FISH 622 Final Examination

Curry Cunningham 2021

Instructions

This final exam is open book and you may reference your course notes and laboratories. ***However, the final exam must be completed independently, without any collaboration.***

The final examination is due by 11:59 pm on Friday April 30, 2021.

Please submit all components of the final exam (i.e. word document, Excel, and R script) via Blackboard, and name each file with your first and last name (e.g. **Exam_FirstName_LastName.docx**, **Exam_FirstName_LastName.R, Exam_FirstName_LastName.xlsx**). If requested, please insert short answers to questions and any useful and/or necessary model output or figures within your word document.

In the event you are unable to submit your completed assignment via Blackboard, please email it to me at: cjcunningham@alaska.edu.

Evaluation

This final exam will be graded out of ***50 possible points***.

Exam Contents

- **FISH 622_Final Exam 2021.pdf** (this file)
- **FISH 622_Final Exam 2021.xlsx** Excel workbook
- **FISH 622_Final Exam 2021.R** R script for exam problems
- **EBS_turbot_speciment.csv** Length-age data for EBS Greenland turbot sampled in the NOAA-AFSC EBS Bottom Trawl Survey

Problem #1 (5 points)

We have discussed the growth process for fish populations extensively throughout the semester. In the ***Problem 1*** sheet of the ***FISH 622_Final Exam 2021.xlsx*** workbook, please use the parameters listed in yellow at the top of the sheet to calculate length-at-age under the von Bertalanffy model and weight-at-age under the allometric growth model for Pacific halibut.

Next, please calculate spawning biomass at age for the female component of the population.

Include figures of length-at-age weight-at-age for each sex, and spawning biomass at age, in the word document you submit.

Problem #2 (10 points)

Over the course of the semester we have often described the mortality and productivity of a cohort across subsequent years/ages. In the ***Problem #2*** section of the ***FISH 622_Final Exam 2021.R*** script associated with this exam you will find several important parameters specified, including:

- The total number of ages: `Nage`
- The ages: `ages`
- The two parameters of the dome-shaped selectivity function
  - Age at which selectivity is maximized: `amax`
  - Width of the dome-shaped selectivity function: `delta`
- Fishing mortality: `Fmort`
- Natural mortality: `M`
- Number of age-1 recruits: `Nr`

You will also find two vectors for numbers-at-age `Na` and catch-at-age `Ca`.

Please use appropriate equations to:

1. Calculate dome-shaped selectivity-at-age: `sa`
2. Calculate fishing mortality at age: `Fa`
3. Calculate total instantaneous mortality at age: `Z`
4. Numbers at age: `Na`
   a. Note: `Na[1] <- Nr`
5. Catch at age: `Ca`

In the word document you submit with this exam, please plot:

- Total instantaneous mortality at age
- Numbers-at-age
- Catch-at-age

Problem #3 (5 points)

Matrix projection models can represent a useful way to simulate age, size, or spatial population dynamics. Please use the following formula to simulate size-structured population dynamics $\mathbf{N_{t+1}} = (\mathbf{XS} + \mathbf{R})\mathbf{N_t}$, for a model with 7 size classes.

In your ***FISH 622_Final Exam 2021.R*** script under ***Problem #3***, I have provided the size transition matrix ($\mathbf{X}$). To complete your model, please:

- Create your survival matrix ($\mathbf{S}$) assuming survival-at-size is:
  - Size class 1: 0.3
  - Size class 2: 0.4
  - Size class 3: 0.5
  - Size class 4: 0.7
  - Size class 5: 0.7
  - Size class 6: 0.8
  - Size class 7: 0.8
- Create your recruitment matrix ($\mathbf{R}$) assuming

- Fecundity
  - Size class 1-3: 0
  - Size class 4: 50
  - Size class 5: 100
  - Size class 6: 150
  - Size class 7: 200
- Early life survival (S_0) from egg to size class 1 is 0.04

Please copy/paste your $\mathbf{S}$ and $\mathbf{R}$ matrices into the word document your submit.

Problem #4 (15 points)

Create a matrix called `N` that has 7 rows and 25 columns. Simulate abundance at size across a 25 years as $\mathbf{N_{t+1}} = (\mathbf{XS} + \mathbf{R})\mathbf{N_t}$ populating your `N` matrix, using `Nstart` as the initial numbers at size in year 0 ($t = 0$).

Plot numbers-at-size across time (`N`) as stacked bars, and include this figure in the word document you submit.

Next, update your survival matrix to include for fishing mortality by multiply the survival rate for size-class i ($survival_i$) by $e^{-s_i F}$, as ($survival_i * e^{-s_i F}$), assuming:

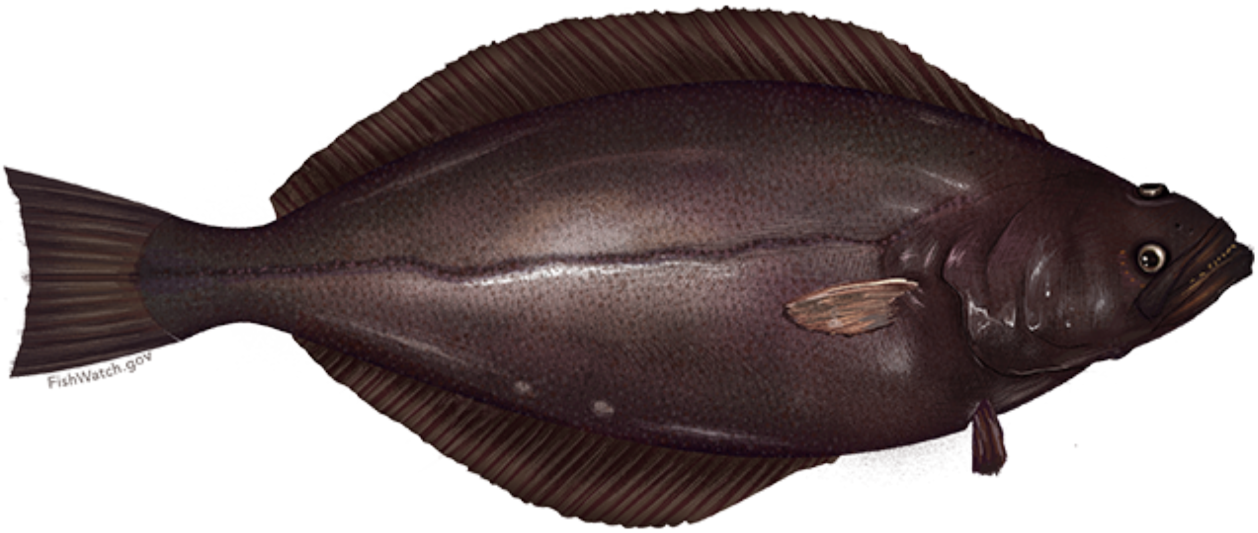
- The instantaneous “fully-selected” fishing mortality rate is $F = 0.2$
- Selectivity-at-size is:
  - $s_{i=1-3} = 0$
  - $s_{i=4} = 0.2$
  - $s_{i=5} = 0.5$
  - $s_{i=6} = 0.75$
  - $s_{i=7} = 1.0$

Simulate numbers-at-size across 25 years using `Nstart` as the initial numbers at size in year 0 ($t = 0$) and your new survival matrix ($\mathbf{S}$), accounting for fishing mortality. Use a new matrix called `N2`.

Plot numbers-at-size accounting for fishing mortality (`N2`) across time as stacked bars, and also include this figure in the word document you submit.

Problem #5 (15 points)

For this problem you are provided with individual specimen data for Eastern Bering Sea Greenland turbot (*Reinhardtius hippoglossoides*) sampled by the NOAA-AFSC Bottom Trawl Survey.



Please fit the von Bertalanffy model to the relationship between length and age for this species. I have provided initial code to load the data and subset to only specimen observations (rows) with complete length and age observations.

To complete this problem, you will need to create functions that:

- Predict length at age under the von Bertalanffy model
  - $L(age) = L_\infty\left(1 - e^{-k(age - t_0)}\right)$
- Calculate the negative log-likelihood of your model, given the data.
  - This function should assume a lognormal likelihood: `logLike <- dnorm(x=log(obs.length +1e-6), mean=log(pred.length +1e-6), sd=sigma, log=TRUE)`
  - Estimate L_∞, k, and σ in log space (to institute a lower bound at zero for these parameters) and t_0 in normal space as this parameter value could be below zero.

Please fit the von Bertalanffy model to these data. Report your estimates for L_∞, k, and t_0 in the word document you submit for the exam. Also, please plot your fitted model as a line, overlaid on the observed length-age data as points.

Thank You

Thank you for being my inaugural calls for FISH 622. I sincerely appreciate all of your hard work and feedback on how to improve the course for future iterations.