ISC/21/SHARKWG-1/08

Updated stock abundance indices for shortfin mako (*Isurus oxyrinchus*) estimated by Japanese longline observer data in the North Pacific Ocean[1]

Minoru Kanaiwa[2], Yasuko Semba[3] and Mikihiko Kai[3]

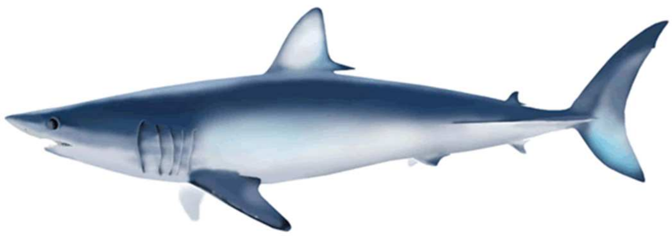
[2]Mie University, Faculty of Bioresources

1577 Kurimamachiya-cho Tsu, Mie 514-8507, JAPAN

33 Fisheries Resources Institute , Japan Fishery Research and Education Agency

5-7-1 Orido, Shimizu-ku, Shizuoka 424-8633, JAPAN

Email: kanaiwa@bio.mie-u.ac.jp



[1]Working document submitted to the ISC Shark Working Group Workshop, 22 February - 26 2021, online. **Document not to be cited without author's permission.**

Abstract

In this paper, the updated standardized CPUEs between 2011 and 2019 estimated using the observer data set of Japanese longline operated in North Pacific Ocean were provided. The same statistical model with previous analysis was used. The estimated annual CPUE showed a flat trend between 2011 and 2016 and slightly decreased after 2016.

Introduction

The purpose of this working paper is to update the standardized CPUE of shortfin mako (*Isurus oxyrinchus*) using the Japanese observer data set collected from the longline fishery operated in the North Pacific Ocean. The same model was used with previous analysis (Kanaiwa et al. 2017).

Material and method

Data sets

Observer set by set data of Japanese longline operated in the North Pacific Ocean was used in this analysis. The observer program started to collect the data in 2008 and only the data between 2011 and 2019 was used for this analysis because of the small number of data before 2011, (**Table 1**). The data which had spatio-temporal and gear information was used for analysis and the number of used data showed in **Table 2**.

The operational area used in this analysis was plotted in **Figs. 1**. The data was mostly gathered around the coastal and offshore areas of Japan.

Statistical methods

All models tested are same structures as used in the Kanaiwa *et al*. (2017). The optimal model selected by BIC was same with previous analysis and it was a generalized additive mixture model. In this model, observed catch number of mako shark was used as a dependent factor and two categories of hooks per baskets (<=4 and >4), year and month were used as independent categorical factors, cruse ID was assumed as random factor and was assumed that the latitude and longitude were followed by 2 dimentional 3 degrees spline function. All calculations were conducted on R 3.6.3 (R Development Core Team, 2005) and mgcv library was used to calculate GAMM (Wood, 2016).

Results and Discussions

The spatial distribution of estimated CPUE showed higher CPUE on the offshore of Northern Japan (**Fig. 2**).

The estimated annual CPUE showed almost flat trend between 2011 and 2016 and slightly decreased after 2016 (**Fig. 3** and **Table 3**). The 95% confidence interval showed a wider range in

2011 and narrower in 2014 (**Fig. 3** and **Table 3**). There was no specific problem on the model convergence and diagnostics. The results of likelihood test are shown in Table 4 to figure out the importance for each variable.

Fig. 4 showed the estimated annual CPUEs resulting from the different models. The factors with the larger Δdeviance removed from the full model one by one in order. The result indicate the recent decreasing trend was alleviated when spatial information (i.e. latitude and longitude) was removed.

Fig. 5 summarizes the annual ratio of categorized CPUEs (CPUE<0.1, 0.1<CPUE<0.2, 0.2<CPUE) based on the operations in each of the 5x5 blocks shown in **Fig. 2**. This result indicated that the ratio of operations in areas with lower standardized CPUE have decreased in recent years, while the ratio of operations in areas with higher standardized CPUE have increased. Therefore, the nominal CPUE in recent year was exorbitance (see light blue line; –latlonhpbmonth in **Fig.4**) and the standardized results suggest that the stock abundance has been decreasing in the area where observer data is available when the area effect was removed in the CPUE standardization.

On the other hand, the annual observer coverages in Japanese longline are low, for example only 1.7%-3.0% north of 23N (Anon. 2020). It is therefore questionable whether these results represent the overall trend of the stock abundance for North Pacific shortfin mako.

References

Anonymous (2020) Annual report to the commision. WCPFC-SC16-AR/CCM-10 (https://www.wcpfc.int/node/45789)

Dunn, P. K. and Smyth, G. K.(1996) Randomized quantile residuals. Journal of Computational and graphical statistics 5 236-244

Kanaiwa, M., Y. Semba and M. Kai (2017) Stock abundance indices for Mako shark estimated by observer data of Japanese longline data in the North Pacific Ocean. ISC/17/SHARKWG01/06 10pp.

R Development Core Team (2005). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URLhttp://www.R-project.org.

Wood, S. N. (2016). Just Another Gibbs Additive Modeler: Interfacing JAGS and mgcv. Journal of Statistical Software, 75(7), 1-15. doi:10.18637/jss.v075.i07

Table 1. The number of observer data.

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
52	68	155	267	650	665	1,353	1,841	1,149	1,059	1,083	1,889	70

Table 2. The number of data used in the analysis.

2011	2012	2013	2014	2015	2016	2017	2018	2019
267	646	665	1,352	1,841	1,118	952	1,083	1,889

Table 3. Output of annual values for point estimates, 95% confidence intervals, and standard error.

	sCPUE	upper 95%	lower 95%	SE
2011	0.0452	0.1105	0.0185	0.4555
2012	0.0453	0.0866	0.0237	0.3302
2013	0.0463	0.0872	0.0246	0.3227
2014	0.0226	0.0380	0.0134	0.2665
2015	0.0324	0.0526	0.0200	0.2467
2016	0.0315	0.0512	0.0193	0.2483
2017	0.0274	0.0456	0.0165	0.2586
2018	0.0241	0.0401	0.0145	0.2586
2019	0.0185	0.0301	0.0114	0.2475

Table 4. Summary of model selection and likelihood test.

	Df	AIC	BIC	logLik	deviance	Δdeviance	Chisq	Chi Df	Pr(>Chisq)
original	25	11429	11608	-5689.3	11379				
-s(lat,lon)	22	11889	12048	-5922.7	11845	466	466.8	3	<0.001
-month	14	11471	11572	-5721.4	11443	64	64.2	11	<0.001
-year	17	11438	11560	-5702.0	11404	25	25.3	8	<0.001
-hpb	24	11593	11765	-5772.4	11545	166	166.2	1	<0.001

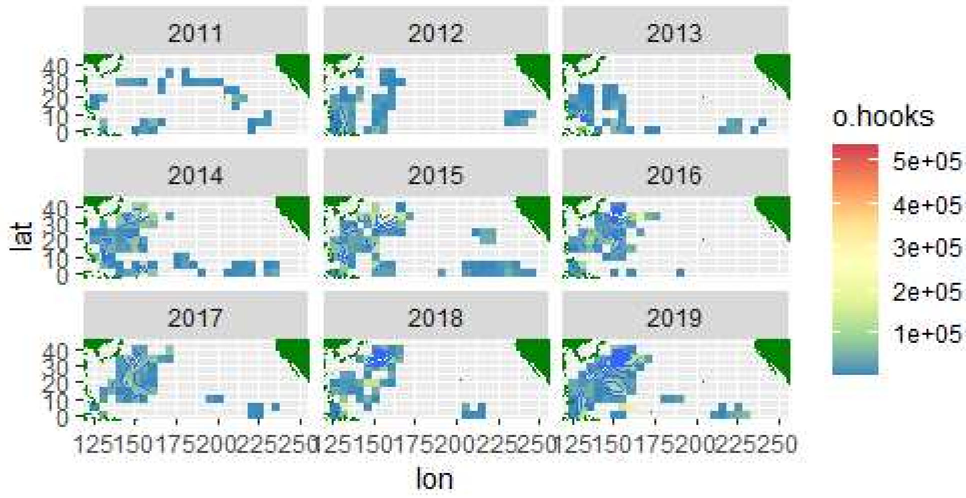


Figure 1 Spatial distributions of observed number of hooks.

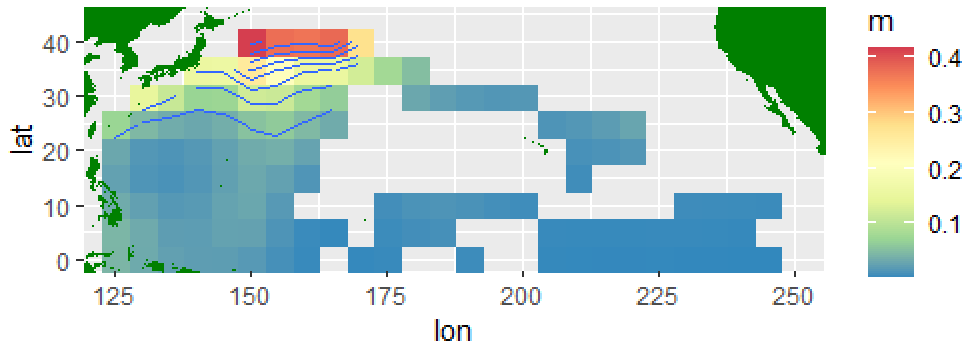


Figure 2. Spatial distributions of estimated CPUE by 5x5 blocks. The color bar shows the absolute value of standardized CPUE.

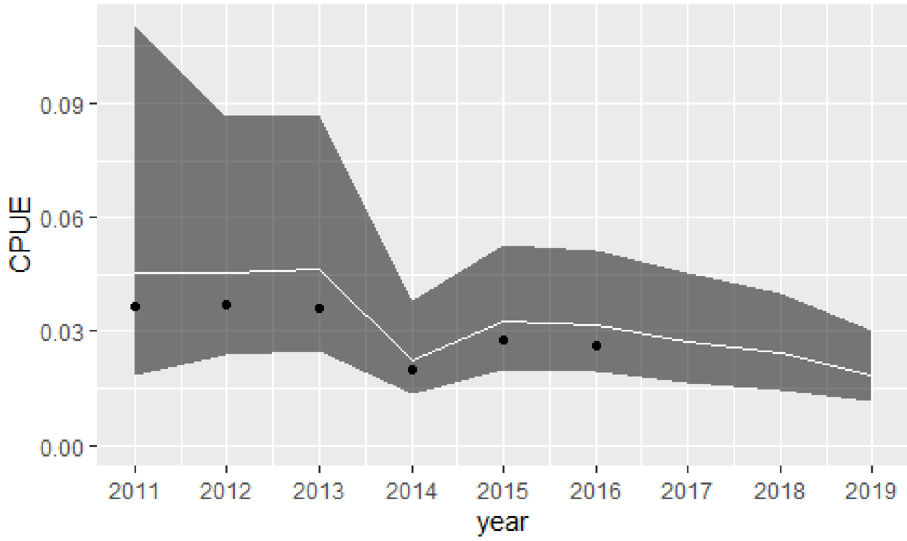


Figure 3. Annual estimated CPUE. The white line is the least squared means and the black dots are the point estimates in the previous analysis. The gray shadow shows 95% confidence interval.

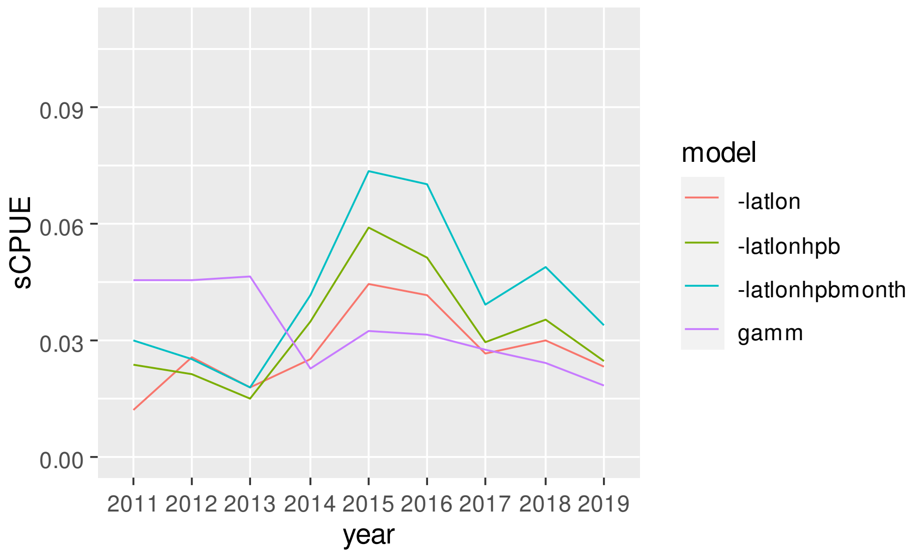


Figure 4. Annual estimated CPUE for several models with different combinations of explanatory variables. "-latlon" denotes that the area (latlon) effect was removed from the full model, "-latlonphb" denotes that the area and gear (hpb) effects were removed from the full model, "-latlonphbmonth" denotes that the area, gear and temporal (month) effects were removed from the full model. "gamm" denotes the generalized additive mixture model including all factors.

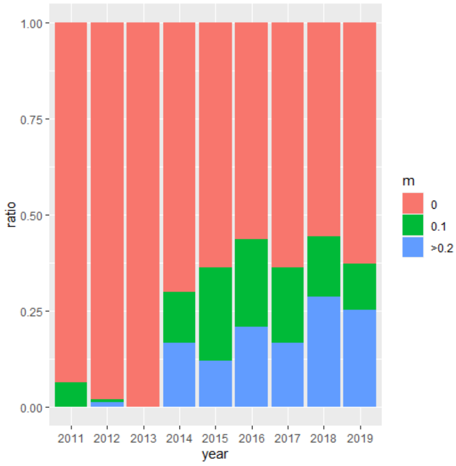


Figure 5. The ratio of operation in each of the 5x5 blocks by year and estimated standardized CPUE (0: CPUE was smaller than 0.1, 0.1: CPUE was between 0.1 and 0.2, >0.2: CPUE was larger than 0.2). The colors indicate the standardized CPUE of each area where operation was conducted.

Appendix 1, Diagnostics of optimal model

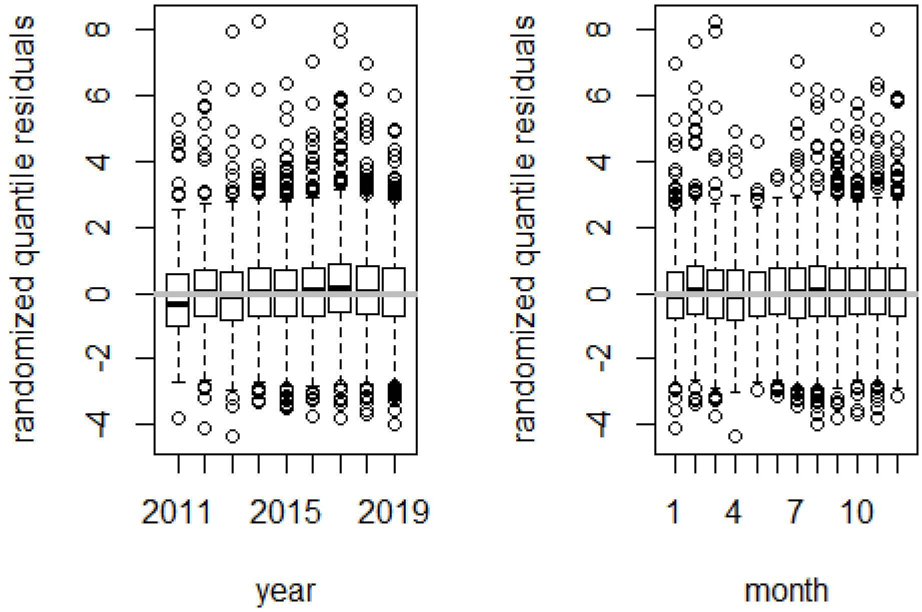


Figure A1 Randomized quantile residuals (Dunn and Smyth, 1996) for each categorical factors.

Appendix 2 Summary of results for glmm parts

```
Generalized linear mixed model fit by maximum likelihood (Laplace Approx
imation) ['glmerMod']
 Family: poisson  ( log )

     AIC      BIC   logLik deviance df.resid 
 11428.6  11608.4  -5689.3  11378.6     9788 

Scaled residuals: 
    Min      1Q  Median      3Q     Max 
-3.6085 -0.3686 -0.1866 -0.1193 20.3477 

Random effects:
 Groups Name        Variance Std.Dev.
 cr.id  (Intercept)  0.7343  0.8569  
 Xr     s(lon,lat)  11.8973  3.4492  
Number of obs: 9813, groups:  cr.id, 590; Xr, 27

Fixed effects:
              Estimate Std. Error z value Pr(>|z|)    
X(Intercept)   -6.77058    0.40217 -16.835  < 2e-16 ***
Xhpb22        -2.12664    0.15570 -13.658  < 2e-16 ***
Xyear2012      0.00158    0.44354   0.004 0.997158    
Xyear2013      0.02376    0.45152   0.053 0.958028    
Xyear2014     -0.69619    0.40928  -1.701 0.088937 .  
Xyear2015     -0.33291    0.39972  -0.833 0.404928    
Xyear2016     -0.36372    0.40726  -0.893 0.371807    
Xyear2017     -0.49987    0.41230  -1.212 0.225365    
Xyear2018     -0.62836    0.40934  -1.535 0.124774    
Xyear2019     -0.89427    0.40171  -2.226 0.026005 *  
Xmonth2       -0.14539    0.11550  -1.259 0.208085    
Xmonth3       -0.60162    0.16881  -3.564 0.000365 ***
Xmonth4       -0.28374    0.22612  -1.255 0.209556    
Xmonth5       -0.29293    0.20937  -1.399 0.161786    
Xmonth6       -0.69783    0.22482  -3.104 0.001910 ** 
Xmonth7       -1.05918    0.21646  -4.893 9.92e-07 ***
```

```
Xmonth8        -1.12020    0.19186  -5.839 5.26e-09 ***
Xmonth9        -1.11374    0.18479  -6.027 1.67e-09 ***
Xmonth10       -1.16176    0.18418  -6.308 2.83e-10 ***
Xmonth11       -1.05341    0.18566  -5.674 1.40e-08 ***
Xmonth12       -1.07159    0.19982  -5.363 8.20e-08 ***
Xs(lon,lat)Fx1  0.85370    0.29454   2.898 0.003750 **
Xs(lon,lat)Fx2  1.03192    0.39463   2.615 0.008925 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation matrix not shown by default, as p = 23 > 12.
Use print(x, correlation=TRUE)  or
    vcov(x)        if you need it
```

Appendix 3 summary of results for gam parts

```
Family: poisson
Link function: log

Formula:
c.mako ~ hpb2 + year + month + s(lon, lat) + offset(log(o.hooks))

Parametric coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -6.77058    0.40688 -16.640  < 2e-16 ***
hpb22       -2.12664    0.15579 -13.651  < 2e-16 ***
year2012     0.00158    0.45170   0.003 0.997209
year2013     0.02376    0.45853   0.052 0.958669
year2014    -0.69619    0.41518  -1.677 0.093572 .
year2015    -0.33291    0.40553  -0.821 0.411695
year2016    -0.36372    0.41263  -0.881 0.378065
year2017    -0.49987    0.41862  -1.194 0.232447
year2018    -0.62836    0.41474  -1.515 0.129759
year2019    -0.89427    0.40799  -2.192 0.028386 *
month2      -0.14539    0.11540  -1.260 0.207694
month3      -0.60162    0.16928  -3.554 0.000379 ***
month4      -0.28374    0.22821  -1.243 0.213755
month5      -0.29293    0.21128  -1.386 0.165610
month6      -0.69783    0.22766  -3.065 0.002175 **
month7      -1.05918    0.21910  -4.834 1.34e-06 ***
month8      -1.12020    0.19387  -5.778 7.56e-09 ***
month9      -1.11374    0.18664  -5.967 2.41e-09 ***
month10     -1.16176    0.18591  -6.249 4.13e-10 ***
month11     -1.05341    0.18734  -5.623 1.88e-08 ***
month12     -1.07159    0.20223  -5.299 1.16e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
             edf Ref.df Chi.sq p-value
s(lon,lat) 20.92  20.92  514.6  <2e-16 ***
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) =  0.408
glmer.ML = 6099.3  Scale est. = 1        n = 9813
```