Notes on the weighting of the indices for the king mackerel VPA analyses

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The VPA results presented to-date (Cass-Calay et al, doc. AW-06) reveal that, with the current set of data and model assumptions, the fit to the fishery-independent indices is poor compared to the fit to the indices derived from fishery CPUE. This is worrisome from the point of view that the fishery-independent indices are constructed from surveys that use standard data collection methodologies year after year, and should thus be free of changes in catchability through time. On the other hand, the assumption of constant catchability for fishery-dependent indices is always subject to scrutiny because it is unlikely that the statistical standardization process can capture all of the factors that affect catchability over time.

The weighting of the indices currently used is to assign a year-specific CV to each index value (γ_{iy}), which is obtained from the CPUE standardization model. Then, an additional variance value, ϑ_i^2, is added to all the values in an index. The negative of the likelihood is computed for each index as follows:

$$-\ln(L_i) = 0.5 \sum_y \frac{\left(\ln(I_{iy}) - \ln(\hat{I}_{iy})\right)^2}{\sigma_{iy}^2} + \ln(\sigma_{iy}^2)$$

where

$\sigma_{iy}^2 = \ln(\gamma_{iy}^2 + 1) + \vartheta_i^2$ is the combined variance from the year-specific GLM estimates and the overall additive variance.

The ϑ_i^2 parameters can be estimated for each available series as explained by Geromont and Butterworth (2001), which is what has been done in the analyses presented to-date. But there may be other options for incorporating additional variance that could be, for example, based on expert opinion. This document briefly explores a few alternatives (Table 2).

The analyses done correspond to the VPA for the Gulf migratory unit that assumes that 50% of the catch in the mixing zone belong to that migratory unit. The γ_{iy} input values are given in Table 2. In terms of diagnostics and results, we present:

- fits to the indices (Figure 1)
- estimated additive variance parameters, ϑ_i (Table 3)
- log-likelihood values $\ln(L_i)$ (Table 4), and
- the average squared residual value, $\frac{1}{n}\sum_y\left(\ln(I_{iy}) - \ln(\hat{I}_{iy})\right)^2$ (Table 5)

Results for Runs 1, 2 and 3 are all very similar. In contrast, results for Runs 4 and 5 show somewhat improved fits to the fishery-independent indices, especially for the groundfish survey (which indexes recruitment) in the last few years of data. This improvement comes at the expense of rather worse fits to the fishery-dependent indices, especially during the most recent years.

These results highlight the fact that there is a conflict in the information about trends that the different indices are providing.

Alternative weighting schemes could be used to expertly to give more credence to some series than the others, as has been done here in Run 4. Or, as in Run 5, to give all series weights that are comparable overall and still retain information on year-to-year precision. Other alternatives are also possible, of course.

LITERATURE CITED

Geromont, H.F., and D.S. Butterworth. 2001. Possible extensions to the ADAPT VPA model applied to western North Atlantic bluefin tuna, addressing in particular the need to account for "additional variance". Col. Vol. Sci. Pap. ICCAT 52: 1663-1705.

Table 1. Different options examined for additional variance. There are 5 index series in the analyses, with series 4 and 5 being the fishery-independent ones.

Run	ϑ_i^2	**Explanation**
1	0 for all *i*	Weight the indices only based on the input CVs
2	Estimate for all *i*	Additional variance estimated as in the models to-date
3	Estimate for *i*=1,2,3	Additional variance estimated for fishery-dependent series only
4	Fix at 0.3^2 for i=1, 2, 3	Additional variance fixed arbitrarily for fishery-dependent series
5	Fix at 0.52^2, 0.43^2, 0.51^2, 0, 0.46^2 for *i*=1 to 5	Additional variance fixed for all series such that the mean value of σ_{iy}^2 for all series is of similar magnitude

Table 2. Mean CV (γ_{iy}) input for all series in each Run

	Run1	Run2	Run3	Run4	Run5
Index1	0.08	0.08	0.08	0.08	0.08
Index2	0.32	0.32	0.32	0.32	0.32
Index3	0.16	0.16	0.16	0.16	0.16
Index4	0.57	0.57	0.57	0.57	0.57
Index5	0.27	0.27	0.27	0.27	0.27

Table 3. Estimated additive variance parameters, ϑ_i for each Run

	Run1	Run2	Run3	Run4	Run5
Index1	0.00	0.06	0.08	0.30	0.52
Index2	0.00	0.00	0.00	0.30	0.43
Index3	0.00	0.11	0.11	0.30	0.51
Index4	0.00	0.67	0.00	0.00	0.00
Index5	0.00	0.26	0.00	0.00	0.46

Table 4. Estimated log-likelihood values $\ln(L_i)$ for each Run

	Run1	Run2	Run3	Run4	Run5
Index1	23.57	24.88	23.44	13.97	7.07
Index2	24.91	25.03	24.78	17.82	12.20
Index3	24.08	23.83	24.11	17.08	8.82
Index4	-18.22	-8.33	-16.62	-9.64	-4.11
Index5	4.43	7.88	4.43	3.98	5.75

Table 5. Estimated average squared residual value by index for each Run

	Run1	Run2	Run3	Run4	Run5
Index1	0.012	0.012	0.014	0.033	0.073
Index2	0.044	0.043	0.045	0.058	0.091
Index3	0.036	0.039	0.038	0.062	0.121
Index4	0.780	0.718	0.752	0.628	0.522
Index5	0.232	0.224	0.231	0.230	0.227

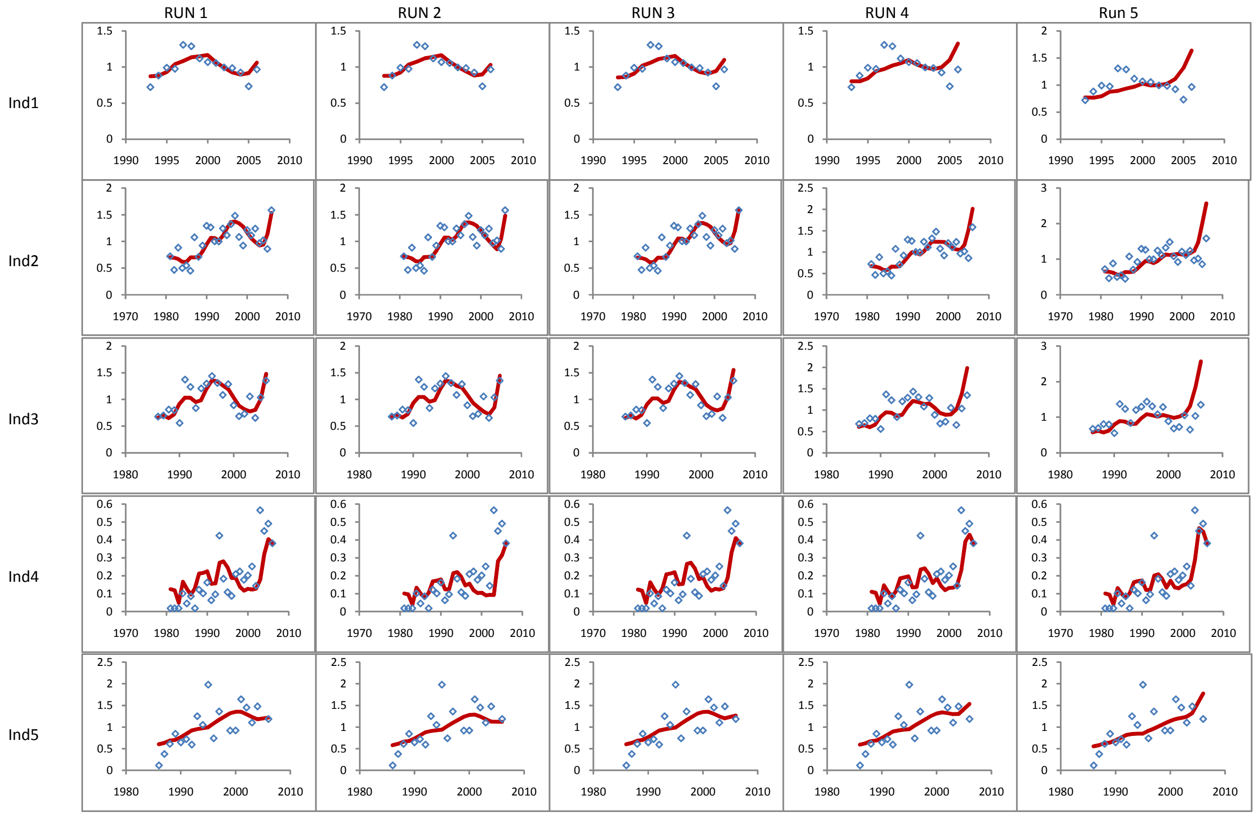

Figure 1. Observed (symbols) and predicted (lines) indices for Gulf of Mexico king mackerel using different variance weighting schemes (see Table 1). Indices 1 to 5 are: 1= Commercial; 2=MRFSS; 3=Headboat; 4=SEAMAP groundfish survey; 5=SEAMAP plankton survey.