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	LOOCV MdAE
catch only models 1983-2014 data						
null model: $ln(N_t) = ln(N_{t-1}) + \epsilon_t$	32		0.999	92.86	0.999	0.256
base (M) 1. $ln(N_t) = \alpha + s(ln(N_{t-1})) + \epsilon_t$	29.1	46	0.824	87.74	0.955	0.323
Precipitation						
V_t = Jun-Jul Precipitation - satellite (S1)						
2a. $ln(N_t)$ = M + βV_t	28.1	44	0.824	90.54	0.99	0.353
3a. $ln(N_t)$ = M + $s(V_t)$	26.9	46	0.791	91.48	1.037	0.354
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	45	0.819	90.12	0.989	0.315
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26.8	44	0.804	92.81	1.021	0.337
V_t = Jun-Jul Precipitation - land gauges (S1)						
2a. $ln(N_t)$ = M + βV_t	28.1	54	0.745	84.14†	0.964	0.351
3a. $ln(N_t)$ = M + $s(V_t)$	26.9	60	0.685	82.15††	0.906‡	0.246
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	45	0.815	89.8	1.01	0.339
3b. $ln(N_t)$ = M + $s(V_{t-1})$	27	43	0.814	93.03	1.05	0.356
V_t = Apr-May Precipitation - satellite (S2)						
2a. $ln(N_t)$ = M + βV_t	28.1	44	0.823	90.49	0.968	0.36
3a. $ln(N_t)$ = M + $s(V_t)$	26.8	42	0.819	94.15	0.996	0.457
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	45	0.82	90.2	0.958	0.374
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26.8	45	0.794	92.14	0.954	0.381
V_t = Apr-May Precipitation - land gauges (S2)						
2a. $ln(N_t)$ = M + βV_t	28.1	47	0.799	88.49	0.913	0.368
3a. $ln(N_t)$ = M + $s(V_t)$	26.2	46	0.781	92.98	0.93	0.389
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	44	0.824	90.51	0.965	0.314
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26.1	42	0.808	95.37	0.994	0.359
Sea surface temperature						
V_t = Mar-May r-SST (S5)						
2a. $ln(N_t)$ = M + βV_t	28.1	46	0.805	89.1	0.961	0.34
3a. $ln(N_t)$ = M + $s(V_t)$	26.7	47	0.784	91.39	0.961	0.423
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	50	0.778	86.86	0.941	0.475
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26.6	51	0.751	89.12	0.928	0.398

Model	Resid. df	Adj. R^2	RMSE	AICc	LOOCV RMSE	LOOCV MdAE
V_t = Oct-Dec ns-SST (L1)						
2a. $ln(N_t)$ = M + βV_t	28.1	45	0.817	89.96	0.981	0.416
3a. $ln(N_t)$ = M + $s(V_t)$	27.1	44	0.81	92.42	0.99	0.434
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	46	0.806	89.15	0.964	0.289
3b. $ln(N_t)$ = M + $s(V_{t-1})$	27.1	45	0.8	91.62	1.019	0.324
Upwelling						
V_t = Jun-Sep SST-derived UPW (L2)						
2a. $ln(N_t)$ = M + βV_t	28.1	55	0.741	83.77†	0.913	0.447
3a. $ln(N_t)$ = M + $s(V_t)$	26.2	57	0.699	86	1.017	0.456
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	44	0.824	90.53	1.007	0.322
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26.1	47	0.772	92.41	1.084	0.35
V_t = Jun-Sep ns-SST (L2)						
2a. $ln(N_t)$ = M + βV_t	28.1	52	0.76	85.38†	0.914	0.432
3a. $ln(N_t)$ = M + $s(V_t)$	26.6	52	0.742	88.38	0.965	0.519
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	46	0.812	89.55	0.97	0.333
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26.6	44	0.798	93.16	0.995	0.307
V_t = Jun-Sep Bakun-UPW (L2)						
2a. $ln(N_t)$ = M + βV_t	28.1	47	0.805	89.03	0.948	0.37
3a. $ln(N_t)$ = M + $s(V_t)$	26.6	48	0.775	91.12	0.945	0.309
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	45	0.817	89.96	0.951	0.342
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26.7	45	0.794	92.29	0.965	0.392
Ocean climate						
V_t = 2.5-year ave r-SST (A1)						
2a. $ln(N_t)$ = M + βV_t	28.1	57	0.726	82.37††	0.844‡‡	0.324
3a. $ln(N_t)$ = M + $s(V_t)$	26.9	65	0.642	78.08††	0.758‡‡‡	0.351
V_t = ONI (A2)						
2a. $ln(N_t)$ = M + βV_t	28.1	49	0.79	87.82	0.916	0.453
3a. $ln(N_t)$ = M + $s(V_t)$	27.5	48	0.785	89.25	0.929	0.44
V_t = Sep-Nov DMI (A3)						
2a. $ln(N_t)$ = M + βV_t	28.1	49	0.787	87.66	0.978	0.425
3a. $ln(N_t)$ = M + $s(V_t)$	25.8	49	0.754	92.23	1.119	0.493
2b. $ln(N_t)$ = M + βV_{t-1}	28.1	45	0.819	90.09	0.95	0.336
3b. $ln(N_t)$ = M + $s(V_{t-1})$	26	44	0.791	94.41	0.947	0.339
V_t = DMI 3-yr ave (A3)						
2a. $ln(N_t)$ = M + βV_t	28.1	56	0.731	82.78†	0.844‡‡	0.345
3a. $ln(N_t)$ = M + $s(V_t)$	27.2	60	0.688	81.51††	0.818‡‡	0.362
catch only models 1998-2014 data						
null model: $ln(N_t) = ln(N_{t-1}) + \epsilon_t$	17		0.432	21.96	0.432	0.133
base (M) 1. $ln(N_t) = \alpha + p(ln(N_{t-1})) + \epsilon_t$	14	27	0.334	22.28	0.422	0.369

Model	Resid. df	Adj. R^2	RMSE	AICc	LOOCV RMSE	LOOCV MdAE
Chlorophyll						
V_t = Jul-Sep ns-CHL (L3)						
2a. $ln(N_t)$ = M + βV_t	13	24	0.327	25.71	0.441	0.344
3a. $ln(N_t)$ = M + $p(V_t)$	12	19	0.325	30.47	0.496	0.333
2b. $ln(N_t)$ = M + βV_{t-1}	13	31	0.311	23.95	0.418	0.348
3b. $ln(N_t)$ = M + $p(V_{t-1})$	12	26	0.311	28.89	1.616	0.362
V_t = Oct-Dec ns-CHL (L3)						
2a. $ln(N_t)$ = M + βV_t	13	24	0.327	25.71	0.445	0.336
3a. $ln(N_t)$ = M + $p(V_t)$	12	35	0.29	26.6	0.391‡	0.217
2b. $ln(N_t)$ = M + βV_{t-1}	13	45	0.277	20.11	0.364‡‡	0.235
3b. $ln(N_t)$ = M + $p(V_{t-1})$	12	41	0.277	25.06	0.384‡	0.278
catch only models 1958-1988 data						
null model: $ln(N_t) = ln(N_{t-1}) + \epsilon_t$	31		0.816	77.52	0.816	0.398
base (M) 1. $ln(N_t) = \alpha + s(ln(N_{t-1})) + \epsilon_t$	27.3	18	0.621	69.95	0.78	0.491
Select covariates available from 1957						
V_t = Jun-Jul Precipitation - land gauges (S1)						
2a. $ln(N_t)$ = M + βV_t	26.3	15	0.62	72.92	0.814	0.501
3a. $ln(N_t)$ = M + $s(V_t)$	24.7	19	0.588	74.79	0.815	0.578
V_t = Sep-Nov DMI (A3)						
2a. $ln(N_t)$ = M + βV_{t-1}	26.3	20	0.6	70.82	0.773	0.427
3a. $ln(N_t)$ = M + $s(V_{t-1})$	24.5	26	0.558	72.45	0.785	0.41
V_t = DMI 3-yr ave (A3)						
2a. $ln(N_t)$ = M + βV_t	26.3	19	0.604	71.1	0.807	0.38
3a. $ln(N_t)$ = M + $s(V_t)$	25.2	24	0.572	71.4	0.814	0.297‡‡‡

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. ‡, ‡‡, and ‡‡‡ = LOOCV RMSE 5%, 10% and 20% below model M, respectively. 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.