Pre-workshop Exercise Solution

Objective: To familiarize participants with reference point calculations in Excel or R and explore the influence of various parameters (e.g., natural mortality rate and steepness of the stock recruitment relationship) on reference points.

Data: inputs.csv

- Weight-at-age (kg)
- Maturity-at-age (proportion)
- Vulnerability-at-age (proportion)
- Natural Mortality rate (M)
- Unfished Equilibrium Recruitment (R_0 = number of age 1 recruits in millions)
- Steepness (h) of the Beverton-Holt stock recruitment relationship

Files:

- Example calculations and equations in Excel: Pre-Workshop Example Calculations.xlxs
- R functions and script to read in data: Pre-Workshop_Exercise.R and functions.R
- A list of example limit reference points has been provided in the Workshop Folder.

Exercise:

For this exercise, answer each of the 11 questions below, using the Excel spreadsheet or R script where necessary from the input data provided. Enter your answers in the table below. When completed, your answers can be checked in the solution file.

Question	Instructions (Excel)	Your Answer
1. What does ϕ_0 mean? a) The average biomass (kg) of spawning individuals in an unfished stock b) The spawning biomass (kg) that would be produced by the average recruit over its lifetime in an unfished stock c) The average biomass (kg) of a new recruit in an unfished stock		b
2. What is the unfished spawning biomass per recruit (ϕ_0), in kg/recruit?	***Excel Hint:*** Look at tab "phi0." Identify the correct value.	8.65
3. What does spawning potential ratio (SPR) mean? a) The proportion of spawning biomass that is produced by the average recruit when the stock is fished at a fishing mortality of F = x, compared to what would be produced by the average recruit if the stock was unfished. b) The ratio between the average biomass of spawning individuals under fished (F = x) versus unfished conditions. c) The proportion of recruits surviving to spawn at least once under fished (F = x) versus unfished conditions.		a
4. What is SPR at: a) F = 0.2 b) F = 0.5	***Excel Hint:*** Look at tab "phiF SPR YPR". Change the values of F in cell **B6**, and report the value of SPR for each.	a) 0.53 b) 0.35
5. What fishing mortality (F), provides an SPR of: a) 40% b) 35%	***Excel Hint:*** Method 1. Look at tab "SPR YPR all F". In the What-If Analysis data table, identify the relevant SPR value (cells **B30-B280**), and read off the corresponding F value.	a) 0.37 b) 0.49

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	Method 2. Look at tab "Fx%SPR". Change the values of X in cell **B21**, and report the value of F for each.	
6. What is the equilibrium spawning stock biomass (SSB) at SPR 40% and SPR35% ($SSB_{F40\%SPR}$ and $SSB_{F30\%SPR}$)? Assume no stock-recruitment relationship. Do $SSB_{F40\%SPR}$ and $SSB_{F30\%SPR}$ change with changes in natural mortality (*M*), e.g., from 0.2 to 0.3?	***Excel Hint:*** Look at tab "SSB at Fx%SPR". Change the values of X in cell **B21**, and report the value of equilibrium SSB at this F for each. Change **M_age** as needed.	M= 0.2: 14.9kt, 13.0kt Yes M=0.3: 7.82kt, 6.83kt
7. What is the equilibrium SSB in unfished conditions (SSB_0)? Does SSB_0 change if the SRR changes, e.g., if steepness (*h*) increases from 0.65 to 0.9 and R_0 remains constant? Does SSB_0 change if *M* changes, e.g., from 0.2 to 0.3?	***Excel Hint:*** Look at tab "SRR and Yield." Identify the correct value. Change **h** and **M_age** as needed.	37.0kt, No Yes: M=0.3: 19.5kt
8. What is the equilibrium SSB that is associated with 50% Rmax when assuming a Beverton-Holt stock recruitment relationship? Does this value change if steepness increases from 0.65 to 0.9 and R_0 remains constant? Does this value change if *M* changes, e.g., from 0.2 to 0.3 for *h* = 0.65?	***Excel Hint:*** Look at tab "SRR and Yield." Identify the correct value. Change **h** and **M_age** as needed.	5.75kt, Yes: h=0.9: 1.06kt, Yes: M=0.3, 3.04kt
9. What is equilibrium spawning stock biomass at maximum sustainable yield (SSB_{MSY})? How does SSB_{MSY} change if steepness increases from 0.65 to 0.9 and R_0 remains constant? Does SSB_{MSY} change if *M* changes, e.g., from 0.2 to 0.3 for *h* = 0.65?	***Excel Hint:*** Look at tab "MSY." Identify the correct value. Change **h** and **M_age** as needed.	12.1kt Yes: h=0.9: 9.26kt Yes: M=0.3: 6.32kt
10. What is the value of the ratio SSB_{MSY}/SSB_0?	***Excel Hint:*** Look at tab "MSY." Identify the correct value. Change **h** and **M_age** as needed.	0.33 Yes: h=0.9: 0.25

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Does SSB_{MSY}/SSB_0 change if steepness increases from 0.65 to 0.9 and R_0 remains constant? Does SSB_{MSY}/SSB_0 change if *M* changes, e.g., from 0.2 to 0.3 for *h* = 0.65?		Yes: M=0.3: 0.32
11. Which reference points estimated above ($SSB_{F40\%}$, SSB_0, $SSB_{50\%Rmax}$, and SSB_{MSY}) depend on assumptions about the steepness (*h*) of the stock-recruitment relationship? Assume that R_0 remains constant. Which of the reference points depend on assumptions about the value of natural mortality (*M*)?		h: $SSB_{50\%Rmax}$, SSB_{MSY}; M: All of them