FISH 6004. Assignment 4

Due November 30, 2021

Marks: 25% of course total

Please copy R scripts and outputs into a word file and submit to me. Organize and label your results clearly. Use captions for any tables or figures you create. You will be marked for clarity of presentation as well as correct results. Email your completed assignment to me, noel.cadigan@mi.mun.ca

1. For the Von Bertalanffy growth model $L(t) = L_\infty(1 - e^{-kt})$, show mathematically that Faben's length increment model is $G(\Delta t) = L(t + \Delta t) - L(t) = \{L_\infty - L(t)\}(1 - e^{-k\Delta t})$. (*7 marks*)
2. The attached file "3Ps cod commercial stats.xlsx" contains some summary statistics taken from the 2019 research document for the assessment of the cod stock in NAFO Subdivision 3Ps. Some of these data look strange, which is not unusual in stock assessment.
    a. Plot average weight (y-axis) versus average length (x-axis) for 2014-2016. Use different (lines and/or points) colors to indicate years. Fit a length weight relationship, $W(l) = al^b$. Determine if there are there statistically significant differences among model parameters for each year? Use a log-weight model, $\log(w) = \log(a) + b * log(l)$. Provide plots of the model fit (predictions versus observations, and residuals), and comment (with rationale) on if you think the model fits well (7 marks).
    b. Using the estimates of *a* and *b* from 2a, fit a Von Bertalanffy weight-at-age model for each year. Use the Francis (1988) model formulation. Are there statistically significant differences among model parameters for each year? Provide plots of the model fit, and comment (with rationale) on if you think the model fits well (19 marks).
    c. Using the results from 2b, extrapolate weights for ages 1-20. Estimate the age-specific natural mortality rate (M) based on the extrapolated weights-at-age using equation (2) in Powers (2014). For this calculation only, assume $M_\infty = 0.1$ and $W_\infty = 25$ for 2014-2016. Plot the results and use colors to indicate years. (7 marks).
    d. Assume that the fishery selectivity function is logistic in form, with the age at 50% selection A50=6 and the age at 95% selection A95=8. Plot the yield per recruit curves for each year using the extrapolated weights in 2b) and M's in 2c). Comment on the differences in the curves. How different are Fmax's and F0.1's? (*7 marks*)
3. Stock-recruit data for 3LNO cod were extracted from NAFO SCR Doc. No. 18/028 (3NO_cod_sr.dat).

a. Fit a Hockey-stick stock-recruit curve. Plot the data and the predicted stock-recruit curve for SSB ϵ (1,300 000). Provide 95% confidence intervals for the parameters. Explain your results. (5 marks).

b. Plot residual diagnostics using the R function nlsResiduals(). Plot the residuals versus year and provide their estimated auto-correlation function (ACF). Is there evidence of model misspecification? (5 marks).

c. Fit a hockey-stick model with auto-correlated errors. Plot the predicted SR curve and compare with the predictions in 3a. Plot residuals and provide their estimated auto-correlation function. Is there still evidence of model misspecification? (5 marks).

d. Fit a Beverton-Holt SR model and compare predictions with the hockey-stick model estimated in 2a. Plot residual diagnostics using the R function nlsResiduals(). Plot the residuals versus year and provide their estimated auto-correlation function. Is there evidence of model misspecification? (5 marks).

e. Compute AIC for the models in 3a), 3c) and 3d). Which model does this statistic indicate is the best fitting? (3 marks).

4. Estimate a SURBA for 3NO cod based on the spring research survey indices. The data you need are provided in S3LNO.RData. Hint: The survey in the spring does not catch age zero cod because they are too small at that time. Hence, all the age zero indices are zero. This creates a SURBA problem if you try to estimate the relative size of the last cohort in the data series. An approach to this problem is to estimate the size of this cohort as the average of the 3 previous cohorts. Another approach is to start the SURBA model at age 1. (30 marks).

References

Francis, R.I.C.C., 1988. Are growth parameters estimated from tagging and age–length data comparable?. Canadian Journal of Fisheries and Aquatic Sciences, 45(6), pp.936-942.

Powers, J.E., 2014. Age-specific natural mortality rates in stock assessments: size-based vs. density-dependent. ICES Journal of Marine Science, 71(7), pp.1629-1637.