-22 [1]
#>    pkgload       1.2.1      2021-04-06 [1]
#>    prettyunits   1.1.1      2020-01-24 [1]
#>    processx      3.5.2      2021-04-30 [1]
#>    ps            1.6.0      2021-02-28 [1]
#>    purrr       * 0.3.4      2020-04-17 [1]
#>    R6            2.5.0      2020-10-28 [1]
#>    Rcpp          1.0.6      2021-01-15 [1]
#>    readr       * 1.4.0      2020-10-05 [1]
#>    readxl        1.3.1      2019-03-13 [1]
#>    remotes       2.3.0      2021-04-01 [1]
#>    reprex        2.0.0      2021-04-02 [1]
#>    rlang         0.4.11     2021-04-30 [1]
#>    rmarkdown     2.8        2021-05-07 [1]
#>    rprojroot     2.0.2      2020-11-15 [1]
#>    rstudioapi    0.13       2020-11-12 [1]
#>    rvest         1.0.0      2021-03-09 [1]
#>    scales        1.1.1      2020-05-11 [1]
#>    sessioninfo   1.1.1      2018-11-05 [1]
#>    showtext      0.9-2      2021-01-10 [1]
#>    showtextdb    3.0        2020-06-04 [1]
#>    stringi       1.6.1      2021-05-10 [1]
#>    stringr     * 1.4.0      2019-02-10 [1]
#>    sysfonts      0.8.3      2021-01-10 [1]
#>    systemfonts   1.0.2      2021-05-11 [1]
#>    testthat      3.0.2      2021-02-14 [1]
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#>    tibble      * 3.1.2      2021-05-16 [1]
#>    tidyr       * 1.1.3      2021-03-03 [1]
#>    tidyselect    1.1.1      2021-04-30 [1]
#>    tidyverse   * 1.3.1      2021-04-15 [1]
#>  D TMB           1.7.20     2021-04-08 [1]
#>    usethis       2.0.1      2021-02-10 [1]
#>    utf8          1.2.1      2021-03-12 [1]
#>    uuid          0.1-4      2020-02-26 [1]
#>    vctrs         0.3.8      2021-04-29 [1]
#>    withr         2.4.2      2021-04-18 [1]
#>    xfun          0.23       2021-05-15 [1]
#>    xml2          1.3.2      2020-04-23 [1]
#>    yaml          2.2.1      2020-02-01 [1]
#>    zip           2.1.1      2020-08-27 [1]
#>  source
#>  local
#>  CRAN (R 4.1.0)
#>
#> [1] C:/Users/aperreau/Documents/R/win-library/4.1
#> [2] C:/Program Files/R/R-4.1.0/library
```