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Red snapper: Iterative re-weighting of data components in the Beaufort Assessment Model

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Introduction

In his review of the SEDAR24 draft report, Dr. Chris Francis (CIE reviewer) recommended iterative re-weighing of data components in the Beaufort Assessment Model (BAM). He also described methods to accomplish this task. His advice was followed by the Assessment Panel, and this working paper documents the procedure and results.

Methods

The BAM includes the capability for each component of the likelihood to be weighted by user-supplied values. For data components, these weights were applied by either adjusting CVs (lognormal components) or adjusting effective sample sizes (multinomial components). In this application to red snapper, CVs of landings and discards (in arithmetic space) were assumed equal to 0.05, to achieve a close fit to these time series yet allowing some imprecision. In practice, the small CVs are a matter of computational convenience, as they help achieve the desired result of close fits to the landings, while avoiding having to solve the Baranov equation iteratively (which is complex when there are multiple fisheries). Thus, weights on landings and discards were not adjusted. Weights on other data components (indices; age and length compositions) were adjusted iteratively.

Initial weights were those provided by the DW. For indices, the initial CVs were set equal to the values estimated by catch-rate standardization. Effective sample sizes of the multinomial components were assumed equal to the number of trips sampled annually, rather than the number of fish measured, reflecting the belief that the basic sampling unit occurs at the level of trip.

Using those initial weights, the BAM was fit first with steepness estimated, as preliminary model runs with steepness fixed lower than ~0.93 did not converge to reasonable solutions (R0 hit its upper bound and the stock was estimated to be severely depleted throughout 1955–2009). Based on the initial fit, we computed standard deviation of normalized residuals (SDNRs). Weights (w) were then calculated for multinomial components as w=1/SDNR^2, and approximated for lognormal components as w=1/SDNR. For multinomial components, these weights were applied as multipliers on the effective sample size (wN), and for lognormal components, as divisors on CV in arithmetic space (CV/w). The model was then re-fit using the new weights, and the procedure was continued until SDNRs were near 1.0 (to match the assumption of standardized residuals, i.e., distributed N(0,1)).

Then, starting from terminal weights in the above procedure, steepness was fixed at h=0.85 (the base model assumption), and the iterations were continued, again until SDNRs were near 1.0.

For indices, the normalized residual for year y was computed,

$$r_y = \log\left(\frac{U_{obs,y}}{U_{exp,y}}\right)/\sigma_y$$

where $U_{obs,y}$ and $U_{exp,y}$ are observed and expected values, and $\sigma_y = \sqrt{\log\,(1 + CV_y^2)}$. For composition data, the normalized residual for year y was computed,

$$r_y = (\mu_{obs,y} - \mu_{exp,y})/\, s.e.(\mu_{obs,y})$$

where $\mu_{obs,y}$ is the observed mean length or age, and $\mu_{obs,y}$ is the observed mean length or age, and s.e. is computed,

$$s.e.(\mu_{obs,y}) = \sqrt{\left[\sum_i (x_i - \mu_{obs,y})^2 P_{obs,iy}\right]/N_y}$$

Here, N_y is the assumed sample size, and $P_{obs,iy}$ is the observed proportion of fish in the ith length or age bin in year y with associated length or age x_i. The mean observed value is computed,

$$\mu_{obs,y} = \sum_i x_i P_{obs,iy}$$

and mean expected values are computed similarly.

Results and discussion

Table 1 shows results of iterative re-weighting when steepness was estimated. Table 2 shows results of iterative re-weighting when steepness was fixed at h=0.85; these weights were used in the assessment.

Not all data sources had enough years of data to compute meaningful SDNRs. Thus, those data sources borrowed weights from similar data sources for which weights could be computed. Length composition of commercial discards used the weight of length composition of commercial landings. Length and age compositions of the private fleet used the weights of length and age compositions (respectively) of the for-hire fleet.

Table 1. SDNRs and weights computed in model fits with steepness estimated.

steepness estimated		SDNR				Weights				Cumulative weights (for next iteration)			
		For-hire		Commercial landings		For-hire		Commercial landings		For-hire		Commercial landings	
Iteration	**Data type**	**landings**	**discards**	**lines**	**dive**	**landings**	**discards**	**lines**	**dive**	**landings**	**discards**	**lines**	**dive**
1	CPUE	5.6	1.7	5.1	-	0.18	0.59	0.20	-	0.18	0.59	0.20	-
a	Length comp	2.7	1.8	2.9	1.0	0.14	0.31	0.12	1.00	0.14	0.31	0.12	1.00
	Age comp	4.8	-	3.3	0.9	0.04	-	0.09	1.23	0.04	-	0.09	1.23
2	CPUE	1.3	0.8	1.1	-	0.77	1.25	0.91	-	0.14	0.74	0.18	-
b	Length comp	0.8	0.9	0.8	1.1	1.56	1.23	1.56	0.83	0.21	0.38	0.19	0.83
	Age comp	0.9	-	1.0	0.9	1.23	-	1.00	1.23	0.05	-	0.09	1.52
3	CPUE	1.2	0.9	1.0	-	0.86	1.06	1.00	-	0.12	0.78	0.18	-
c	Length comp	1.0	1.1	0.9	1.0	1.02	0.91	1.18	1.00	0.22	0.35	0.22	0.83
	Age comp	0.9	-	1.0	0.9	1.38	-	1.11	1.29	0.07	-	0.10	1.97
4	CPUE	1.1	1.0	1.0	-	0.93	1.05	1.00	-	0.11	0.82	0.18	-
d	Length comp	1.0	1.0	1.0	1.0	1.02	0.92	0.98	0.98	0.22	0.32	0.22	0.81
	Age comp	0.9	-	1.0	0.9	1.21	-	1.00	1.13	0.09	-	0.10	2.23
5	CPUE	1.03	0.96	0.99	-								
e	Length comp	0.99	1.00	1.05	1.00								
	Age comp	0.95	-	0.98	0.96								

Table 2. SDNRs and weights computed in model fits with steepness fixed at *h*=0.85, as in the base run. The shaded weights were applied in the assessment, resulting in the shaded SDNRs. Although one more iteration was performed, those weights were not used because they did not noticeably improve performance overall, but did degrade the CPUE fits somewhat.

			SDNR				Weights				Cumulative weights (for next iteration)			
			For-hire		Commercial landings		For-hire		Commercial landings		For-hire		Commercial landings	
steepness fixed 0.85			**landings**	**discards**	**lines**	**dive**	**landings**	**discards**	**lines**	**dive**	**landings**	**discards**	**lines**	**dive**
	6	CPUE	1.05	1.05	1.02	-	0.95	0.95	0.98	-	0.10	0.78	0.17	-
f		Length comp	1.38	1.48	0.92	1.01	0.53	0.46	1.18	0.98	0.12	0.15	0.25	0.79
		Age comp	2.97	-	1.09	1.18	0.11	-	0.84	0.72	0.01	-	0.09	1.60
	7	CPUE	0.95	1.11	1.02	-	1.05	0.90	0.98	-	0.11	0.71	0.17	-
g		Length comp	1.02	1.08	0.85	1.02	0.96	0.86	1.38	0.96	0.11	0.13	0.35	0.76
		Age comp	1.18	-	1.15	1.03	0.72	-	0.76	0.94	0.01	-	0.06	1.51
	8	CPUE	0.97	1.06	1.03	-	1.03	0.94	0.97	-	0.11	0.67	0.17	-
h		Length comp	1.05	1.03	0.90	0.99	0.91	0.94	1.23	1.02	0.10	0.12	0.43	0.78
		Age comp	1.19	-	1.10	1.18	0.71	-	0.83	0.72	0.01	-	0.05	1.08
	9	CPUE	1.03	1.05	1.04	-	0.97	0.95	0.96	-	0.11	0.63	0.16	-
i		Length comp	1.03	1.03	0.93	0.99	0.94	0.94	1.16	1.02	0.10	0.11	0.50	0.79
		Age comp	0.85	-	0.88	0.99	1.38	-	1.29	1.02	0.01	-	0.07	1.10
	10	CPUE	1.04	1.06	1.01	-	0.96	0.94	0.99	-	0.11	0.60	0.16	-
j		Length comp	1.06	1.04	1.01	1.00	0.89	0.92	0.98	1.00	0.09	0.10	0.49	0.79
		Age comp	1.04	-	1.02	0.96	0.92	-	0.96	1.09	0.01	-	0.07	1.20
	11	CPUE	1.04	1.00	1.01	-	0.96	1.00	0.99	-	0.10	0.60	0.16	-
k		Length comp	0.96	0.92	1.00	1.00	1.09	1.18	1.00	1.00	0.09	0.12	0.49	0.79
		Age comp	1.05	-	1.01	1.00	0.91	-	0.98	1.00	0.01	-	0.07	1.20
	12	CPUE	0.98	0.98	1.01	-								
l		Length comp	0.96	0.98	1.01	1.00								
		Age comp	1.05	-	1.01	0.99								