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Standardized Jack mackerel CPUE for the offshore fleet

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Abstract

The nominal CPUE of the offshore fleet (EU, Russia, Korea and Vanuaru) fishing for Jack mackerel has previously been used as a nominal tuning index for the assessment of Jack mackerel. The index consisted of the nominal average catch per fishing day for the fleets of EU, Vanuatu and Korea. During the 2018 Jack mackerel benchmark workshop, a working document was presented describing the methods for a combined standardized CPUE of the four fleets mentioned above (SCW6-Doc5). The current working document is an extension of that work, which now includes the data for 2017. The CPUE standardization is based on a GAM model that takes into account a number of linear factors (year, vessel, month, SST) and a smoothed interaction factor between latitude and longitude. While the full exploration of different model configurations has been included in the working document to the benchmark workshop, here only the agreed model configuration has been included in the analysis.

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1 Introduction

The assessment of Jack Mackerel in the southern Pacific is based on many different sources of information, including the nominal Catch per Unit Effort (expressed as catch per day) of the EU fleet. The use of nominal CPUE for calibrating stock assessments is known to be potentially problematic and therefore SPRFMO (2011) recommended that to serve as indices of abundance, the CPUE should be standardized to take into account factors such as historical changes in vessels, fishing areas, seasonal fishing patterns and environmental factors. This standardization approach has already been applied by China (Li et al, 2013).

In this document, the catch and effort data for the offshore fleet (Eu, Korea, Russia, Vanuatu) is analysed with the aim to develop a standardized CPUE series. 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. Further details on the selection of the final model can be found in the working document to the benchmark meeting (SCW06-Doc05)

2 Material and methods

Data from Korea, Russia and Vanuatu was made available by Craig Loveridge on 11 October 2017. Data for EU fisheries was already available as part of the SPRFMO database but also with the underlying spreadsheets that we used to submit the data to SPRFMO. Two vessels were removed from the dataset because of apparent problems with the units used for catch reporting.

Number of vessels participating in the fishery

year	EU	KOR	RUS	VUT	(all)
2006	1	0	0	0	1
2007	6	2	0	0	8
2008	6	2	1	4	13
2009	7	2	4	4	17
2010	5	2	0	4	11
2011	2	2	2	2	8
2012	0	2	0	2	4
2013	1	1	0	2	4
2014	2	1	0	2	5
2015	2	2	1	2	7
2016	2	2	0	1	5
2017	2	1	1	0	4
2018*	1	0	0	0	1

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

'*' Year 2018 is imcomplete in this table and all subsequent tables.

Summed haul durations in hours

year	EU	KOR	RUS	VUT	(all)
2006	1,131	0	0	0	1,131
2007	836	1,817	0	0	2,653
2008	3,529	1,559	553	8,935	14,576
2009	6,087	1,301	1,115	7,512	16,015
2010	3,219	1,381	0	6,357	10,957
2011	341	2,385	1,770	2,041	6,537
2012	0	920	0	4,253	5,173
2013	1,455	919	0	2,815	5,189
2014	2,453	649	0	2,809	5,911
2015	2,122	910	478	2,631	6,141
2016	1,333	1,775	0	1,118	4,226
2017	2,705	224	483	0	3,412
2018*	1,665	0	0	0	1,665

Table 2: Summed haul duration (hours)

Number of fishing days

year	EU	KOR	RUS	VUT	(all)
2006	110	0	0	0	110
2007	164	145	0	0	309
2008	156	166	62	233	617
2009	160	159	83	174	576
2010	104	125	0	144	373
2011	20	155	121	100	396
2012	0	116	0	182	298
2013	137	89	0	164	390
2014	148	77	0	153	378
2015	115	95	38	122	370
2016	91	174	0	85	350
2017	196	34	51	0	281
2018*	129	0	0	0	129

Table 3: Number of fishing days

Fishing days has been defined as days when a haul has been reported. Unfortunately, it is not possible to distinguish between days searching, days steaming and days transshipping based on the data available.

Number of hauls

year	EU	KOR	RUS	VUT	(all)
2006	240	0	0	0	240
2007	643	352	0	0	995
2008	703	398	94	1,731	2,926
2009	924	291	184	1,356	2,755
2010	490	261	0	886	1,637
2011	47	432	208	273	960
2012	0	160	0	562	722
2013	198	128	0	358	684
2014	385	125	0	392	902
2015	388	198	82	435	1,103
2016	206	325	0	180	711
2017	536	58	88	0	682
2018*	236	0	0	0	236

Table 4: Number of hauls

Length of the fishing season

year	EU	KOR	RUS	VUT	(all)
2006	240	0	0	0	240
2007	194	162	0	0	356
2008	172	188	89	245	694
2009	168	195	120	198	681
2010	122	208	0	171	501
2011	41	197	175	149	562
2012	0	167	0	263	430
2013	233	139	0	202	574
2014	170	93	0	201	464
2015	148	120	52	159	479
2016	136	188	0	167	491
2017	277	88	75	0	440
2018*	181	0	0	0	181

Table 5: Length of the fishing season (days)

The length of the fishing season is defined as the number of days between the first haul and the last haul in a year.

Total annual catch (tonnes) by species

vesselcp	year	BRU	CJM	MAC	MAS	UBA	(all)
EU	2006	0	25,486	0	1,123	0	26,609
EU	2007	0	88,253	0	3,157	0	91,410
EU	2008	0	72,572	0	2,288	0	74,860
EU	2009	407	91,926	0	4,134	0	96,467
EU	2010	108	31,207	0	266	0	31,581
EU	2011	14	1,184	0	0	0	1,198
EU	2013	63	10,011	0	226	0	10,300
EU	2014	65	20,509	0	742	88	21,404
EU	2015	152	28,006	0	893	52	29,103
EU	2016	40	11,469	0	791	176	12,476
EU	2017	74	23,590	0	1,447	73	25,184
EU	2018*	289	9,619	0	117	207	10,232
EU	(all)	1,212	413,832	0	15,184	596	430,824
KOR	2007	0	10,523	0	1,199	0	11,722
KOR	2008	0	12,377	0	961	0	13,338
KOR	2009	0	13,759	0	715	0	14,474
KOR	2010	0	8,182	0	84	0	8,266
KOR	2011	0	9,253	0	24	0	9,277
KOR	2012	0	5,491	0	0	0	5,491
KOR	2013	0	5,266	0	110	0	5,376
KOR	2014	0	4,077	0	21	0	4,098
KOR	2015	0	5,748	0	79	0	5,827
KOR	2016	0	6,429	77	408	0	6,914
KOR	2017	0	1,235	0	190	0	1,425
KOR	(all)	0	82,340	77	3,791	0	86,208
RUS	2008	0	4,799	0	386	0	5,185
RUS	2009	0	8,503	0	534	0	9,037
RUS	2011	0	8,228	0	12	0	8,240
RUS	2015	0	2,523	0	573	11	3,107
RUS	2017	1	3,188	0	37	0	3,226
RUS	(all)	1	27,241	0	1,542	11	28,795
VUT	2008	0	101,955	0	8,458	0	110,413
VUT	2009	0	80,165	0	4,667	0	84,832
VUT	2010	0	45,934	0	639	0	46,573
VUT	2011	0	7,627	0	0	0	7,627
VUT	2012	0	16,462	0	0	0	16,462
VUT	2013	0	15,525	0	0	0	15,525
VUT	2014	0	15,473	0	0	0	15,473
VUT	2015	0	21,224	607	0	0	21,831
VUT	2016	0	7,385	553	0	0	7,938
VUT	(all)	0	311,750	1,160	13,764	0	326,674

Table 6: Total estimated catch by species

The total catch by species is derived from the estimated catch in the haul by haul data from the contracting parties. Table 6 only includes species where the cumulated catch over all fleets and years is more than ton).

According to SC01-14 (European Union 2013 Annual Report) there is a difference between the haul-by-haul estimated catch by the skipper and the overall catch reported to SPRFMO for the earlier years of the time series. No attempt has been made to change the haul-by-haul data and therefore the overall quantities cannot be directly compared with the total catch in the SPRFMO catch series.

Total catch of jack mackerel

year	EU	KOR	RUS	VUT	(all)
2006	25,486	0	0	0	25,486
2007	88,253	10,524	0	0	98,777
2008	72,573	12,377	4,800	101,955	191,705
2009	91,927	13,759	8,504	80,166	194,355
2010	31,207	8,183	0	45,934	85,324
2011	1,185	9,253	8,229	7,628	26,294
2012	0	5,492	0	16,463	21,954
2013	10,012	5,267	0	15,526	30,804
2014	20,510	4,078	0	15,473	40,061
2015	28,007	5,749	2,524	21,224	57,503
2016	11,470	6,430	0	7,385	25,284
2017	23,591	1,235	3,188	0	28,014
2018*	9,620	0	0	0	9,620

Table 7: Total estimated catch of Jack mackerel

Mean catch per week of jack mackerel

year	EU	KOR	RUS	VUT	(all)
2006	1,062	.	.	.	1,062
2007	1,025	263	.	.	644
2008	789	269	282	658	500
2009	686	362	274	612	484
2010	452	282	.	429	388
2011	148	193	150	173	166
2012	.	203	.	206	205
2013	313	239	.	310	288
2014	410	314	.	303	342
2015	718	303	281	424	431
2016	358	189	.	352	300
2017*	429	112	228	.	256

Table 8: Mean catch per week of Jack Mackerel

Mean catch per week is the metric that is being used as an indicator of abundance.

Mean number of days fished per week

year	EU	KOR	RUS	VUT	(all)
2006	4.6	.	.	.	4.6
2007	4.5	5.1	.	.	4.8
2008	4.5	4.9	3.6	4.5	4.4
2009	4.2	4.5	3.6	4.5	4.2
2010	4	4.2	.	4.1	4.1
2011	4	4.1	3.3	3.8	3.8
2012	.	4.2	.	4	4.1
2013	4.1	4	.	4.4	4.2
2014	4.6	5.3	.	4.5	4.8
2015	4.5	5.1	4.1	4.3	4.5
2016	3.6	5	.	4	4.2
2017	4.1	3	3.6	.	3.6

Table 9: Mean number of fishing days per week

Spatial distribution of the fishery by year

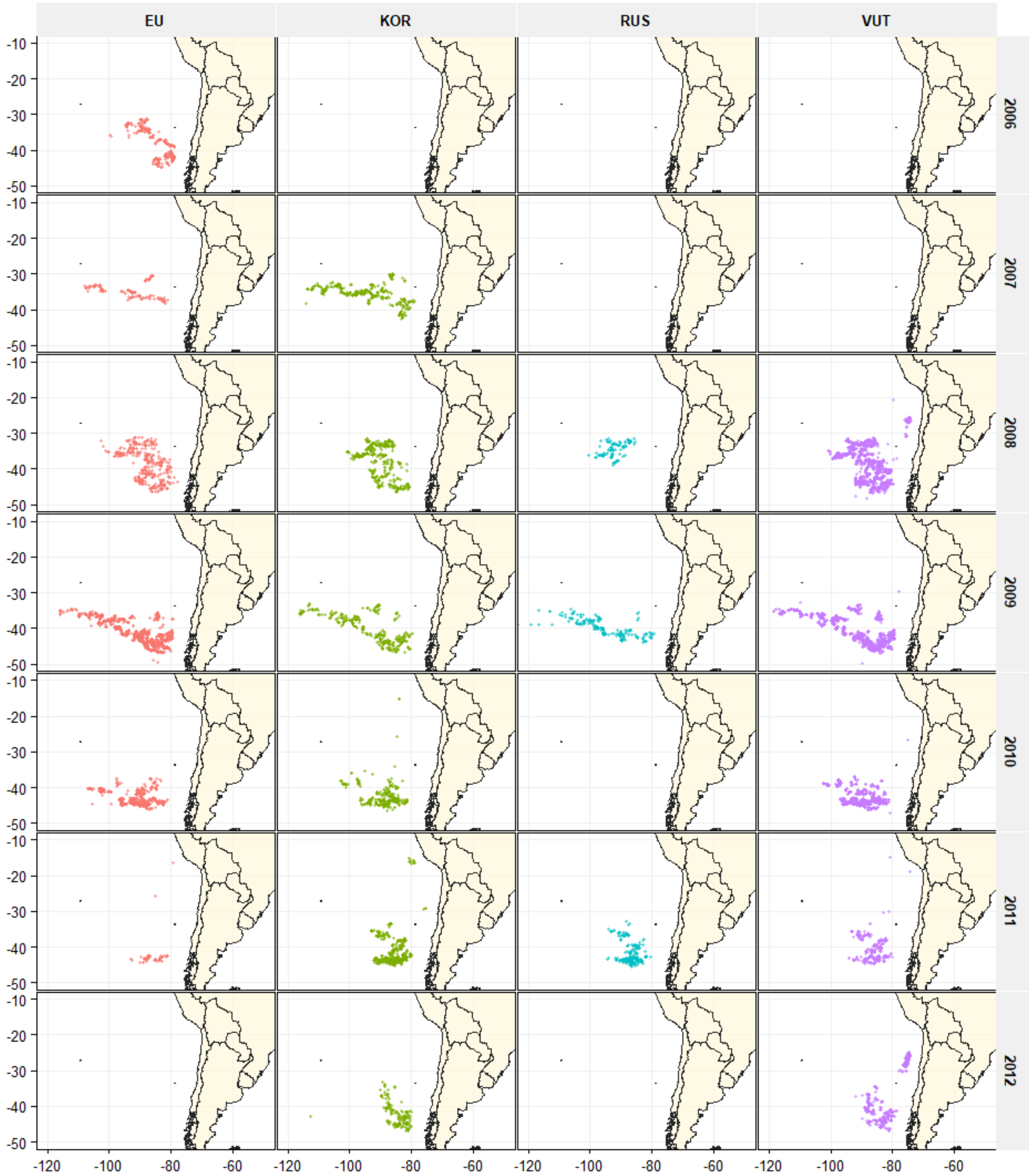

Figure 1: Jack mackerel Haul positions per year for EU, Korea, Russia and Vanuatu. - continued on next page

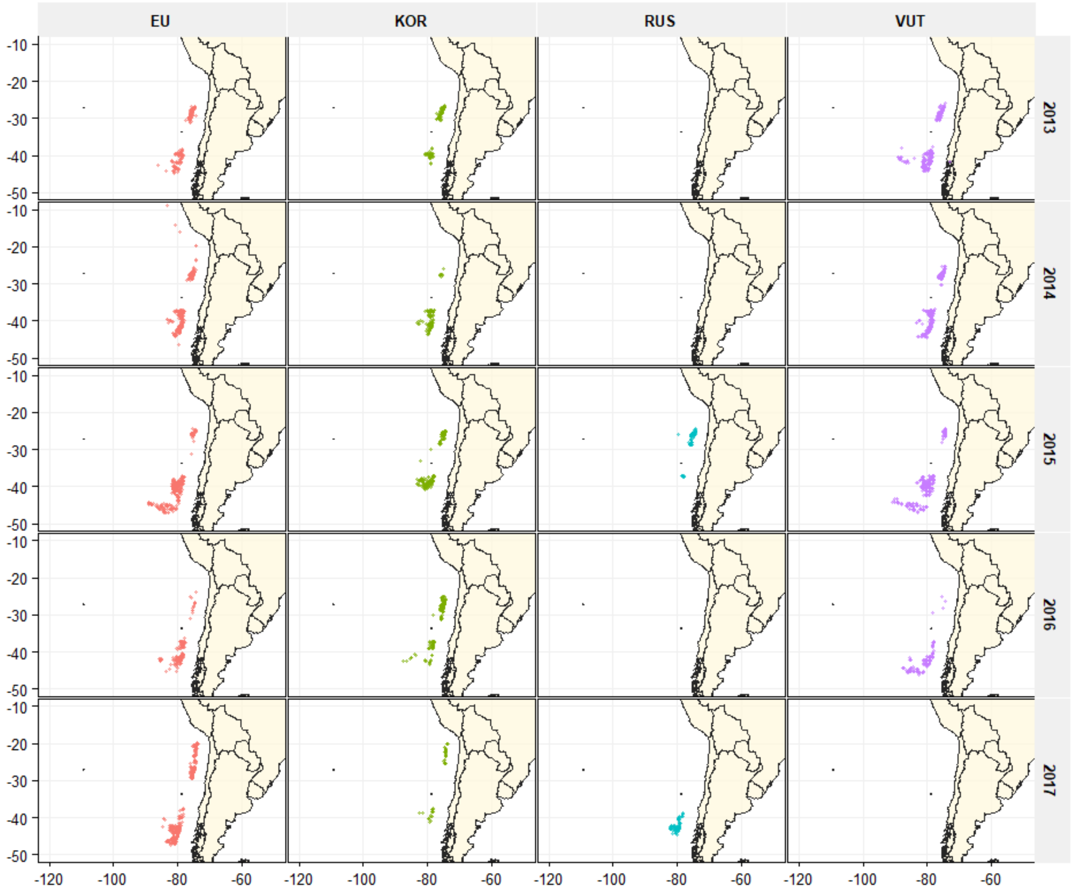

Figure 1: Jack mackerel Haul positions per year for EU, Korea, Russia and Vanuatu. - continued from previous page

Mean catch per week of jack mackerel per rectangle

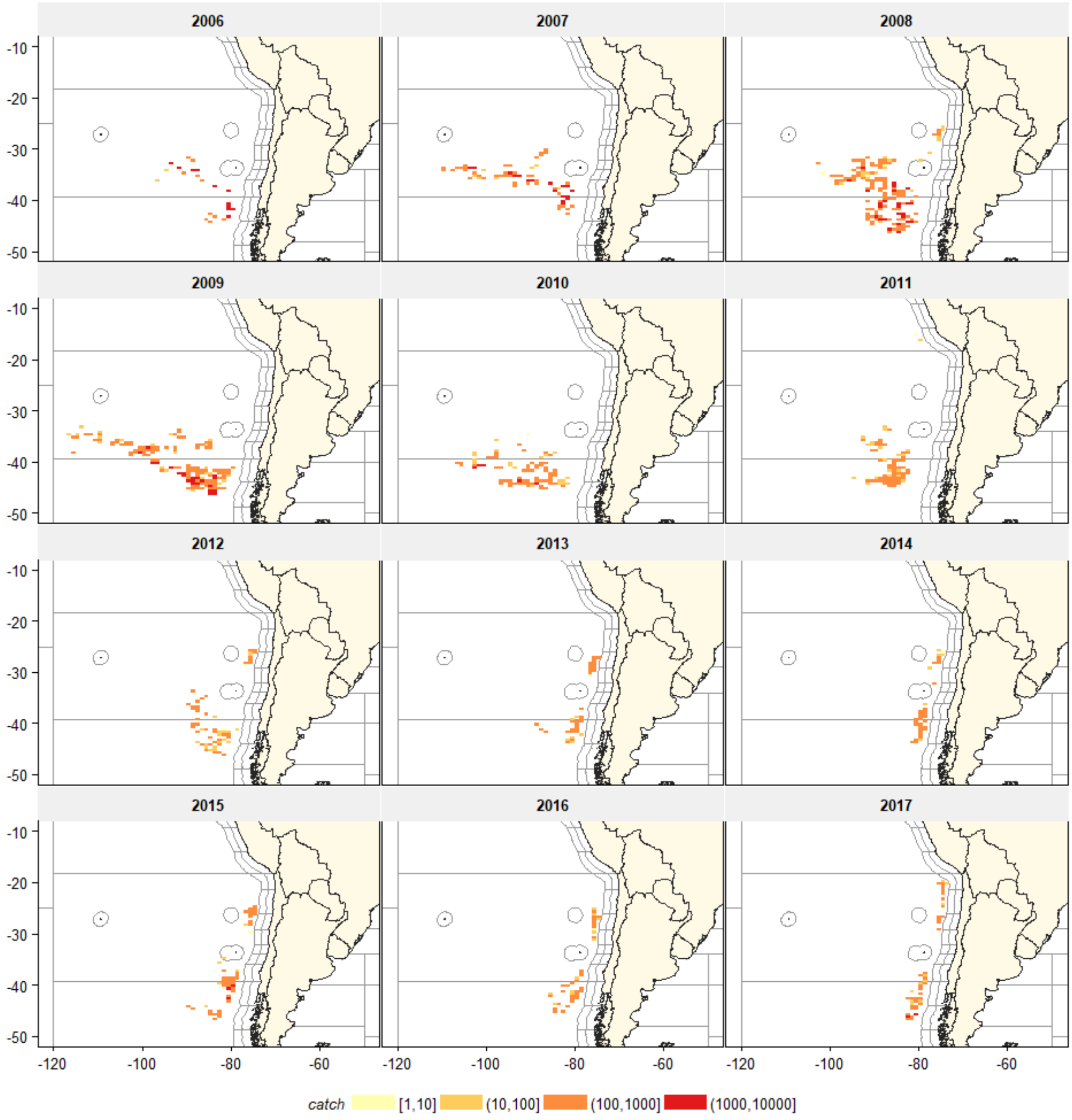

Figure 2: Jack mackerel mean catch per week per rectangle (one degree longitude and 1/2 degree latitude).

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/). In the final model selected during SCW06, only the temperature anomaly has been included in the analysis.

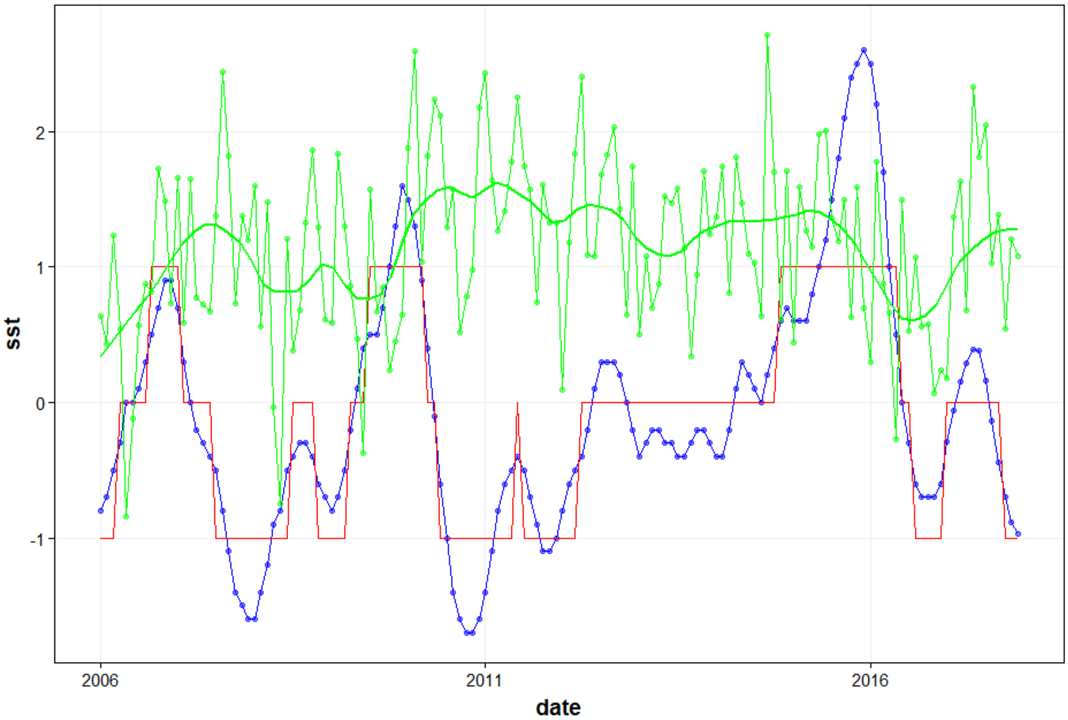

Figure 3: El Nino temperature anomaly (blue line) and estimated ELE indicator (red line). Humboldt Current Index (green line).

3 Results

The general modelling approach has been to use GAM models to assess the dependency on the weekly catch of jack mackerel on different variables. The final 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 (number of fishing days per week) as the offset (the log is taken because of the log-link function). The linear explanatory variables are vessel, month and sea surface temperature anomaly. The GAM smoothing function is applied to latitude in combination with longitude.

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

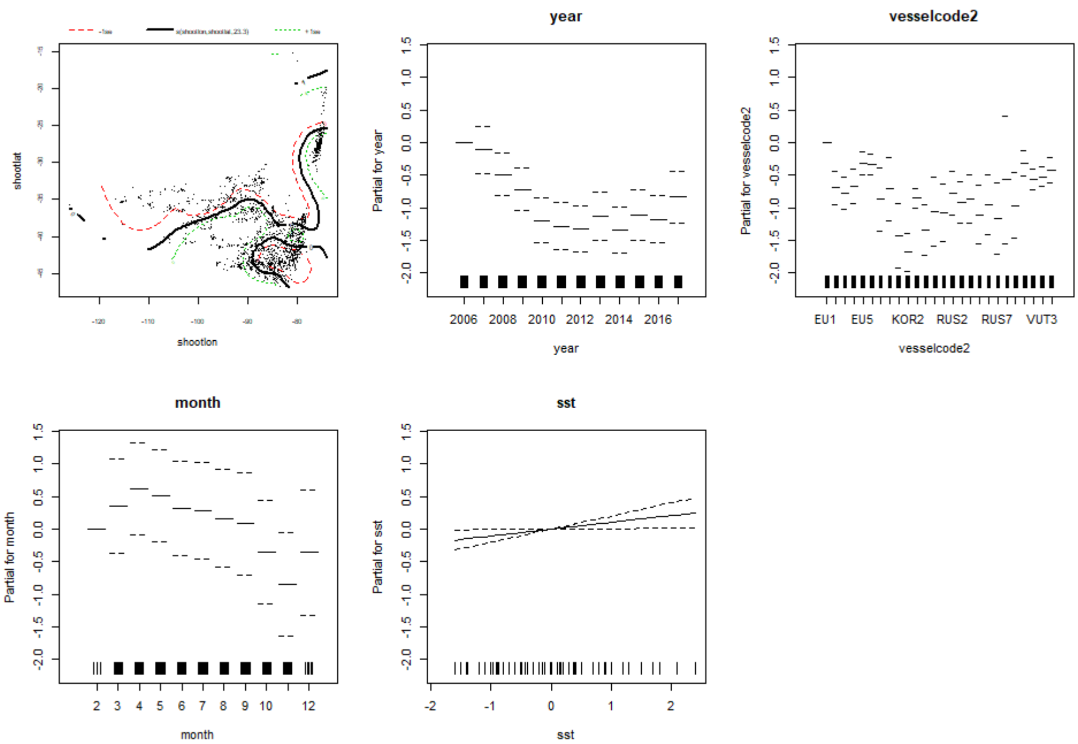

Figure 4: Final GAM model: Estimates of the different effects

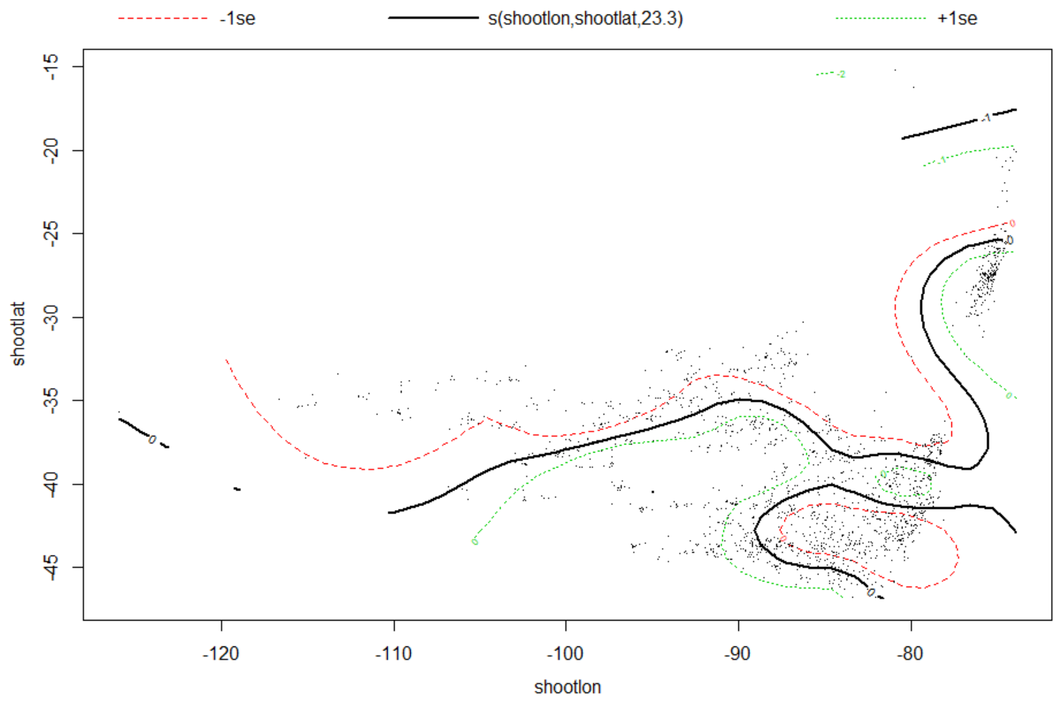

Figure 5: Final GAM model: Estimates of the spatial smoother effects

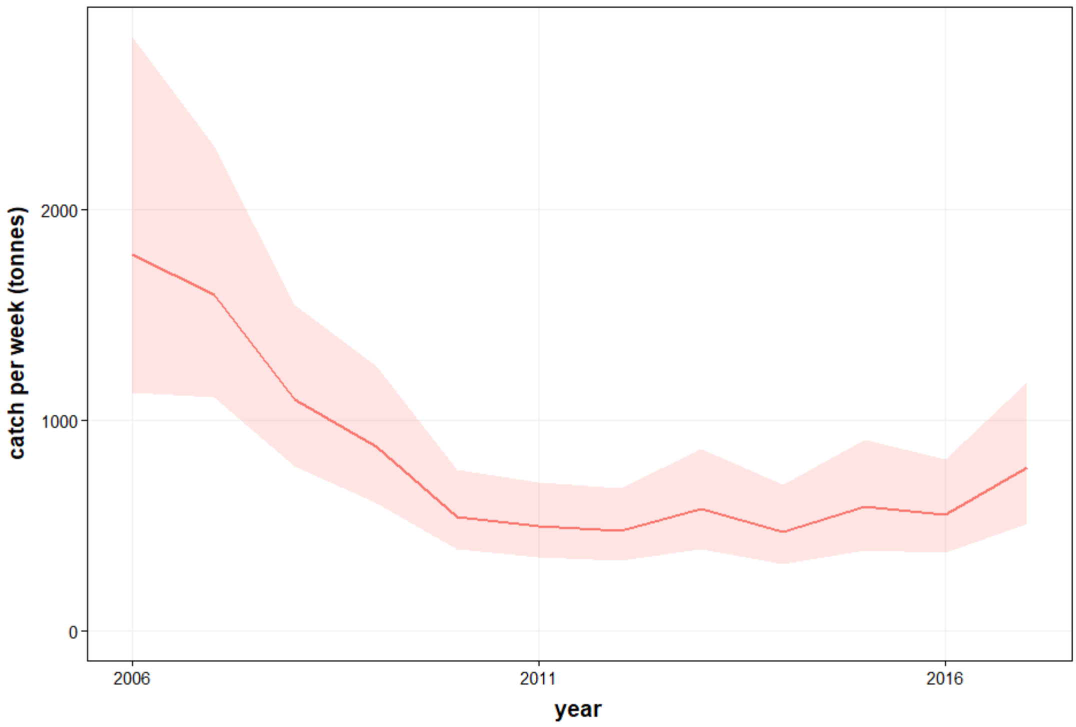

Figure 6: Final GAM model: standardized CPUE for jack mackerel

ANOVA results

The ANOVA results of the final model are shown below. Note that while SST was a marginally significant effect during the benchmark workshop in 2018, after adding the 2017 it is no longer a significant effect. However, SST has been maintained in the final model so as not to change the model configuration.

```
Family: Negative Binomial(2.155)
Link function: log

Formula:
catch ~ year + vesselcode2 + month + sst + s(shootlon, shootlat) +
    offset(log(effort))

Parametric Terms:
            df  Chi.sq p-value
year        11 244.370  <2e-16
vesselcode2 25 320.657  <2e-16
month       10 102.506  <2e-16
sst          1   4.563  0.0327

Approximate significance of smooth terms:
                       edf Ref.df Chi.sq  p-value
s(shootlon,shootlat) 23.30  27.19  126.2 7.87e-15
```

Jack mackerel Standardized CPUE for offshore fleets

year	cpue	upr	lwr
2006	1788	2819	1134
2007	1595	2298	1107
2008	1099	1547	781
2009	873	1254	608
2010	543	763	386
2011	497	706	349
2012	476	680	333
2013	580	862	390
2014	468	692	317
2015	589	910	381
2016	551	814	373
2017	775	1179	509

Table 11: Final GAM model: Predicted year effects and confidence intervals

4 Discussion and conclusions

The nominal CPUE of the offshore fleet fishing for Jack mackerel has previously been used as a tuning index for the assessment. The index consisted of the nominal average catch per fishing day for the fleets of EU, Vanuatu and Korea. The nominal CPUE series of Russia was also being used in the assessment. China has standardized their CPUE series in 2013 which is also part of the assessment.

A working document has been presented to the Scientific Committee Workshop in May 2018 (SCW6-Doc05) with the methodology to standardize the offshore fleets CPUE for Jack mackerel. THe new standardized CPUE series applies to the fleets of 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 Korea, Vanuatu and Russia while the analysis was carried out by scientists from the EU delegation. The methodology is largely similar to the methodology being used for the Chinese CPUE standardization.

The final model for standardizing the CPUE of these fleets models the catch by week and takes into account of the vessel, month, sea surface temperature anomaly and a smooth interaction between latitude and longitude with an offset of log effort (in number of days per week). The new standardized CPUE series starts in 2006 as this is the first year for which haul by haul information was available to carry out this analysis.

Although SST is no longer a significant effect after adding the 2017 data, it has been maintained in the final model so as not to change the model configuration. The effect of SST on the model outcome is expected to be negligable.

5 Acknowledgements

We would like to acknowledge the permission granted by the delegations of 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 Southeast 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 (2013) REFERENCE TO BE ADDED; EU national report 2013!!

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.