Primer for Surplus Production Method –

Schaefer Depletion Estimators

# Summary

The main reason for assessing fish stocks is to prevent declines in the stock that could result in collapse, which would result in a number of negative social and economic outcomes for local communities. Even data limited fisheries have a variety of data available to them to assess stock condition. In those cases where there has been long-term collection of catch and effort data, a surplus production model can be used to determine MSY-based reference points and overall stock condition.

This is a guide to use a Schaefer surplus production model to estimate maximum sustainable yield (MSY) and the stock biomass at maximum sustainable yield (BMSY) to determine the stock condition.

# Introduction

The main reason for assessing fish stocks is to prevent declines that could result in collapse. Even the most complex modern stock assessment methods are based on some basic data, particularly the catch of fish from all the fisheries. Total catch is the basis of some of the oldest models, surplus production models. Some of these models have been in use since the mid-20th century and are still used today in both data rich and data limited fisheries.

In this primer, we will walk through the steps to apply a Schaefer surplus production model (1954) to fishery catch and effort data. This method is based on biological process of birth, death, and growth as well as an assumption that the fishery catch or catch per unit effort are a reflection of the general stock increases and decreases.

# Description of Schaefer Production Model

In the simplest sense, all populations change from year to year based on how many how many are born and how many die. The same general principles apply when looking at fish stock biomass, where the biomass of fish available in any given year can be determined by the biomass that existed last year, which is then increased by the biomass of recruits and the growth in overall biomass over the year and decreased by the amount of biomass that dies from both natural mortality and catch (Hilborn and Walters, 1992).

The Schaefer model in particular is based on a logistic growth model with the added impact of catch (Hilborn and Walters, 1992). This method estimates stock biomass and fishing mortality using catch, effort, and any available indices of relative abundance without the inclusion of stock age or length structure. This model does not reflect any age structure in a population, and the dynamics of natural mortality, growth, and recruitment are aggregated into a single intrinsic rate of population biomass increase, modified by fishing mortality. It also assumes that the CPUE is proportional to the stock abundance.

The term surplus production is based on the concept that on average over time fish populations produce more young than are needed to sustain the population (Hilborn and Walters, 1992). Therefore, those “extra” fish may be safely harvested. The most common fishery reference point is based on maximum sustainable yield. This is the greatest amount of catch or yield that can be removed while keeping the stock sustainable. Fishing at levels beyond MSY long term leads to stock depletion.



Figure 1. Theoretical surplus production curve that show maximum sustainable yield (MSY) for surplus production and the stock biomass at maximum sustainable yield (BMSY).

# Calculating Schaefer Method

**Step 1: Getting Started**

1. Target Species
	1. Determine a target species for which there are at least ten years of total catch data (if discards are low, then you can use just landings), fishery effort, and an associated index of relative abundance.
	2. It will be necessary to determine a value of intrinsic rate of population growth, which may be researched from FishBase or the literature for the species.
2. Excel Spreadsheet
	1. Use the Excel spreadsheet to hold the data (in the Data sheet) and conduct analyses (in the Main sheet).

**Step 2: Input Data**

Input the following data into the Schaefer model spreadsheet in the ‘data’ tab.

1. The total catch by year for the stock. The total catch must include all sources of fishing mortality, including levels of bycatch removals. If bycatch is low in the fisheries, then only landings may be used as the catch.
2. The CPUE calculated for the fish stock. It is important that the CPUE be considered reflective of the overall trends in abundance in the fish stock as a whole.

**Step 3: Running the Model**

In the ‘Main’ tab

1. Input the determined value of r (intrinsic rate of increase).
2. Go to ‘Solver’ in the Data menu and click Solve. The Solver will minimize the observed sum of squares for the CPUE. This is a measure of the difference between the observed CPUE that was input and the model predicted CPUE, which assumes that the best model fit had the smallest differences between those values.
3. The model estimates both MSY (the level of catch that is sustainable over the long term) and BMSY (the level of stock biomass that will happen when the fishery fishes at MSY long term. BMSY can be used as a reference point level for the fishery to determine whether the fish stock is overfished.

# References

Hilborn R., and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics, & Uncertainty. Chapman and Hall, New York.

Schaefer, M.B. 1954. Some aspects of the dynamics of populations important to the management of marine fisheries. IATTC Bull. Pp 25-56.