CONCH SIMULATOR

EXCEL PROGRAM DOCUMENTATION

I) Program 'CONCH_GROWTH_GOMPERTZ'

1) **'Conch_Growth_Gompertz.xls'** is a spreadsheet program to create individual growth curves under the Gompertz function. Individual variability is achieved by incorporating random error, with known probability distribution, in the growth parameters.

2) Assumes that growth follows the Gompertz function.

3) Needs: a) Point estimates of a growth-in-weight function for queen conch (or other species if desired).

4) Assumes Normal (Winfinity, G) and Uniform (W0) distributions of the parameters (can change assumption).

- The Normal distribution needs the mean and standard deviation of the parameters.

- The Uniform distribution needs the upper and lower values of the parameters.

Instructions:

1) Define growth parameters (from literature, simulation, or local growth studies)

2) Create multiple sets of random growth parameters (drag cells A51 to D51 to generate desired number of individual growth curves).

**Here, the Normal distribution is used for Winf and G, Uniform for W0.

3) Estimate Weight at Age for each individual growth curve.

4) (calculated with each set of random parameters).

5) Create a number of individual growth curves for weight-at-age

6) Plot the growth curves.

7) Press F9 key to generate new random curves.

II) Program CONCH_SIMULATOR

1) **'Conch_Simulator.xls'** is an age-based fisheries simulation model for queen conch, adapted from the Fortran Program 'CONCHMGTSIM' (Valle-Esquivel, 2003) for spreadsheet use.

2) The assumptions and equations used in the model are provided in Section 7 of the manual.

3) The program creates a conch population and simulates exploitation patterns to generate fishery yields.

4) The population model follows growth, maturity, natural mortality, and recruitment patterns, with conch-specific parameters (from '**Parameters_Conch_Simulator.xls'**).

5) Population structure can be modified by changing the parameters of the growth, maturity, natural mortality, and growth functions. The proportion of mature by age can follow a normal probability distribution or a knife-edge assumption. Natural mortality can be constant.

6) The fishery is represented by a single fleet with its corresponding fishing effort, catchability, selectivity, and fishing mortality patterns.

7) Different patterns of exploitation can be simulated by changing fishing effort, catchability, and selectivity.

8) All components are age-based. Ages 0-10, in annual steps are included. Can be expanded to include more ages or different time steps (e.g. Age 0.1, 0.2, …., 9.8, 9.9, 10).

9) The program runs for 31 years, in annual time steps. The exploitation period runs for 20 years (years 1 to 21), the management period (in management scenarios only) runs from years 22 to 31. The first year (year 0) represents the virgin population, which is exposed only to fishing mortality.

10) The number of years and the time step can be modified (e.g., to fractions of years, months, or weeks). To modify the time step, other annual parameters (e.g., natural mortality, growth) must be changed accordingly.

11) The (age-structured) variables of interest are known over the whole exploitation and management periods: effort, fishing mortality (F), population size (numbers), spawning stock (numbers), total biomass (kg), spawning stock biomass (MT), recruits (numbers), catch (numbers), yield (kg), CPUE (kg/unit effort). The biomass depletion levels at the end of the exploitation and the management periods are known.

12) Eight simulation scenarios are provided in separate spreadsheets to illustrate the implementation of the conch simulator. The assumptions are described in Section 7 of the Manual.

I) Scenarios to illustrate the effect of different fishing mortality levels:

1) Base-Case Scenario - Intermediate Depletion Level, DL=50%

2) Low Depletion Level, DL=20%

3) High Depletion Level, DL= 80%

II) Scenarios to illustrate implementation of management regulations on a severely depleted stock (DL=20%):

4a) Change Size Limit Hist.– the selectivity is modified to only recruit conch of older ages into the fishery. Applied during the historical period.

4b) Change Size Limit Mgt- The program is extended to have different selectivities in historic and management periods. The selectivity (1) in the historic period remains at base-case (20% depletion) level (recruitment at age 2); selectivity (2) during the management years is increased to recruit older (larger), age 4 conch.

5) Fishing Effort Reduction (F10% Reduction) – Effort is reduced by 10% each management year, Effort (year 31) = 0.

6) Temporal Closures – A permanent 10 year-closure is implemented during the management period, which is extended by an additional 10 years to reintroduce fishing mortality at historic levels. Seasonal closures cannot be implemented in the current configuration, unless the simulation time-step is changed to Months.

7) Variable Effort – Increase then decrease. A 10% increase is applied each year during the historic period, and a 5% reduction is implemented in the management period.

Instructions

1) Yellow highlights indicate cells where changes need to be applied for each scenario.

2) Configure parameters (based on models in '**Parameters_Conch_Simulator.xls'**).

a) Gompertz growth function
b) Beverton-Holt SRR
c) Set the percent maturity-at-age
d) Set initial number of recruits
e) Set natural mortality function (M) parameters for M-at-Age OR set M at constant value for all ages.

3) Set the number of ages- Currently configured for Ages 0-10.

4) Set the Selectivity by age (can approximate a meat weight selectivity from MW-at-Age). Not selected (not recruited into the fishery)= 0; Selected=1.

5) Choose desired Depletion Level (option to choose DL in numbers or biomass).

6) To find appropriate fishing effort (f) or catchability (q) to achieve desired selected Depletion Level use GOAL SEEK function in Excel (In DATA tab – WHAT IF ANALYSIS – GOAL SEEK):

A) To find FISHING EFFORT:

1. Fix the catchability by fixing the Q multiplier (Qmult) to desired level:

Q1 = 0.00001 * Qmult.

2. Find the f multiplier (Fmult) that will produce a desired DL by the end of the historic period. Fmult scales effort in year 1 to give appropriate (scaled) efforts over the time series. Effort values for years 2-31 change with respect to effort 1.

Effort 1 = 1000 * Fmult
Fmult * Effort in year 1 = Scaled Effort levels for years 1-31.

Example: Sheet '**INT_DL_50%-Base_case'**
GOAL SEEK
SET CELL **B43** (DL)
TO VALUE **0.5** (for base-case DL=50%)
BY CHANGING CELL **B40** (Fmult)

3. Base-case configuration is for CONSTANT effort over the time-series.

4. To change effort pattern over time, change efforts in years 2, 3,…, 31 WITH RESPECT TO EFFORT IN YEAR 1.

B) OR, to find CATCHABILITY:

1. Fix effort level by fixing Fmult

2. Use GOAL SEEK to find Qmult that will produce desired DL.

3. Base-case configuration has CONSTANT Q over time. Can change catchability pattern by changing Q in years 2, 3, …31 WITH RESPECT TO Q IN YEAR 1.

Example: Sheet '**INT_DL_50%-Base_case'**
GOAL SEEK
SET CELL **B43** (DL)
TO VALUE **0.5** (for base-case DL=50%)
BY CHANGING CELL **B41** (Qmult)

7) Management scenarios assume a depleted stock at 20% (Scenario 3). Other scenarios use base-case DL= 50%.

8) A summary of the variables of interest and corresponding figures with trajectories are provided at the bottom of each spreadsheet.