Pribilof Islands red king crab random effects model

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Random Effects Model

A random effects model was fit to the survey male biomass (>=120mm) for estimation of MMB at mating (Model developed for use in NPFMC groundfish assessments). The random effects model uses the same CVs of biomass by year as calculated for the 3-yr running average. The random effects model was fit to the survey data at the time of the survey. The likelihood equation for the random effects model is,

$$\sum_{i=1}^{Yrs}\left[\ln(2\pi\sigma_i^2)+\frac{(B_i-\hat{B}_i)^2}{\sigma_i^2}\right]+\sum_{i=2}^{Yrs}\left[\ln(2\pi\sigma_\pi^2)+\frac{(\hat{B}_i-\hat{B}_{i-1})^2}{\sigma_\pi^2}\right]$$

Where,

B_i is the log of observed biomass in year i

$\hat{B}_i$ is the model estimated log biomass in year i

σ_i^2 is the variance of observed log biomass in year i

σ_π^2 is the variance of the deviations in log survey biomass between years (i.e. process error variance). σ_π^2 was estimated as $e^{2\lambda}$, where λ is a parameter estimated in the random effects model.

Yrs is the number of years of survey biomass values

The process error variance was not estimable for the Pribilof red king crab data due to the high variances of the yearly estimates of biomass. Figure 1 shows the random effects model fits with various fixed values of process error from 0.005 to 0.5 as well as the 3-year running average. The CPT in September 2016 and the SSC in October 2016 recommended investigating using a constant cv or standard deviation when fitting the random effects model. The average cv of mature male biomass was 0.67 and the median cv 0.648. The median cv of 0.648 allowed the estimation of process error at 0.006, however the model did not converge using constant standard deviations or with the average cv = 0.67 (Figure 2). A simple exponential model (Following Spencer, Figure 3) was used to estimate the variance ratio at 3.75 and the process error at 0.1 (Figures 2 and 3). The random effects model results in more smoothing than the 3-year running average model. The random effects model with process error fixed at 0.1 and the results with the estimated process error of 0.006 (constant cv = 0.648) could be viewed as bracketing an appropriate model for biomass estimation. Another method to approximate the process error is the estimate the variance of the first difference in log biomass. The variance of the first differences in log biomass for Pribilof red king crab is 0.046 and for Bristol Bay red king crab 0.089. Figure 2 shows the fit for a process error of 0.05 compared to 0.1.

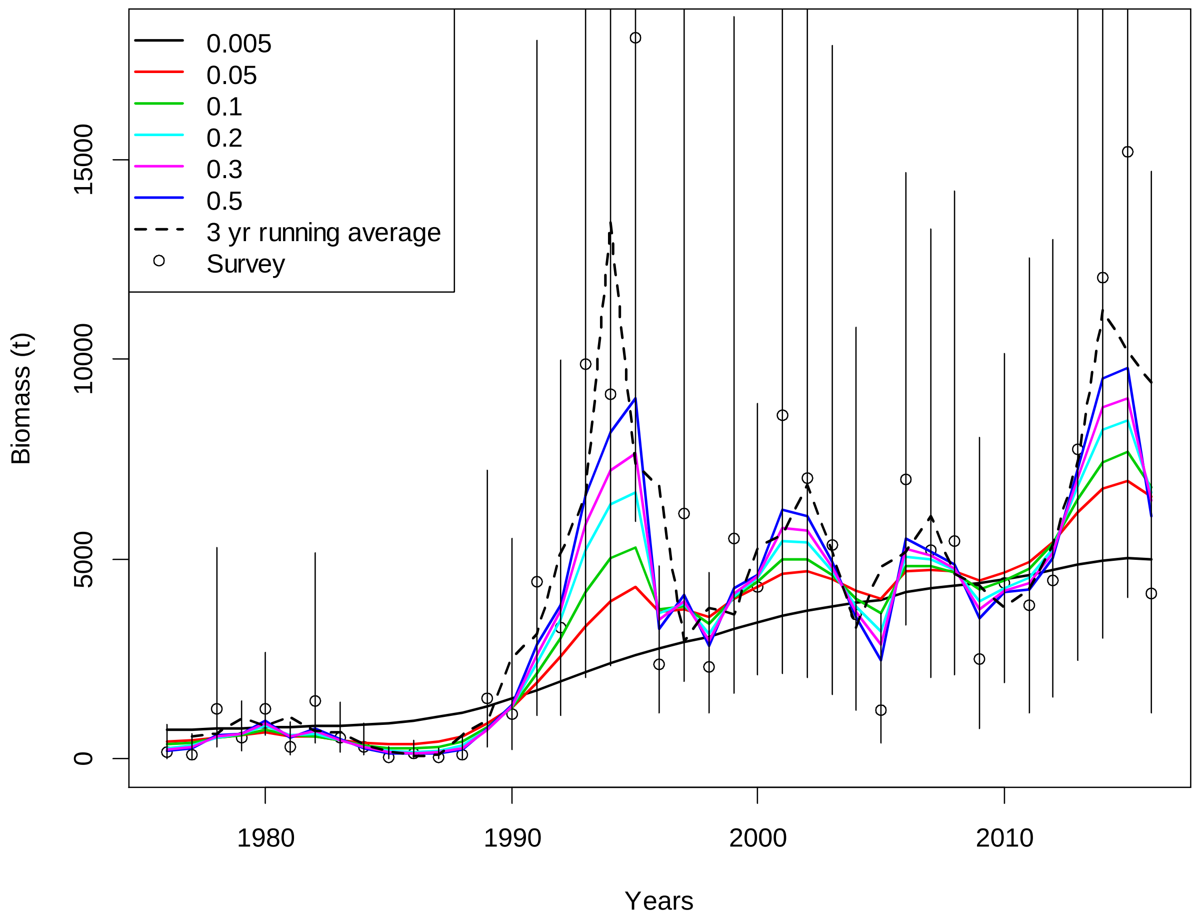

Figure 1. Random effects model estimates of mature male biomass with process error fixed at 0.005, 0.05, 0.1, 0.2, 0.3 and 0.5, and biomass estimated using the 3-year running average.

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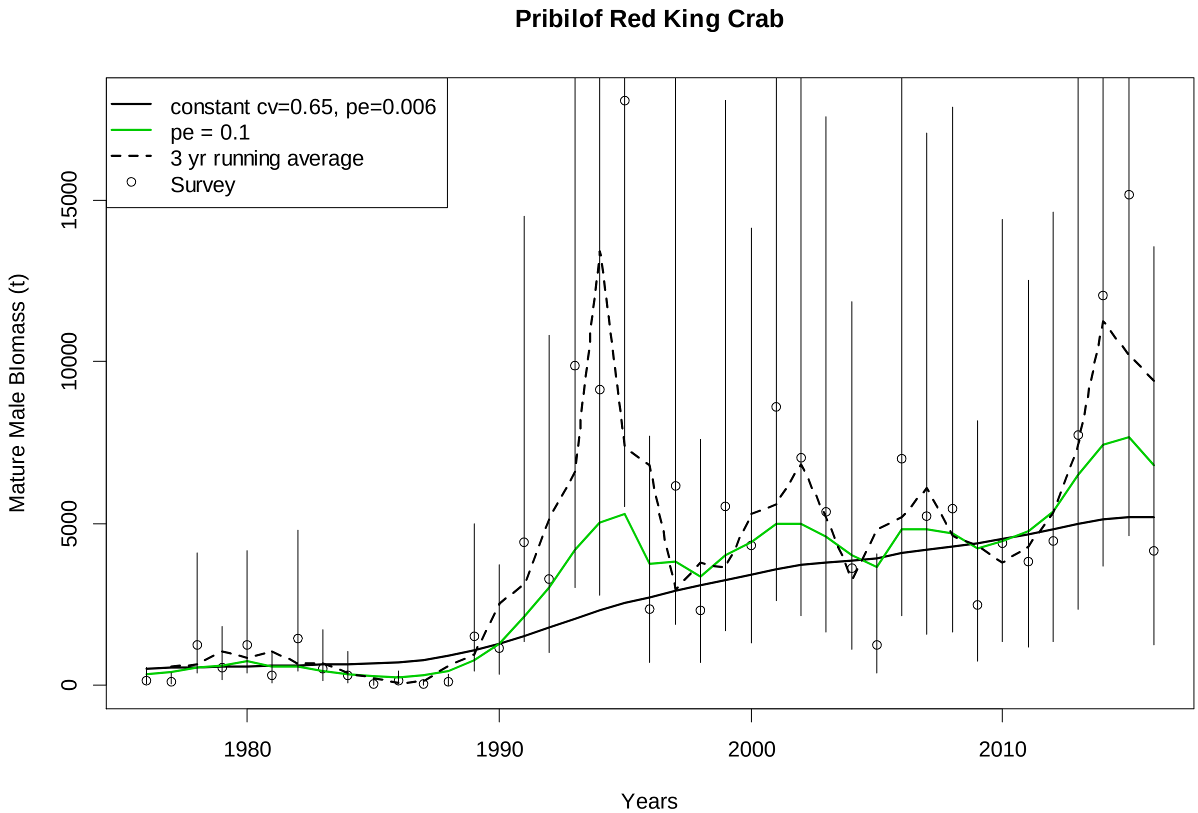

Figure 2. Random effects model estimates of Mature male biomass with process error estimated where cv of biomass was set at 0.648 for all years (pe=0.006), fixed at 0.1, and biomass estimated using the 3-year running average. Approximate lognormal confidence intervals were estimated using a constant cv = 0.648.

From Spencer presentation at Wakefield 2015

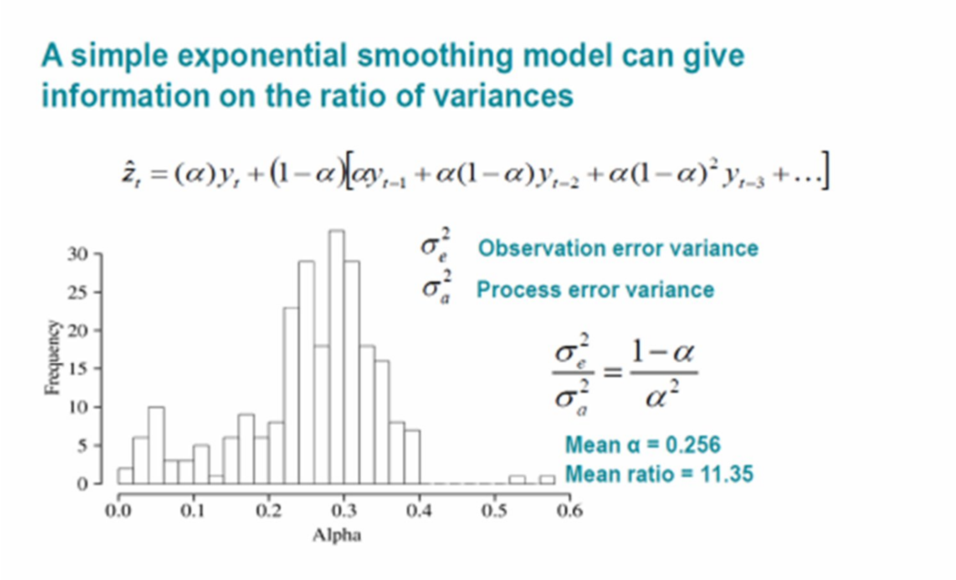

Figure 3. Using a simple exponential smoothing model to estimate the variance ratio of observation error and process error.