**Exercise 2. Data-rich methods (Arctic sardine MU1)**

**Exercise Goal:** Identify ways to approach defining an LRP for Arctic sardine MU1 in a data-rich context.

**Exercise Questions:**

1. Evaluate at least 3 approaches to defining an LRP for Arctic sardine MU1and identify the “preferred” approach that you feel is most consistent with the candidate criteria for best-practice indicators and LRPs (and any other criteria you feel is important).
2. As a group, prepare a 1-2 slide (< 5 minute) presentation to explain

* Candidate approaches considered, and their pros/cons
* The preferred approach (indicator and LRP)
* The rationale for and underlying assumptions of the preferred approach and any considerations for the role of Arctic sardine as a forage fish
* Include a time series plot of the indicator and add a line to represent the LRP

**Background:**

An age structured model has been fit for Arctic sardine in MU1. The model is a multi-fleet Stock Reduction Analysis (SRA, Walters et al. 2006) fit using the Rapid Conditioning Model in [SAMtool](https://cran.r-project.org/web/packages/SAMtool/SAMtool.pdf). The SRA model applied here is comparable to other statistical catch-at-age (SCA) models such as iSCAM ([Martell 2017](https://github.com/smartell/iSCAM)). As an SRA, the model assumes historical catches are known exactly. The model assumes a Beverton-Holt stock recruitment (SR) relationship with steepness (*h*) of 0.75 and a constant natural mortality rate (*M*) of 0.3. The model was conditioned to catch and size composition data (50 years) and an acoustic survey of spawning stock biomass (years 26-50). The fleets consist of a purse seine fleet with logistic selectivity and a gillnet fleet with dome shaped selectivity.

**Dataset:**

* Mean weight-at-age (g), maturity-at-age (proportion mature), and vulnerability-at-age (proportion selected to the fishery) over the historical time period (50 years)
* Model-estimated spawning stock biomass (SSB in kt), recruitment (Rec of Age 0 in billions), total biomass (B in kt), catch (kt), fishing mortality rate (*F*), empirical acoustic index of SSB (kt) for years 26-50.
* Equilibrium *SSB0* and *SSBMSY* are calculated in the R script as a starting point

**Note:**

For the purpose of this exercise, the system is assumed to be at equilibrium (vital rates are assumed to be stationary). The variability in annual estimates of weight-at-age, maturity-at-age, and vulnerability-at-age is assumed to be random variation about the mean.

**Some options:** (some calculations have been started in the R script)

* Empirical indicator (acoustic index of SSB) and LRP
* Model-based indicator (e.g., SSB) and theoretical (e.g., *SSB0*, *SSBMSY*) or historical LRP (e.g., minimum SSB from which the stock as recovered)
* Model-based indicator based on stock recruitment relationship

Table 1. Data Files for Exercise 2

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| --- | --- | --- |
| File Type | File Name | Description |
|  | Exercise 2 Background Figures.html | Fishery background and figures |
| CSV layer | ex2\_at\_age\_data.csv | Natural mortality-, weight-, maturity-, and vulnerability-at-age |
| CSV layer | ex2\_data.csv | SSB, recruitment, total biomass, catch, F, acoustic index by year  Survey indices for entire stock are and MU1 by year |
| C:\Users\barretttj\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\3B9046F.tmp | ex2.R | R script that imports data with plots and calculations started |
| C:\Users\barretttj\AppData\Local\Microsoft\Windows\INetCache\Content.MSO\3B9046F.tmp | functions.R | R script with functions (in main LRP directory) |