Preliminary Discussion about the 2022 Forecast Process

Sara Miller

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Contents

1 Objective

To determine the process for the 2022 Southeast Alaska (SEAK) preseason pink salmon forecast using data through 2020.

2 Executive Summary

Forecasts were developed using an approach originally described in Wertheimer et al. (2006), and modified in Orsi et al. (2016) and Murphy et al. (2019). We used a similar approach to Murphy et al. (2019), but assumed a log-normal error. This approach is based on a multiple regression model with juvenile pink salmon catch-per-unit-effort (CPUE) and temperature data from the Southeast Alaska Coastal Monitoring Survey (SECM; Murphy et al. 2020) or satellite sea surface temperature data (SST and SST Anomaly, NOAA Global Coral Bleaching Monitoring, 5km, V.3.1, Monthly, 1985-Present' time series (https://coastwatch.pfeg.noaa.gov/erddap/griddap/NOAA_DHW_monthly.html). Based on prior discussions, the index of juvenile abundance (i.e., CPUE) was based on the pooled-species vessel calibration coefficient.

Leave-one-out cross validation (hindcast) and model performance metrics were used to evaluate the forecast accuracy of models. These metrics included Akaike Information Criterion corrected for small sample sizes (AICc values; Burnham and Anderson 2004), the mean absolute scaled error (*MASE* metric; Hyndman and Kohler 2006), the weighted mean absolute percentage error (*wMAPE*; based on the last 5 years), leave one out cross validation *MAPE* (*MAPE_LOOCV*), and significant coefficients (i.e., covariates) in the model.

3 Analysis

3.1 Hierarchical models

Forty five hierarchical models were investigated. The full model was:

$$E(y) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2,$$

where X_1 is the average CPUE for catches in either the June or July survey, whichever month had the highest average catches in a given year, and was based on the pooled-species vessel calibration coefficient, X_2 is a temperature index, and β_3 is the interaction term between CPUE and a temperature index. The CPUE data were log-transformed in the model, but temperature data was not. The simplest model did not contain a temperature variable (model m1 or 1). None of the interactions were significant (see Appendix); therefore only additive models (23 models) were considered further.

Table 1: Parameter estimates for the 23 potential models.

model	term	estimate	std.error	statistic	p.value
m1	(Intercept)	2.2891818	0.208	11.019	0.000
m1	CPUE	0.4379654	0.071	6.157	0.000
m2	(Intercept)	4.4699466	0.545	8.196	0.000
m2	CPUE	0.4595498	0.054	8.582	0.000
m2	ISTI3_May	-0.2774746	0.067	-4.172	0.000
m3	(Intercept)	4.7958758	0.582	8.244	0.000
m3	CPUE	0.4650143	0.052	8.950	0.000
m3	ISTI10_May	-0.3320310	0.074	-4.461	0.000
m4	(Intercept)	5.0332354	0.613	8.204	0.000
m4	CPUE	0.4668849	0.051	9.129	0.000
m4	ISTI15_May	-0.3761665	0.082	-4.609	0.000
m5	(Intercept)	5.1986918	0.628	8.275	0.000
m5	CPUE	0.4692675	0.050	9.323	0.000
m5	ISTI20_May	-0.4111851	0.086	-4.761	0.000
m6	(Intercept)	6.1885346	1.089	5.681	0.000
m6	CPUE	0.4879450	0.058	8.369	0.000
m6	ISTI3_MJJ	-0.3785836	0.105	-3.621	0.002
m7	(Intercept)	6.7120995	1.035	6.487	0.000
m7	CPUE	0.4962538	0.054	9.170	0.000
m7	ISTI10_MJJ	-0.4555927	0.105	-4.322	0.000
m8	(Intercept)	6.9551755	0.965	7.209	0.000
m8	CPUE	0.4990322	0.051	9.833	0.000
m8	ISTI15_MJJ	-0.5075099	0.104	-4.891	0.000
m9	(Intercept)	7.0782279	0.909	7.783	0.000
m9	CPUE	0.5015600	0.048	10.371	0.000
m9	ISTI20_MJJ	-0.5456648	0.102	-5.327	0.000
m10	(Intercept)	4.7146749	0.560	8.423	0.000
m10	CPUE	0.4536812	0.052	8.807	0.000
m10	IS3_May	-0.3102179	0.069	-4.498	0.000
m11	(Intercept)	5.8517417	1.125	5.202	0.000
m11	CPUE	0.4731809	0.060	7.853	0.000
m11	IS3_MJJ	-0.3460234	0.108	-3.205	0.004
m12	(Intercept)	6.9293673	1.093	6.341	0.000
m12	CPUE	0.4725788	0.053	8.879	0.000
m12	Chatham_Strait_SST_MJJ	-0.4837577	0.113	-4.289	0.000

model	term	estimate	std.error	statistic	p.value
m13	(Intercept)	5.8907128	0.570	10.339	0.000
m13	CPUE	0.5001176	0.043	11.754	0.000
m13	Chatham_Strait_SST_May	-0.4935996	0.076	-6.469	0.000
m14	(Intercept)	6.9449013	0.952	7.293	0.000
m14	CPUE	0.4800203	0.050	9.673	0.000
m14	Chatham_Strait_SST_AMJJ	-0.5461599	0.110	-4.945	0.000
m15	(Intercept)	6.5665654	0.986	6.662	0.000
m15	CPUE	0.4752439	0.053	9.019	0.000
m15	Icy_Strait_SST_MJJ	-0.4280415	0.097	-4.392	0.000
m16	(Intercept)	5.4564543	0.519	10.509	0.000
m16	CPUE	0.5144098	0.044	11.692	0.000
m16	Icy_Strait_SST_May	-0.4594586	0.073	-6.280	0.000
m17	(Intercept)	6.5378101	0.890	7.342	0.000
m17	CPUE	0.4849005	0.050	9.615	0.000
m17	Icy_Strait_SST_AMJJ	-0.4923234	0.102	-4.835	0.000
m18	(Intercept)	6.8011220	0.976	6.967	0.000
m18	CPUE	0.4604035	0.051	9.097	0.000
m18	NSEAK_SST_MJJ	-0.4648662	0.099	-4.675	0.000
m19	(Intercept)	5.6755303	0.525	10.810	0.000
m19	CPUE	0.4852638	0.041	11.718	0.000
m19	NSEAK_SST_May	-0.4697650	0.071	-6.623	0.000
m20	(Intercept)	6.7569868	0.887	7.617	0.000
m20	CPUE	0.4701853	0.048	9.701	0.000
m20	NSEAK_SST_AMJJ	-0.5257282	0.103	-5.101	0.000
m21	(Intercept)	6.4006714	0.997	6.419	0.000
m21	CPUE	0.4784909	0.054	8.835	0.000
m21	SST_Jordan_MJJ	-0.4161797	0.100	-4.174	0.000
m22	(Intercept)	5.3700806	0.536	10.017	0.000
m22	CPUE	0.5185630	0.046	11.273	0.000
m22	SST_Jordan_May	-0.4529434	0.077	-5.919	0.000
m23	(Intercept)	6.4146402	0.898	7.143	0.000
m23	CPUE	0.4875430	0.052	9.449	0.000
m23	SST_Jordan_AMJJ	-0.4822201	0.104	-4.657	0.000

3.2 Performance Metrics

The model summary results using the performance metrics AICc, *MASE*, *wMAPE*, and *MAPE_LOOCV* are shown in Table 2. For all of these metrics, the smallest value is the preferred model. Models with Δ_iAICc ≤ 2 have substantial support, those in which $4 \leq \Delta_i$AICc ≤ 7 have considerably less support, and models with Δ_iAICc > 10 have essentially no support (Burnham and Anderson 2004). The performance metric *MAPE* was calculated as

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}|\frac{A_t - F_t}{A_t}|$$

where A_t is the observed values and F_t are the predicted values. The performance metric *wMAPE* was calculated as

$$wMAPE = \sum_{t=1}^{n}\frac{1}{w_t}\sum_{t=1}^{n}|\frac{A_t - F_t}{A_t}|w_t.$$

The AICc in Table 2 is the AICc value and not the Δ_iAICc. The performance metric AICc suggests that models m19 and m13 are the recommended models. The performance metrics *MASE* and *MAPE_LOOCV* suggest that models m16, m22, m19 and m13 are the recommended models. The performance metric *wMAPE* suggests that models m20, m16, m22, and m19 are the recommended models.

Table 2: Summary of model outputs and forecast error measures. These metrics included Akaike Information Criterion corrected for small sample sizes (AICc values), the mean absolute scaled error (MASE metric), the weighted mean absolute percentage error (wMAPE; based on the last 5 years), and leave one out cross validation MAPE (MAPE_LOOCV).

model	terms	fit	AdjR2	AICc	MASE	wMAPE	MAPE_LOOCV
m1	CPUE	27.568	0.627	30.21	0.399	0.184	0.116
m2	CPUE + ISTI3_May	23.986	0.790	18.77	0.284	0.134	0.087
m3	CPUE + ISTI10_May	23.592	0.803	17.28	0.276	0.128	0.084
m4	CPUE + ISTI15_May	23.599	0.810	16.52	0.278	0.119	0.084
m5	CPUE + ISTI20_May	23.994	0.816	15.74	0.274	0.111	0.082
m6	CPUE + ISTI3_MJJ	31.465	0.763	21.57	0.308	0.130	0.094
m7	CPUE + ISTI10_MJJ	30.411	0.797	17.99	0.286	0.119	0.087
m8	CPUE + ISTI15_MJJ	29.191	0.821	15.08	0.263	0.105	0.079
m9	CPUE + ISTI20_MJJ	28.281	0.838	12.85	0.246	0.092	0.073
m10	CPUE + IS3_May	23.412	0.805	17.09	0.269	0.127	0.083
m11	CPUE + IS3_MJJ	31.628	0.741	23.63	0.321	0.138	0.099
m12	CPUE + Chatham_Strait_SST_MJJ	23.659	0.796	18.17	0.298	0.092	0.088
m13	CPUE + Chatham_Strait_SST_May	19.138	0.873	7.20	0.238	0.077	0.070
m14	CPUE + Chatham_Strait_SST_AMJJ	24.394	0.824	14.80	0.277	0.072	0.080
m15	CPUE + Icy_Strait_SST_MJJ	20.922	0.800	17.64	0.294	0.090	0.087
m16	CPUE + Icy_Strait_SST_May	16.927	0.868	8.11	0.212	0.066	0.062
m17	CPUE + Icy_Strait_SST_AMJJ	21.063	0.819	15.36	0.282	0.077	0.083
m18	CPUE + NSEAK_SST_MJJ	21.710	0.813	16.18	0.286	0.078	0.084
m19	CPUE + NSEAK_SST_May	17.566	0.877	6.47	0.224	0.070	0.066
m20	CPUE + NSEAK_SST_AMJJ	21.877	0.830	14.00	0.270	0.063	0.078
m21	CPUE + SST_Jordan_MJJ	21.177	0.790	18.75	0.306	0.097	0.091
m22	CPUE + SST_Jordan_May	17.334	0.858	9.88	0.221	0.066	0.065
m23	CPUE + SST_Jordan_AMJJ	21.212	0.812	16.27	0.290	0.080	0.085

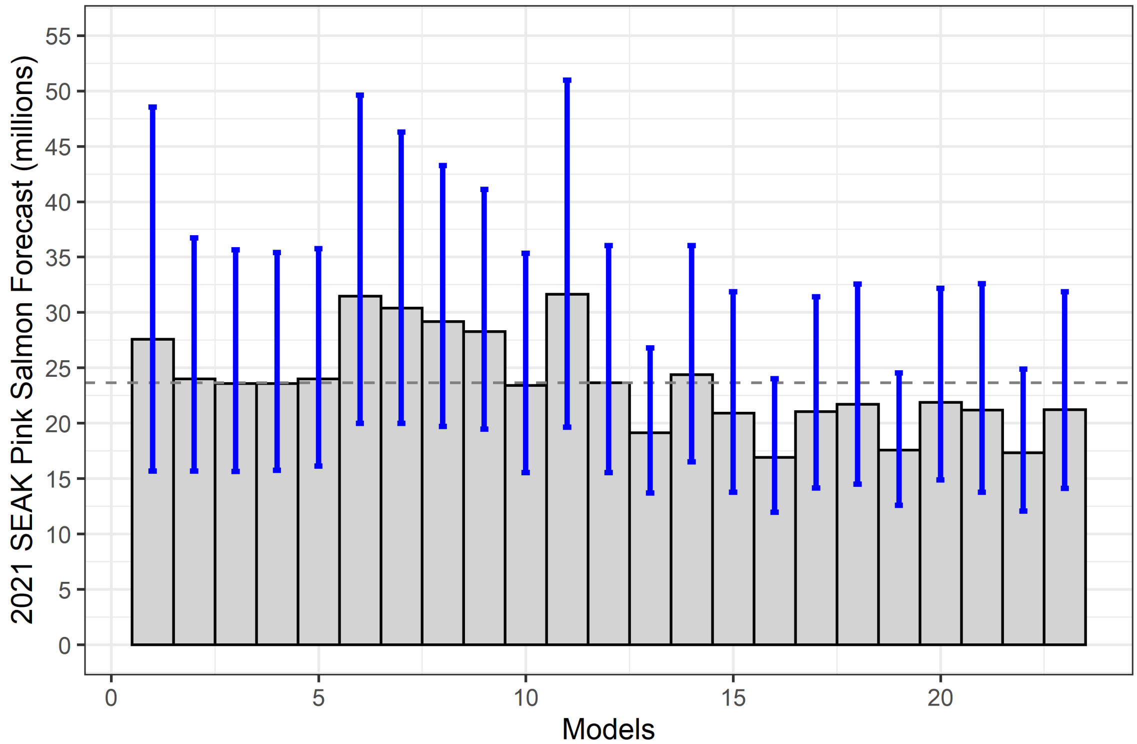

Figure 1: The 2021 SEAK pink salmon harvest (millions) forecast by model. The 80% prediction intervals (corrected for log transformation bias in a linear-model) around each forecast were calculated using the car package (Fox and Weisberg 2019) in program R (R Core Team 2020). The dotted horizontal line is the average forecast across all models. The SEAK pink salmon harvest in 2021 (based on the November 18, 2020 advisory announcement) was a point estimate of 28 million fish (80% prediction interval: 19–42 million fish).

4 References

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5 Appendix

Table 3: Parameter estimates for the 23 interaction models.

model	term	estimate	std.error	statistic	p.value
m1	(Intercept)	2.2891818	0.208	11.019	0.000
m1	CPUE	0.4379654	0.071	6.157	0.000
m2	(Intercept)	5.5000607	1.678	3.277	0.004
m2	CPUE	0.1034146	0.550	0.188	0.853
m2	ISTI3_May	-0.4028292	0.204	-1.972	0.063
m2	CPUE:ISTI3_May	0.0430304	0.066	0.650	0.523
m3	(Intercept)	5.3476073	1.787	2.992	0.007
m3	CPUE	0.2701309	0.598	0.452	0.656
m3	ISTI10_May	-0.4017039	0.226	-1.777	0.092
m3	CPUE:ISTI10_May	0.0244329	0.075	0.327	0.747
m4	(Intercept)	5.0806682	1.871	2.715	0.014
m4	CPUE	0.4499176	0.633	0.711	0.486
m4	ISTI15_May	-0.3823424	0.244	-1.565	0.134
m4	CPUE:ISTI15_May	0.0021937	0.081	0.027	0.979
m5	(Intercept)	4.7960554	1.886	2.543	0.020
m5	CPUE	0.6149077	0.643	0.956	0.351
m5	ISTI20_May	-0.3574078	0.253	-1.414	0.174
m5	CPUE:ISTI20_May	-0.0193146	0.085	-0.227	0.823
m6	(Intercept)	1.9591583	2.592	0.756	0.459
m6	CPUE	2.4143936	1.084	2.227	0.038
m6	ISTI3_MJJ	0.0165585	0.243	0.068	0.946
m6	CPUE:ISTI3_MJJ	-0.1788905	0.101	-1.780	0.091
m7	(Intercept)	2.2233006	2.370	0.938	0.360
m7	CPUE	2.4377236	0.939	2.596	0.018
m7	ISTI10_MJJ	-0.0114003	0.236	-0.048	0.962
m7	CPUE:ISTI10_MJJ	-0.1908928	0.092	-2.071	0.052
m8	(Intercept)	3.1474179	2.310	1.363	0.189
m8	CPUE	2.0406049	0.860	2.373	0.028
m8	ISTI15_MJJ	-0.1099114	0.242	-0.454	0.655
m8	CPUE:ISTI15_MJJ	-0.1599028	0.089	-1.796	0.088
m9	(Intercept)	3.9888764	2.279	1.750	0.096
m9	CPUE	1.7040630	0.819	2.081	0.051
m9	ISTI20_MJJ	-0.2082355	0.250	-0.833	0.415
m9	CPUE:ISTI20_MJJ	-0.1304306	0.089	-1.471	0.158
m10	(Intercept)	5.4729832	1.743	3.139	0.005
m10	CPUE	0.1891072	0.577	0.328	0.747
m10	IS3_May	-0.4033029	0.214	-1.884	0.075
m10	CPUE:IS3_May	0.0322978	0.070	0.460	0.650
m11	(Intercept)	2.4527240	2.679	0.916	0.371

model	term	estimate	std.error	statistic	p.value
m11	CPUE	2.0869230	1.161	1.797	0.088
m11	IS3_MJJ	-0.0250873	0.254	-0.099	0.922
m11	CPUE:IS3_MJJ	-0.1516223	0.109	-1.391	0.180
m12	(Intercept)	5.1805161	3.350	1.546	0.139
m12	CPUE	1.1206497	1.172	0.956	0.351
m12	Chatham_Strait_SST_MJJ	-0.3064132	0.340	-0.900	0.379
m12	CPUE:Chatham_Strait_SST_MJJ	-0.0654395	0.118	-0.553	0.586
m13	(Intercept)	4.4920196	1.991	2.257	0.036
m13	CPUE	1.0189622	0.708	1.439	0.166
m13	Chatham_Strait_SST_May	-0.3141302	0.256	-1.225	0.235
m13	CPUE:Chatham_Strait_SST_May	-0.0659378	0.090	-0.734	0.472
m14	(Intercept)	6.0246372	2.972	2.027	0.057
m14	CPUE	0.8146399	1.022	0.797	0.435
m14	Chatham_Strait_SST_AMJJ	-0.4422199	0.337	-1.313	0.205
m14	CPUE:Chatham_Strait_SST_AMJJ	-0.0375871	0.115	-0.328	0.747
m15	(Intercept)	5.8840374	2.742	2.146	0.045
m15	CPUE	0.7199518	0.916	0.786	0.441
m15	Icy_Strait_SST_MJJ	-0.3614611	0.268	-1.349	0.193
m15	CPUE:Icy_Strait_SST_MJJ	-0.0237539	0.089	-0.268	0.792
m16	(Intercept)	4.9193092	1.621	3.035	0.007
m16	CPUE	0.7136394	0.570	1.253	0.226
m16	Icy_Strait_SST_May	-0.3869900	0.220	-1.761	0.094
m16	CPUE:Icy_Strait_SST_May	-0.0265351	0.076	-0.351	0.730
m17	(Intercept)	6.2205746	2.471	2.517	0.021
m17	CPUE	0.5975071	0.817	0.732	0.473
m17	Icy_Strait_SST_AMJJ	-0.4569134	0.277	-1.651	0.115
m17	CPUE:Icy_Strait_SST_AMJJ	-0.0124870	0.090	-0.138	0.892
m18	(Intercept)	5.3567440	2.736	1.958	0.065
m18	CPUE	1.0065245	0.965	1.043	0.310
m18	NSEAK_SST_MJJ	-0.3198518	0.275	-1.162	0.260
m18	CPUE:NSEAK_SST_MJJ	-0.0546809	0.097	-0.567	0.578
m19	(Intercept)	4.4982267	1.664	2.703	0.014
m19	CPUE	0.9336459	0.602	1.551	0.137
m19	NSEAK_SST_May	-0.3162165	0.218	-1.452	0.163
m19	CPUE:NSEAK_SST_May	-0.0580543	0.078	-0.747	0.464
m20	(Intercept)	5.8500460	2.514	2.327	0.031
m20	CPUE	0.8068581	0.872	0.925	0.366
m20	NSEAK_SST_AMJJ	-0.4229203	0.286	-1.479	0.156
m20	CPUE:NSEAK_SST_AMJJ	-0.0380016	0.098	-0.387	0.703
m21	(Intercept)	5.8349102	2.817	2.071	0.052
m21	CPUE	0.6796370	0.935	0.727	0.476
m21	SST_Jordan_MJJ	-0.3604203	0.278	-1.296	0.211
m21	CPUE:SST_Jordan_MJJ	-0.0197165	0.091	-0.216	0.832
m22	(Intercept)	4.4637880	1.599	2.791	0.012
m22	CPUE	0.8607822	0.570	1.511	0.147
m22	SST_Jordan_May	-0.3294812	0.219	-1.504	0.149
m22	CPUE:SST_Jordan_May	-0.0459866	0.076	-0.603	0.554
m23	(Intercept)	6.1341893	2.519	2.435	0.025
m23	CPUE	0.5868566	0.832	0.705	0.489
m23	SST_Jordan_AMJJ	-0.4506805	0.284	-1.586	0.129
m23	CPUE:SST_Jordan_AMJJ	-0.0110908	0.093	-0.120	0.906