Stock-recruitment and reference points

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Date: June 16–18, 2025
Location: Minnesota DNR's office space in Canal Park, Duluth, Minnesota
Time: Class is from 9am–12pm and 1pm–5pm

Software

Students should come to the workshop with **R**, **RStudio**, and the **RTMB** package installed:

- R: https://cran.r-project.org
- RStudio (free version): https://posit.co/download/rstudio-desktop/

To install the RTMB package, open R and run:

```
install.packages("RTMB")
```

Once RTMB is installed, follow this link and run through the calculations to check that the installation was successful:

https://cloud.r-project.org/web/packages/RTMB/vignettes/RTMB-introduction.html

If you run into issues, contact Charlie Belinsky.

Lessons and code will be shared via a github repository, which will be made available during the workshop.

Day 1: recruitment foundations and model fitting

Morning session: biological and conceptual foundations

- **Introductions and brief overview of the course**
- **An extended introduction to recruitment including:**
  - Basic life history and demographic processes that influence recruitment
  - Conceptual models of density dependence (compensation, depensation)
  - The rationale for modeling stock-recruitment relationships
  - Problems in the assessment of stock-recruitment relationships

Afternoon session: fitting stock-recruitment models in R

- Lecture on additional stock-recruitment parameterizations
- Simulating and fitting stock recruitment models in R

> **Note**
>
> If time allows, we will demonstrate errors-in-variables and the impact it has on stock-recruitment parameter estimates

Day 2: additional complexities, per-recruit calculations, and introduction to reference points

Morning session: recruitment complexities and per-recruit calculations

- **This session covers:**
  - Autocorrelation and other complexities
  - Vulnerability, yield per recruit, spawning stock biomass per recruit
  - More practice simulating and estimating models

> **Note**
>
> If time allows, we will estimate a hierarchical stock-recruitment model using RTMB

Afternoon session:

An extended introduction to biological reference points, including:

- **History and rationale**
  - Origins of MSY (maximum sustainable yield)
  - Evolution toward biological and proxy reference points
  - Kobe plots and sustainability status
  - Role of reference points in harvest control rules
- **Types of reference points**
  - Biological reference points: FMSY, BMSY
  - Limit vs. target reference points (e.g., Flimit, Btrigger)
  - Proxy reference points (e.g., F40%, SSB35%)
- **Ways to estimate reference points**
  - Equilibrium methods
  - Simulation-based methods

> **Note**
>
> If time allows, a group algebra exercise to derive equilibrium recruitment

Day 3: estimating reference points and harvest control rule design

Morning session:

- Estimating equilibrium and simulation-based FMSY, BMSY in R
  - Yellow perch example
  - Whitefish example

Afternoon session:

- **Lecture on the science and art of feedback policy design**
  - Dynamic programming and analytical solutions
  - Approximation in policy space
  - Management strategy evaluation and Monte Carlo simulation
  - Reinforcement learning

> **Note**
>
> If time allows, a demonstration of estimating simple linear control rules using approximation in policy space