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Standardizing abundance index for recruitment of chub mackerel in the Northwest Pacific

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Summary

In this document, we provide the summary of the CPUE standardization for Pacific chub mackerel following the "CPUE Standardization Protocol for Chub Mackerel". The year trends of the recruitment indices were derived from standardized CPUE, by applying the delta-GLM-tree models to the data from surface trawl surveys in summer (June and July) and autumn (September and October). We recommend these indices to be utilized in the Technical Working Group for the Chub Mackerel Stock Assessment.

This document describes following the order of the bullets specified in the CPUE Standardization Protocol for Chub Mackerel.

(1) Literature review to identify the candidate explanatory variables

Based on the literature search and the documents in previous TWG, we identified two candidate variables that can affect the presence and abundance of chub mackerel recruitments. First, since the recruitment index of chub mackerel is known to be affected by water temperature (Nishijima et al. 2017, Hashimoto et al. 2019), we used available information about water temperature. For the summer recruitment CPUE standardization, we incorporated the temperature at sea surface (SST) and at the 50m depth (T50) into the explanatory variables, and, for the autumn recruitment CPUE standardization, we used the SST and the temperature at 30m depth (T30) as explanatory variables. The temperatures, corresponding to in-situ ones, were measured at the same time as the surveys. Second, to account for the spatial effect on the recruitment CPUE, we incorporated the area identity as a fixed effect in the model. Please refer to "(5) Model details" for the details in determining the area identity.

(2) The spatio-temporal distributions of catch, effort, and CPUE.

The surface trawl surveys have been conducted by FRA in summer (June and July) and autumn (September and October) in a broad range of the Northwestern Pacific (Figs. 1-4). The standardizations of these survey data are necessary because survey areas had slightly changed due to varying climatic and environmental conditions during the surveys while there were no systematic temporal shifts in the survey effort (Figs. 1 and 2). The summer surveys were conducted on a yearly-basis from 2002 to 2020 in the area approximately from 141.5º E to 170.0º W and 32.0º–45.0º N, while the autumn surveys were conducted from 2005 to 2020 in the area approximately from 141.5º–175º E and 37.0º–50.0º N (Figs. 1 and 2). The CPUE (Figs. 3 and 4) were calculated as the number of fish per hour of towing.

Table 1. The summary of the survey (number of surveys, number of surveys with positive catches of chub mackerel, and the mean nominal CPUE) and the result of standardization (standardized CPUE and confidence interval) for the summer recruitment survey.

Year	Number of surveys (Number of stations * months)	Number of positive catches	Mean nominal CPUE (Catch/hour)	Standardized CPUE	Lower 95% CI	Upper 95% CI
2002	86	16	3.01	4.38	1.25	12.44
2003	128	15	31.75	44.79	8.16	136.04
2004	123	24	172.87	111.09	40.68	246.96
2005	115	16	20.77	28.07	7.03	72.64
2006	126	3	0.31	15.23	0.04	93.72
2007	123	24	296.27	213.80	71.34	506.62
2008	113	16	53.31	217.90	17.23	764.34
2009	128	25	43.49	43.41	14.96	98.61
2010	95	18	26.28	17.32	5.19	43.70
2011	67	12	5.43	6.55	1.45	20.33
2012	81	20	58.59	43.49	13.70	98.54
2013	87	17	2073.92	1765.52	498.75	4674.09
2014	85	5	20.13	28.76	2.08	127.19
2015	89	19	48.97	104.74	27.79	252.82
2016	91	32	889.41	924.72	360.92	2043.34
2017	93	18	736.59	701.86	208.96	1676.80
2018	76	23	3259.93	2430.72	882.32	5306.47
2019	108	26	92.58	96.18	34.78	208.16
2020	61	28	486.87	766.67	259.22	1680.36
2021	122	58	2392.03	2408.48	1228.91	4153.96

Table 2. The summary of the survey (number of surveys, number of positive catches, and the mean nominal CPUE) and the result of standardization (estimated density and confidence interval) for the autumn recruitment survey.

Year	**Number of surveys (Number of stations * months)**	**Number of positive catches**	**Mean nominal CPUE (Catch/hour)**	**Standardized CPUE**	**Lower 95% CI**	**Upper 95% CI**
2005	53	14	23.6	15.1	4.9	35.9
2006	56	5	0.8	2.5	0.3	9.2
2007	46	13	10.0	9.8	3.0	23.5
2008	40	9	9.7	7.8	1.9	20.1
2009	49	22	60.7	33.2	13.6	69.4
2010	49	19	16.9	11.3	4.4	22.8
2011	42	12	4.5	3.3	1.0	8.2
2012	37	16	18.2	16.7	6.2	37.3
2013	39	26	1346.6	810.6	374.8	1447.9
2014	32	21	95.1	47.1	21.7	93.7
2015	34	18	169.0	106.1	40.1	240.3
2016	29	15	1339.5	758.1	264.0	1702.5
2017	28	14	645.0	242.9	73.4	550.6
2018	28	26	6237.1	2891.8	1349.8	5298.9
2019	26	20	261.0	132.2	56.9	257.0
2020	35	26	660.6	680.4	327.9	1237.2
2021	43	31	651.2	378.2	188.4	681.8

Figure 1. Spatio-temporal distribution of the summer survey efforts (hours of towing). Rectangles with bold black lines are the area stratification determined by delta-GLM-tree.

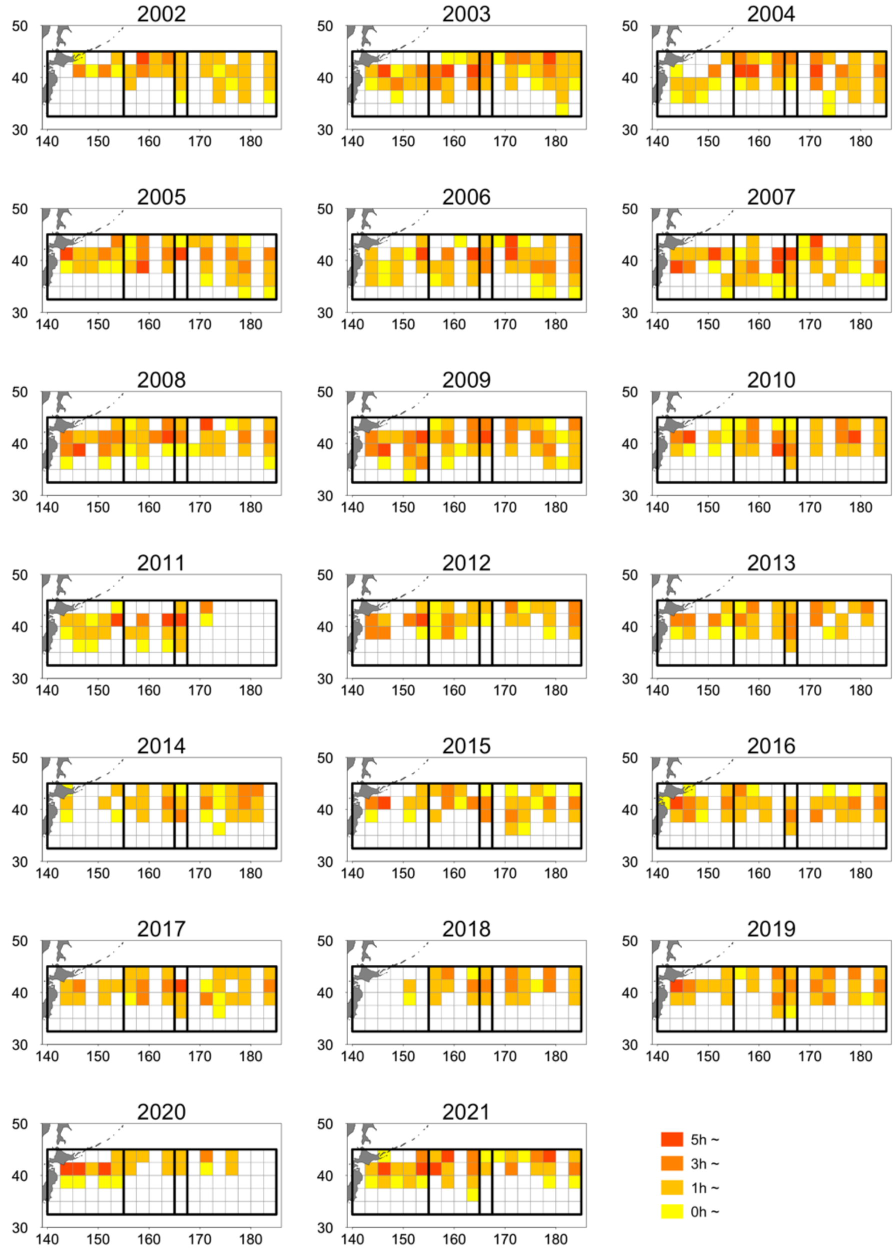


Figure 2. Spatio-temporal distribution of the autumn survey efforts (hours of towing). Rectangles with bold black lines are the area stratification determined by delta-GLM-tree.

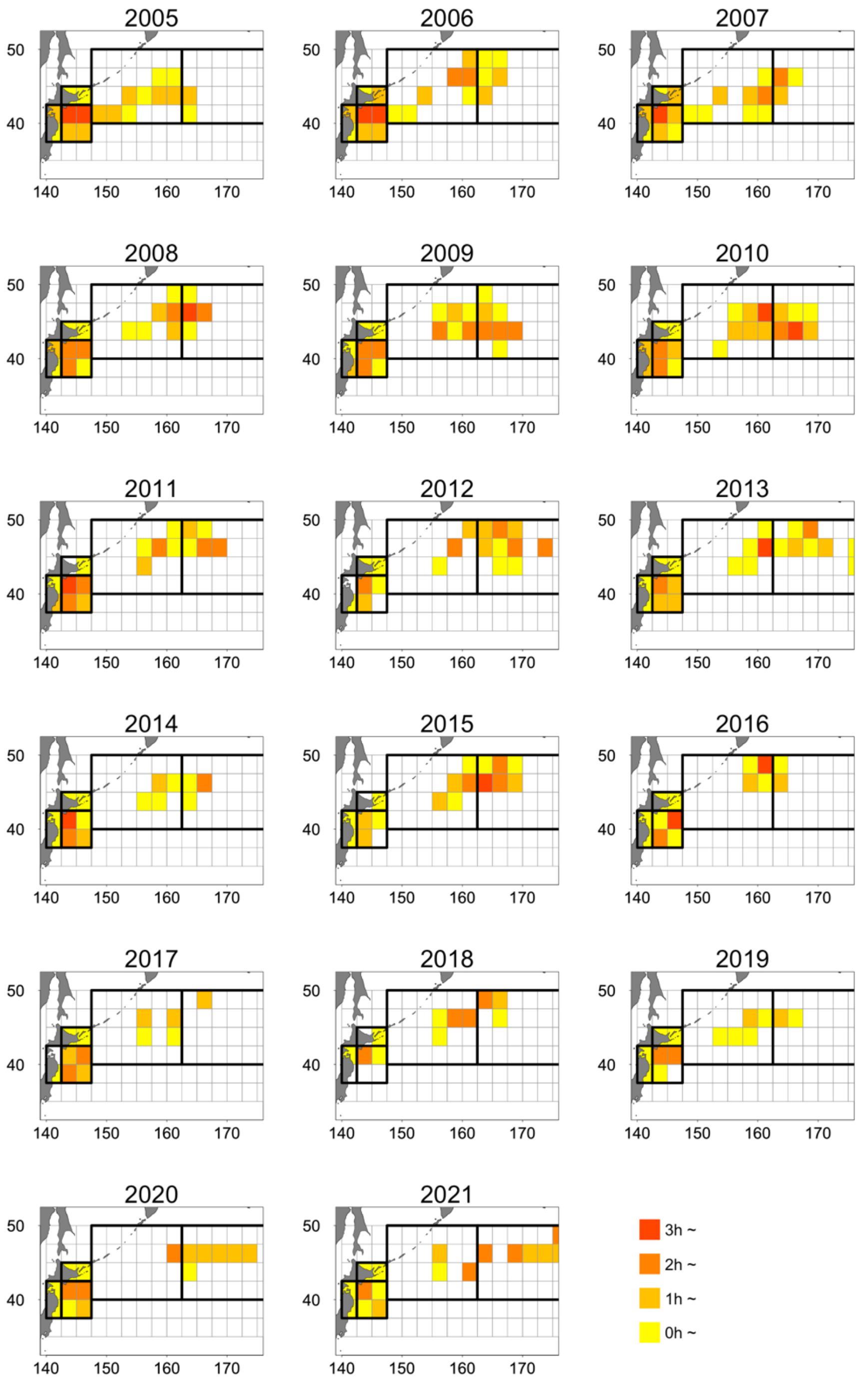


Figure 3. Spatio-temporal distribution of the summer survey CPUEs (number per hour). Rectangles with bold black lines are the area stratification determined by delta-GLM-tree.

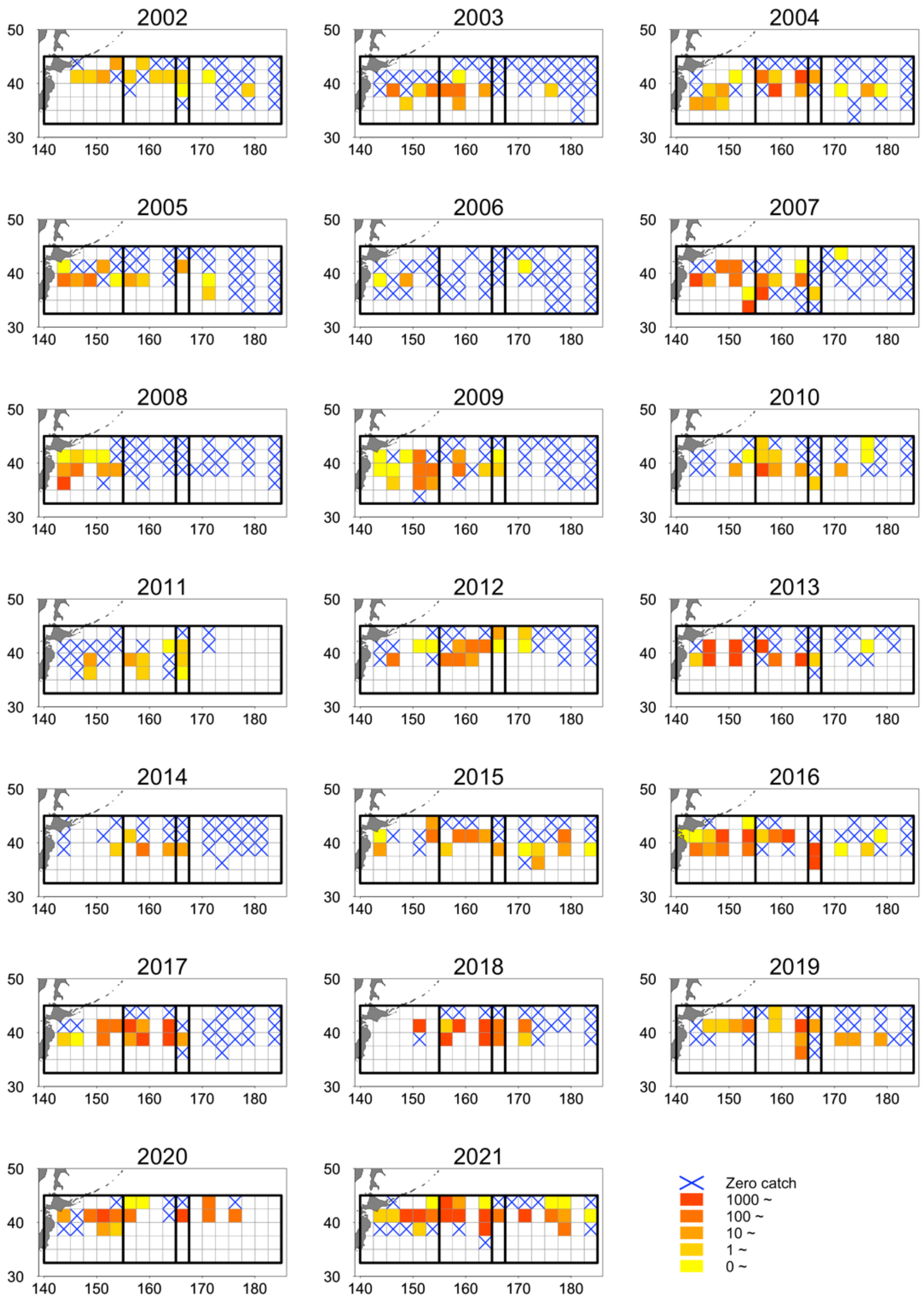
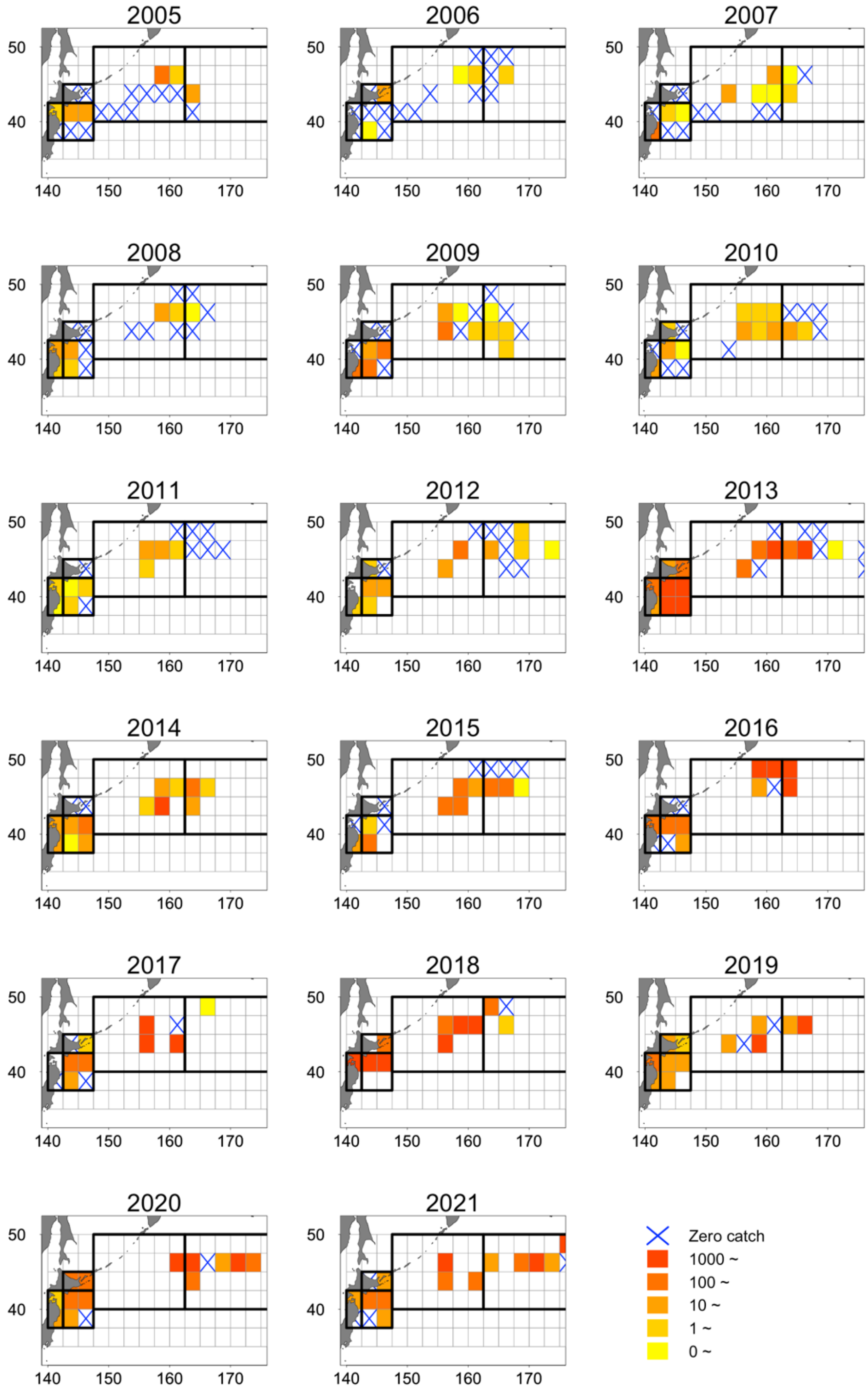


Figure 4. Spatio-temporal distribution of the autumn survey CPUEs (number per hour). Rectangles with bold black lines are the area stratification determined by delta-GLM-tree.



(3) Plots representing the correlation between the variables

In the following, we present (i) the yearly trends of scaled temperature (Fig. 5, Fig. 6), (ii) the yearly trends of the CPUE (Fig. 7, Fig. 8), and (iii) the relationship between temperature and CPUE (Fig. 9, Fig. 10), for the summer and autumn surveys. In addition, we present the correlation between SST and T50 of the summer survey data (Fig. 11) and between SST and T30 of the autumn survey data (Fig. 12).

Figure 5. Yearly trends of SST and T50 used in the summer CPUE standardization.

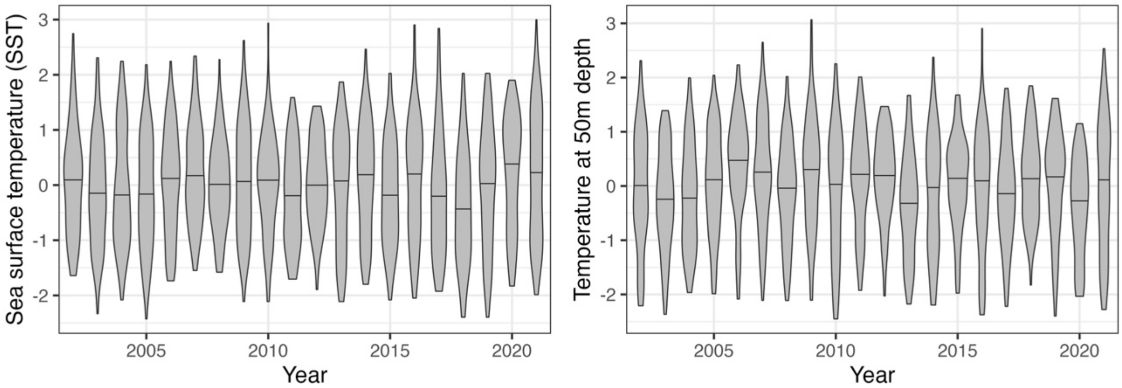


Figure 6. Yearly trends of SST and T30 used in the autumn CPUE standardization.

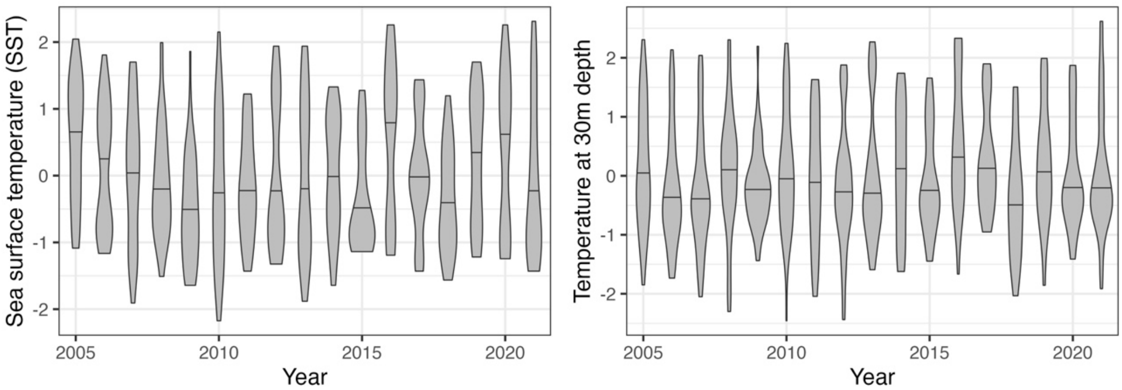


Figure 7. The yearly trend of the number of positive CPUE (left panel) and the average positive CPUE (right panel) of the summer survey. The y-axis of the right panel is log-scaled.

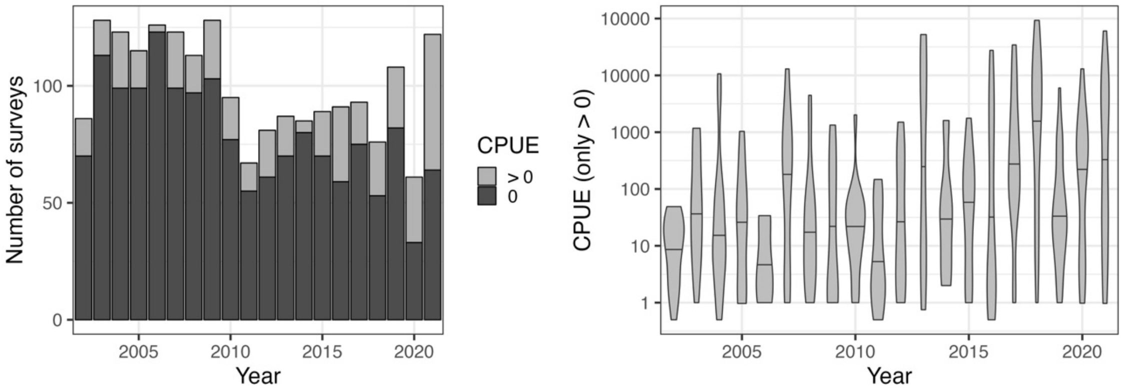


Figure 8. The yearly trend of the number of positive CPUE (left panel) and the average positive CPUE (right panel) of the autumn survey. The y-axis of the right panel is log-scaled.

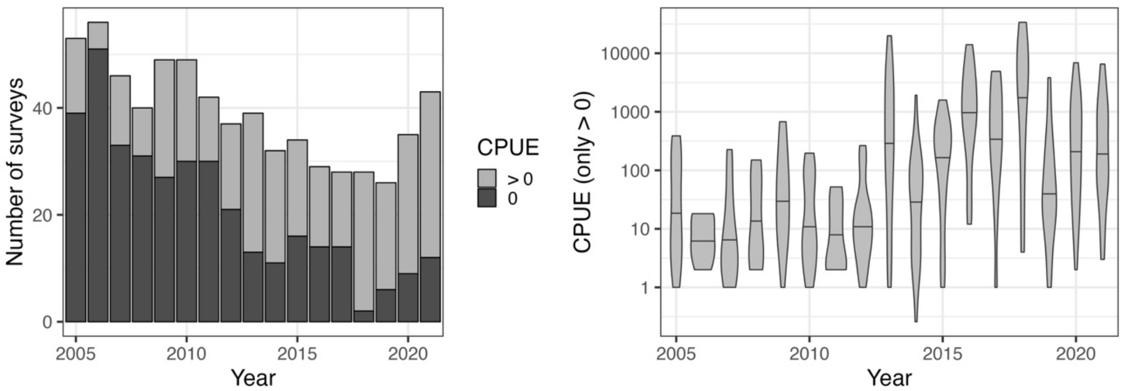


Figure 9. The relationships between CPUE and sea surface temperature (SST) (a: all CPUEs, b: only positive CPUEs in log scale), or temperature at 50m depth (c: all CPUEs, d: only positive CPUEs in log scale) of the summer survey data.

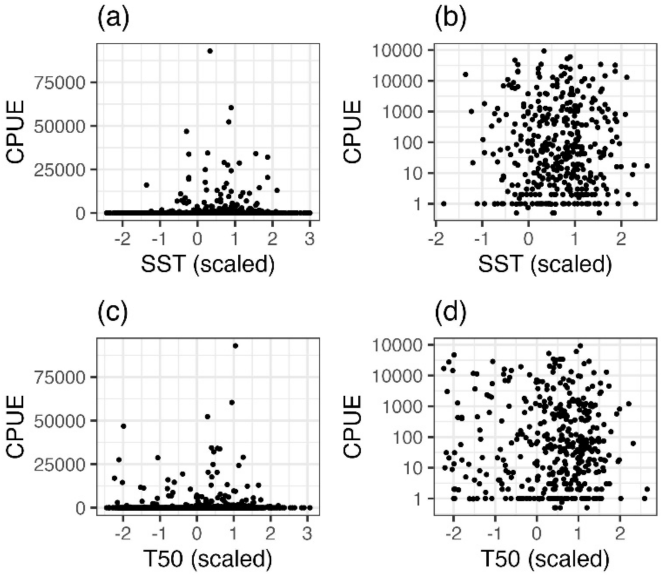


Figure 10. The relationships between CPUE and sea surface temperature (SST) (a: all CPUEs, b: only positive CPUEs in log scale), or temperature at 30m depth (T30) (c: all CPUEs, d: only positive CPUEs in log scale) of the autumn survey data.

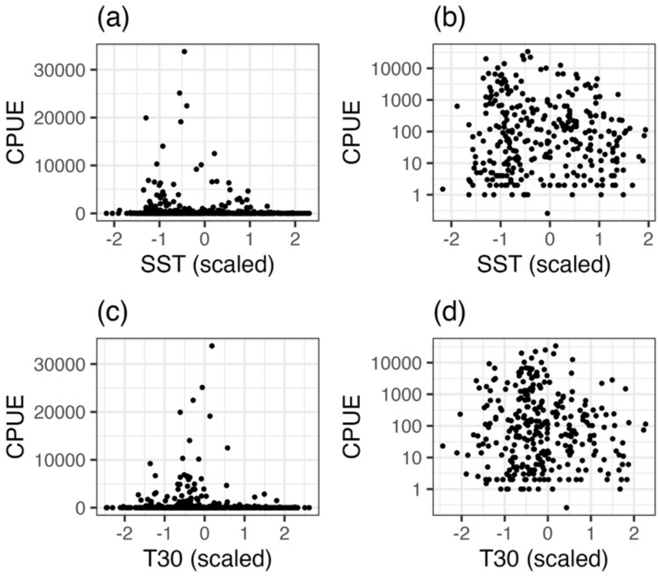


Figure 11. The correlation between SST and T50 of summer survey data. Pearson's correlation coefficient was 0.648.

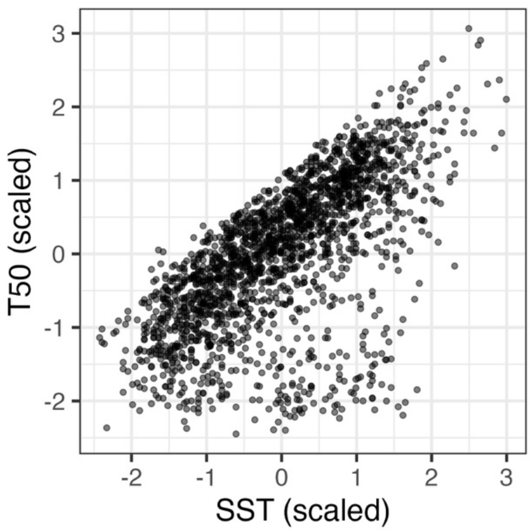
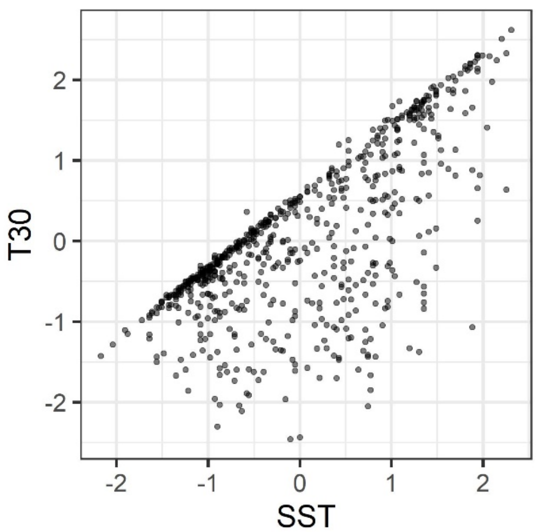


Figure 12. The correlation between SST and T30 of autumn survey data. Pearson's correlation coefficient was 0.688.



(4) Explanatory variables in the full model

For summer survey standardization, we incorporated (i) year (categorical), (ii) area (categorical, determined by delta-GLM-tree), (iii) year:area (interaction), (iv) SST (continuous), (v) SST^2, (vi) T50 (continuous), (vii) $T50^2$, and (viii) SST:T50 (interaction) as fixed effects.

For autumn survey standardization, we incorporated (i) year (categorical), (ii) area (categorical, determined by delta-GLM-tree), (iii) year:area (interaction), (iv) SST (continuous), (v) SST^2, (vi) T30 (continuous), (vii) $T30^2$, and (viii) SST:T30 (interaction) as fixed effects.

(5) Model details

We used delta-GLM-tree for the standardization of both summer and autumn data (Hashimoto et al 2019). Delta GLM is the two-step generalized linear model where the probability of occurrence and the density or CPUE when occurred were modelled separately. The delta-GLM-tree analysis allows one to perform the delta GLM by simultaneously conducting area (post-)stratification based on “GLM-tree” (Ichinokawa and Brodziak 2010), where areas were sequentially separated, so that predictive error (AICc in this case) be the smallest.

We constructed the delta-GLM-tree models. While the probability of occurrence was modelled with a binomial distribution (logit link), the CPUE when occurred was modelled with a gamma distribution (log link). The distribution of the CPUE modelling was selected based on AICc. The results of the stratification are shown in Figs. 1 and 3 for the summer data, and Figs 2 and 4 for the autumn data.

(6) **Best model**

We performed the brute-force model selection approach and determined the best models based on AICc. The models where ΔAICc (difference of AICc with the best model) is less than two (Table 3, 5), and the estimated coefficients in the best models (Table 4, 6) are shown.

The differences in AICc (ΔAICc) between the best and the second models were small for both summer standardization and there were multiple models with ΔAICc<2 (Table 4 and 5). The results suggest uncertainties in model selection especially for the factor of SST and T50 or T30. We conducted a sensitivity analysis by investigating the second-best model for the summer and autumn recruitment CPUE and comparing its standardized values with that of the best model.

Table 3. Result of the model selection for the standardization of summer survey CPUE.

Occurrence model (binomial)			Positive CPUE model (gamma)					
Explanatory variables	df	logLik	Explanatory variables	df	logLik	Number of areas	AICc	Δ AICc
SST + I(SST^2) + T50 + Area:Year + Area + Year	83	-631.18	Area + Year	24	-2740.7	4	6969.98	0
SST + I(SST^2) + T50 + Area:Year + SST:T50 + Area + Year	84	-630.25	Area + Year	24	-2740.7	4	6970.36	0.38
SST + I(SST^2) + Area:Year + Area + Year	82	-632.57	Area + Year	24	-2740.7	4	6970.54	0.56
SST + I(SST^2) + T50 + Area:Year + Area + Year	83	-631.18	Area + SST + Year	25	-2739.91	4	6970.64	0.66
SST + I(SST^2) + T50 + Area:Year + SST:T50 + Area + Year	84	-630.25	Area + SST + Year	25	-2739.91	4	6971.03	1.05
SST + I(SST^2) + Area:Year + Area + Year	82	-632.57	Area + SST + Year	25	-2739.91	4	6971.2	1.22
SST + I(SST^2) + T50 + I(T50^2) + Area:Year + Area + Year	84	-630.69	Area + Year	24	-2740.7	4	6971.23	1.26

SST + I(SST^2) + T50 + I(T50^2) + Area:Year + Area + Year	84	-630.69	Area + SST + Year	25	-2739.91	4	6971.9	1.92
SST + I(SST^2) + T50 + Area:Year + Area + Year	83	-631.18	Area + T50 + Year	25	-2740.69	4	6972.21	2.23
SST + I(SST^2) + T50 + I(T50^2) + Area:Year + SST:T50 + Area + Year	85	-630.22	Area + Year	24	-2740.7	4	6972.55	2.57

Table 4. The estimated coefficients in the best models for the standardization of summer survey CPUE.

Occurrence model (binomial)				Positive CPUE model (gamma)	
Explanatory variable	Coefficient	Explanatory variable	Coefficient	Explanatory variable	Coefficient
SST	1.801	Year2003	-0.880	Year2003	2.319
SST^2	-0.918	Year2004	0.202	Year2004	3.100
T50	0.178	Year2005	-0.679	Year2005	2.241
Area1	-0.237	Year2006	-2.408	Year2006	0.097
Area2	-2.968	Year2007	-0.121	Year2007	4.187
Area3	-0.921	Year2008	0.119	Year2008	3.084
Area4	-1.801	Year2009	-0.120	Year2009	2.395
		Year2010	-1.911	Year2010	1.384
		Year2011	-1.691	Year2011	0.371
		Year2012	-1.560	Year2012	1.866
		Year2013	-0.466	Year2013	6.121
		Year2014	-2.802	Year2014	2.154
		Year2015	-1.708	Year2015	3.044
		Year2016	0.489	Year2016	5.049
		Year2017	-0.845	Year2017	4.509
		Year2018	0.110	Year2018	5.705
		Year2019	-1.164	Year2019	2.711
		Year2020	-0.009	Year2020	4.624
		Year2021	-0.165	Year2021	5.504

		Area2:Year2003	0.053		
		Area3:Year2003	0.438		
		Area4:Year2003	-15.399		
		Area2:Year2004	-0.138		
		Area3:Year2004	0.144		
		Area4:Year2004	1.113		
		Area2:Year2005	0.592		
		Area3:Year2005	-0.326		
		Area4:Year2005	1.271		
		Area2:Year2006	0.916		
		Area3:Year2006	-15.328		
		Area4:Year2006	-14.339		
		Area2:Year2007	-0.806		
		Area3:Year2007	-0.332		
		Area4:Year2007	-0.980		
		Area2:Year2008	-15.584		
		Area3:Year2008	-17.870		
		Area4:Year2008	-16.600		
		Area2:Year2009	-15.546		
		Area3:Year2009	-0.351		
		Area4:Year2009	0.531		
		Area2:Year2010	2.734		

		Area3:Year2010	2.801		
		Area4:Year2010	0.823		
		Area2:Year2011	-12.604		
		Area3:Year2011	1.757		
		Area4:Year2011	2.129		
		Area2:Year2012	1.804		
		Area3:Year2012	2.878		
		Area4:Year2012	5.232		
		Area2:Year2013	0.421		
		Area3:Year2013	0.303		
		Area4:Year2013	0.232		
		Area2:Year2014	-12.783		
		Area3:Year2014	1.987		
		Area4:Year2014	2.122		
		Area2:Year2015	3.773		
		Area3:Year2015	2.704		
		Area4:Year2015	1.301		
		Area2:Year2016	0.398		
		Area3:Year2016	0.004		
		Area4:Year2016	1.844		
		Area2:Year2017	-14.258		
		Area3:Year2017	3.375		

		Area4:Year2017	0.271		
		Area2:Year2018	1.080		
		Area3:Year2018	1.359		
		Area4:Year2018	4.199		
		Area2:Year2019	2.558		
		Area3:Year2019	2.928		
		Area4:Year2019	1.817		
		Area2:Year2020	3.522		
		Area3:Year2020	1.330		
		Area4:Year2020	3.368		
		Area2:Year2021	4.111		
		Area3:Year2021	2.845		
		Area4:Year2021	6.009		

Table 5. Model selection of the standardization of autumn survey CPUE.

Occurrence model (binomial)			Positive CPUE model (gamma)					
Explanatory variables	df	logLik	Explanatory variables	df	logLik	Number of areas	AICc	ΔAICc
SST + I(SST^2) + T30 + I(T30^2) + Area + Year	25	-341.44	Area + T30 + I(T30^2) + Year	24	-1971.15	5	4731.14	0
SST + T30 + I(T30^2) + Area + Year	24	-343.4	Area + T30 + I(T30^2) + Year	24	-1971.15	5	4732.72	1.58
SST + I(SST^2) + T30 + I(T30^2) + SST:T30 + Area + Year	26	-341.16	Area + T30 + I(T30^2) + Year	24	-1971.15	5	4732.92	1.78
SST + T30 + I(T30^2) + SST:T30 + Area + Year	25	-342.93	Area + T30 + I(T30^2) + Year	24	-1971.15	5	4734.11	2.97
SST + T30 + I(T30^2) + Area + Year	25	-342.74	Area + SST + I(SST^2) + T30 + I(T30^2) + Year	27	-1967.83	6	4734.13	2.99
T30 + I(T30^2) + Area + Year	24	-342.74	Area + SST + I(SST^2) + T30 + I(T30^2) + Year	27	-1969.05	6	4734.2	3.06
SST + I(SST^2) + T30 + I(T30^2) + Area + Year	26	-340.52	SST + T30 + SST:T30 + Year	21	-1976.29	6	4734.91	3.76
SST + T30 + SST:T30 + Area + Year	24	-344.55	Area + T30 + I(T30^2) + Year	24	-1971.15	5	4735.04	3.9
SST + T30 + I(T30^2) + Area + Year	24	-344.98	Area + SST + I(SST^2) + Year	24	-1970.78	5	4735.14	3.99

Table 6. The estimated coefficients in the best models for the standardization of autumn survey CPUE.

Occurrence model (binomial)				Positive CPUE model (gamma)			
Explanatory variable	Coefficient	Explanatory variable	Coefficient	Explanatory variable	Coefficient	Explanatory variable	Coefficient
SST	-0.474	Year2006	-1.601	Area1	4.676	Year2006	-1.046
I(SST^2)	-0.245	Year2007	-0.090	Area2	4.072	Year2007	-0.405
T30	-0.450	Year2008	-0.494	Area3	4.931	Year2008	-0.460
I(T30^2)	-0.320	Year2009	0.369	Area4	2.619	Year2009	0.634
Area1	1.028	Year2010	0.579	Area5	4.398	Year2010	-0.541
Area2	-1.821	Year2011	-0.205	T30	-0.278	Year2011	-1.436
Area3	-0.577	Year2012	1.241	T30^2	-0.440	Year2012	-0.385
Area4	-1.678	Year2013	2.171			Year2013	3.266
Area5	0.076	Year2014	1.682			Year2014	0.555
		Year2015	1.180			Year2015	1.503
		Year2016	1.690			Year2016	3.271
		Year2017	0.894			Year2017	2.382
		Year2018	3.584			Year2018	4.380
		Year2019	2.620			Year2019	1.382
		Year2020	2.599			Year2020	3.019
		Year2021	2.556			Year2021	2.457

(7) Diagnostics of the model and the residuals

The best delta-GLM-tree model for summer recruitment CPUE standardization was diagnosed by evaluating the spatio-temporal distributions of deviance residuals of the binomial (Fig. 13) and gamma models (Fig.14). It seems that there were no temporal trends in the residuals of the binomial (Fig. 13b) or gamma (Fig. 14b) models, and no spatial biases for both model residuals (Fig. 13c, 14c). The binomial model was additionally diagnosed by the area under the ROC (receiver operating characteristic) curve (AUC), which quantifies the performance of the classification model and ranges from 0 to 1 where 0.5 suggests the random prediction and 1 suggests 100% correct prediction. Generally, 0.8 to 0.9 AUC value is considered as a good prediction ability. The AUC was 0.898 (Fig. 13d), suggesting its good prediction. The residuals of the gamma distribution do not appear to follow a normal distribution (Fig. 14a). The QQ-plot suggests some deviance from the expected distribution and the one-sample Kolmogorov-Smirnov test indicates that the residual distribution significantly deviates from the normal distribution ($p = 0.005$).

The best delta-GLM-tree model for autumn recruitment CPUE standardization was diagnosed in the same way (Fig. 15, 16). The residuals of the binomial and gamma models did not show spatial biases (Fig. 15c, 16c). However, the residuals of the binomial model were larger in the later years (Fig. 15b), posing the possibility that the distribution of the stock has shifted toward Area 2 during the later years where the estimated probability of occurrence was lower (Table 6). However, the interaction of year and area was not selected in the binomial model. The residuals of the gamma model did not systematically change along with year. AUC suggests that the binomial model prediction was good (0.828, Fig. 15d). The residuals of the gamma model significantly deviate from the expected normal distribution (Fig. 16a, d, $p = 0.039$ in one-sample Kolmogorov-Smirnov test).

Figure 13. Diagnostics of the binomial (probability of occurrence) model in the delta-GLM-tree model for the standardization of summer CPUE. (a) Distribution of the deviance residuals, temporal (b) and spatial (c) trends of the deviance residuals, and (d) the receiver operating characteristic (ROC) curves and the area under the curve (AUC) value.

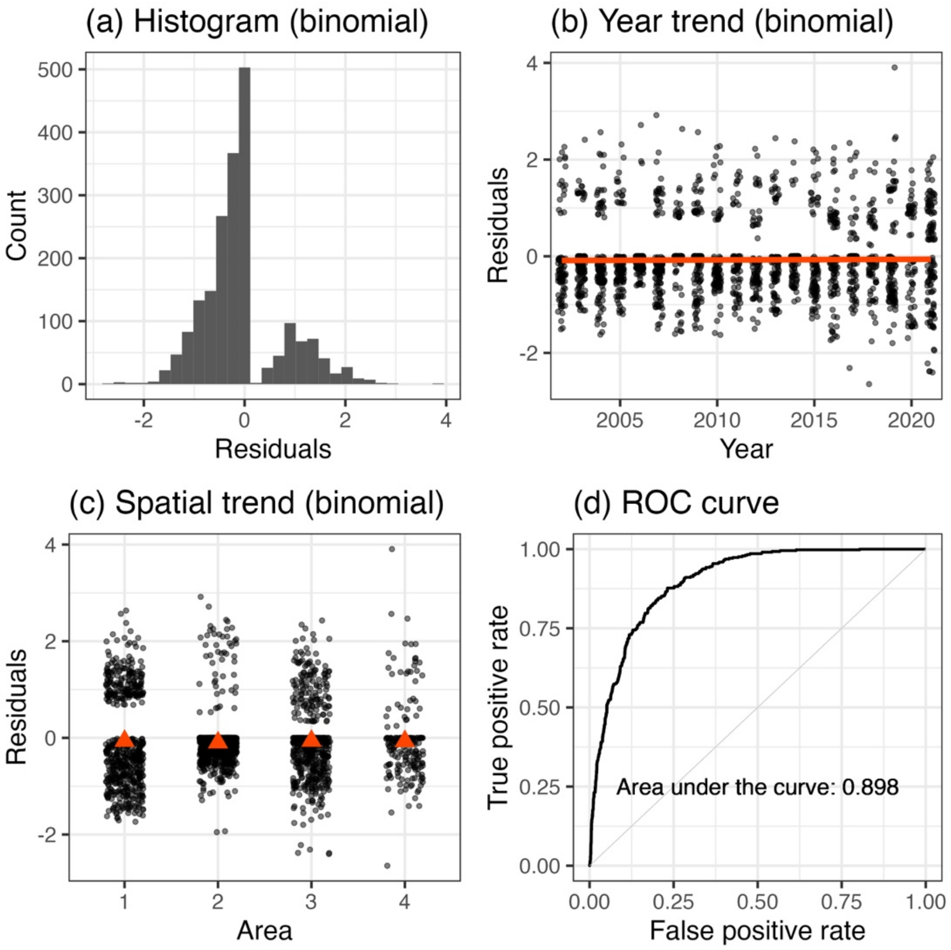


Figure 14. Diagnostics of the gamma (positive CPUE) model in the delta-GLM-tree model for the standardization of summer CPUE. (a) Distribution of the deviance residuals, temporal (b) and spatial (c) trends of the deviance residuals, and (d) the QQ-plot.

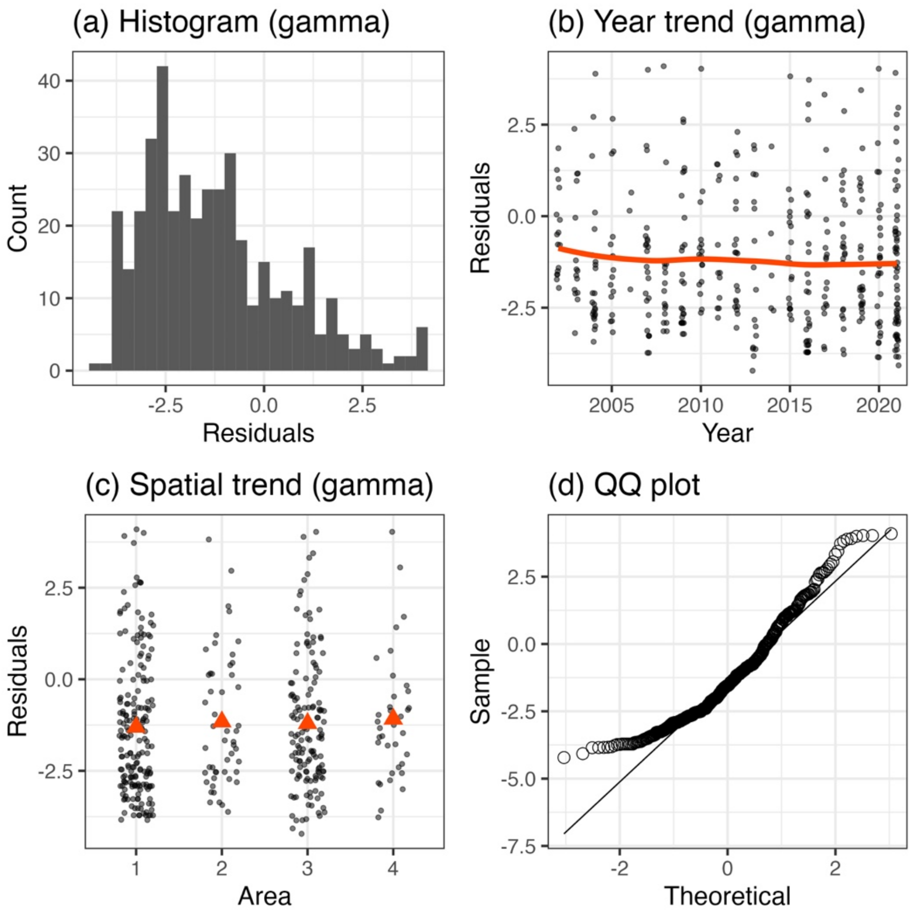


Figure 15. Diagnostics of the binomial (probability of occurrence) model in the delta-GLM-tree model for the standardization of autumn CPUE. (a) Distribution of the deviance residuals, temporal (b) and spatial (c) trends of the deviance residuals, and (d) the receiver operating characteristic (ROC) curves and the area under the curve (AUC) value. The orange line in (b) show the smoothed curve drawn by a locally estimated scatterplot smoothing (LOESS) function and the orange triangles in (c) show the average in each area.

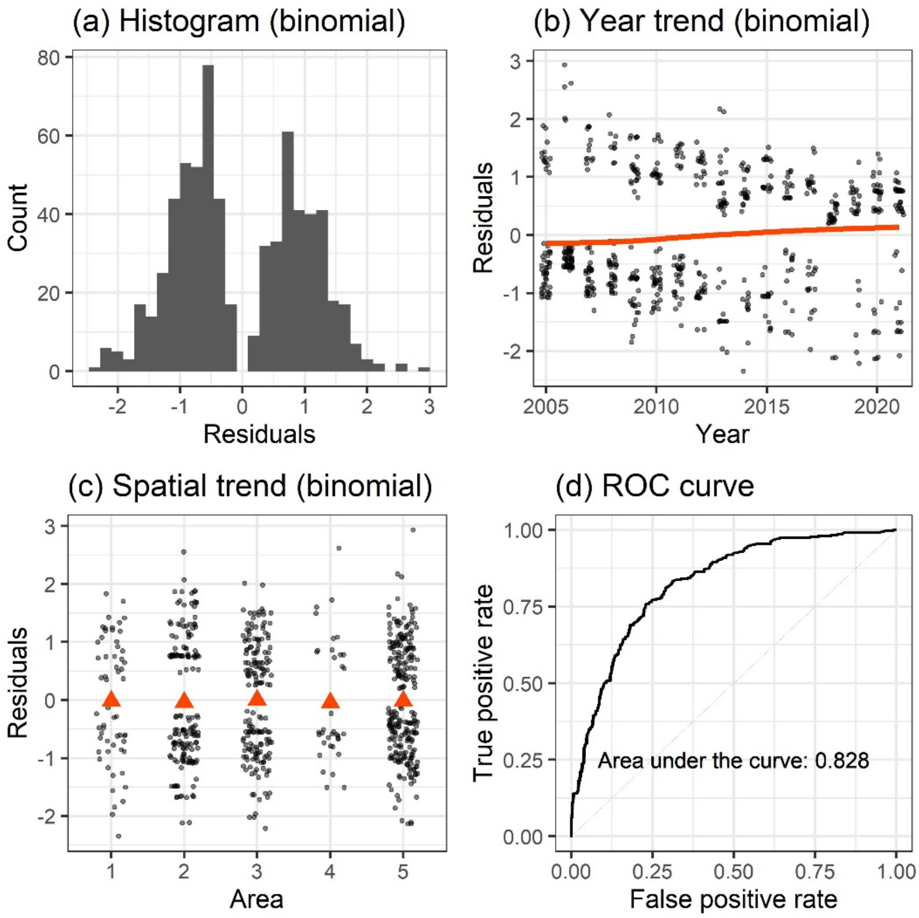
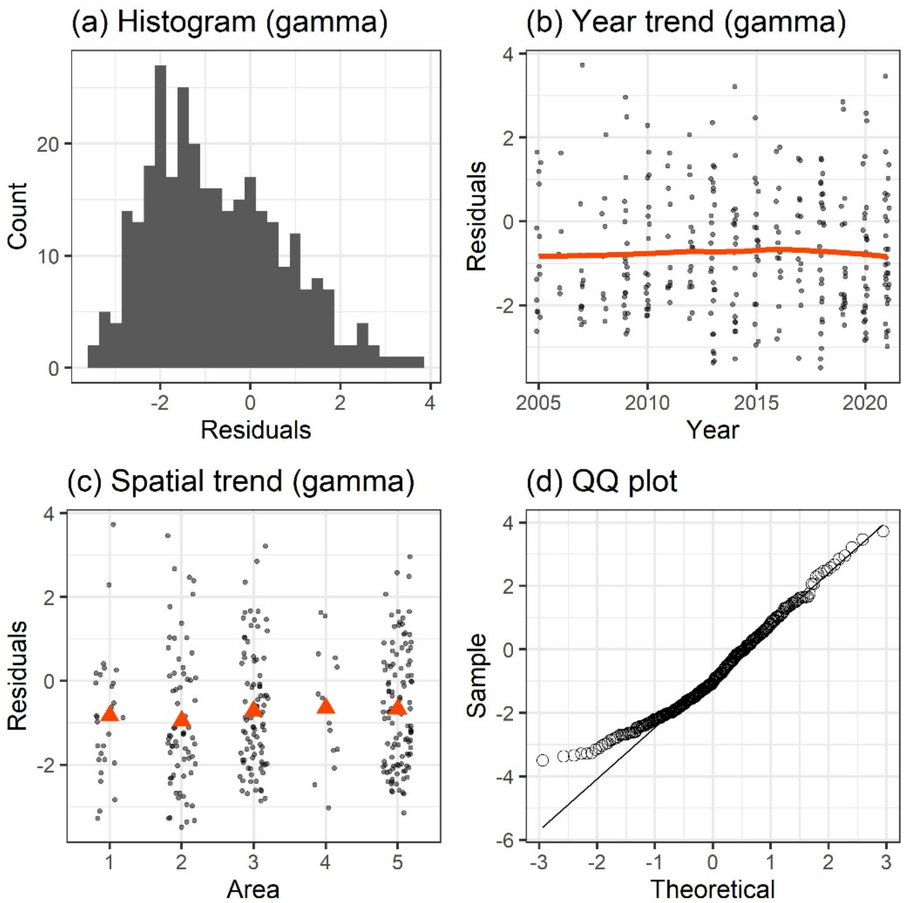


Figure 1**6**. Diagnostics of the gamma (positive CPUE) model in the delta-GLM-tree model for the standardization of autumn CPUE. (a) Distribution of the deviance residuals, temporal (b) and spatial (c) trends of the deviance residuals, and (d) the QQ-plot. The orange line in (b) show the smoothed curve drawn by a locally estimated scatterplot smoothing (LOESS) function and the orange triangles in (c) show the average in each area.



(8) Estimated relationships between the explanatory variables and the response variable

In the best model for summer recruitment CPUE, Year, Area, Area:Year (interaction term), SST, SST^2, and T50 were retained as the explanatory variables for the binomial model, and Year and Area for the gamma model (Tables 3, 4). Occurrence probability (binomial model) had a unimodal relationship with SST and a linear relationship with T50 (Fig. 17a, c).

The best model for autumn recruitment CPUE included Year, Area, SST, SST^2, T30, and $T30^2$ in the binomial model, and Year, Area, T30, and $T30^2$ (interaction term) in the gamma model (Table 5, 6). Occurrence probability (binomial model) showed a unimodal response against SST and T30 (Fig. 18a, c). Positive CPUE also showed a unimodal response against T50 (Fig. 18d).

Figure 17. Relationship between catch probability and sea surface temperature (SST, a) or water temperature at 50m depth (T50, c), and relationship between positive CPUE and SST (b) or T50 (d) in the summer survey. The lines are predicted values with the effects of other parameters averaged. The points are the observed values.

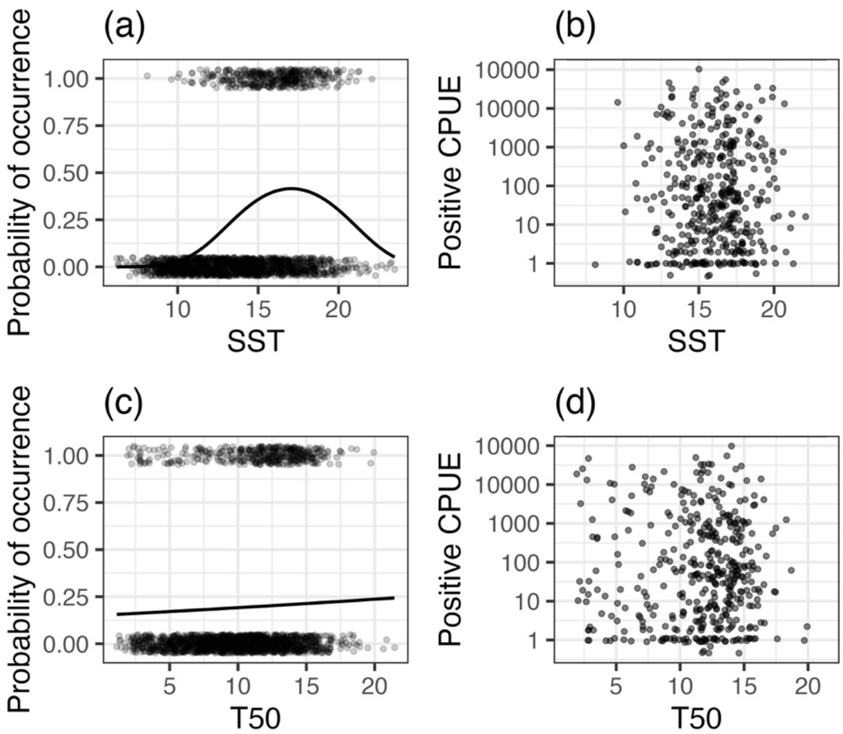
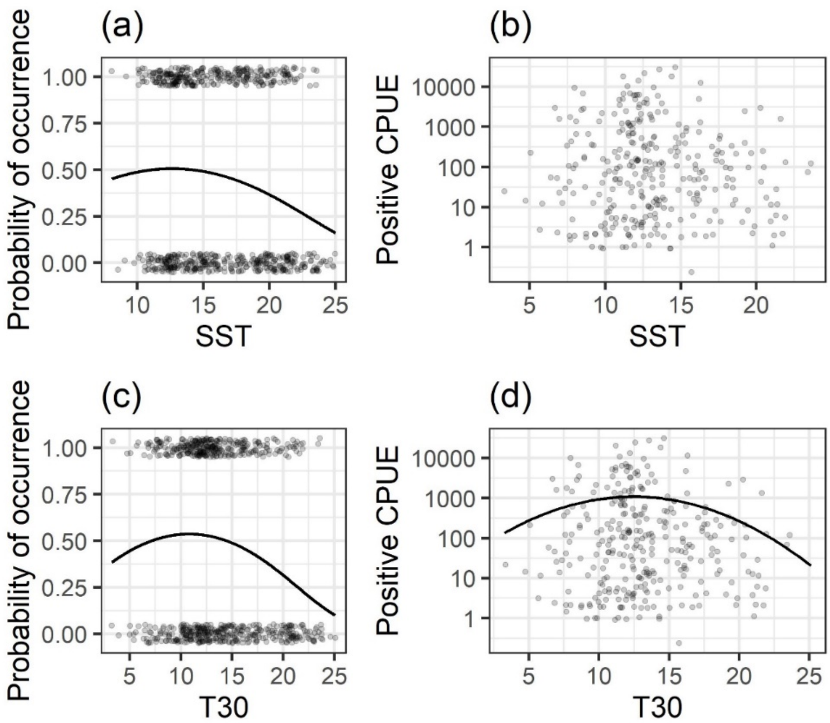


Figure 18. Relationship between the probability of occurrence and sea surface temperature (SST, a) or water temperature at 30m depth (T30, c), and relationship between positive CPUE (log scale) and SST (c) or T30 (d) in the autumn survey. The lines are predicted values with the effects of other parameters averaged. The points are the observed values.



(9) Yearly standardized CPUE and its uncertainty

To derive the standardized CPUE values, we calculated predicted CPUE values per each category (for the continuous variables, we divided their range at small regular intervals) of selected variables (e.g., Area = 1, 2, 3…, Year = 2002, 2003, 2004…, SST = 10.0, 11.0, 12.0…), and calculated the arithmetic mean (for variables except Area) and area-weighted mean of the yearly predicted values. Each area for the standardized recruitment CPUEs was assumed to be the rectangle surrounding the survey grids (Figs. 1-4). This averaging for extracting the year trend was necessary due to the nonlinearity of the logit link function in the delta-gamma model (Hashimoto et al. 2019). Confidence intervals were evaluated by sampling posterior distribution with 1000 replicates using the R package ‘arm’ (Gelman and Su 2021). The standardized CPUE values and confidence intervals are shown in the next section and in Table 1, 2.

(10) Comparison of the nominal and standardized CPUEs

The yearly patterns of summer recruitment CPUE trends were similar between nominal and standardized CPUEs, though the standardization estimated lower probability of positive CPUE (Fig. 19a-c).

The yearly patterns of autumn recruitment CPUE trends were also similar between nominal and standardized CPUEs (Fig. 20). The index has been maintained at higher value since 2016 than before 2012, but with a great variability.

The standardized values obtained by the second-best models in summer and autumn surveys were quite close to those obtained by the best models (Fig. 19d-f, Fig. 20d-f, respectively), suggesting the robustness of standardized indices to model selection.

Figure 19. The yearly trends of nominal and standardized values of (a) the probability of positive CPUE, (b) positive CPUE after scaling (divided by means), and (c) CPUE after scaling (divided by means) of the summer recruitment CPUE. Blue shaded areas are 95% confidence intervals of standardized CPUE.

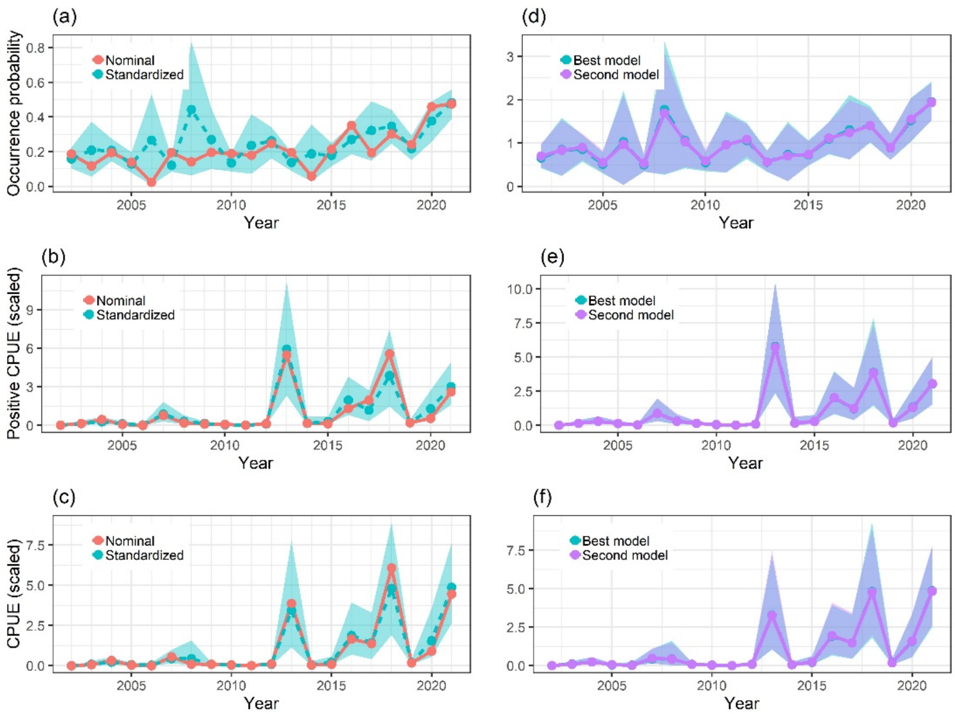
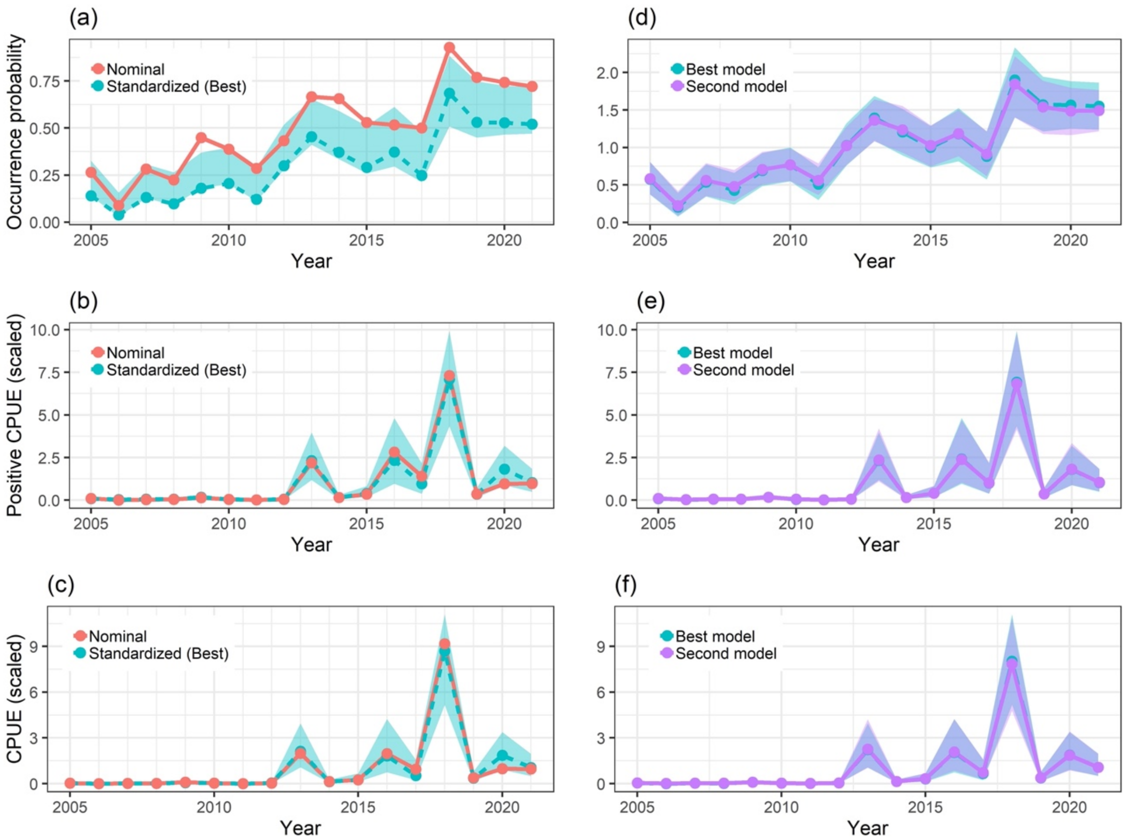


Figure 20. The yearly trends of nominal and standardized values of (a) the probability of positive CPUE, (b) positive CPUE after scaling (divided by means), and (c) CPUE after scaling (divided by means) of the autumn recruitment CPUE. Blue shaded areas are 95% confidence intervals of standardized CPUE. The comparison between the results of the best and second-best models: (d) the probability of positive CPUE, (e) positive CPUE after scaling (divided by means), and (f) CPUE after scaling (divided by means).



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