

# Overview of Statistical Stock Assessment FISH 6004 (Introduction to Fish Stock Assessment in R)

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## Course Outline for Fall 2021

Lectures are 1:00-4:00 pm each Tuesday, and labs are 9-11:30 am Thursdays.

No lab September 30 (to be confirmed) and November 11 (confirmed).

Fall semester break, October 11-12. No Lecture October 12.

## Lecture Topics

1. Overview of fish stock assessment (Sept 14)
  - i. *What is stock assessment (SA).*
  - ii. *SA vs. Management.*
  - iii. *Different types of SA.*
  - iv. *Fish population dynamics: growth, recruitment, mortality, intrinsic growth, carrying capacity.*
  - v. *yield vs. fishing effort.*
  - vi. *The progression of fishing a new stock, changes in the fish and changes in the fishery.*
  - vii. *SA data*
2. Fisheries Dependent and Independent (Surveys) Indices of Stock Size (Sept 21)
  - i. *Data from fisheries*
    - a. *catch per unit effort (CPUE),*
    - b. *interpreting fishery catch data (relation to stock abundance and distribution)*
    - c. *measures from individual fish (weights, lengths, age determination, condition factor)*
  - ii. *Data from surveys*
    - a. *Survey types (trawl, acoustic, fishery gear surveys, questionnaires to fishermen, visual counts)*
    - b. *Survey design (random, stratification, systematic, transect methods)*
    - c. *Survey indices and relation to stock abundance and distribution*
    - d. *Measures from individual fish*
3. Population Models and Management Reference Points (Sept 28)
  - i. *Exponential and Logistic models*
  - ii. *The surplus production model*
  - iii. *Yield per recruit (age-based)*

- a) *F<sub>max</sub> and derivatives (e.g., F<sub>0.1</sub>)*
  - b) *Age, weight and F – how to get the most from a fishery*
  - c) *Uncertainties in yield per recruit.*
- iv. *Spawner per recruit*
- v. *Age-based Maximum Sustainable Yield (MSY)*
- vi. *Discrete- and Continuous-time models*

#### 4. Models, Data, and Statistical Inference using R (2 lectures: Oct 5+19)

- i. *Bringing models and data together, judging how well model predictions and the data “fit”*
- ii. *Complexity in models, adding parameters, reality vs. simplicity*
- iii. *Methods to judge how well models and data “fit”*
- iv. *Least squares approach – residual error*
- v. *Non-linear estimation, using R to find minimum sum of residual error*
- vi. *Numerical optimization and root finding.*
- vii. *Estimating uncertainty about the model*
- viii. *Methods based on parametric statistics, SD, SE, 95% CI, Variance...Normal distributions*
- ix. *Bootstrap*

#### 5. Growth of Individual Fish (Oct 26)

- i. *Growth data – length and weight at age or weight at length, tagging data*
- ii. *Use of data and problems with extrapolations*
- iii. *Von Bertalanffy growth model for length at age ( $L_t = L_{inf}(1 - e^{-K(t-t_0)})$ )*
  - a) *estimation using nls()*
  - b) *weighted estimation*
  - c) *Regression confidence intervals and bootstrap-t*
  - d) *parameter collinearity*
  - e) *alternative formulation of the Von Bertalanffy model*
- iv. *Biphasic model*
- v. *Growth in Weight ( $W_t = a L_t^b$ )*
- vi. *Gompertz Growth Model*
- vii. *Fabens model for growth from tagging data.*
- viii. *Individual variability in growth*
- ix. *Non-random samples due to gear selectivity and sampling designs*
- x. *Age measurement error*
- xi. *Several populations*

#### 6. Population Model Estimation and Inference (Nov 2)

- i. *Estimation of Surplus Production Models*
  - a) *Parameter constraints versus estimation*
  - b) *Parameter correlations and model identifiability*
  - c) *Stock status evaluations*

- ii. *Implications of process error*
- iii. *A little on Bayesian methods*
- iv. *3LN redbfish case study*

## 7. Stock Recruitment models (Nov 9)

- i. *Importance of stock-recruit models in sustainable fisheries management*
- ii. *Properties of a good stock-recruit relationship*
- iii. *Important life-history processes*
- iv. *Stock-recruit data uncertainties*
- v. *Beverton-Holt, Ricker, Hockey-Stick models*
- vi. *Estimation*
- vii. *Auto-correlated errors*

## 8. Age Structured Population Models (Nov 16)

- i. *Why is Age Important?*
- ii. *Cohort Strength Model*
  - a) *Estimation*
  - b) *Case Study: 3NO cod*
- iii. *Cohort Strength Model with Random year Effects*
- iv. *SURBA: Survey-based cohort model*
  - a) *Estimation*
  - b) *Case Study: 3NO cod*
- v. *Retrospective Analysis*
- vi. *Harvest Advice*
  - a) *Catch multiplier projections*

## 9. Virtual and Sequential Population Analysis (Nov 23)

- i. *Virtual Population Analysis*
- ii. *Sequential Population Analysis*
- iii. *Convergence*
- iv. *Estimation*
- v. *ADAPT and other software*
- vi. *3NO cod ADAPT*

## 10. Modern Stock Assessment (Nov 30)

- i. *Integrated Assessments*
- ii. *Data weighting*
- iii. *State-space models*
- iv. *Northern cod – NCAM*
- v. *Censored likelihoods*
  - a) *catch*
  - b) *survey zero's*

- c) *partial surveys*
- vi. *Age Compositions*
  - a) *Additive logistic normal multinomial*
  - b) *Multiplicative logistic normal multinomial*
- vii. *Likelihood components*
- viii. *Future*
- ix. *Statistical Catch-at-Age (SCA): 3NO cod*

**Useful Texts:**

Modelling and Quantitative Methods in Fisheries by Malcolm Haddon  
Marine Fisheries Ecology by Jennings, Kaiser and Reynolds.

**Additional texts:**

A Guide to Fisheries Stock Assessment. From Data to Recommendations by Andy Cooper.  
Surveys of Fisheries Resources by Gunderson 1993  
Some papers will be assigned in lectures

**Marking scheme:**

Five assignments of 25 marks each (one every 2 weeks approximately). Course mark based on best 4 assignment marks. No exams.