**Lecture 11 (Potential Biological Removals)**

The Potential Biological Removals (PBR) is a system for managing unintended bycatch of marine mammals in the USA. The PBR determines the maximum level of bycatch consistent with rebuilding to a target level using the formula:

(1)

where is the PBR for year *t*, is the maximum rate of increase, is the “minimum estimate of absolute abundance for year *t*\*” (the most recent year to year *t* for which there is an estimate of absolute abundance), and is the “recovery factor” (a value between 0.1 and 1). The value of is taken to be the lower yth percentile of the sampling distribution for the estimate of absolute abundance during year *t*, i.e. where is the estimate of absolute abundance for year *t*, *x* determines the yth percentile under the assumption that is lognormally distributed with a standard error of the logarithm of , where is the related to CV of the lognormal distribution according to or

The values for the parameters of Eqn 1 are based on management strategy evaluation. The operating model is a deterministic logistic population dynamics model in numbers, i.e.:

(2)

where *K* is carrying capacity, and is the catch during year *t* (assumed to be lognormally distributed about with a CV of CVC). is the bias of the bycatches relative to the PBR. Estimates of absolute abundance are assumed to be available every zth year with expectation given by and a CV of CVN, where is is the bias of the surveys.

**Task 1**.

* Read through the code and check it matches the equations above.
* The initial version of the MSE is provided in the “Lecture 11 Class.R”. The MSE should be used to select the value for “y” such that the probability of a stock initially at 0.3*K* will rebuild to 0.5*K* within 100 years is 80% for scenario 0 for values of 0.04 and 0.12 (corresponding to cetaceans and pinnipeds) when equals 1. Table 1 lists values for the parameters of the operating model for scenario 0. Hint: You will use the uniroot function in R.

**Task 2.**

* Part 1. Given the value of “y” from Task 1, run simulations for scenarios 1-7 to find the scenario / value for that leads to the lowest probability of recovery to 0.5*K* by year 100.
* Part 2. Find the value for such that the probability of recovery to 0.5*K* by year 100 is 80% for the scenario selected in Part 1.
* Part 3. Rerun scenarios 1-7 with the value of “y” selected in Task 1 and the value for from Part 2 of Task 2 to check that the probability of recovery for all scenarios is at least 80%.

Table 1. The values of the parameters for scenario 0.

|  |  |
| --- | --- |
| **Parameter** | **Value** |
|  | 0.04, 0.12 |
| CVC | 0.3 |
| CVN | 0.2 |
| *Z* | 4 |
|  | 1 |
|  | 1 |

Table 2. The values of the parameters for scenarios 1-7.

|  |  |
| --- | --- |
| **Scenario** | **Value** |
| 1 | CVC =1.2 |
| 2 | CVN =0.8 |
| 3 | *z* = 8 |
| 4 | = 1.2 |
| 5 | = 1.2 |
| 6 | *R*max is half assumed value |
| 7 | Survey CV is half assumed value |