Appendices: Non-spawner covariate tests

Table A1. Covariate tests for the October-March catch (N_t). M is the base model with prior season October-March catch (N_{t-1}) and July-September catch two seasons prior (S_{t-2}) as the covariates. To the base model, the environmental covariates are added. ns-SST is nearshore (0-80km) and r-SST is regional (0-160km) SST. Similarly, ns-Chl is nearshore chlorophyll. The nested F-tests are given in Supporting Information. The models are nested sets, e.g. 1, 2a, 3a and 1, 2b, 3b.

Model	Resid. df	Adj. R^2	RMSE	AICc	LOOCV RMSE
catch only models 1983-2014 data					
null model: $ln(N_t) = ln(N_{t-1}) + \epsilon_t$	32		0.999	92.86	0.999
base (M) 1. $ln(N_t) = \alpha + s(ln(N_{t-1})) + s(ln(S_{t-2})) + \epsilon_t$	26.6	57	0.7	84.58	1.055
Precipitation					
V_t = Jun-Jul Precipitation - satellite (S1)					
2a. $ln(N_t)$ = M + βV_t	25.7	58	0.685	86.48	1.083
3a. $ln(N_t)$ = M + $s(V_t)$	24.6	56	0.681	89.91	1.141
2b. $ln(N_t)$ = M + βV_{t-1}	25.6	56	0.7	87.93	1.066
3b. $ln(N_t)$ = M + $s(V_{t-1})$	24.5	58	0.669	89.1	1.058
V_t = Apr-May Precipitation - satellite (S2)					
2a. $ln(N_t)$ = M + βV_t	25.6	56	0.7	87.88	1.071
3a. $ln(N_t)$ = M + $s(V_t)$	24.4	54	0.694	92.11	1.098
2b. $ln(N_t)$ = M + βV_{t-1}	25.6	57	0.692	87.16	1.041
3b. $ln(N_t)$ = M + $s(V_{t-1})$	24.4	56	0.677	90.46	1.049
Sea surface temperature					
V_t = Mar-May r-SST (S5)					
2a. $ln(N_t)$ = M + βV_t	25.7	60	0.668	84.84	1.057
3a. $ln(N_t)$ = M + $s(V_t)$	24.4	64	0.614	84.05	0.999‡
2b. $ln(N_t)$ = M + βV_{t-1}	25.6	59	0.673	85.4	1.039
3b. $ln(N_t)$ = M + $s(V_{t-1})$	24.3	58	0.663	89.56	1.026
V_t = Oct-Dec ns-SST (L1)					
2a. $ln(N_t)$ = M + βV_{t-1}	25.7	56	0.701	87.9	1.077
3a. $ln(N_t)$ = M + $s(V_{t-1})$	24.8	57	0.681	89.39	1.132
Upwelling					
V_t = Jun-Sep SST-derived UPW (L2)					
2a. $ln(N_t)$ = M + βV_t	25.6	63	0.64	82.14†	1.005
3a. $ln(N_t)$ = M + $s(V_t)$	23.8	63	0.616	86.65	1.084
2b. $ln(N_t)$ = M + βV_{t-1}	25.6	56	0.7	87.92	1.104
3b. $ln(N_t)$ = M + $s(V_{t-1})$	23.9	57	0.665	91.36	1.186

Model	Resid. df	Adj. R^2	RMSE	AICc	LOOCV RMSE
V_t = Jun-Sep ns-SST (L2)					
2a. $ln(N_t) = \text{M} + \beta V_t$	25.6	64	0.635	81.7†	1.029
3a. $ln(N_t) = \text{M} + s(V_t)$	24.2	63	0.625	85.93	1.089
2b. $ln(N_t) = \text{M} + \beta V_{t-1}$	25.7	56	0.698	87.67	1.083
3b. $ln(N_t) = \text{M} + s(V_{t-1})$	24.2	55	0.683	91.65	1.114
V_t = Jun-Sep Bakun-UPW (L2)					
2a. $ln(N_t) = \text{M} + \beta V_t$	25.6	58	0.682	86.21	1.036
3a. $ln(N_t) = \text{M} + s(V_t)$	24.3	61	0.638	87.11	1.056
2b. $ln(N_t) = \text{M} + \beta V_{t-1}$	25.7	58	0.684	86.38	1.015
3b. $ln(N_t) = \text{M} + s(V_{t-1})$	24.4	59	0.66	88.75	1.081
Ocean climate					
V_t = 2.5-year ave r-SST (A1)					
2a. $ln(N_t) = \text{M} + \beta V_t$	25.7	66	0.615	79.58††	0.893‡‡
3a. $ln(N_t) = \text{M} + s(V_t)$	24.7	72	0.546	75.6††	0.752‡‡‡
V_t = ONI (A2)					
2a. $ln(N_t) = \text{M} + \beta V_t$	25.7	57	0.693	87.05	1.022
3a. $ln(N_t) = \text{M} + s(V_t)$	25.1	57	0.683	88.17	1.072
2b. $ln(N_t) = \text{M} + \beta V_{t-1}$	25.7	56	0.7	87.89	1.076
3b. $ln(N_t) = \text{M} + s(V_{t-1})$	24.3	57	0.675	90.58	1.046
V_t = Sep-Nov DMI (A3)					
2a. $ln(N_t) = \text{M} + \beta V_t$	25.7	56	0.696	87.28	1.09
3a. $ln(N_t) = \text{M} + s(V_t)$	23.6	58	0.657	91.55	1.2
2b. $ln(N_t) = \text{M} + \beta V_{t-1}$	25.7	56	0.702	87.91	1.076
3b. $ln(N_t) = \text{M} + s(V_{t-1})$	23.8	69	0.565	81.29†	0.876‡‡
V_t = Aug tide level					
2a. $ln(N_t) = \text{M} + \beta V_t$	25.7	57	0.693	87.2	1.068
3a. $ln(N_t) = \text{M} + s(V_t)$	24.8	56	0.687	89.7	1.083
2b. $ln(N_t) = \text{M} + \beta V_{t-1}$	25.7	63	0.64	81.97†	0.943‡‡
3b. $ln(N_t) = \text{M} + s(V_{t-1})$	23.8	68	0.575	82.38†	0.951‡
catch only models 1958-1989 data					
null model: $ln(N_t) = ln(N_{t-1}) + \epsilon_t$	32		0.804	79	0.804
base (M) 1. $ln(N_t) = \alpha + s(ln(N_{t-1})) + s(ln(S_{t-2})) + \epsilon_t$	26.8	15	0.604	74.71	0.913
Select covariates available from 1957					
V_t = Jun-Jul Precipitation - land gauges (S1)					
2a. $ln(N_t) = \text{M} + \beta V_t$	25.8	12	0.604	78	0.95
3a. $ln(N_t) = \text{M} + s(V_t)$	24.3	18	0.566	79.39	0.946
V_t = Sep-Nov DMI (A3)					
2a. $ln(N_t) = \text{M} + \beta V_{t-1}$	25.8	17	0.588	76.2	0.902
3a. $ln(N_t) = \text{M} + s(V_{t-1})$	24.1	21	0.553	78.56	0.906

Model	Resid. df	Adj. R^2	RMSE	AICc	LOOCV RMSE
V_t = Aug tide level					
2a. $ln(N_t)$ = M + βV_{t-1}	25.8	19	0.58	75.29	0.877
3a. $ln(N_t)$ = M + $s(V_{t-1})$	24.2	22	0.552	78.08	0.898
catch only models 1998-2014 data					
null model: $ln(N_t) = ln(N_{t-1}) + \epsilon_t$	17		0.432	21.96	0.432
base (M) 1. $ln(N_t) = \alpha + p(ln(N_{t-1})) + \epsilon_t$	14	27	0.334	22.28	0.422
Chlorophyll					
V_t = Jul-Sep ns-CHL (L3)					
2a. $ln(N_t)$ = M + βV_t	13	24	0.327	25.71	0.441
3a. $ln(N_t)$ = M + $s(V_t)$	12	19	0.325	30.47	0.496
2b. $ln(N_t)$ = M + βV_{t-1}	13	31	0.311	23.95	0.418
3b. $ln(N_t)$ = M + $s(V_{t-1})$	12	26	0.311	28.89	1.616
V_t = Oct-Dec ns-CHL (L3)					
2a. $ln(N_t)$ = M + βV_t	13	24	0.327	25.71	0.445
3a. $ln(N_t)$ = M + $s(V_t)$	12	35	0.29	26.6	0.391‡
2b. $ln(N_t)$ = M + βV_{t-1}	13	45	0.277	20.11†	0.364‡‡
3b. $ln(N_t)$ = M + $s(V_{t-1})$	12	41	0.277	25.06	0.384‡
V_t = Jan-Mar ns-CHL					
2a. $ln(N_t)$ = M + βV_t	13	33	0.308	23.66	0.428
3a. $ln(N_t)$ = M + $s(V_t)$	12	27	0.308	28.61	0.463
2b. $ln(N_t)$ = M + βV_{t-1}	13	21	0.333	26.3	0.475
3b. $ln(N_t)$ = M + $s(V_{t-1})$	12	15	0.333	31.25	0.512

Notes: LOOCV = Leave one out cross-validation. RMSE = root mean square error, AICc = Akaike Information Criterion corrected for small sample size. † = AIC greater than 2 below model M (base catch model). †† = AIC greater than 5 below model M. ‡ = LOOCV RMSE 5% below model M. ‡‡ = LOOCV RMSE 10% below model M. t indicates current season (Jul-Jun) and $t-1$ is prior season. Thus a Jan-Mar covariate with $t-1$ would be in the same calendar year as the Jul-Sep catch, though in a prior fishing season. With the exception that for covariates that are calendar year (Jan-Dec) or multiyear, t is the current calendar year.