**Example Application VI (State-space production models)**

The production (or biomass dynamics) model in LECTC2.CPP and LECT2.R is an observation error estimator, i.e. all of the error is in the observation model and the population dynamics are assumed to be deterministic. This is a common way to fit production models, but may be sub-optimal. The standard Schaefer production model can extended to allow for process error as follows:

  (1)

where  is the biomass at the start of year *y*, *r* is the intrinsic rate of growth, *K* is the carrying capacity,  is the catch during year *y*, and  is the extent of process error. The standard observation error estimator corresponds to =0 for all years *y*. The objective function includes a penalty when process error is estimated, i.e.:

 (2)

Given Equation 1, there are now three formulations:

* the observation error estimator (=0 for all years);
* the errors-in-variables estimator (estimated but  pre-specified); and
* the state-space estimator (estimated and ).

It is hard to distinguish process from observation error so for this assignment  is assumed known. In addition, this example is based on two indices of abundance (unlike LECTC2 which had only one).

The tasks for this assignment:

* extend Ex5class.cpp to include a second index of abundance (hint: set Nsim to 1 avoid too many runs);
* extend the model to include process error (and Equation 2);
* run the simulations to see if there are benefits to a state-space formulation (could I have chosen better summary metrics);
* see what happens as the extent of process error (value of SigmaR) increases / the extent of observation error (value of SigmaI) decreases;
* examine what happens if you try to estimate the extent of process error as well as the extent of observation error; and
* think about what would make the extent of process error more estimable.