Standardization of CPUE of Japanese seabream caught in large set net fisheries in Shimane Prefecture

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Summary

Data	Data from large set net fisheries operating along the coast of Shimane Prefecture (catch of Japanese seabream per vessel per day), FRA-ROMS reanalysis data (temperatures at depth from 10 to 30 m)
Units	Catch per vessel per day (kg/day・vessel)
Period of available data	2007 to 2021
Period used for standardization	2007 to 2021
Data extraction for standardization	Reanalysis values from FRA-ROMS II for the Shimane Prefecture coastline were used for the temperatures at depth from 10 to 30 m
Statistical software packages	R (4.2.1). The function used is MASS. The mgcv package was used for model calculations.
Statistical model	Generalized linear model: lognormal distribution
Explanatory variables applied in the full model	Year (category, fixed), month (category, fixed), vessel (category, fixed), water temperature (continuous)
Selection method for final model	The model selection is based on AIC for the lognormal distribution model.
Explanatory variables selected in the final model	Year (category, fixed), month (category, fixed), vessel (category, fixed), water temperature (continuous)
Extraction method for yearly trends	Annual average of projected values in dummy data with the explanatory variables evenly distributed
Calculation method for confidence intervals	Data were generated through bootstrapping with allowing replacement, and the calculation to find the standardized CPUE (catch per unit effort) from the best model was repeated 1,000 times. Model selection was not applied.
Standardization results	The estimated standardized CPUE was slightly higher in 2009 to 2012, lower in 2013 to 2020, and increased in 2021.

1 Background

Until now, it had been assumed that there was no significant annual fluctuation in the fishing effort of the western Sea of Japan and East China Sea stock of Japanese seabream, and since it has been difficult to accurately determine this, abundance indices have not been used in stock assessment. However, a significant decrease in fishing effort has been noted in recent years due to stagnant fish prices and the voluntary restraint of operations following the coronavirus outbreak in 2020. In such cases, it is extremely important to estimate the abundance index (CPUE: catch per unit effort), which is said to represent relative changes in biomass in stock assessments, and to introduce it into stock calculations.

Since set net fisheries do not actively search for fish schools but instead wait for the fish to come to them, it is thought to better reflect fluctuations in biomass, and we will use catch data from large set net fisheries in Shimane Prefecture to calculate abundance indices. The data obtained here includes landings by operation day and vessel, which are combined with separately obtained water temperature data for each area to standardize the CPUE (Maunder and Punt 2004, Shono 2004).

2 Data and methods

2.1 Data used

Data on landings of large set nets by 20 companies established in three areas of Shimane Prefecture (Oki, Izumo, and Iwami) were used. Catch (kg/day･vessel) of Japanese seabream from January to December 2007 to 2021 was aggregated by day and by vessel (= management entity). Water temperatures were related to mean water temperatures at 10m and 30m depths in the waters off Oki, Izumo, and Iwami from FRA-ROMS II reanalysis values.

2.2 Statistical model

Since there was only non-zero catch data, the natural logarithm of landings per vessel per day was used as the response variable, and year (Year), month (Month), vessel (Vessel), and water temperature (Temp) were used as explanatory variables.

$$\ln CPUE \sim N(\mu, \sigma^2)$$

$$\mu = \alpha + factor(Year) + factor(Month) + factor(Corp) + \beta \cdot Temp$$

CPUE is the daily catch in weight, μ and σ2 are the mean and variance of the natural log-transformed CPUE, N is the normal distribution, and α is the intercept.

The choice of explanatory variables was determined using the AIC (the Akaike information criterion). 95% confidence intervals were obtained by bootstrapping (1,000 times).

3 Results

The full model was selected as determined by AIC (Tables 1 and 2). Model diagnostic results showed no major problems with the normality and equal variances of the residuals (Figs. 1 and 2).

Standardized CPUE decreased in 2008, increased in 2009, and then decreased again through 2014. It increased once in 2016 and 2017, but showed low values again after 2018, then increased in 2021.

References

Maunder, M. N., and A. E. Punt (2004) Standardizing catch and effort data: a review of recent approaches. Fish. Res., 70, 141-159.

Shono, H. (2004) A review of some statistical approaches used for CPUE standardization. Bull. Jpn. Soc. Fish. Oceanogr., 68, 106-120.

Table 1 Results of model selection by StepAIC

Start: AIC=115018.4

logcatch ~ factor(year) + factor(month) + factor(vessel) + temp

	Df	Deviance	AIC
<none>		45708	115018
- temp	1	45923	115195
- factor(year)	14	46137	115346
- factor(month)	11	46893	115969
- factor(vessel)	19	48780	117454

Table 2 Summary table

glm(formula = logcatch ~ factor(year) + factor(month) + factor(vessel) + temp, family = gaussian)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-4.8067	-0.7311	-0.0977	0.6719	6.4211

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	3.65425	0.10268	35.588	< 2e-16	***
factor(year)2008	-0.26313	0.02972	-8.854	< 2e-16	***
factor(year)2009	-0.08591	0.02881	-2.982	0.00287	**

factor(year)2010	-0.17465	0.03028	-5.767	8.12e-09	***
factor(year)2011	-0.13687	0.02951	-4.639	3.52e-06	***
factor(year)2012	-0.17636	0.02988	-5.903	3.61e-09	***
factor(year)2013	-0.30346	0.03044	-9.970	< 2e-16	***
factor(year)2014	-0.37551	0.02955	-12.706	< 2e-16	***
factor(year)2015	-0.33685	0.02974	-11.328	< 2e-16	***
factor(year)2016	-0.22076	0.02924	-7.550	4.46e-14	***
factor(year)2017	-0.23985	0.03066	-7.822	5.34e-15	***
factor(year)2018	-0.34302	0.03087	-11.111	< 2e-16	***
factor(year)2019	-0.29539	0.03059	-9.657	< 2e-16	***
factor(year)2020	-0.33259	0.03119	-10.663	< 2e-16	***
factor(year)2021	-0.13493	0.03085	-4.373	1.23e-05	***
factor(month)2	-0.10676	0.04306	-2.480	0.01316	*
factor(month)3	0.10255	0.03907	2.625	0.00867	**
factor(month)4	0.58783	0.03545	16.583	< 2e-16	***
factor(month)5	0.53324	0.03533	15.094	< 2e-16	***
factor(month)6	0.64570	0.04135	15.615	< 2e-16	***
factor(month)7	0.75915	0.05253	14.451	< 2e-16	***
factor(month)8	0.59180	0.06839	8.653	< 2e-16	***
factor(month)9	0.71292	0.07142	9.982	< 2e-16	***
factor(month)10	0.74099	0.05926	12.504	< 2e-16	***
factor(month)11	0.57526	0.04885	11.776	< 2e-16	***
factor(month)12	0.27672	0.04310	6.420	1.37e-10	***
factor(vessel)B	0.39364	0.03353	11.739	< 2e-16	***
factor(vessel)C	0.12692	0.03535	3.591	0.00033	***
factor(vessel)D	-0.15358	0.03187	-4.819	1.45e-06	***
factor(vessel)E	-0.31462	0.03545	-8.874	< 2e-16	***
factor(vessel)F	-0.43664	0.03947	-11.062	< 2e-16	***
factor(vessel)G	0.04811	0.03687	1.305	0.19196	
factor(vessel)H	-0.24238	0.03922	-6.181	6.45e-10	***
factor(vessel)I	-0.07081	0.03636	-1.948	0.05146	.
factor(vessel)J	0.51133	0.03518	14.534	< 2e-16	***
factor(vessel)K	-0.47570	0.03873	-12.281	< 2e-16	***
factor(vessel)L	0.18400	0.03972	4.632	3.63e-06	***
factor(vessel)M	0.49566	0.03234	15.328	< 2e-16	***
factor(vessel)N	-0.21015	0.04053	-5.185	2.17e-07	***

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factor(vessel)O     -0.21036     0.03730   -5.639 1.72e-08 ***
factor(vessel)P      0.02327     0.03935    0.591   0.55428
factor(vessel)R      0.25369     0.03315    7.652 2.03e-14 ***
factor(vessel)S      0.32074     0.03383    9.482   < 2e-16 ***
factor(vessel)T      0.09089     0.03328    2.731   0.00631 **
factor(vessel)U      0.31695     0.03687    8.597   < 2e-16 ***
temp                -0.07875     0.00589 -13.369   < 2e-16 ***
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Signif. codes:   0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 1.20326)

    Null deviance: 51170   on 38032   degrees of freedom
Residual deviance: 45708   on 37987   degrees of freedom
AIC: 115018

Number of Fisher Scoring iterations: 2
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Table 3: Calculated and scaled CPUE of Japanese seabream by year (relative value when the mean is 1)

Year	Standardized CPUE (kg/day)	Lower confidence limit 2.5%	Upper confidence limit 97.5%	CV (%)	scaled_ CPUE	Lower confidence limit 2.5%	Upper confidence limit 97.5%
2007	13.24	12.63	13.90	2.32	1.25	1.25	1.25
2008	10.17	9.68	10.75	2.57	0.96	0.95	0.97
2009	12.15	11.63	12.67	2.19	1.15	1.15	1.14
2010	11.12	10.55	11.70	2.61	1.05	1.04	1.06
2011	11.54	11.06	12.06	2.19	1.09	1.09	1.09
2012	11.10	10.64	11.56	2.11	1.05	1.05	1.04
2013	9.77	9.35	10.23	2.25	0.92	0.92	0.92
2014	9.09	8.74	9.48	2.09	0.86	0.86	0.86
2015	9.45	9.06	9.82	2.07	0.89	0.89	0.89
2016	10.61	10.21	11.03	1.95	1.00	1.01	1.00

2017	10.41	9.96	10.88	2.20	0.98	0.98	0.98
2018	9.39	9.04	9.78	1.99	0.89	0.89	0.88
2019	9.85	9.44	10.26	2.09	0.93	0.93	0.93
2020	9.49	9.11	9.92	2.16	0.90	0.90	0.90
2021	11.57	11.06	12.08	2.19	1.09	1.09	1.09

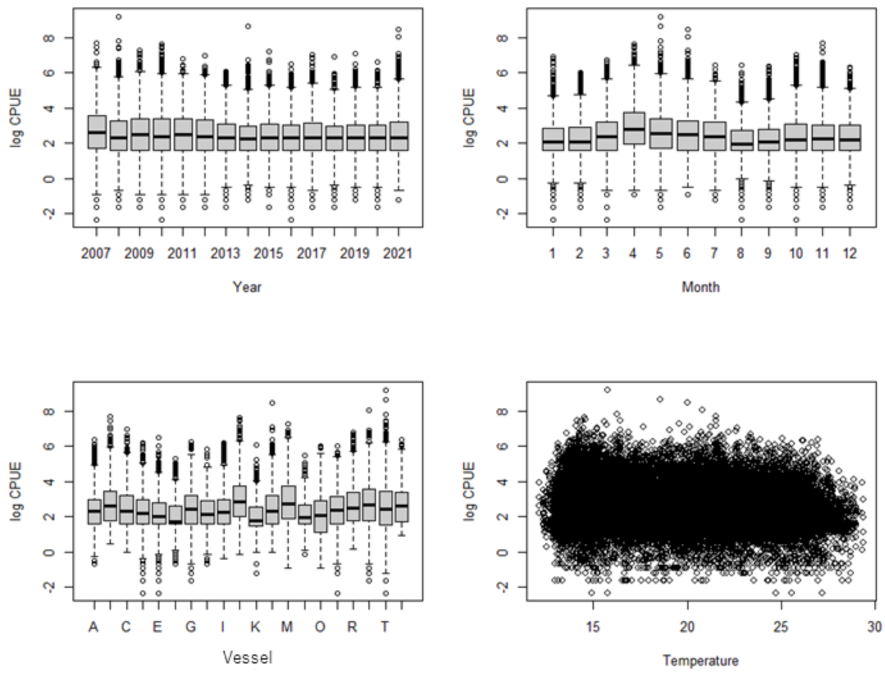

Fig. 1. The relationship between the logarithmized CPUE and the year (top left), month (top right), vessel (bottom left), and water temperature (bottom right)

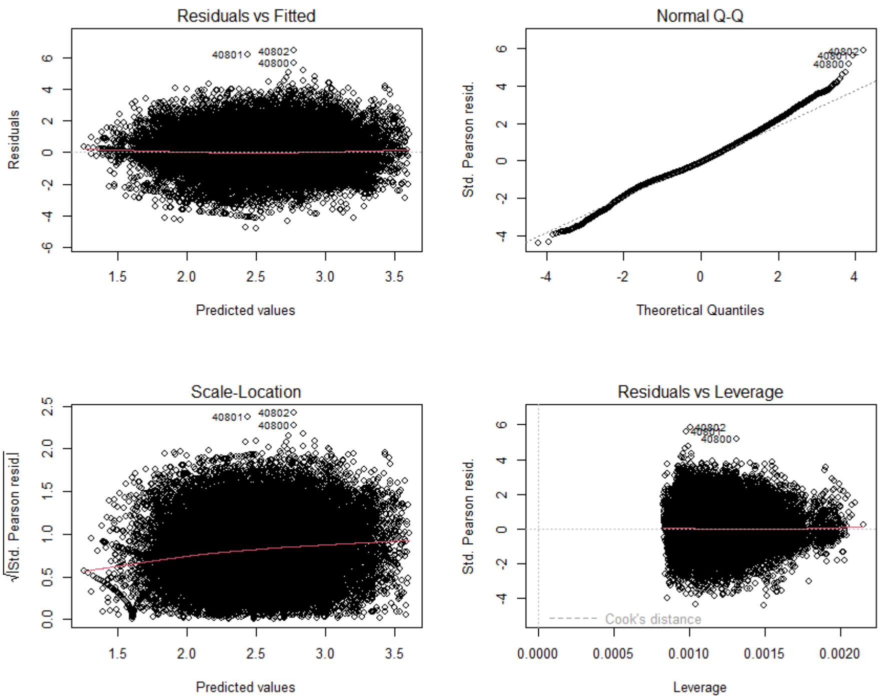

Fig. 1. Summary graphs of catch rate models

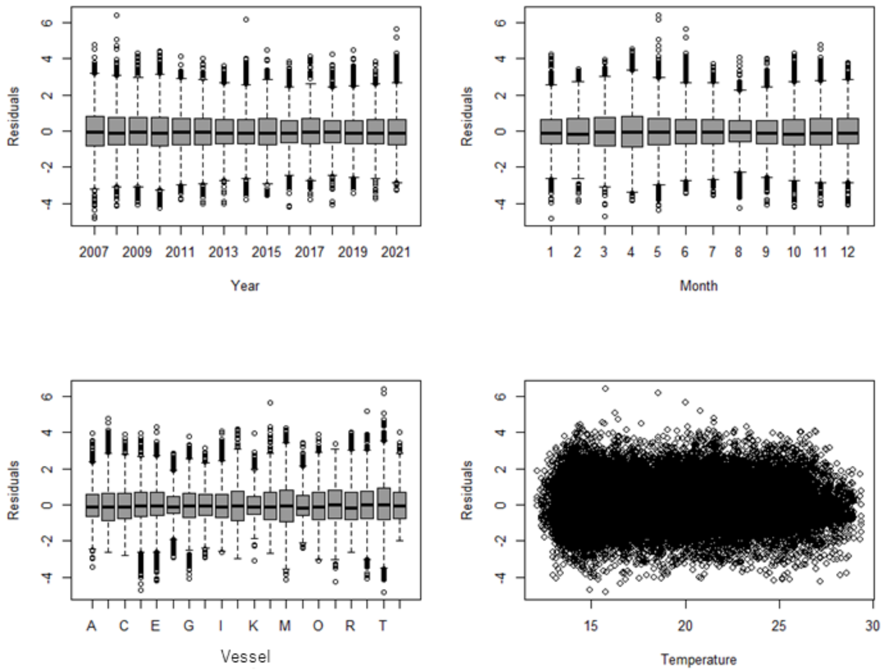

Fig. 3. Residual plots for each explanatory variable

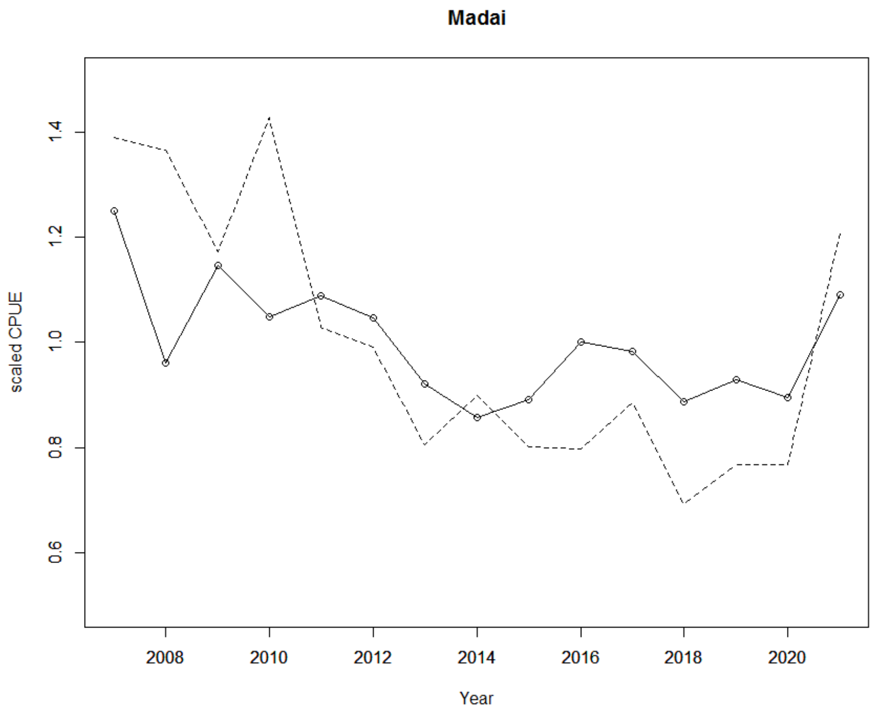

Fig. 4. Annual fluctuations in standardized CPUE (solid line) and nominal CPUE (dashed line) for Japanese seabream

The vertical axis indicates the scaled CPUE.

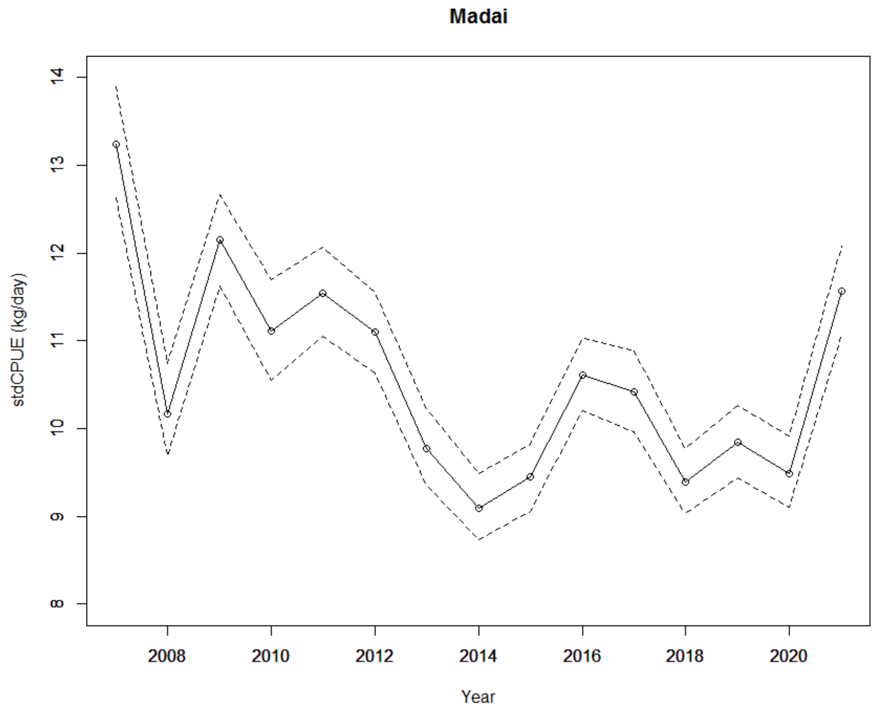

Fig. 5. Annual fluctuations in the mean (solid line) and 95% confidence interval (dashed line) of the calculated standardized CPUE of Japanese seabream