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UPDATED PROJECTIONS FOR THE BAYESIAN PRODUCTION MODEL (BSP2JAGS) FROM THE 2017 SHORTFIN MAKO SHARK ASSESSMENT

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SUMMARY

The Bayesian Surplus Production (BSP) using JAGS (BSP2JAGS), which was used for the north Atlantic population in the 2017 ICCAT shortfin mako assessment was revised to include updated catch data through 2017, a wider range of TACs used in the projections and a longer projection time period. The current year was updated to 2018. The model found that the population has probably decreased over the last two years, and the projections are more pessimistic than they were in the 2017 assessment.

RÉSUMÉ

La production excédentaire bayésienne (BSP) à l'aide de JAGS (BSP2JAGS), qui a été utilisée pour la population de l'Atlantique Nord dans l'évaluation 2017 de l'ICCAT sur le requin-taupe bleu a été révisée pour inclure des données de capture actualisées jusqu'en 2017 inclus, une gamme plus large de TAC utilisés dans les projections et une période de projection plus longue. L'année en cours a été mise à jour à l'année 2018. Le modèle a révélé que la population avait probablement diminué au cours des deux dernières années et les projections sont plus pessimistes qu'elles ne l'étaient dans l'évaluation de 2017.

RESUMEN

El modelo de producción excedente bayesiana (BSP) utilizando JAGS (BSP2JAGS), que fue utilizado para la población del Atlántico norte en la evaluación del marrajo dientuso de ICCAT de 2017 fue revisado para incluir los datos actualizados de captura hasta 2017, un rango más amplio de TAC usados en las proyecciones y un periodo de proyección más largo. El año actual se actualizó a 2018. El modelo halló que la población probablemente había descendido en los dos últimos años, y las proyecciones son más pesimistas que las de la evaluación de 2017.

KEYWORDS

Catch/effort, Mathematical models, Stochastic models, Stock assessment, Population dynamics

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1. Introduction

The intersessional workplan for the ICCCAT Sharks Working Group included an update of the BSP2JAGS model that was used to make projections for the north Atlantic mako shark population at the 2017 ICCAT assessment (Anon. 2017, Babcock and Cortes 2017). This model is similar in structure to the JABBA model that was also used in the 2017 assessment (Anon. 2018, Winker *et al.* 2018), but there are some slight differences in how the priors are set up. At the 2017 assessment, projections were only done using the BSP2JAGS model, and only for the North Atlantic.

2. Methods

The Bayesian Surplus Production Model using JAGS (BSP2JAGS) from the 2017 assessment was updated with new catch data through 2017. The priors for all parameters, CPUE indices and model configurations were all identical to the models run in 2017 (Anon. 2017, Babcock and Cortes 2017, Meyer and Millar 1999, Plummer 2015, Su and Yajima 2014). As in the assessment, the four model runs for the North Atlantic were: (1) task 1 catches, Schaefer model, (2) alternative catches, Schaefer model, (3) task 1 catches, generalized production model, and (4) alternative catches, generalized production model.

The current model differs from the previous model in that revised task 1 catch data were used for 2015-2017. Catch data were not available in 2018, so the mean of 2017 and 2016 was used for 2018. These catches are 2991 in 2015, 3351 in 2016, 3112 in 2017 and 3231.5 in 2018. Only Task 1 catch data were available, so the value of the alternative catch estimate from 2015 (4256mt) was continued forward to 2018 for the alternative catch runs. For years from 2019 through 2073 the catch was set equal to a TAC between 0 and 4000mt in 100mt increments.

3. Results

Because the same data and priors were used in this analysis as in the 2017 assessment, the estimated model parameters were similar to the values estimated in 2017, with slight differences due to re-running the Markov Chain Monte Carlo (MCMC) routine (**Table 1**). The estimated values of the current biomass and current harvest rate in 2018 were somewhat more pessimistic than the values in 2017, because the population continuing to decline in recent years (**Table 1, Figure 1**). The projections showed the median population continuing to decline in the future for any TAC greater than about 1000 mt, with a low probability of rebuilding within two generations unless TACs are reduced below 400 mt (**Table 2, Figure 2**).

4. Discussion

Because the reported task 1 catches in 2016 and 2017 were quite similar to the catches assumed in the 2017 assessments, the current projections are similar to those made at the 2017 assessment. These projections assume that the size selectivity of the fishery has not changed, so this analysis is not able to evaluate whether any changes in selectivity have influenced population trajectories. These results should therefore be interpreted with caution.

5. Acknowledgements

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Table 1. Model convergence diagnostics (Rhat should be close to 1, n.eff should be greater than 100) and posterior means (standard errors) for model outputs for north Atlantic shortfin mako sharks. C1 and C2 are catch scenarios (Anon. 2017).

Parameter	1N C1 Schaefer	2N C2 Schaefer	3N C1 generalized	4N C2 generalized
Rhat	1.04	1.02	1.26	1.02
n.eff	260	540	330	430
K(1000)	154.73(0.31)	236.33(0.32)	119.14(0.28)	196.57(0.36)
r	0.04(0.55)	0.03(0.5)	0.03(0.38)	0.02(0.4)
B_0/Bmsy	1.82(0.13)	1.7(0.15)	1.35(0.13)	1.24(0.17)
B_{2018}/Bmsy	0.79(0.24)	0.7(0.26)	0.67(0.21)	0.59(0.29)
HR_{2018}/HRmsy	3.28(0.51)	4.11(0.51)	3.38(0.39)	3.86(0.42)

Table 2. Kobe probabilities averaged over the four models BSP2JAGS models shown in **Table 1**.

(a) Probability of $B/B_{MSY} > 1$

	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
0	5	7	8	9	11	13	15	23	31	39	46	52	57	61	65	69
100	5	7	8	9	10	12	14	22	29	36	41	47	52	57	61	64
200	5	7	8	9	10	12	14	21	27	33	40	44	48	52	56	59
300	6	7	7	9	10	11	13	20	26	31	36	42	45	48	52	55
400	5	6	7	8	9	11	12	18	24	29	34	38	41	45	48	51
500	6	7	8	8	10	11	12	17	23	28	32	36	39	42	45	47
600	6	6	7	8	9	10	11	17	21	26	30	33	36	38	40	42
700	5	6	7	8	9	10	10	15	20	24	27	30	32	35	37	39
800	5	6	7	7	8	9	10	15	18	22	25	28	30	32	34	35
900	5	6	7	7	8	9	9	13	17	20	22	24	27	29	30	31
1000	6	6	7	7	8	8	9	13	16	19	21	23	25	26	28	28
1100	5	6	7	7	8	8	9	12	14	16	18	20	21	23	24	25
1200	5	6	7	7	7	8	8	11	13	15	17	18	20	21	22	23
1300	5	6	6	7	7	7	8	11	12	13	15	16	18	19	19	20
1400	5	6	6	7	7	7	8	10	12	13	14	15	16	17	18	18
1500	5	6	6	6	7	7	8	9	11	12	13	14	15	15	16	16
1600	5	6	6	6	7	7	7	8	10	10	11	12	12	13	13	14
1700	5	5	6	6	6	7	7	8	9	9	10	11	11	12	12	12
1800	5	6	6	6	7	7	7	7	8	9	10	10	10	10	11	11
1900	6	6	6	6	6	7	6	7	8	8	8	9	9	9	9	10
2000	5	6	6	6	6	6	6	7	7	8	8	8	8	8	8	9
2100	5	5	5	6	6	6	6	6	6	6	6	7	7	7	7	7
2200	6	6	6	5	5	5	5	5	5	6	6	6	6	6	6	6
2300	5	5	6	5	5	5	5	5	5	5	5	5	6	5	5	6
2400	6	6	5	5	5	5	5	5	5	5	5	5	5	5	4	4
2500	6	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4
2600	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4
2700	6	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3
2800	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	3
2900	6	5	5	4	4	4	4	4	3	3	3	2	2	2	2	2
3000	6	5	4	4	4	4	3	3	2	3	2	2	2	2	2	2
3100	5	5	4	4	4	4	3	3	2	2	2	2	2	2	2	2
3200	5	5	4	4	4	3	3	2	2	2	1	1	1	1	1	1
3300	6	5	4	4	4	3	3	2	2	2	2	1	1	1	1	1
3400	5	5	4	4	4	3	3	2	2	2	1	1	1	1	1	1
3500	6	5	4	4	4	3	3	2	2	1	1	1	1	1	1	1
3600	6	5	4	4	3	3	3	2	2	1	1	1	1	1	1	1

3700	5	4	4	3	3	2	2	1	1	1	1	1	1	1	1	1
3800	6	5	4	3	3	2	2	2	1	1	1	1	1	1	1	0
3900	5	5	4	4	3	3	2	1	1	1	1	0	0	0	0	0
4000	6	4	4	3	3	2	2	1	1	1	1	1	1	1	1	1

(b) Probability of $F/F_{MSY}<1$

	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
200	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
300	100	100	100	100	100	100	100	99	100	99	99	99	99	99	99	99
400	98	98	98	98	98	98	98	98	98	98	98	98	97	98	98	97
500	95	95	94	95	95	95	94	94	94	94	93	93	93	93	93	93
600	90	89	89	89	90	89	89	88	88	88	88	88	88	87	87	87
700	82	83	83	83	83	82	82	82	82	81	81	81	81	81	80	81
800	74	74	74	74	74	74	74	73	72	73	72	72	72	72	71	71
900	66	66	66	66	66	66	65	65	64	64	64	63	63	63	62	62
1000	57	56	56	56	56	56	56	57	56	56	56	56	55	55	55	55
1100	48	48	48	48	48	47	47	46	47	46	46	46	46	46	46	46
1200	40	39	40	40	40	40	40	40	40	40	39	39	39	39	39	38
1300	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
1400	27	27	27	27	27	28	28	27	27	28	28	28	28	28	27	27
1500	22	22	22	23	23	23	23	23	23	23	24	23	24	24	24	23
1600	18	18	18	18	18	18	18	19	19	19	19	19	19	19	19	19
1700	15	15	15	15	16	15	15	16	16	16	16	16	16	16	16	16
1800	12	12	12	13	13	13	13	13	13	14	14	14	14	14	14	14
1900	10	10	10	10	10	10	10	11	11	12	11	12	12	12	12	12
2000	9	9	9	9	9	9	9	9	9	10	10	9	10	10	10	10
2100	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8	8
2200	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	7
2300	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6
2400	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5
2500	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4
2600	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4
2700	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3
2800	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2900	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3000	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
3100	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1
3200	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3300	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3400	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3500	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
3600	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0

370 0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
380 0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
390 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(c) Probability of $B/B_{MSY}>1$ and $F/F_{MSY}<1$

	2019	2020	2021	2022	2023	2024	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
0	5	7	8	9	11	13	15	23	31	39	46	52	57	61	65	69
100	5	7	8	9	10	12	14	22	29	36	41	47	52	57	61	64
200	5	7	8	9	10	12	14	21	27	33	40	44	48	52	56	59
300	6	7	7	9	10	11	13	20	26	31	36	42	45	48	52	55
400	5	6	7	8	9	11	12	18	24	29	34	38	41	45	48	51
500	6	6	7	8	10	10	12	17	23	28	32	36	39	42	45	47
600	5	6	7	8	9	10	11	16	21	26	29	32	35	38	40	42
700	5	6	7	8	8	9	10	15	19	23	26	29	32	35	37	39
800	5	6	7	7	8	9	10	14	18	22	25	28	29	32	34	35
900	5	6	6	7	8	9	9	13	17	20	22	24	27	28	30	30
1000	5	6	6	7	7	8	9	12	16	18	21	23	24	26	27	28
1100	5	5	6	7	7	8	8	11	14	16	18	19	21	22	23	24
1200	5	5	6	6	6	7	8	10	13	15	16	18	19	21	22	23
1300	4	5	5	6	6	6	7	10	11	13	14	15	17	18	18	19
1400	4	5	5	5	6	6	6	9	11	12	13	14	15	16	17	17
1500	4	4	5	5	5	6	6	8	9	11	12	13	14	14	15	15
1600	4	4	5	5	5	5	6	7	8	9	10	11	11	12	12	13
1700	3	4	4	4	5	5	5	6	7	8	9	10	10	11	11	11
1800	3	3	4	4	4	4	5	5	6	7	8	9	9	9	10	10
1900	3	3	4	4	4	4	4	5	6	7	7	8	8	8	9	9
2000	3	3	3	3	4	4	4	5	5	6	6	6	7	7	7	8
2100	2	3	3	3	3	3	3	4	4	5	5	6	6	6	6	6
2200	2	2	3	3	3	3	3	3	3	4	4	5	5	5	5	5
2300	2	2	2	2	3	2	3	3	3	4	4	4	4	4	5	5
2400	2	2	2	2	2	2	2	3	3	3	4	4	4	4	4	4
2500	1	1	1	2	2	2	2	2	3	3	3	3	3	3	3	3
2600	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3
2700	1	1	1	1	1	1	1	2	2	2	2	2	2	3	3	2
2800	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2
2900	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
3000	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1
3100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3200	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3300	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1
3400	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
3500	0	0	0	0	0	0	1	1	1	1	0	0	1	1	1	1
3600	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0

370 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
380 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
390 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

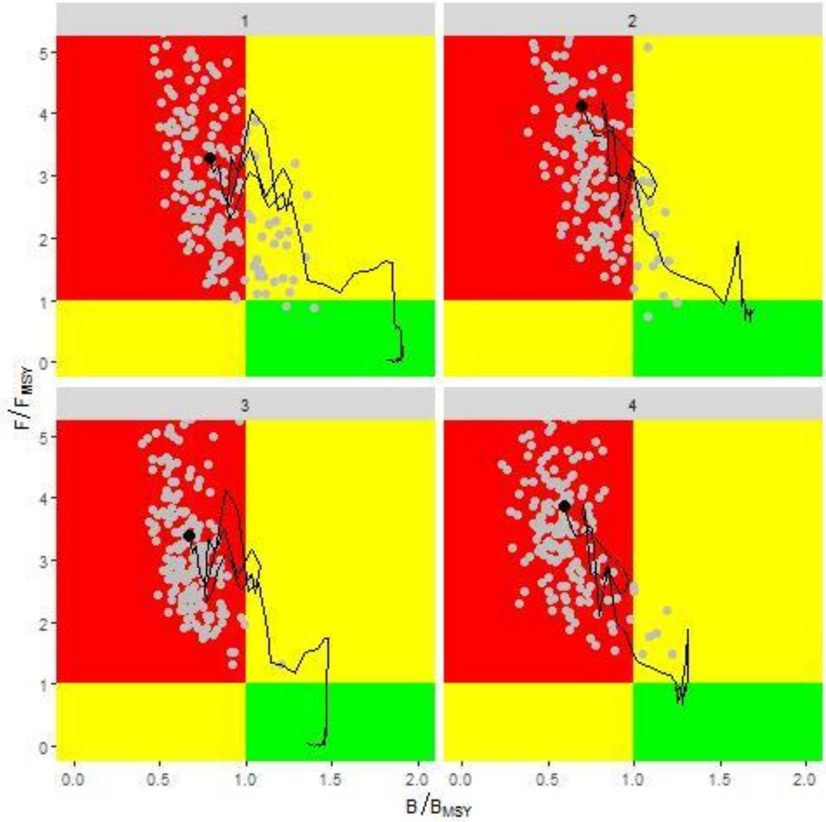

Figure 1. Kobe plots for North Atlantic mako shark where the current year is 2018.

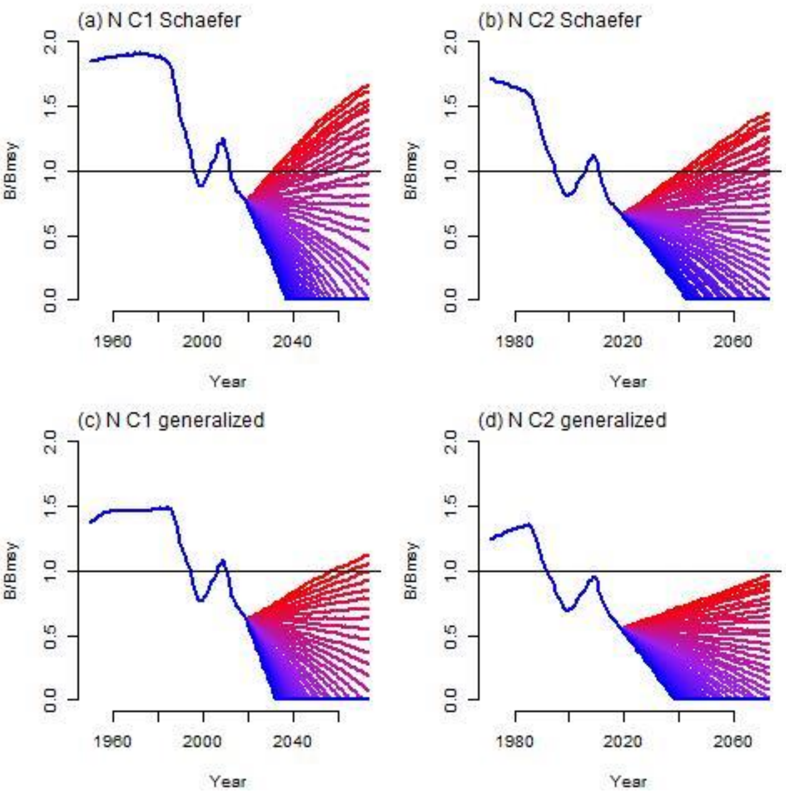

Figure 2. Projections for North Atlantic mako shark. Lines are TACs from 0 to 4000 mt in 100 mt increments. First projection year is 2019, last year is 2073.