Homework 3: FISH 553 Advanced R

Open a new script in R and put the following information at the top using comments:

```
# Name: First Last
# Homework 3
```

Complete the tasks below and be sure to label each question with comments as before. When your script is complete, save it as LastName_Homework3.R, then clear your workspace (Workspace/Clear all) and run through your script again to make sure you don't have any 'object not found' errors. Then go to the course website on Canvas to submit your R script.

Background

In this week's homework you will write R code to fit the famous Ricker curve (Ricker 1954) and Beverton-Holt curve (Beverton & Holt 1957) to spawner-recruit data.

The equation for the Ricker curve is:

$$R = aS\exp(-bS)$$

The equation for the Beverton-Holt curve is:

$$R = \frac{aS}{b+S}$$

For both models, *R* is the number of recruits (for salmon this is the number of fish that are old enough to be caught in the fishery), *S* is the number of spawners (adult fish), and *a* and *b* are parameters to be estimated.

We will be predicting the number of recruits from the number of spawning fish using a classic dataset for Skeena River sockeye salmon published in Shepard & Withler (1958). In the original paper, the authors drew by hand their best fit to the data (Figure 1 on the final page).

Question 1 (40 points)

Create a function Ricker.curve() that has arguments Ricker.a, Ricker.b, and sigma (parameters to be estimated), and a filename. For this problem the filename will refer to the data in file "HW3 Skeena sockeye.csv". The function will return the negative log-likelihood for the model fit to the data, assuming (as in the lectures) a normal likelihood function.

Write code that calls mle2() or optim() to find the estimates of Ricker.a, Ricker.b, and sigma that minimize the negative log-likelihood in Ricker.curve().

Starting values: reasonable starting values are a=5; b=0.001, sigma=1000. Try using method Nelder-Mead. Expected negative log-likelihood values are around 350-400 (or log-likelihood of -350 to -400).

In your R script, include the function call that results in the minimum negative log-likelihood.

Question 2 (40 points)

Repeat Question 1, but write a BevertonHolt() function that fits the Beverton-Holt curve to the model instead, with arguments BHa, BHb, sigma, and filename. As in Question 1, use mle2() or optim() to find the estimates of BHa, BHb, and sigma that minimize the negative log-likelihood, assuming a normal likelihood.

Hints: suitable starting values will be a=5000, b=1000, sigma=1000. To ensure that a and b remain positive, consider using method "L-BFGS-B" and setting upper and lower bounds on the three estimated parameters.

Question 3 (20 points)

To determine which model provides the best fit to the data, we use the small-sample corrected Akaike Information Criterion (AICc), which is based on the number of parameters we estimate in the model (p), the number of data points (n) that the model is fitted to, and the negative log-likelihood (-ln*L*) for the best model fit to the data:

$$\mathrm{AIC}_c = -2\ln L + 2p + \frac{2p(p+1)}{n-p-1}$$

Calculate the AICc* for the two models in Question 1 and Question 2. The model with the lowest AICc is the best model. In commented out notes in your R script, report the negative log-likelihood and AICc for each model, and report which model you think fits the data the best.

*For those attempting fully generalizable code, use logLik() to extract the log-likelihood from a temporary variable storing the outputs of lme2().

Hints: (1) mle2() returns the log-likelihood, optim() returns the negative log-likelihood. (2) Try a large number of starting values for a and b for both models. (3) Explore the model fits to the data by plotting the data and the model fits.

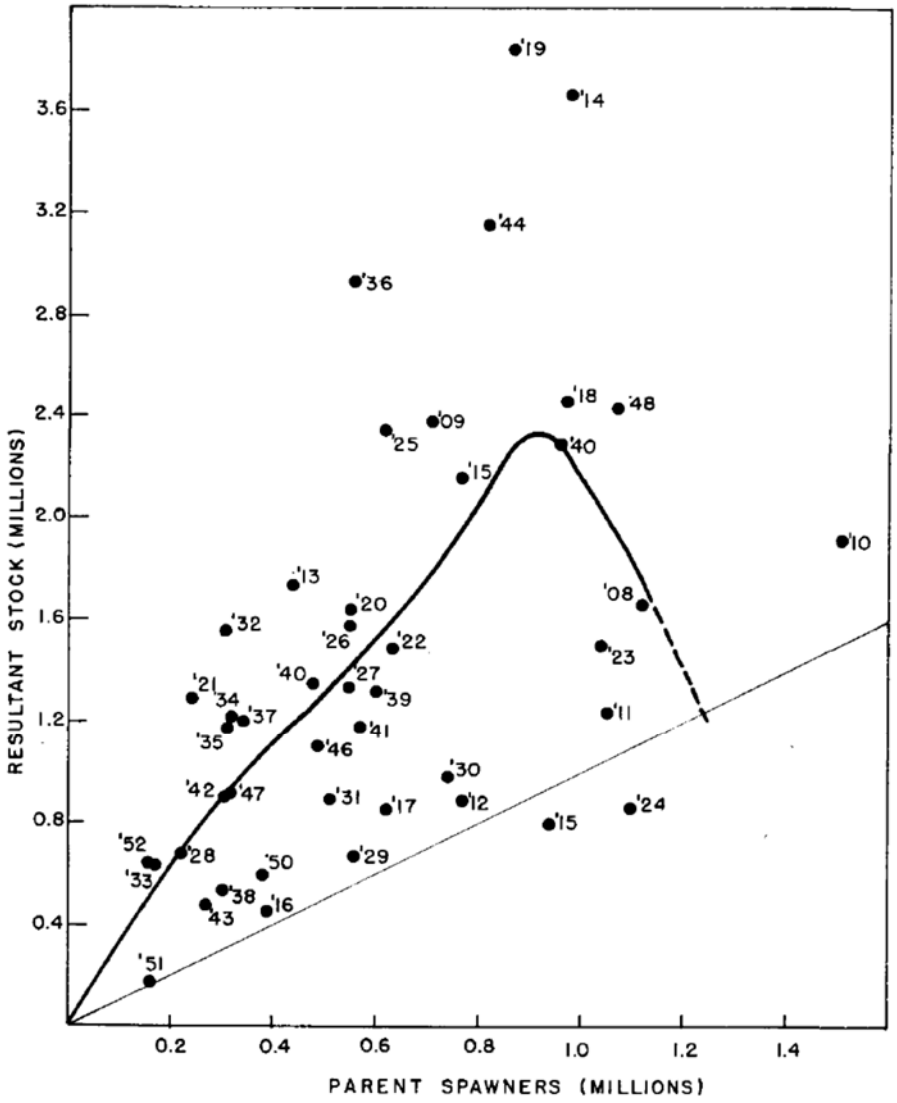

Figure 1. Skeena River sockeye salmon spawners (x-axis) and recruits (y-axis), as published in Shepard & Withler (1958).

References

Beverton, R. J. H. and S. J. Holt. 1957. On the dynamics of exploited fish populations. Fisheries Investigations Series II 19:1-533.

Ricker, W. E. 1954. Stock and recruitment. Journal of the Fisheries Research Board of Canada 11:559-623.

Shepard, M. P. and F. C. Withler. 1958. Spawning stock size and resultant production for Skeena sockeye. Journal of the Fisheries Research Board of Canada 15:1007-1025.