Re-evaluation of coefficient of variance (CV) in growth curve using the latest otolith data

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Summary

The growth function for Pacific bluefin tuna (PBF) stock assessment was developed when 2016 assessment using the aging data based on a lot of the otolith observations. The CV in current assessment model, therefore, is fixed values for age-0 (A1) (0.259) and for age-3 (A2) and older (0.044). The CV for intermediate from age-0 to age-3 is determined by interpolation. Although, there are no remarkable inconsistencies with any other data sources used for the PBF assessment so far, the PBFWG agreed to review the CV using the latest otolith dataset for the next benchmark assessment. The conditional age-at-length dataset for estimating CVs was updated with the latest 7,453 otolith samples. The data filtering for input in SS3 was followed as in the previous PBF growth study. Through the several exercises, ASPMRfix with estimating age selectivity was proposed as the best way to estimate the CV in growth curve for next assessment. We, however, have a few concerns on the poor fit, unsmooth confidence interval and so on. The actual CV values will re-estimate during the meeting in accordance with the decision by the PBFWG.

1. Introduction

The growth function for Pacific bluefin tuna (PBF) stock assessment was developed when 2016 assessment using the aging data based on a lot of the otolith observations (Fukuda et al. 2015). The length-at-age data for this growth curve was examined by daily rings (18.6-60.1 cm in folk length (FL)) and annual rings (70.5-271 cm in FL) of 1,782 PBFs caught by Japanese and Taiwanese fisheries, following the age determination manual (Shimose and Ishihara 2015). The von Bertalanffy growth function was applied to all assessments after 2016 assessments to date. The uncertainty of parameter estimation of the growth curve is narrow based on the bootstrap test (Ishihara et al. 2023).

The individual variances of length-at-age, i.e., coefficient of variance (CV) in Stock Synthesis 3 (SS3), was evaluated by length-conditional method (Lee et al. 2019) and length composition and conditional age-at-length (CAAL) data (ISC 2016). Because the estimated variance of length composition data generally stabilized after fish mature, the CV for older than age-3 PBFs are assumed to be consistent in the current assessment model. The CV in current assessment model, therefore, is fixed values for age-0 (A1) (0.259) and for age-3 (A2) and older (0.044). The CV for intermediate from age-0 to age-3 is determined by interpolation. Although, there are no remarkable inconsistencies with any other data sources used for the PBF assessment so far and the growth curve is reliable (Ishihara et al.2023), the PBFWG agreed to review the CV using the latest otolith dataset for the next benchmark assessment (ISC 2023).

This paper describes the exercises to estimate the CV using the latest length-at-age data. The collected in the Japan and Taiwan were aggregated and were allocated into the appropriate fleet data according to the fishery information such as gear, location and month. We evaluated CV values using several settings for the PBF assessment models.

2. Materials and Methods

The 2763 otolith aging data from Japan and 4690 otolith aging data from Taiwan were utilized for this exercise. More than 5,000 samples were updated from previous analysis to date thanks to continuous efforts for collecting the otolith by the experts. The range of Japanese data for age and length were age 0-29 and 18.6-274 cm in FL, respectively. Those of Taiwanese data were age 4-28 and 143-275 cm in FL. The number of otolith data at age and the relationship between length and age are shown in Figure 1 and 2. In this exercise, the data being within (average length) ± (2 x standard deviation) at each age was utilized to exclude the misreporting data following the data filtering in previous study (Fukuda 2015), whereas the exercises with all data were shown for the reference to investigate if the exclusion of the data lead to unexpected underestimation of the variance. As a result of data filtering by standard deviation, 371 data, i.e. around 5% of whole dataset, were removed from the exercises. The samples for older than age 20 were aggregated into the age 20 as plus group in accordance with the age setting in PBF assessment.

The PBF stock assessment use plenty of the length composition data for most fleets and its selectivity was estimated as length-based selectivity, while some fleets also have age-besed selectivity to represent quasi-selectivity both for availability change and contact selectivity. Because the simultaneous estimation of length selectivity and CV for growth curve has interaction to each other in the parameter estimation, we applied an ASPMRfix analysis whose parameters other than parameters related to the population scale and CV for old age in this exercise. Additionally, ASPMRfix with estimation of age selectivity (ASPMRfix_ageselex), which enables to change the age selectivity according to the change of CV estimation, resulting in relaxing CV estimation. The full dynamics model with CAAL data was also tested just for the comparison. Finally, we fixed the CV values at maximum likelihood estimation (MLE) in ASPMRfix and ASPMRfix_ageselex and calculated the full dynamics model to evaluate the performances of alternative CVs. The runs for this exercise were summarized in Table 1.

These analyses were done by SS3.30.14.08 and the input files were based on the simple updates, which were personally shared among modeling team members (ctl_PBF_2024_0131.ss, dat_PBF_2024_0131.ss and its derived control.ss_new). The MLE for the ASPMRfix and ASPMRfix_ageselex were derived from the full dynamics model without CAAL data. The aging errors by age defined in the data file are as they were, i.e., no aging bias at any age and little uncertain during age-0 to age-2 (sd: 0.001) but somewhat uncertain for age-3 and older PBFs (sd: 1.000). A minor correction for constant standard deviation for length at age data was made in ctl file, changing from 0.1 to 0, which was unintentionally added in the previous assessment.

3. Results and discussion

Model 1, i.e., ASPMRfix with CAAL data excluding outlier, indicated that the CV for A1 was slightly changed, while one for A2 became smaller than current assumption as in Model 0. On the other hand, Model 2, i.e., ASPMRfix_ageselec with CAAL data excluding outlier, showed larger CV for A1 and smaller one for A2. Naturally, the using all data made CV wider. It is difficult to discuss the validity of estimated CVs only by this result, we applied the CVs estimsted in Model 1 and Model 2 into the fully integrated models (Model1 CVfix and Model 2 CVfix in Table 1).

The results of exercise using full dynamics model with alternative CV values were also shown in Table 1. Those negative loglikelihood (LL) values indicated that the CVs estimated in Model 2 made an improvement in terms of the fit to the data, especially for the fit to the size composition. The LL values for the fleets which are mainly target around younger PBFs, i.e., Fleet 12, 13, 16, probably due to the wider CV for A1 (Table 2). The improvement of LL in size composition data did not influence negatively on the fit to the other data, such as catch and abundance indices (Table 3). The confidence intervals in growth curve for younger age were slightly wider and those for older age were slightly narrower compared to the current assumption (Figure 3). The change on CVs made little change on the estimation of SSB and recruitment trajectory in the assessment period (Figure 4).

The fits to the CAAL data by fleets in Model 2 were shown in Figure 5-16. The fits to the CAAL data were generally good, whereas that for Taiwanese Fleet in South fishing ground, i.e. Fleet 3, showed discrepancy between the observations and expectations. The PBFWG can discuss further on how to deal with the Taiwanese data in the assessment meeting. Also, the authors have concerns on the somewhat unsmooth confidence interval in growth curve (Figure 4) and validity of the age at A2. Although there remain a few points of contention, we propose the way to estimate the CV using ASPMRfix_age selex with data excluding the data outside of average length ± standard deviation for the next assessment. If the dataset and any other points of contention are as they were in this document, the values estimated by proposed way is also a proposal by authors.

4. Conclusion

The authors review the CV estimation in growth curve. The dataset for estimating CVs was updated with the latest 7,453 otolith samples. The data filtering for input in SS3 was followed as in the previous PBF growth study in Fukuda et al (2015). Through the several exercises, ASPMRfix with estimating age selectivity was proposed as the best way to estimate the CV in growth curve for next assessment. We, however, have a few concerns on the poor fit, unsmooth confidence interval and so on. The actual CV values will re-estimate during the meeting in accordance with the decision by the PBFWG.

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Table 1 Specification, the estimated CV and loglikelihood values for each trial run.

Model	Model type	CAAL data	Age selex	Length selex	CV for age 0	CV for age 3 and older	LL in total	LL in CAAL	LL in size comp	LL in indices
Model 0	Fully integrated model	Not use	Estim.	Estim.	0.2590 (Fix)	0.0440 (Fix)	1478.22*	-	1535.01	-80.4822
Model 1	ASPMRfix	Excl. ave±2sd	Fix at MLE	Fix at MLE	0.2545 (Estim.)	0.0397 (Estim.)	1656.55**	1738.03**	-	-87.0509
Model 2	ASPMRfix_ageselex	Excl. ave±2sd	Estim.	Fix at MLE	0.2780 (Estim.)	0.0401 (Estim.)	1599.41**	1686.88**	-	-77.7185
Model 3	Fully integrated model	Excl. ave±2sd	Estim.	Estim.	0.2859 (Estim.)	0.0424 (Estim.)	3194.03****	1706.6**	1535.12	-70.9583
Model 1'	ASPMRfix	all data	Fix at MLE	Fix at MLE	0.2706 (Estim.)	0.0507 (Estim.)	2063.86***	2138.83***	-	-74.6455
Model 2'	ASPMRfix_ageselex	all data	Estim.	Fix at MLE	0.3136 (Estim.)	0.0536 (Estim.)	1951.50***	2025.63***	-	-71.3922
Model 3'	Fully integrated model	all data	Estim.	Estim.	0.2843 (Estim.)	0.0517 (Estim.)	3576.39*****	2069.87***	1551.02	-67.5356
Model 1 CVfix	Fully integrated model	Not use	Estim.	Estim.	0.2545 (Fix)	0.0397 (Fix)	1497.61*	-	1552.15	-78.3752
Model 2 CVfix	Fully integrated model	Not use	Estim.	Estim.	0.2780 (Fix)	0.0401 (Fix)	1474.49*	-	1530.76	-79.6428

※1 The number of asterisc in columns of LL in total and CAAL means the runs which are comparable in terms of the amount of data.

※2 The shaded rows indicate the calculation just for information purpose.

Table 2 Negative Loglikelihood values in Model 0, Model 1 CVfix and Model 2 CVfix. Negative values in a column for difference indicate improvement of fit to data.

Fleet Name	Model 0	Model1 CVFix	Model2 CVFix	Diff (Model2 Cvfix - Model 0)
F1JPN_LL(S4)	38.50	37.75	37.87	-0.62
F2JPN_LL(1993-)(S1-3)	101.58	102.62	102.36	0.77
F3TWN_LLSouth	42.24	40.71	41.02	-1.22
F4TWN_LLNorth	6.42	6.79	6.74	0.31
F5JPN_TPS_PO	65.46	66.75	66.58	1.12
F6JPN_TPS_SOJ	89.42	89.38	88.78	-0.63
F7JPN_TPS_SOJ(Farming)	19.77	19.99	20.01	0.24
F8JPN_SPPS(S1,3,4)	150.70	150.01	151.90	1.20
F9JPN_SPPS(S2)	65.25	63.84	66.67	1.42
F10JPN_SPPS(Farming)	30.25	29.81	30.71	0.46
F11KOR_LPPS	56.13	55.24	57.33	1.20
F12JPN_Troll(S2-4)	186.22	191.91	181.23	-4.98
F13JPN_Troll(S1)	59.77	63.29	56.49	-3.28
F14JPN_Troll(Farming)	0.00	0.00	0.00	0.00
F15JPN_PoleLine	0.00	0.00	0.00	0.00
F16JPN_SetNet(S1-3)	372.69	379.04	368.95	-3.74
F17JPN_SetNet(S4)	99.74	97.25	101.49	1.75
F18JPN_SetNet(HK_AM)	44.36	45.45	44.29	-0.08
F19JPN_Others	0.00	0.00	0.00	0.00
F20EPO_COMM(-2001)	0.22	0.25	0.14	-0.08
F21EPO_COMM(2002-)	44.83	47.56	45.19	0.36
F22EPO_Sports(2014-)	61.47	64.49	63.02	1.55
F23EPO_Sports(-2013)	0.00	0.00	0.00	0.00
Total	1535.01	1552.15	1530.76	-4.26

Table 3 Negative log-likelihood by components in Model 0 and Model 2 CVFix.

	Model 0	Model2 CVFix
TOTAL	1478.22	1474.49
Catch	0.281783	0.24656
Equil_catch	0	0
Survey	-80.4822	-79.6428
SizeFreq	1535.01	1530.76
Recruitment	-3.84716	-4.21373
InitEQ_Regime	0.269596	0.26659
Parm_softbounds	0.0503252	0.05233
Parm_devs	26.9375	27.0255

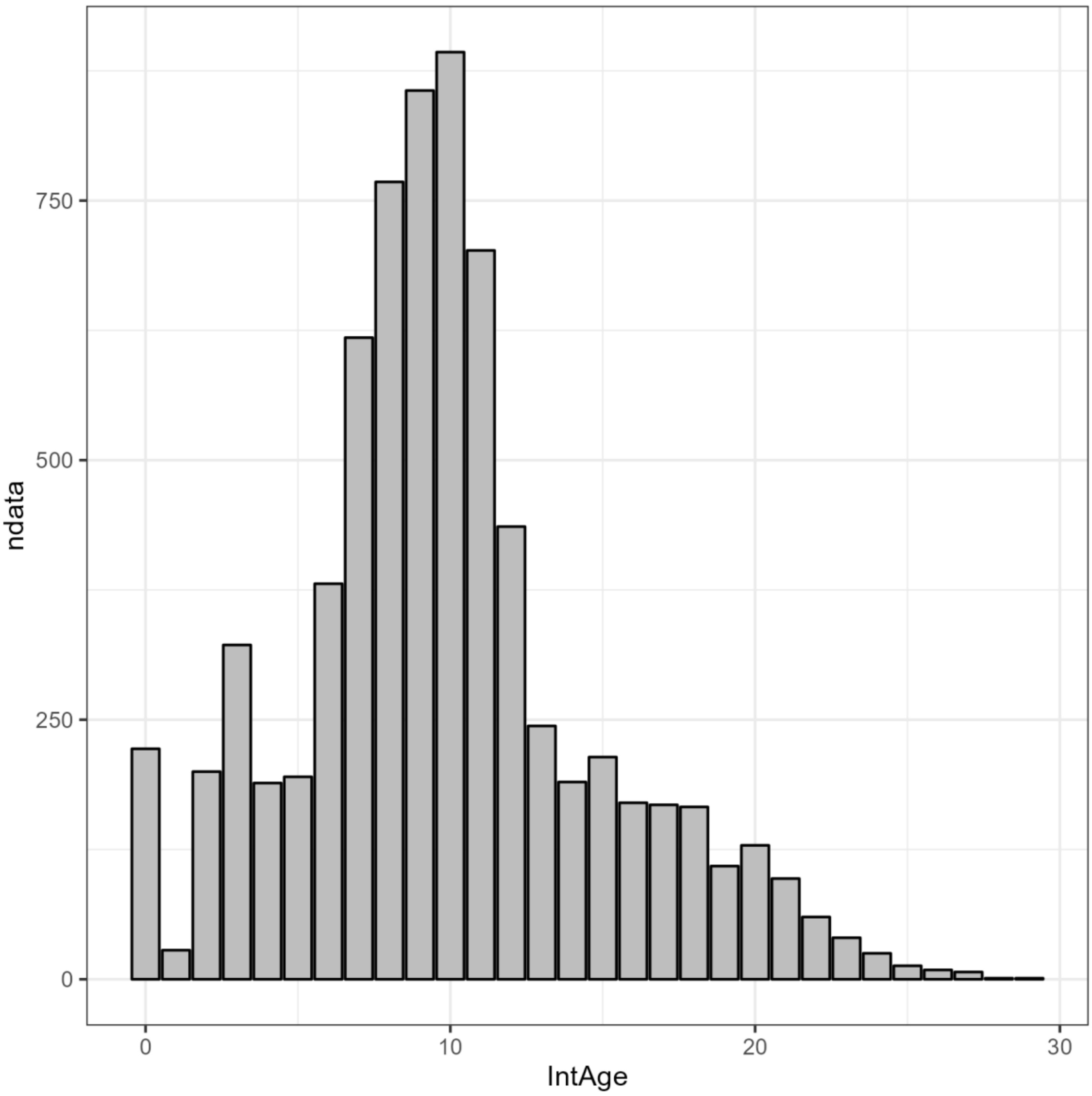

Figure 1. The number of length-at-age data by age before data filtering.

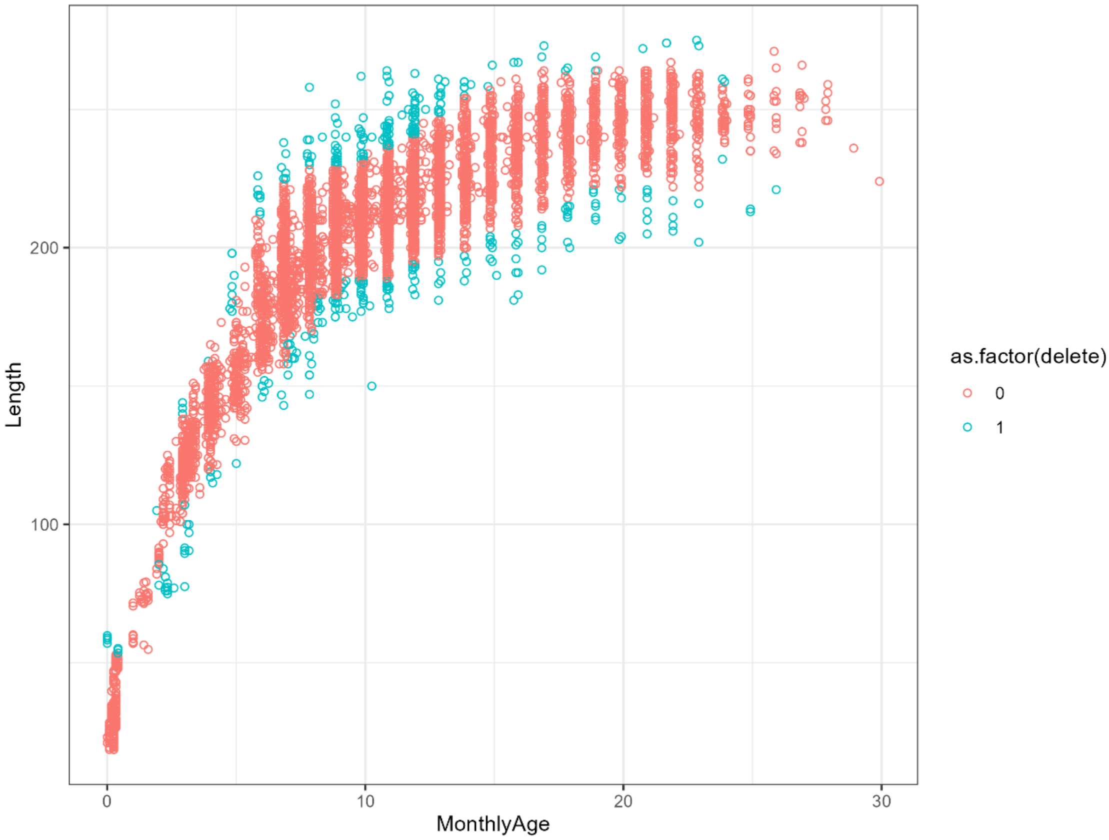

Figure 2. Scatter plot between age and length. Red open circles were within average length ± 2 standard deviation at each age, while the blue open circles were excluded from a part of exercises.

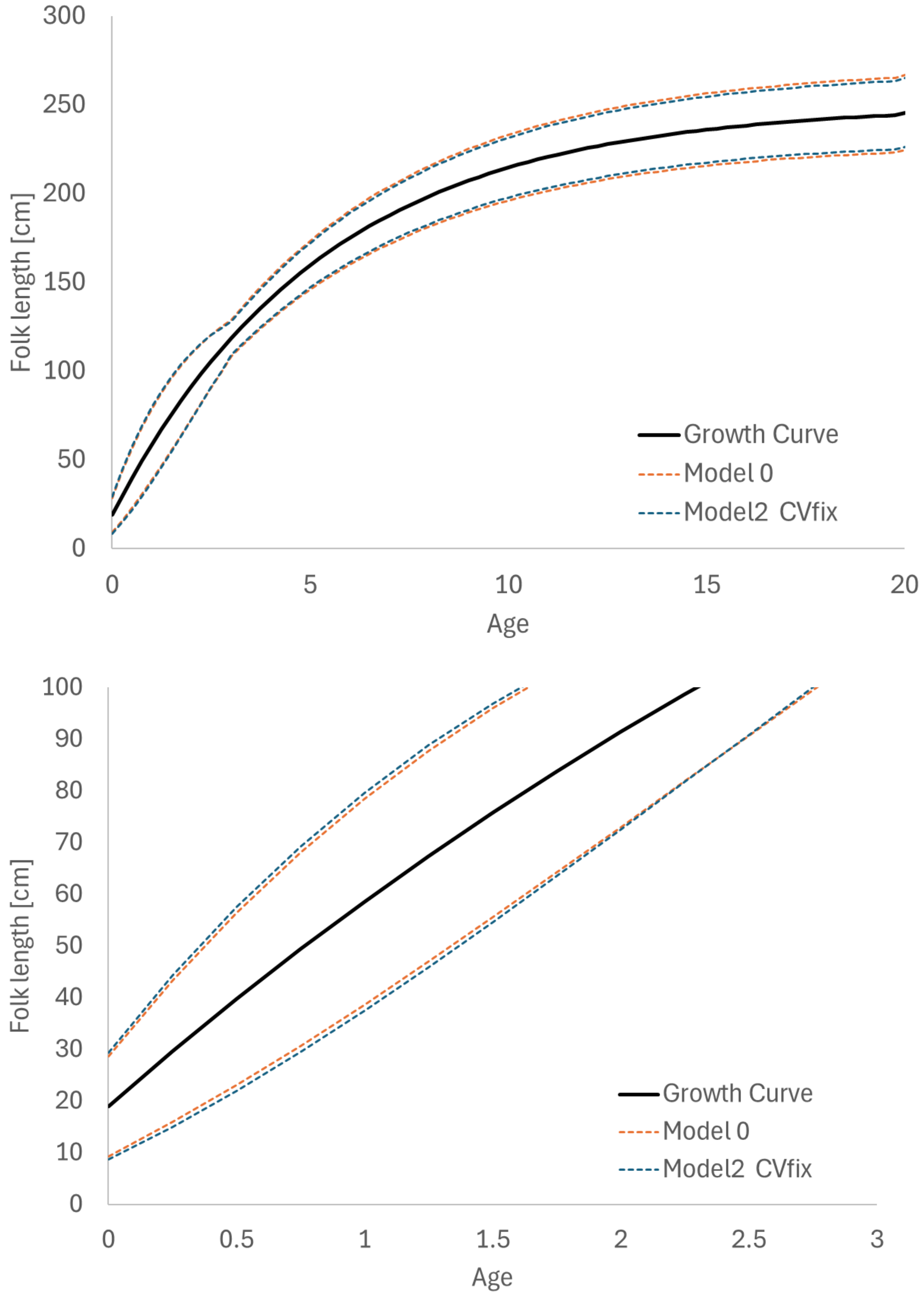

Figure 3 Growth curve and confidence intervals in Model 0 and Model 2 CVfix. The bottom panel focuses on it for less than 100 cm in folk length.

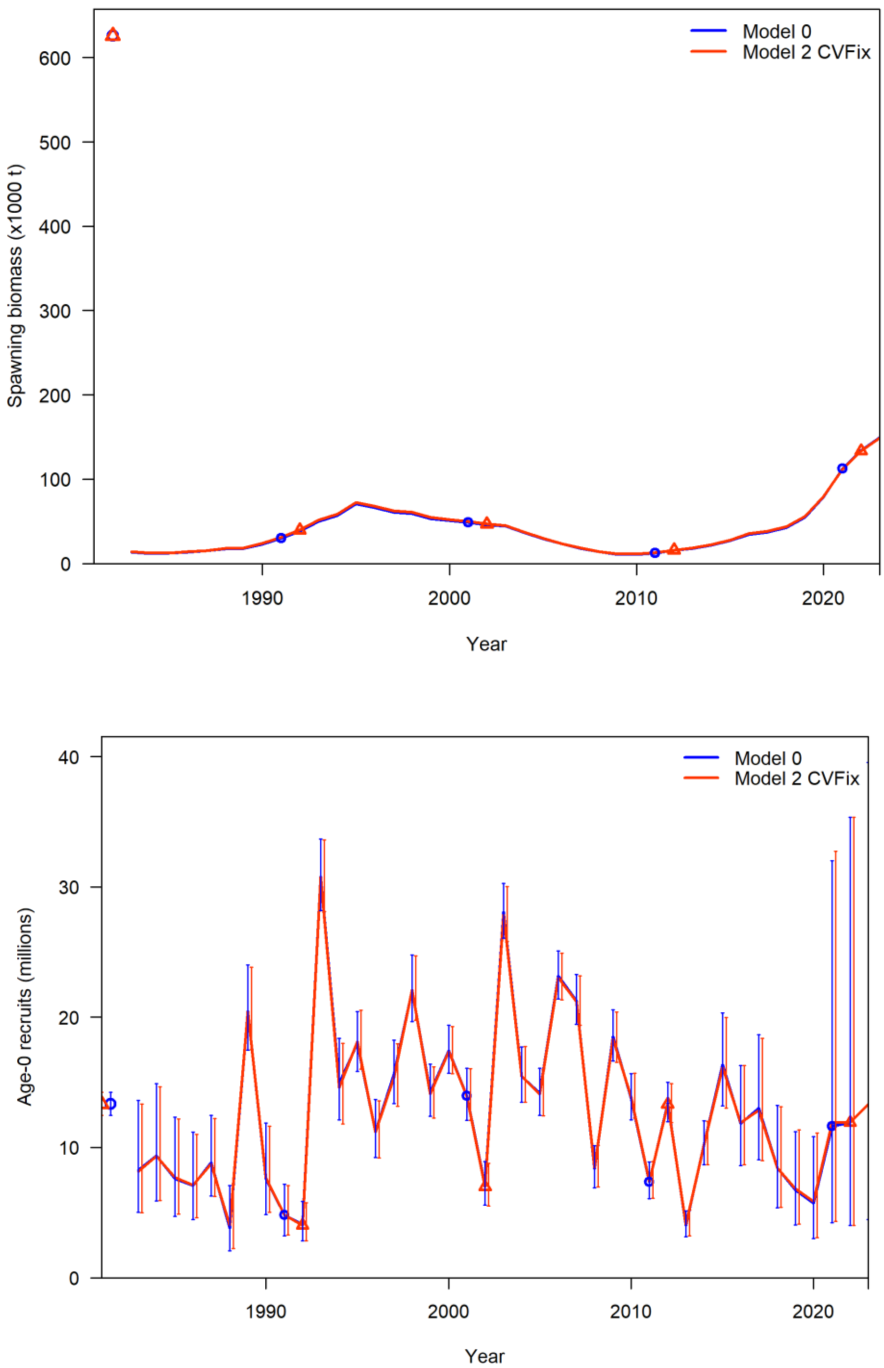

Figure 4. Comparison of SSB (top) and recruitment (bottom) trajectories between Model 0 and Model 2 CVfix.

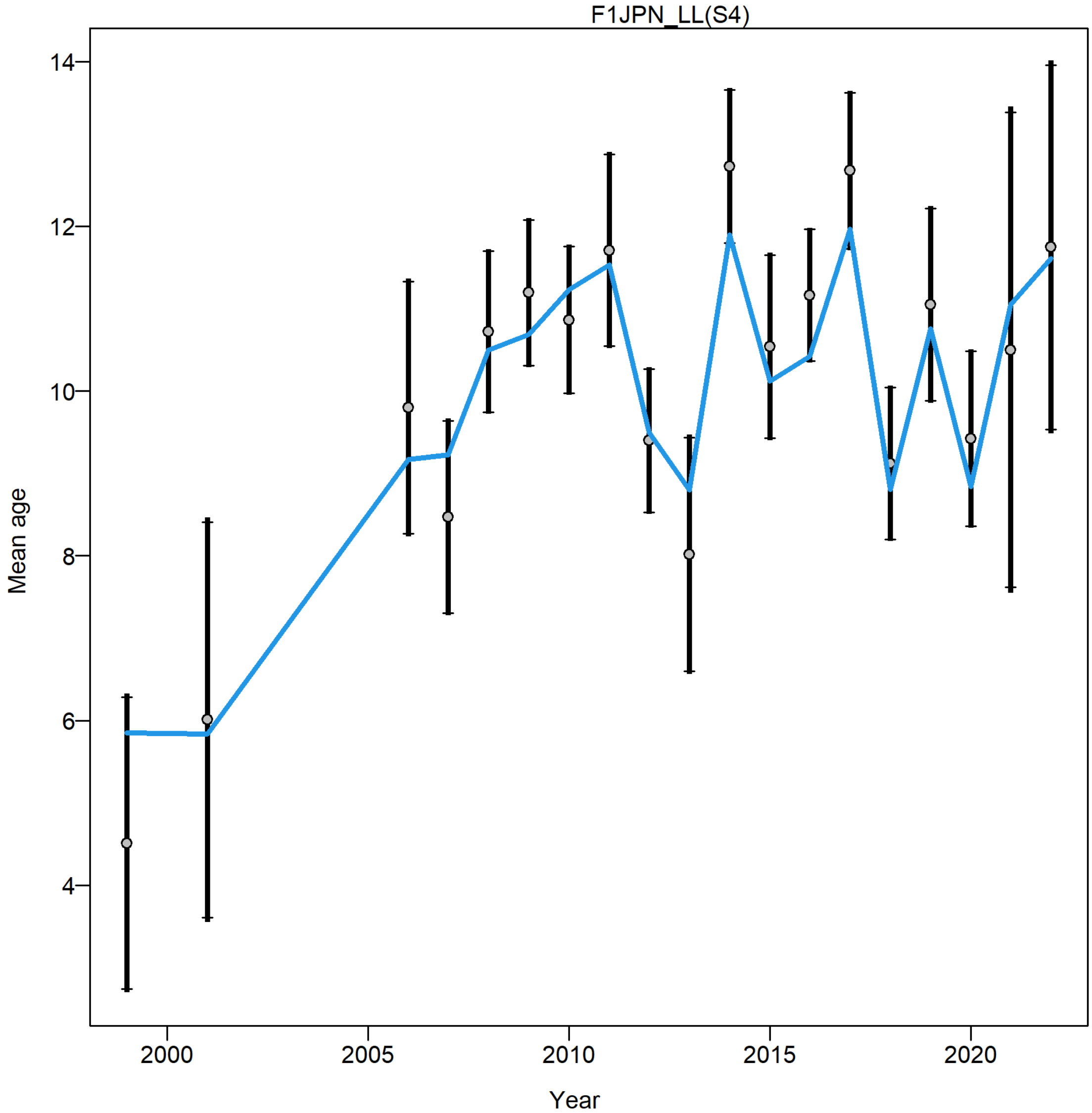

Figure 5. Mean age from conditional age-at-length (CAAL) data for F1JPN_LL(S4).

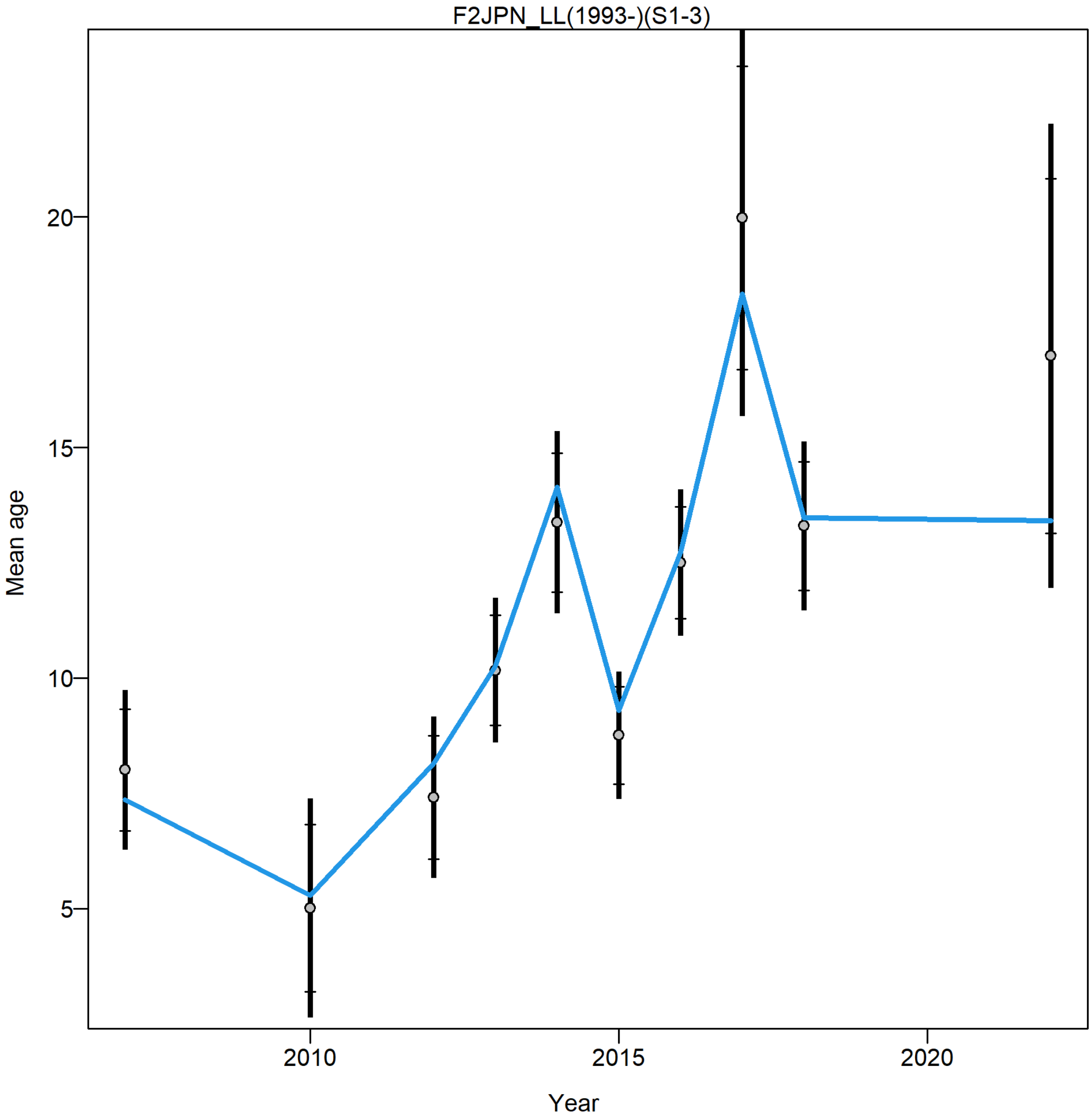

Figure 6. Mean age from conditional age-at-length (CAAL) data for F2JPN_LL(1993-)(S1-3).

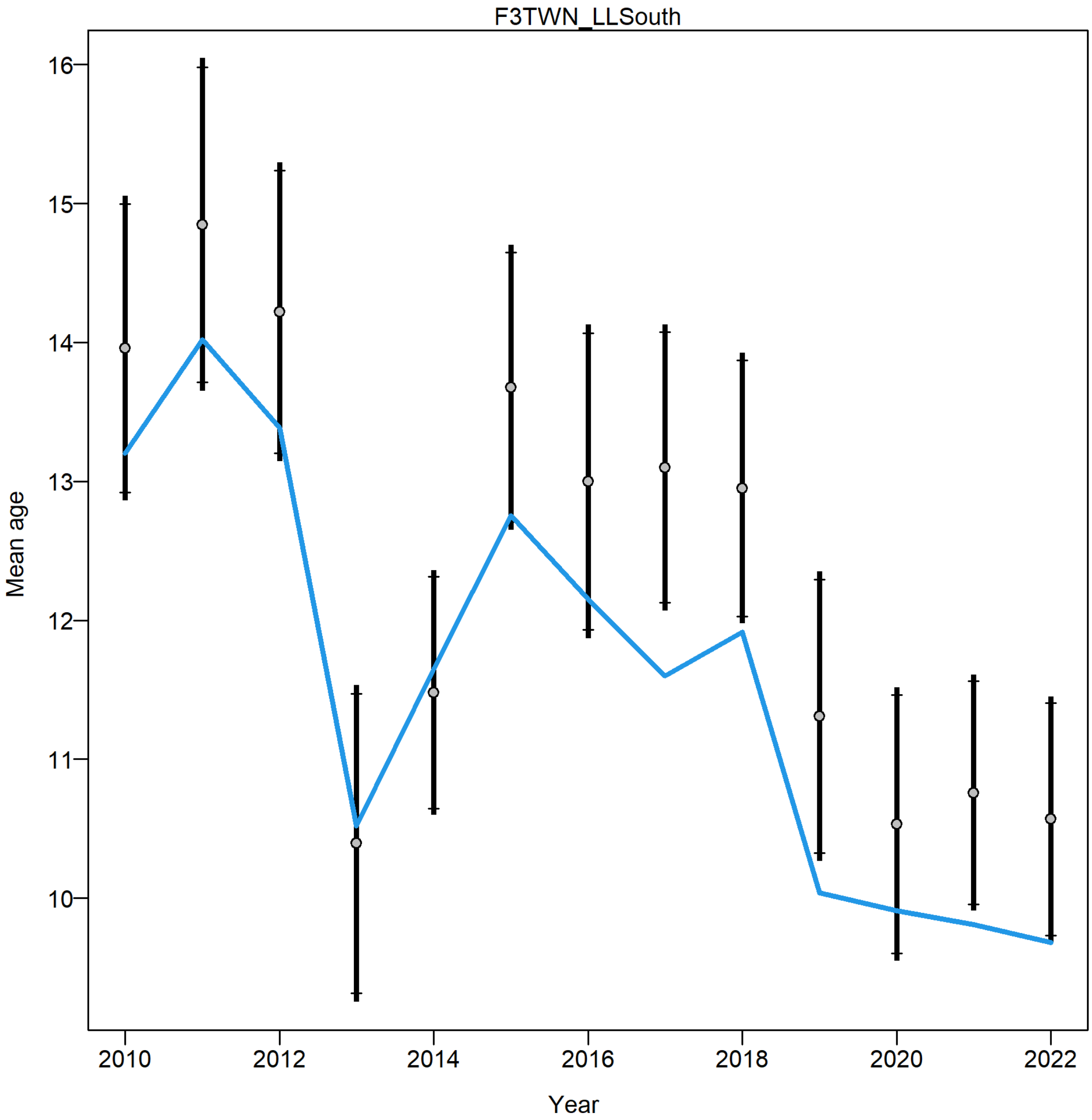

Figure 7. Mean age from conditional age-at-length (CAAL) data for F3TWN_LLSouth.

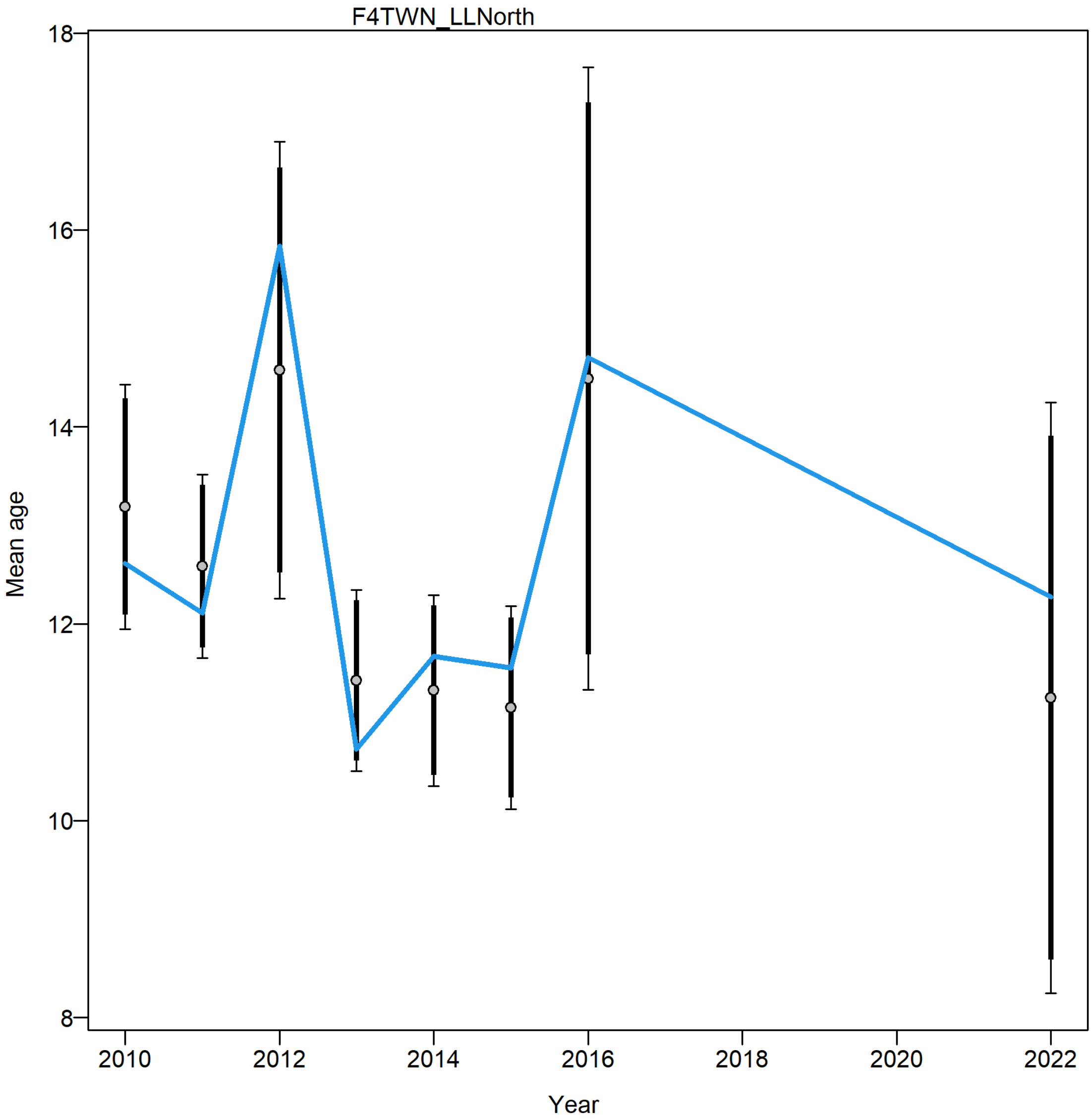

Figure 8. Mean age from conditional age-at-length (CAAL) data for F4TWN_LLNorth.

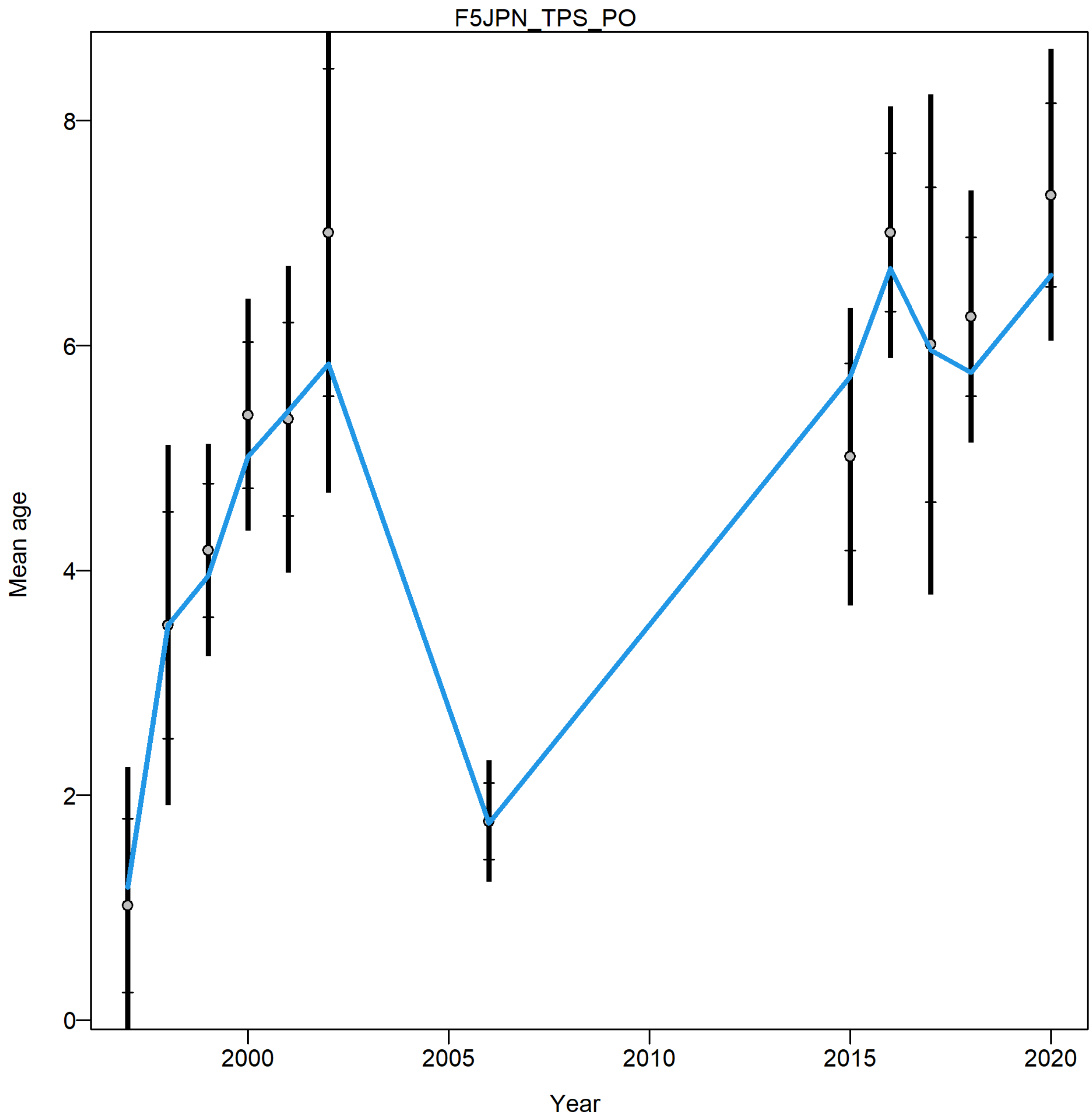

Figure 9. Mean age from conditional age-at-length (CAAL) data for F5JPN_TPS_PO.

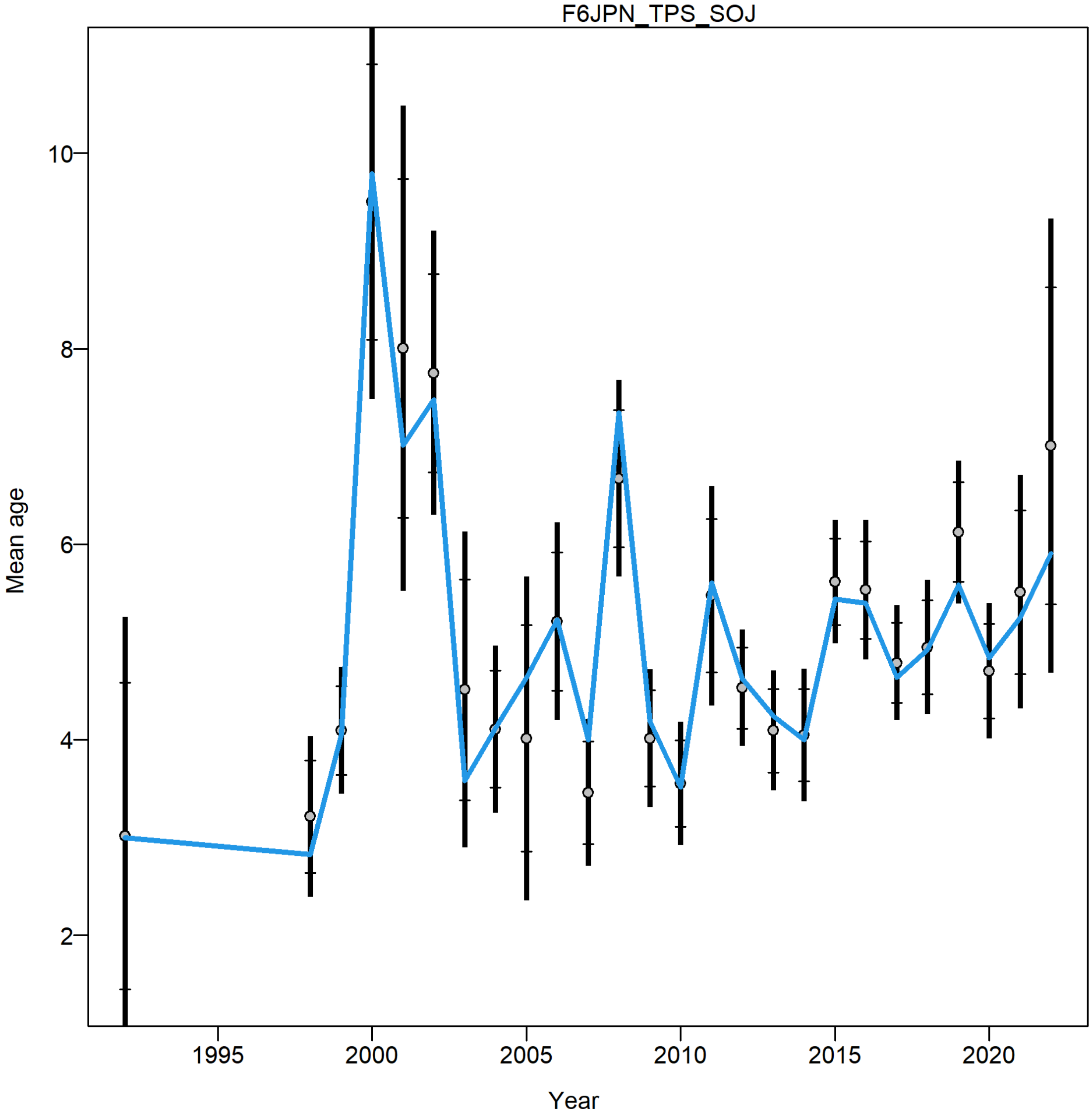

Figure 10. Mean age from conditional age-at-length (CAAL) data for F6JPN_TPS_SOJ.

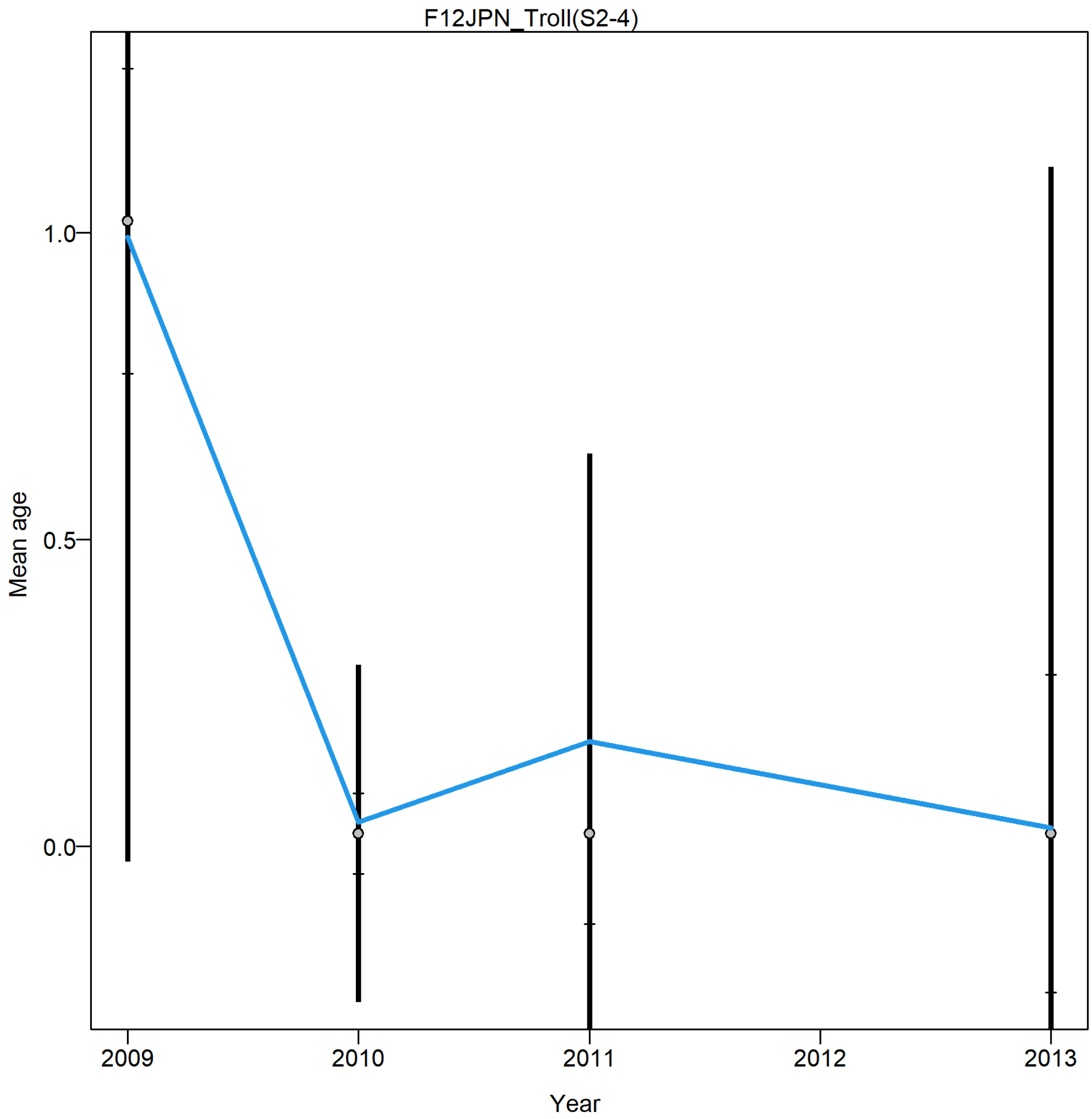

Figure 11. Mean age from conditional age-at-length (CAAL) data for F12JPN_Troll(S2-4).

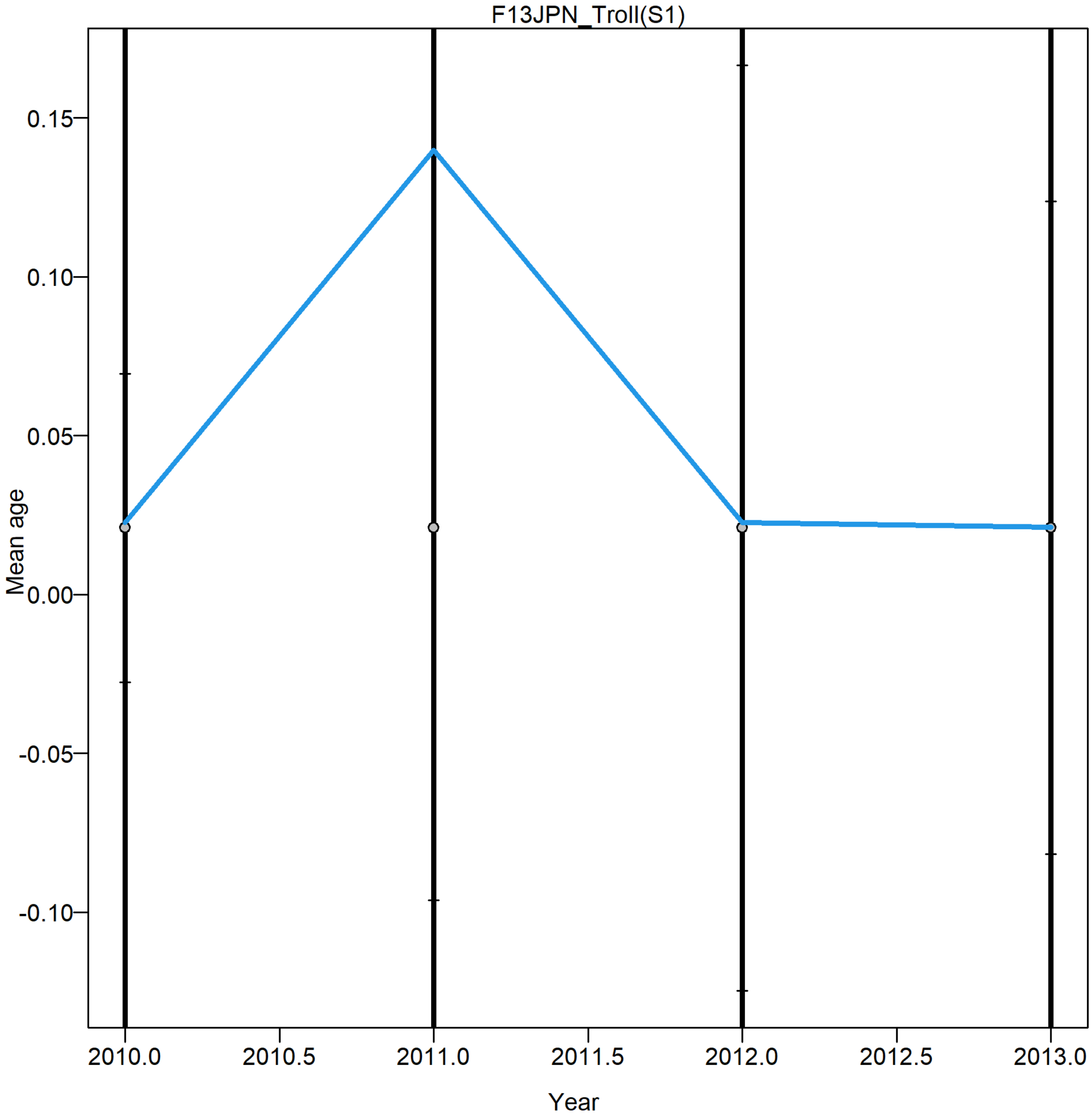

Figure 12. Mean age from conditional age-at-length (CAAL) data for F13JPN_Troll(S1).

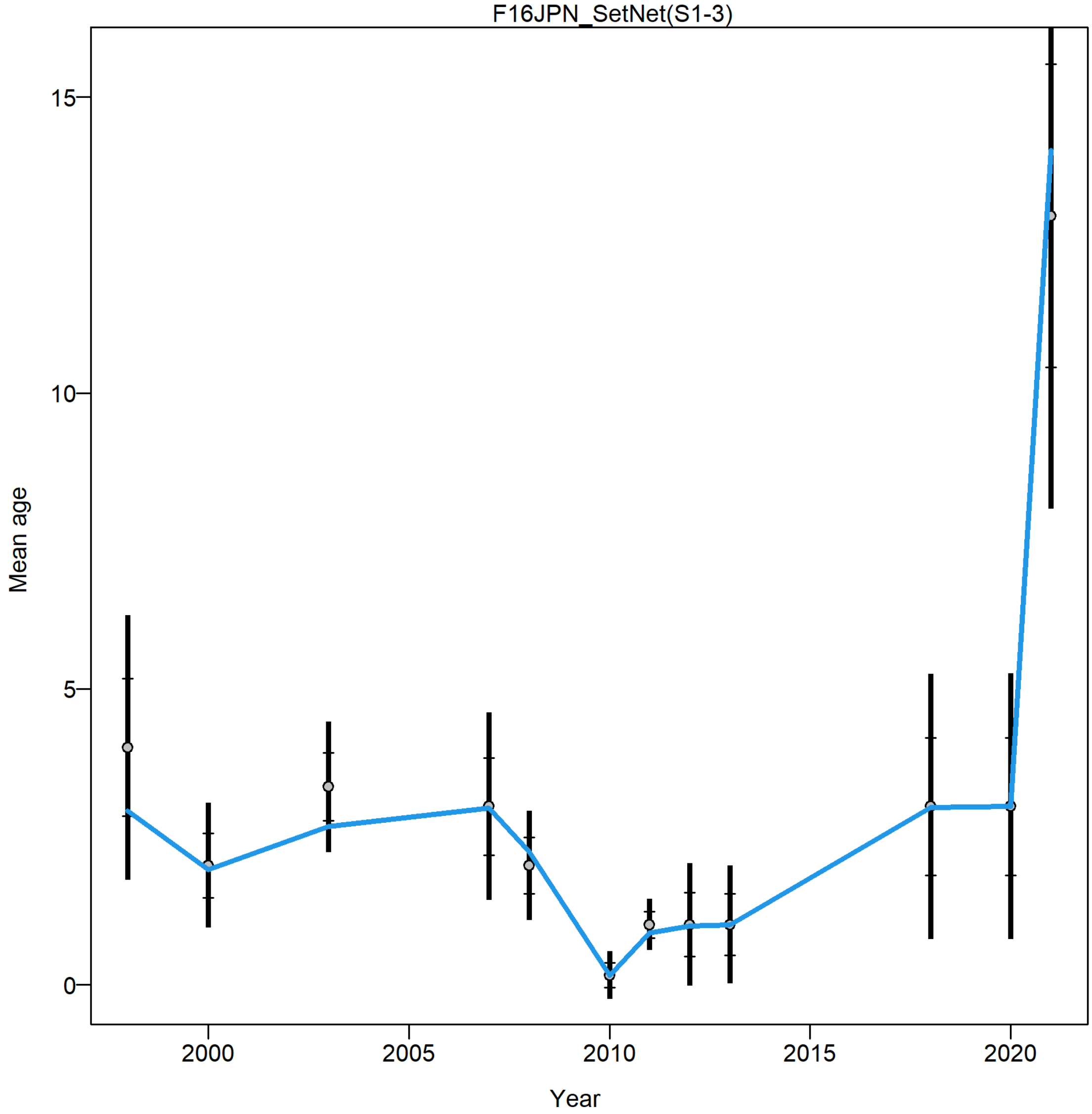

Figure 13. Mean age from conditional age-at-length (CAAL) data for F16JPN_SetNet(S1-3).

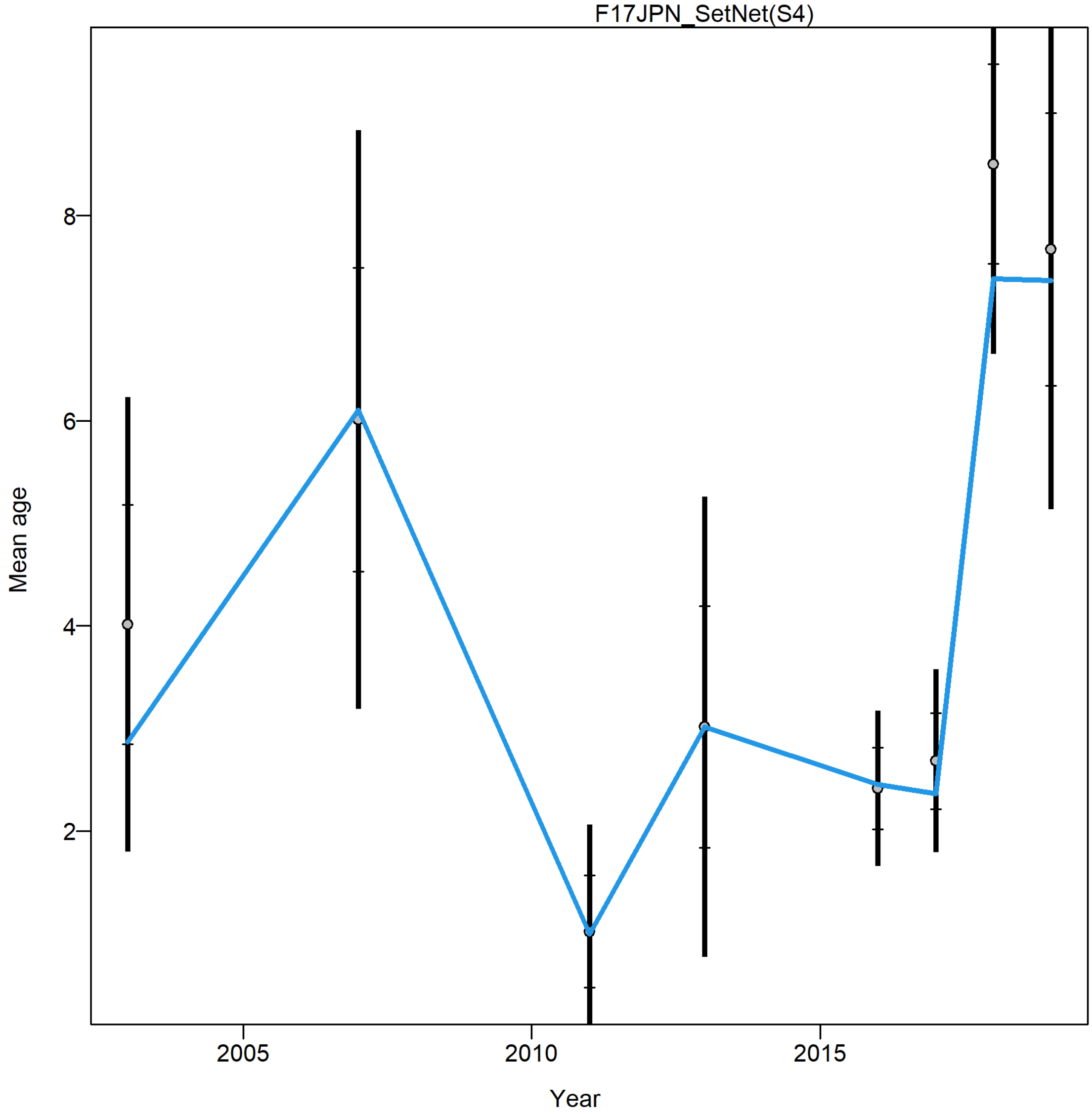

Figure 14. Mean age from conditional age-at-length (CAAL) data for F17JPN_SetNet(S4).

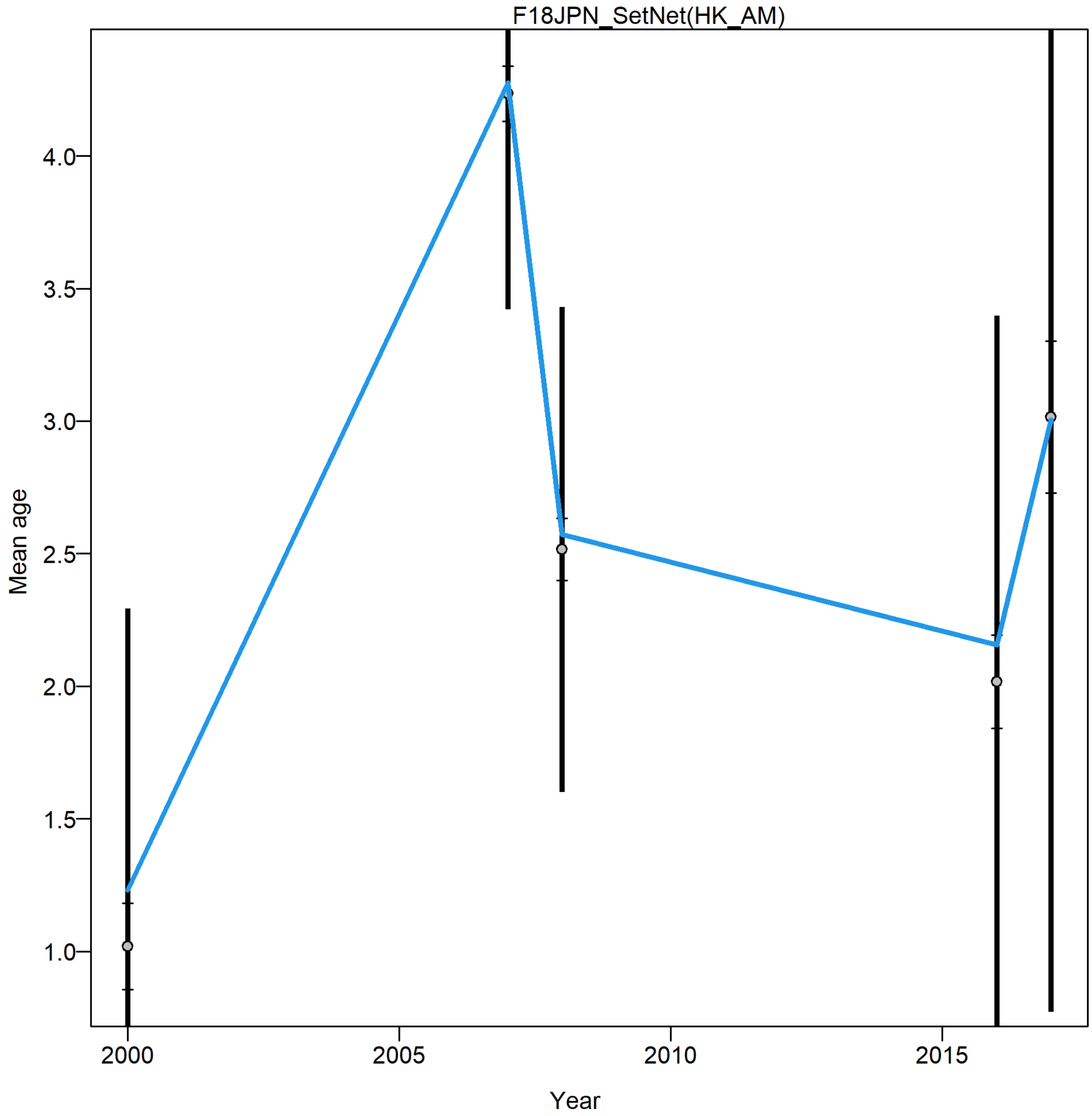

Figure 15. Mean age from conditional age-at-length (CAAL) data for F18JPN_SetNet(HK_AM).

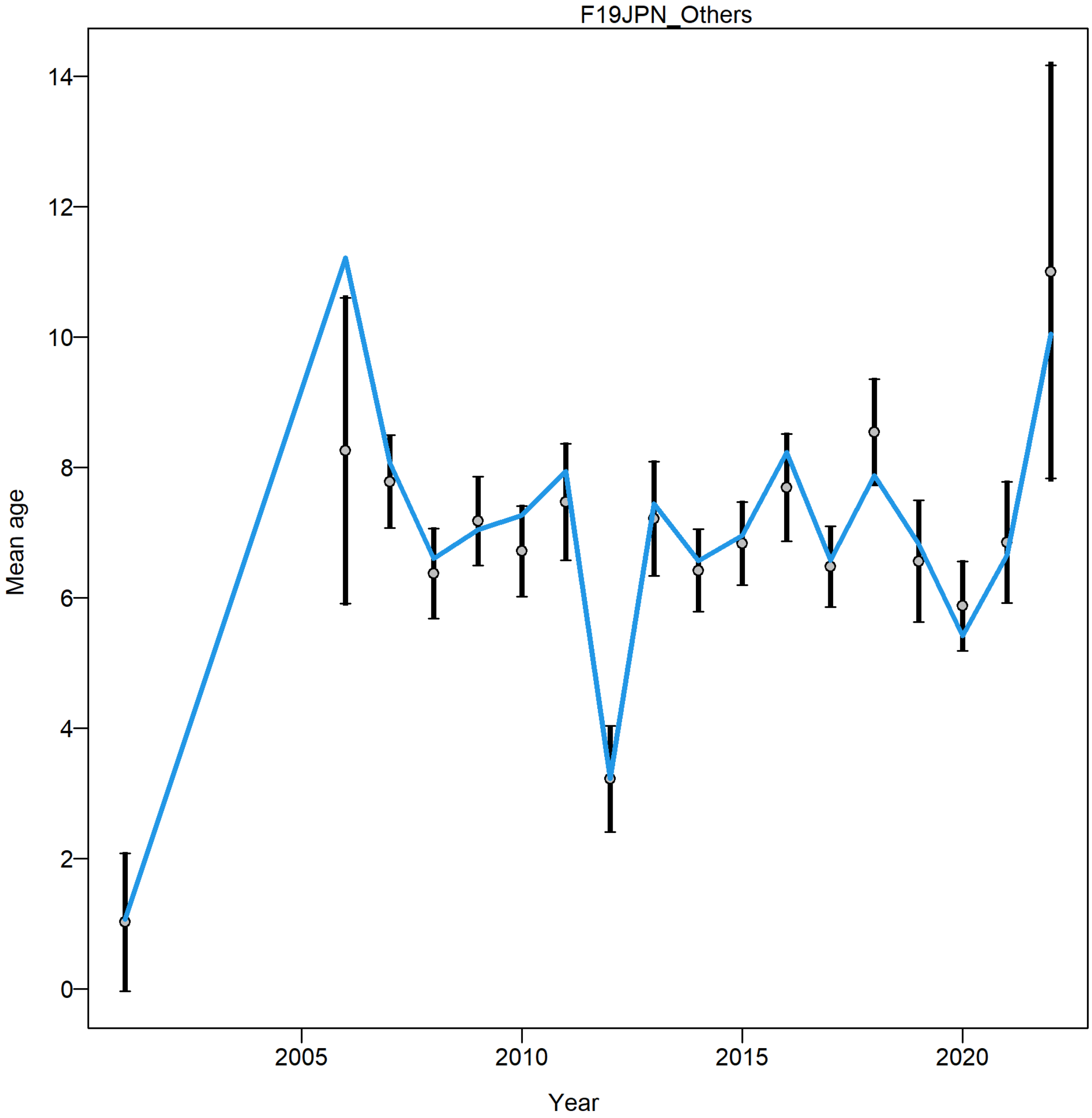

Figure 16. Mean age from conditional age-at-length (CAAL) data for F19JPN_Others.