

Supplementary Material

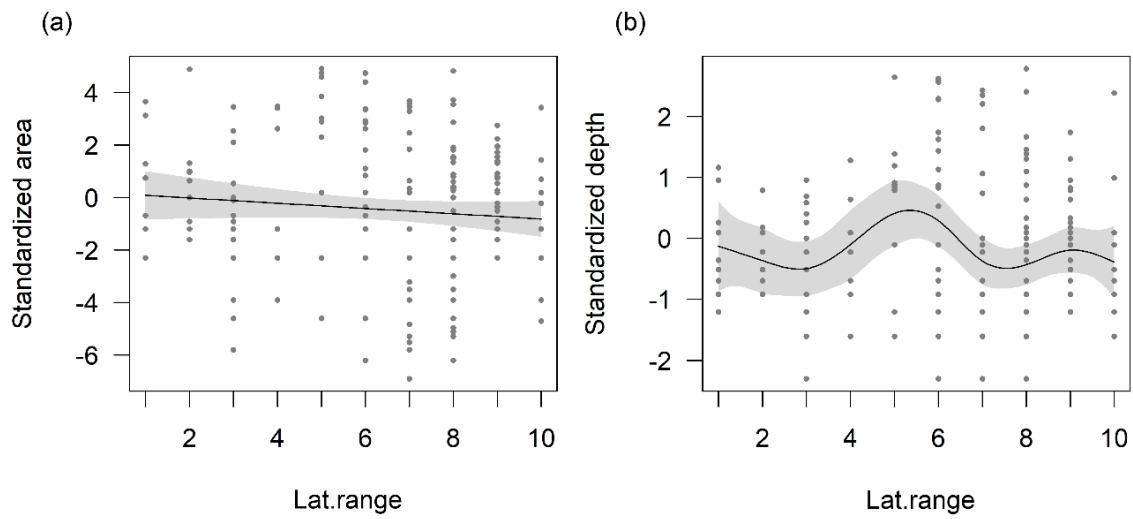


Fig. S1. Spatial distribution of estuarine habitat along the south-eastern coast of Australia including the non-significant effects of latitude range (Lat.range) upon (a) total estuarine area and (b) average estuary depth. The shaded areas and points represent the 95% confidence intervals of model estimates and the empirical data.

Table S1. Comparisons between univariate Generalized Additive Models (GAM) and Zero-Inflated Generalized Additive Models (ZIGAM), including the corresponding logarithmic marginal likelihood (logE) and Akaike information criterion (AIC) values.

Model	Variable	GAM		ZIGAM	
		logE	AIC	logE	AIC
Spatiotemporal	Year	-936.04	39254.42	-568.80	38696.84
	Month	-929.68	38805.94	-562.44	38246.37
	Lat.range	-786.25	29208.12	-419.02	28649.41
	Fishery	-894.35	34031.08	-527.11	33471.30
Environmental	SST	-938.21	30554.44	-692.77	29874.20
	SCUR	-971.37	33831.27	-725.93	32651.03
	NCUR	-973.33	33554.44	-727.89	32874.20
	WCUR	-946.95	32161.00	-701.51	31480.76
	ECUR	-950.67	32567.11	-705.23	31886.87
	Rain	-1030.79	38826.58	-785.35	38146.34
	Est.N	-977.47	33748.59	-732.03	33068.35
	Area	-988.84	35763.03	-743.40	35082.79
	Depth	-976.68	34112.09	-731.24	33431.85

Table S2. Stepwise variable selection procedure of the large-scale spatio-temporal predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value). m^2

Fishery	Model	AIC	Δ AIC	wAIC	p-value
Estuarine setlines	Null	10305.30	6183.39	<0.0001	
	Year	9916.38	5794.47	<0.0001	
	Month	10264.03	6142.12	<0.0001	
	Lat.range	4481.00	359.09	<0.0001	<0.001
	Lat.range + Year	4132.58	10.67	0.0047	<0.001
	Lat.range + Month	4460.67	338.76	<0.0001	
Coastal setlines	Null	4996.45	1871.76	<0.0001	
	Year	4656.21	1531.52	<0.0001	
	Month	4810.37	1685.68	<0.0001	
	Lat.range	3582.02	457.33	<0.0001	<0.001
	Lat.range + Year	3409.79	285.10	<0.0001	
	Lat.range + Month	3292.25	167.56	<0.0001	<0.001
Handlines	Null	3124.69	0	0.9999	<0.001
	Year	3282.42	1145.18	<0.0001	
	Month	3121.08	983.84	<0.0001	
	Lat.range	3211.22	1073.98	<0.0001	
	Lat.range + Year	2339.90	202.66	<0.0001	<0.001
	Lat.range + Month	2199.24	62.00	<0.0001	<0.001
Prawn trawl	Null	2274.07	136.83	<0.0001	
	Year	2137.24	0	0.9999	<0.001
	Month	1522.13	418.33	<0.0001	
	Lat.range	1480.50	376.70	<0.0001	
	Lat.range + Year	1378.54	274.74	<0.0001	
	Lat.range + Month	1350.13	246.33	<0.0001	<0.001
Fish trawl	Null	1285.45	181.65	<0.0001	
	Year	1177.85	74.05	<0.0001	<0.001
	Month	1103.80	0	0.9999	<0.001
	Lat.range	2004.96	344.13	<0.0001	
	Lat.range + Year	1902.05	241.22	<0.0001	
	Lat.range + Month	1944.09	283.26	<0.0001	
Hauling nets	Null	1846.90	186.07	<0.0001	<0.001
	Year	1727.19	66.36	<0.0001	<0.001
	Month	1783.73	122.90	<0.0001	
	Lat.range	1660.83	0	0.9999	<0.001
	Lat.range + Year	3963.02	885.77	<0.0001	
	Lat.range + Month	3859.39	782.14	<0.0001	
	Year	3688.38	611.13	<0.0001	
	Month	3567.42	490.17	<0.0001	<0.001

	Lat.range + Year	3467.20	389.95	<0.0001	
	Lat.range + Month	3201.24	123.99	<0.0001	<0.001
	Lat.range + Month + Year*	3077.25	0	0.9999	<0.001
Mesh nets	Null	11875.70	5941.11	<0.0001	
	Year	11865.09	5930.50	<0.0001	
	Month	11663.29	5728.70	<0.0001	
	Lat.range	6403.95	469.36	<0.0001	<0.001
	Lat.range + Year	6293.31	358.72	<0.0001	
	Lat.range + Month	6021.96	87.37	<0.0001	<0.001
	Lat.range + Month + Year*	5934.59	0	0.9999	<0.001

* Final models

Table S3. Stepwise variable selection procedure of the large-scale environmental predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia on estuarine setline fisheries. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	10305.30	6431.63	<0.0001	
SST	6630.16	2756.49	<0.0001	
Rain	10239.37	6365.70	<0.0001	
Est.N [#]				
Area	5271.32	1397.65	<0.0001	<0.001
Depth	6871.69	2998.02	<0.0001	
Area + SST*	3873.67	0	0.9999	<0.001
Area + Rain [#]				

* Final models

[#] Non-significant model

Table S4. Stepwise variable selection procedure of the large-scale environmental predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia on coastal setline fisheries. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	4996.45	3404.56	<0.0001	
SST	2477.67	885.78	<0.0001	<0.001
NEAC [#]				
SEAC	3414.78	1822.89	<0.0001	
WEAC	2923.62	1331.73	<0.0001	
EEAC [#]				
Rain	4696.74	3104.85	<0.0001	
SST + SEAC	2073.72	481.83	<0.0001	
SST + WEAC*	1591.89	0	0.9999	<0.001
SST + Rain [#]				

* Final models

[#] Non-significant model

Table S5. Stepwise variable selection procedure of the large-scale environmental predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia on handline fisheries. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	3282.43	882.77	<0.0001	
SST	2651.55	251.89	<0.0001	<0.001
NEAC [#]				
SEAC	2983.88	584.22	<0.0001	
WEAC	2836.09	436.43	<0.0001	
EEAC [#]				
Rain	3247.74	848.08	<0.0001	
SST + SEAC	2548.79	149.13	<0.0001	
SST + WEAC	2417.26	17.60	0.0001	<0.001
SST + Rain	2640.39	240.73	<0.0001	
SST + WEAC + Rain	2399.66	0	0.9998	<0.001

* Final model

[#] Non-significant model

Table S6. Stepwise variable selection procedure of the large-scale environmental predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia on prawn trawl fisheries. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	1522.13	459.77	<0.0001	
SST	1389.96	327.60	<0.0001	
NEAC [#]				
SEAC	1323.85	261.49	<0.0001	
WEAC	1369.58	307.22	<0.0001	
EEAC [#]				
Rain	1510.36	448	<0.0001	
Est.N [#]				
Area	1248.28	185.92	<0.0001	<0.001
Depth [#]				
Area + SST	1184.88	122.52	<0.0001	
Area + SEAC	1144.32	81.96	<0.0001	
Area + WEAC	1128.93	66.57	<0.0001	<0.001
Area + Rain	1236.23	173.87	<0.0001	
Area + WEAC + SST	1082.60	20.24	<0.0001	<0.001
Area + WEAC + Rain	1111.30	48.94	<0.0001	
Area + WEAC + SST + Rain*	1062.36	0	0.9999	<0.001

* Final models

[#] Non-significant model

Table S7. Stepwise variable selection procedure of the large-scale environmental predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia on fish trawl fisheries. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	2004.96	371.23	<0.0001	
SST	1802.43	168.70	<0.0001	<0.001
NEAC [#]				
SEAC	1852.17	218.44	<0.0001	
WEAC [#]				
EEAC [#]				
Rain	1978.38	344.65	<0.0001	
Est.N [#]				
Area	1827.62	193.89	<0.0001	
Depth	1824.28	190.55	<0.0001	
SST + SEAC	1675.32	41.59	<0.0001	<0.001
SST + Rain	1764.50	130.77	<0.0001	
SST + Area	1690.63	56.90	<0.0001	
SST + Depth	1689.83	56.10	<0.0001	
SST + SEAC + Rain*	1633.73	0	0.9999	<0.001
SST + SEAC + Area [#]				
SST + SEAC + Depth [#]				

* Final models

[#] Non-significant model

Table S8. Stepwise variable selection procedure of the large-scale environmental predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia on hauling net fisheries. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	3963.02	1639.76	<0.0001	
SST	2866.88	543.62	<0.0001	<0.001
NEAC [#]				
SEAC	3532.84	1209.58	<0.0001	
WEAC	3211.61	888.35	<0.0001	
EEAC [#]				
Rain	3843.28	1520.02	<0.0001	
Est.N [#]				
Area	3886.66	1563.40	<0.0001	
Depth	3624.70	1301.44	<0.0001	
SST + SEAC	2704.38	381.12	<0.0001	
SST + WEAC	2491.58	168.32	<0.0001	<0.001
SST + Rain	2854.39	531.13	<0.0001	
SST + Area	2811.67	488.41	<0.0001	
SST + Depth	2709.44	386.18	<0.0001	
SST + WEAC + Rain	2482.16	158.90	<0.0001	
SST + WEAC + Area	2462.51	139.25	<0.0001	
SST + WEAC + Depth	2333.50	10.24	0.0059	<0.001
SST + WEAC + Depth + Rain*	2323.26	0	0.9940	0.001

* Final models

[#] Non-significant model

Table S9. Stepwise variable selection procedure of the large-scale environmental predictors for the binomial zero-inflated generalized additive model of bull shark occurrence along the south-eastern coast of Australia on mesh net fisheries. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	11875.70	4740.98	<0.0001	
SST	8270.97	1136.25	<0.0001	<0.001
Rain	11620.99	4486.27	<0.0001	
Est.N [#]				
Area	10677.14	3542.42	<0.0001	
Depth	9159.57	2024.85	<0.0001	
SST + Rain	8229.74	1095.02	<0.0001	
SST + Area	7367.39	232.67	<0.0001	
SST + Depth	7139.27	4.55	0.0932	<0.001
SST + Depth + Rain	7134.72	0	0.9067	0.017

* Final models

Non-significant mode

Table S10. Stepwise variable selection procedure of the spatio-temporal effects for the generalized additive models of the environmental conditions (Env.var) responsible to influence the bull shark occurrence along the south-eastern coast of Australia. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Env.var	Model	AIC	Δ AIC	wAIC	p-value	
Rain	Null	1897.86	113.27	<0.0001		
	Year	1893.18	108.59	<0.0001		
	Month	1823.87	39.28	<0.0001	<0.001	
	Lat.range	1867.88	83.29	<0.0001		
	Lat.range x Year	1863.27	78.68	<0.0001		
	Lat.range x Month	1842.32	57.73	<0.0001		
	Month + Lat.range	1790.32	5.73	<0.0001		
	Month + Year	1818.04	33.45	<0.0001		
	Month + Lat.range x Year*	1784.59	0.00	0.999	<0.001	
	SST	Null	33676.34	9386.17	<0.0001	
Year		33624.16	9333.99	<0.0001		
Month		28646.57	4356.40	<0.0001		
Lat.range		30420.69	6130.52	<0.0001		
Lat.range x Year		30354.61	6064.44	<0.0001		
Lat.range x Month		24777.21	487.04	<0.0001	<0.001	
Lat.range x Month + Year		24623.71	333.54	<0.0001		
Lat.range x Month + Lat.range x Year*		24290.17	0.00	0.999	<0.001	
WEAC		Null	16067.37	1369.67	<0.0001	
		Year	16010.67	1312.97	<0.0001	
	Month	15307.94	610.24	<0.0001		
	Lat.range	15225.14	527.44	<0.0001		
	Lat.range x Year	15487.25	789.55	<0.0001		
	Lat.range x Month	15206.44	508.74	<0.0001	<0.001	
	Lat.range x Month + Year	15163.29	465.59	<0.0001		
	Lat.range x Month + Lat.range x Year*	14697.70	0.00	0.999	<0.001	
	SEAC	Null	51621.11	20220.60	<0.0001	
		Year	33413.48	2012.97	<0.0001	
Month		36692.60	5292.09	<0.0001		
Lat.range		33177.79	1777.28	<0.0001	<0.001	
Lat.range x Year		31907.23	506.72	<0.0001	<0.001	
Lat.range x Month		34582.35	3181.84	<0.0001		
Lat.range x Year + Month		32615.78	1215.27	<0.0001		
Lat.range x Year + Lat.range x Month*		31400.51	0	0.9999	<0.001	

* Final models

Table S11. Stepwise variable selection procedure of the predictive (2020-2030) spatio-temporal generalized additive models of sea surface temperature increase along the south-eastern coast of Australia. Included are all candidate models and their respective AIC, delta AIC (Δ AIC = model AIC – lower AIC), AIC weights (wAIC). Significance levels of the analysis of variance between previous nested model and the new variable to be included are also included for each step (p-value).

Model	AIC	Δ AIC	wAIC	p-value
Null	7848821	3295692	<0.0001	
Year	7838205	3285076	<0.0001	
Month	6427336	1874207	<0.0001	<0.001
Latitude	7330726	2777597	<0.0001	
Month x Latitude	4633258	80129	<0.0001	<0.001
Month x Latitude + Year*	4553129	0	0.9999	<0.001

* Final model