SPRFMO
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9th MEETING OF THE SCIENTIFIC COMMITTEE

Held virtually, 27 September to 2 October 2021

SC9-JM02

CPUE Standardization for the Offshore Fleet Fishing for Jack mackerel in the SPRFMO Area

European Union

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SC9-JM01

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European Union

Corresponding author: mpastoors@pelagicfish.eu

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Abstract

Prior to 2018 two offshore CPUE series have been used in the assessment of Jack Mackerel: the standardized Chinese CPUE and the nominal offshore fleet CPUE (EU, Vanuatu, Korea, Russia). During the benchmark assessment of 2018, the nominal offshore CPUE has been converted into a standardized CPUE series. This working document presents the updated results of a fully combined and standardized Offshore CPUE index that is based on the haul-by-haul data of China, EU, Korea, Vanuatu and Russia as contained in the SPRFMO database. Permission to utilize that information was granted by the respective Contracting Parties while the analysis was carried out by scientists from the EU delegation. The standardization procedure is identical to the procedure followed during the benchmark in 2018.

The working document consists of a description of the data available for the analysis and the method used to generate the standardized CPUE index. The final GAM model consists of a number of discrete factors (year, vessel, month and El Nino Effect) and a smoothed interaction between latitude and longitude.

Of the offshore fleets, only the Russian federation has been fishing during the year of the Covid pandemic (2020). When preparing the CPUE analysis for SC9, it was found that the modelling approach was sensitive to this exceptional situation. The modelling approach has been to use GAM models to assess the dependency on the weekly catch of jack mackerel on different variables. The same explanatory variables have been used as determined during the benchmark in 2018. The GAM model consisted of catch (per week) as the main variable, the year effect (as factor) as the main explanatory variable and the log of effort as the offset (the log is taken because of the log-link function). In the model up to SC8 (2020), the other explanatory variables were vessel, month, lat-long (with spatial smoother) and El Nino Effect (ELE).

In preparing for SC9 (2021), it was found that this model did no longer perform as anticipated. Possibly due to a very low number of observations during 2020 (due to Covid), the

estimated CPUE and confidence intervals for 2020 were identical to the values estimated for the first year in the time series. It was hypothesized that this error could be generated by the relatively large number of vessels (and thereby degrees of freedom) used in the model. A new CPUE model was then tested in which the explanatory factor vessel was replaced by the explanatory variable contracting party. The rationale behind this change was that the trends in CPUE by contracting party are largely similar to the trend in CPUE in vessels within contracting party.

Comparisons are presented between the 'old' CPUE model (by vessel) and the 'new' CPUE model (by contracting party) and between the 2020 CPUE model (from SC8) and the 'new' 2021 CPUE model.

1 Introduction

The assessment of Jack Mackerel in the southern Pacific is based on many different sources of information, including two standardized Catch per Unit Effort time series for China and for other Offshore fleets. Because both fleets are basically operating a similar type of fishery, it was suggested to combine the two fleets into one overarching offshore fleet. With the availability of the Chinese CPUE data, this analysis has now been performed. The standardization approach is identical to the standardization reported in 2018 for the offshore fleet (SC, 2013). Data has been obtained from the SPRFMO secretariat after permission was granted by the different contracting parties that the data could be used for this CPUE analysis.

2 Material and methods

Data from EU, Korea, Russia, Vanuatu and China was made available by the SPRFMO secretariat on 8th July 2021. Two vessels were removed from the dataset because of apparent problems with the units used for catch reporting. During 2020, due to the COVID pandemic, only Russia fished for Jack mackerel in the SPRFMO area.

Below, summary information by year and contracting party is presented for: * number of vessels participating in the fishery * total catch of jack mackerel * number of fishing days * mean catch of jack mackerel per day

Number of vessels participating in the fishery

year	CHN	EU	KOR	RUS	VUT	(all)
2008	0	6	2	0	4	12
2009	13	8	2	0	4	27
2010	9	6	2	0	4	21
2011	6	2	2	0	2	12
2012	3	0	2	0	2	7
2013	2	1	1	0	2	6
2014	3	2	1	0	2	8
2015	6	2	2	1	2	13
2016	2	2	2	0	1	7
2017	2	2	1	1	0	6
2018	2	0	2	0	0	4
2019	2	1	2	1	0	6
2020	0	0	0	1	0	1

Table 1: Number of vessels participating in the Jack mackerel fishery by Contracting Party

Total catch of jack mackerel per year

year	CHN	EU	KOR	RUS	VUT	(all)
2008	0	71,650	12,377	0	101,955	185,982
2009	117,963	90,722	13,759	0	80,166	302,610
2010	63,606	31,258	8,183	0	45,934	148,981
2011	32,862	1,185	9,253	0	7,628	50,928
2012	13,012	0	5,492	0	16,463	34,966
2013	8,329	10,012	5,267	0	15,526	39,133
2014	21,155	20,510	4,078	0	15,473	61,215
2015	29,180	28,007	5,749	2,524	21,224	86,683
2016	20,208	11,470	6,430	0	7,385	45,492
2017	16,586	27,652	1,235	3,188	0	48,662
2018	24,366	0	3,717	0	0	28,084
2019	22,706	11,789	7,444	9,412	0	51,352
2020	0	0	0	5,245	0	5,245
(all)	369,974	304,254	82,983	20,370	311,753	1,089,333

Table 2: Total catch of Jack mackerel by contracting party

Number of fishing days

Number of days when at least one haul has been reported.

year	CHN	EU	KOR	RUS	VUT	(all)
2008	0	416	224	0	708	1,348
2009	1,301	537	173	0	584	2,595
2010	869	289	125	0	438	1,721
2011	591	29	205	0	169	994
2012	260	0	116	0	323	699
2013	177	137	89	0	223	626
2014	304	208	77	0	233	822
2015	362	171	104	38	214	889
2016	277	115	195	0	85	672
2017	165	255	31	51	0	502
2018	230	0	92	0	0	322
2019	217	85	111	104	0	517
2020	0	0	0	55	0	55
(all)	4,753	2,242	1,542	248	2,977	11,762

Table 3: Number of fishing days by contracting party

Mean catch per day of jack mackerel

year	CHN	EU	KOR	RUS	VUT	(all)
2008	.	173	55	.	145	124
2009	91	169	80	.	137	119
2010	73	109	65	.	105	88
2011	56	41	45	.	45	47
2012	50	.	47	.	51	49
2013	47	74	59	.	70	63
2014	70	100	53	.	66	72
2015	81	166	55	68	99	94
2016	73	100	33	.	87	73
2017	101	108	40	63	.	78
2018	106	.	40	.	.	73
2019	105	142	67	90	.	101
2020	.	.	.	95	.	95
(all)	77	118	53	79	89	82

Table 4: Mean catch per day of Jack Mackerel

Haul positions by contracting party and year

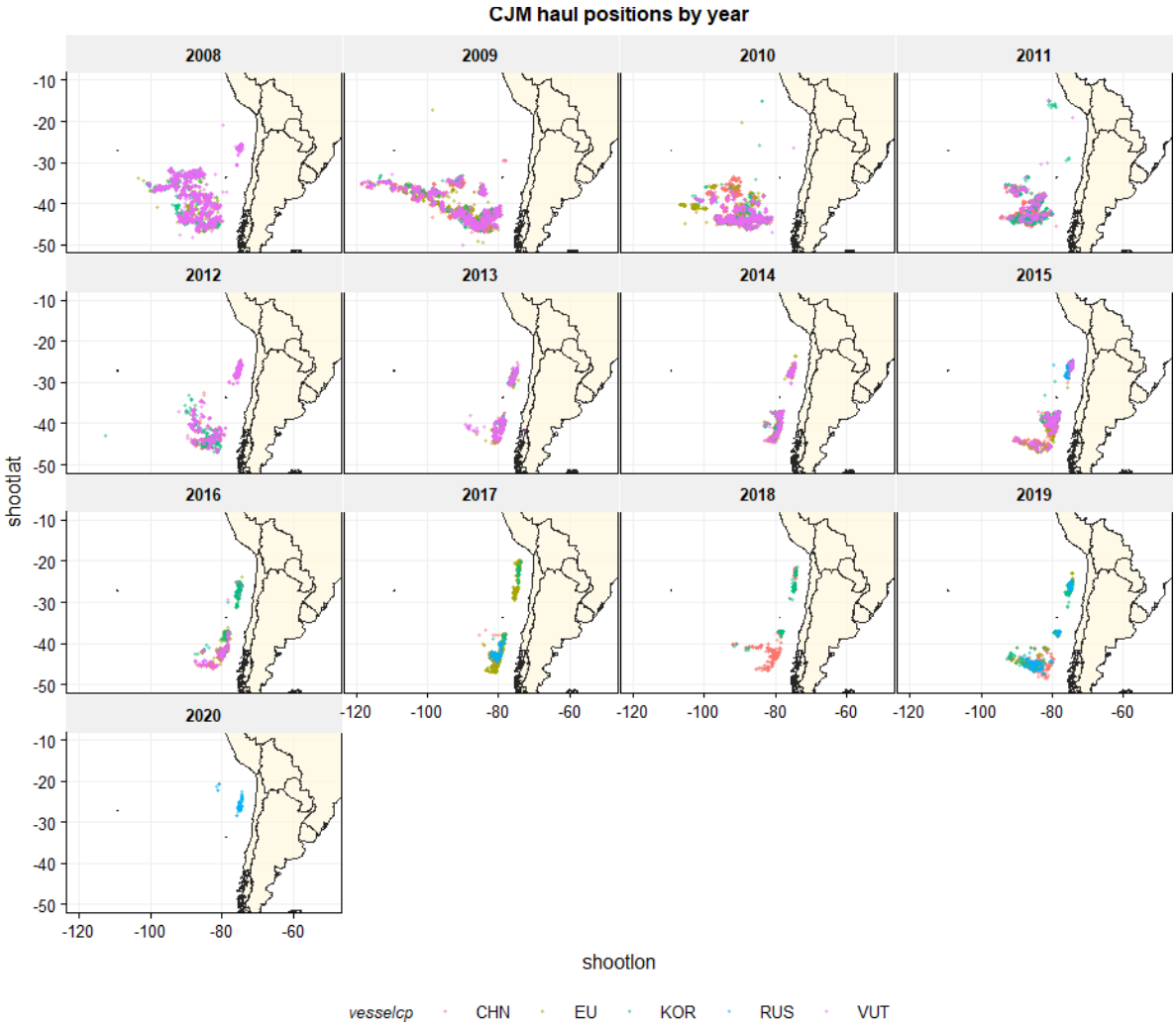

Figure 1: Haul positions where Jack mackerel has been caught (by year). Colours indicate the different contracting parties

Jack mackerel Log CPUE by week and yearly average Log CPUE

The plot below shows the distributions of log CPUE by week and by contracting party. Log CPUE was calculated as the log of catch per week divided by the number of fishing days per week. The average log CPUE is drawn as a dashed black line. The colours indicate the different individual vessels that generated the CPUE. This shows that the trend in CPUE by individual vessel is largely consistent with the trend in CPUE by contracting party.

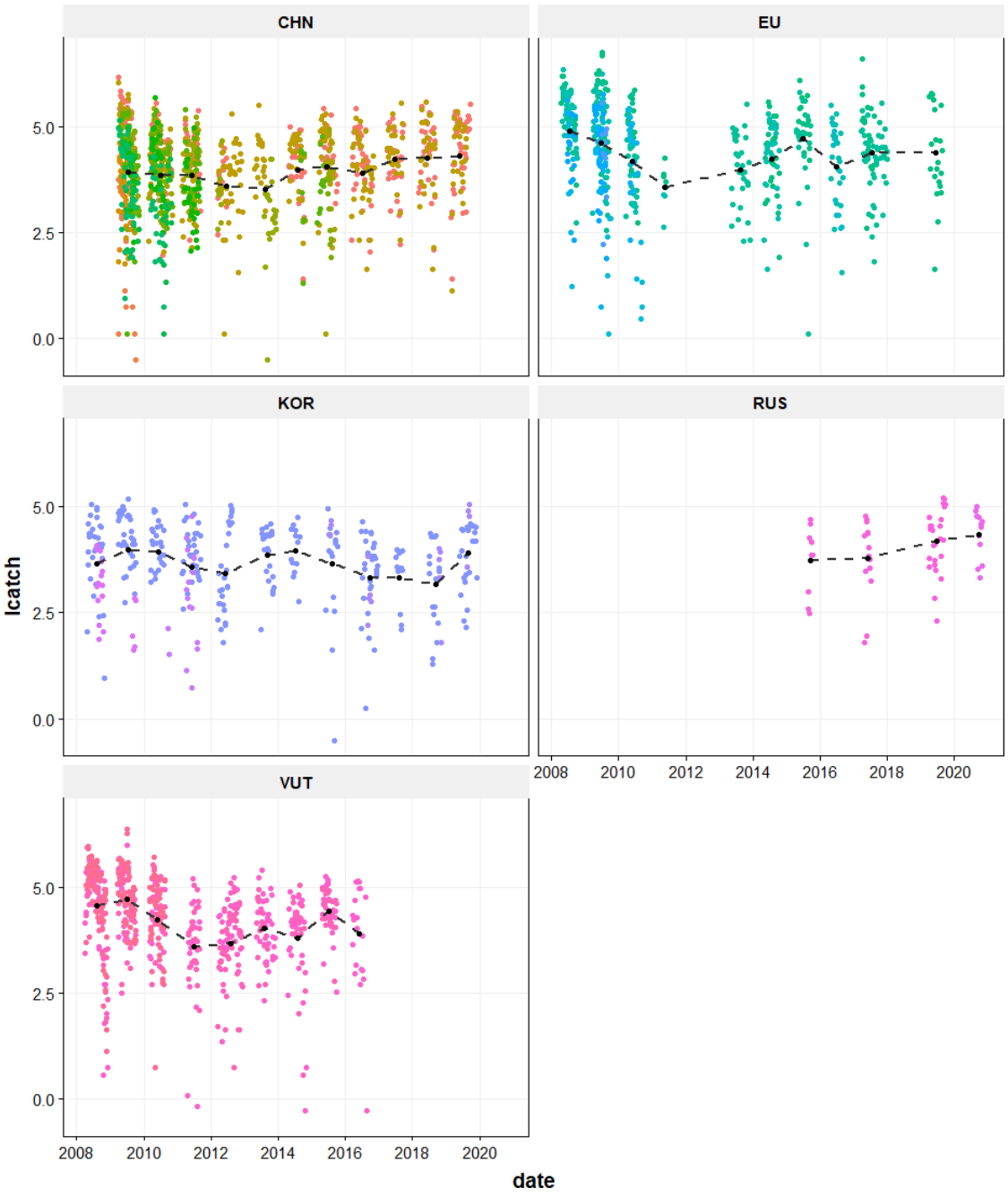

Figure 2: Jack mackerel log CPUE (log(catch / ndays)) by week.

El Nino effect and Humbold_current index

It has been hypothesized that the catch rate of jack mackerel by area and season could be dependent on the climatic situation, characterized by El Nino events (NOAA, https://www.esrl.noaa.gov/psd/data/correlation/oni.data) or the Humboldt Current Index (http://www.bluewater.cl/HCI/)

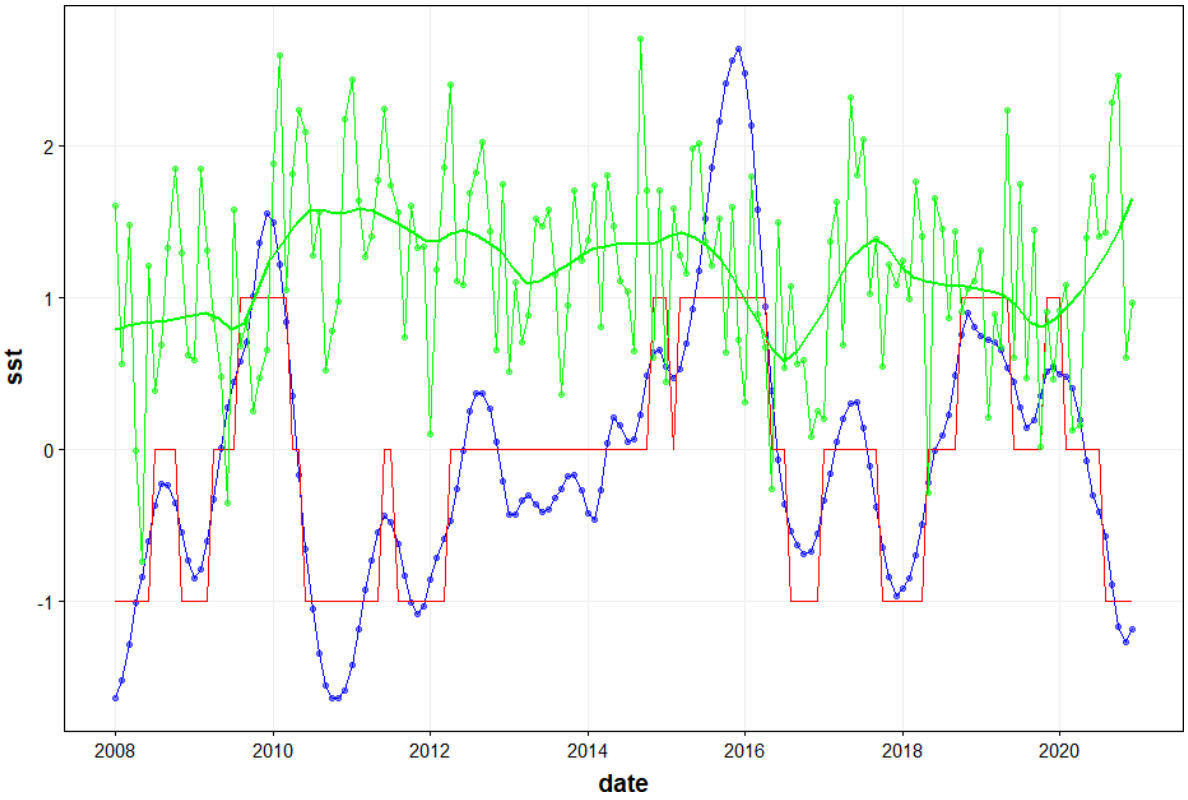

Figure 3: El Nino temperature anomaly (blue line) and ELE indicator (red line). Humboldt Current Index (green line)

3 Results

The modelling approach has been to use GAM models to assess the dependency on the weekly catch of jack mackerel on different variables. The same explanatory variables have been used as determined during the benchmark in 2018. The GAM model consists of catch (per week) as the main variable, the year effect (as factor) as the main explanatory variable and the log of effort as the offset (the log is taken because of the log-link function).

In the model up to SC8 (2020), the other explanatory variables were vessel, month, lat-long (with spatial smoother) and El Nino Effect (ELE), so that the final model was:

Catch ~ offset(log(effort)) + year + vessel + month + s(lat-lon) + ELE

In preparing for SC9 (2021), it was found that this model did no longer perform as anticipated. Possibly due to a very low number of observations during 2020 (due to Covid), the estimated CPUE and confidence intervals for 2020 were identical to the values estimated for the first year in the time series. It was hypothesized that this error could be generated by the relatively large number of vessels (and thereby degrees of freedom) used in the model. A new CPUE model was then tested in which the explanatory factor vessel was replaced by the contracting party. The rationale behind this change can be seen in Figure 2 where the trends in CPUE by contracting party are largely similar to the trend in CPUE in vessels within contracting party. The new final model is:

Catch ~ offset(log(effort)) + year + vesselcp + month + s(lat-lon) + ELE

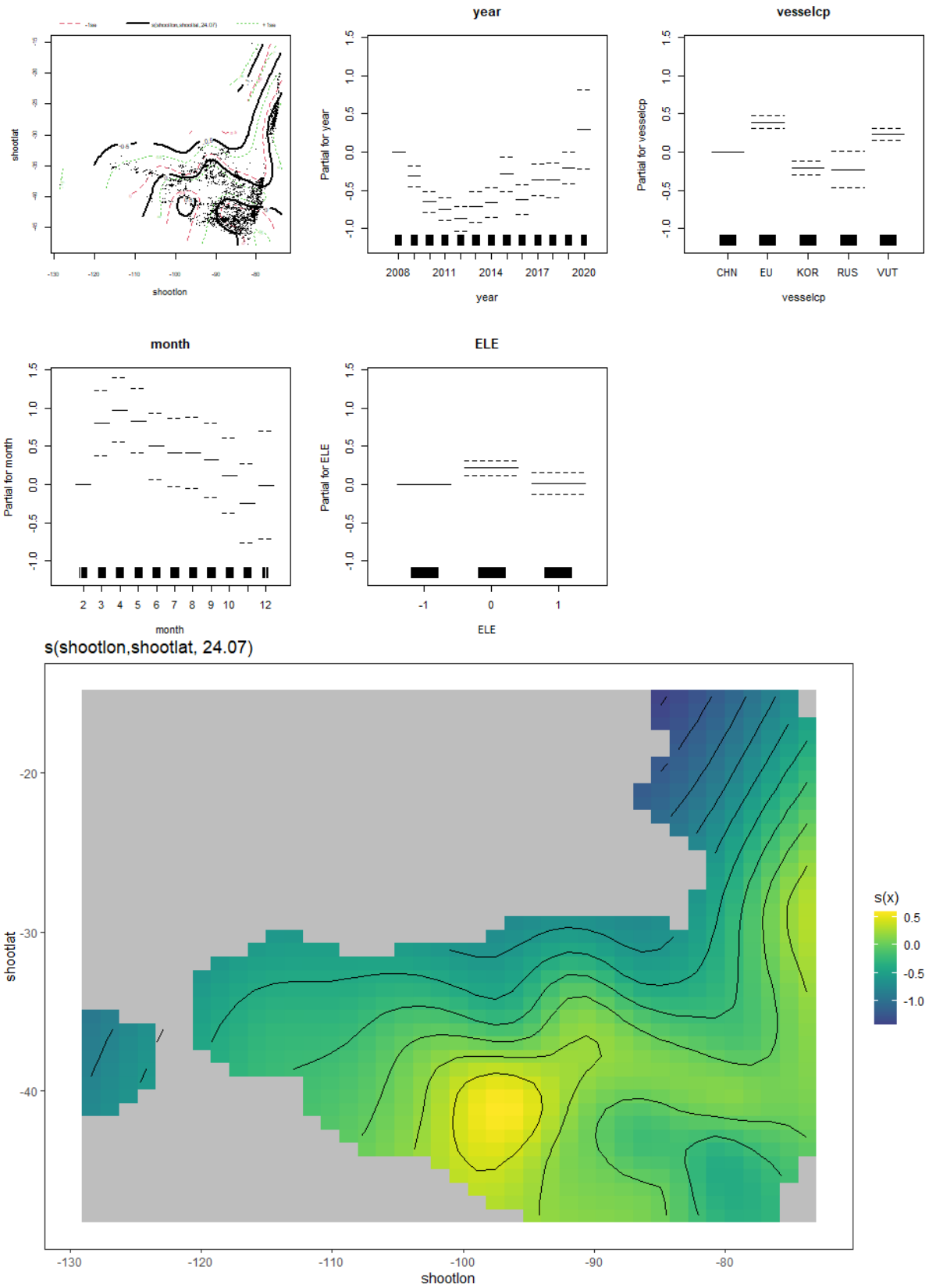
year
vesselcp
month
ELE
Partial for year
Partial for vesselcp
Partial for month
Partial for ELE
2008
2011
2014
2017
2020
CHN
EU
KOR
RUS
VUT
2 3 4 5 6 7 8 9 10 12
-1
0
1
s(shootlon,shootlat, 24.07)
shootlat
shootlon
s(x)
0.5
0.0
-0.5
-1.0
-20
-30
-40
-130
-120
-110
-100
-90
-80

Figure 5:

Comparing trends in CPUE

In the plot below, comparisons are presented between the 'old' CPUE model (by vessel) and the 'new' CPUE model (by contracting party) and between the 2020 CPUE model (from SC8) and the 'new' 2021 CPUE model (for SC9). Not that the 'old' CPUE model has estimated CPUE and confidence intervals for 2020 identical to the 2008 due to an apparent error in the model.

Figure 6: GAM standardized offshore fleet CPUE for jack mackerel. Top: comparison of 'old' CPUE model estimated by vessel with 'new' CPUE model by contracting party. Bottom: comparison of 2020 CPUE model with the 'new' 2021 CPUE model

Model diagnostics

```
Family: Negative Binomial(1.819)
Link function: log

Formula:
catch ~ year + vesselcp + month + s(shootlon, shootlat) + ELE +
    offset(log(effort))

Parametric Terms:
         df Chi.sq  p-value
year     12 228.58  < 2e-16
vesselcp  4 169.35  < 2e-16
month    10  96.00 3.43e-16
ELE       2  24.84 4.04e-06

Approximate significance of smooth terms:
                      edf Ref.df Chi.sq p-value
s(shootlon,shootlat) 24.07  27.62  129.1  <2e-16
```

Table 5: ANOVA results with final model GAM

Jack mackerel standardized CPUE index

year	cpue	lwr	upr
2008	1749	1316	2325
2009	1278	959	1701
2010	913	691	1206
2011	829	631	1088
2012	733	549	979
2013	855	616	1186
2014	908	662	1245
2015	1311	917	1874
2016	942	686	1295
2017	1220	885	1681
2018	1214	873	1687
2019	1424	1014	2000
2020	2367	1340	4180

Table 6: GAM standardized offshore fleet CPUE for jack mackerel

4 Discussion and conclusions

This working document describes the standardized CPUE for the offshore fleets (China, EU, Korea, vanuatu and Russia) based on the haul-by-haul data contained in the SPRFMO database. Permission to utilize that information was granted by the delegations of the contracting parties while the analysis was carried out by scientists from the EU delegation.

The modelling approach has been to use GAM models to assess the dependency on the weekly catch of jack mackerel on different variables. The same explanatory variables have been used as determined during the benchmark in 2018. The GAM model consists of catch (per week) as the main variable, the year effect (as factor) as the main explanatory variable and the log of effort as the offset (the log is taken because of the log-link function).

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Catch ~ offset(log(effort)) + year + vessel + month + s(lat-lon) + ELE

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Catch ~ offset(log(effort)) + year + vesselcp + month + s(lat-lon) + ELE

Comparisons are presented between the ‘old’ CPUE model (by vessel) and the ‘new’ CPUE model (by contracting party) and between the 2020 CPUE model (from SC8) and the ‘new’ 2021 CPUE model (Figure 6) .

5 Acknowledgements

We would like to acknowledge the permission granted by the delegations of China, Russia, Vanuatu and Korea to utilize their haul-by-haul data for the analysis of standardized CPUE of the offshore fleet fishing for Jack mackerel. Sharing access to vessel data has made it possible to improve the indicator that can be used in the assessment.

6 References

Li, G., X. Zou, X. Chen, Y. Zhou and M. Zhang (2013). “Standardization of CPUE for Chilean jack mackerel (Trachurus murphyi) from Chinese trawl fleets in the high seas of the South-east Pacific Ocean.” Journal of Ocean University of China 12(3): 441-451.

SPRFMO (2011) Report of the Jack Mackerel Subgroup. Tenth Science Working Group of SPRFMO, 19 – 23 September 2011, Port Vila, Vanuatu.

SPRFMO (2018) CPUE standardization for the offshore fleet fishing for Jack mackerel in the SPRFMO area (SCW6-Doc05). Sixth Science Committee Workshop, 28-30 May 2018, Valparaiso, Chile.