Surplus production models

Fox and Schaefer Models

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Introduction

Surplus production models are called as Holistic models. These models could be computed with less input data unlike analytic models. This model deals with total stock biomass along with fishing effort and yield. To operate this model, catch and effort data are needed as input data.

Objectives

The objective of this model is to calculate the optimum level of effort. The total effort applied produces maximum yield. The maximum yield could be sustained by applying optimal effort without affecting the long term productivity of the stock. The yield thus generated without affecting the stock with optimal FMSY is usually refered to as Maximum Sustainable Yield (MSY).

Surplus production model

This model does not take into account age and growth. Hence, it could be safely applied to tropical stocks, where calculation of age of tropical fish is more cumbersome.

When catch and effort data are applied for a number of years, the MSY thus generated will be more meaningful for sustainable fishery.

The two models will be highlighted in this chapter.

1. Schaefer model

2. Fox model

Schaefer model

The catch per effort or yield per unit of effort is designated as Y/f. The Y/f is a function of effort, ‘f’. MSY could be computed from the following equation.

$$Y(i) \over f(i)$$ = a + b x f(i) --> (1)

In Schaefer model, the slope ‘b’ will be negative if the catch per unit of effort ‘y/f’, decreases for increasing effort. This model implies one effort level for which ‘y/f’ value obtained just after the first boat fishes on the stock for the first time. Hence, the intercept value is positive. Thus ‘- a/b’ is positive and ‘y/f’ is zero for f = -a/b. As the negative value of catch per unit effort, ‘y/f’ is will not be a reality, this model applies to f values lower than ‘- a/b’. For unexploited stock or for stock which is less exploited, this model could be used. Even at very few levels of effort, the straight line reaches zero and attains annihilation.

Fox model

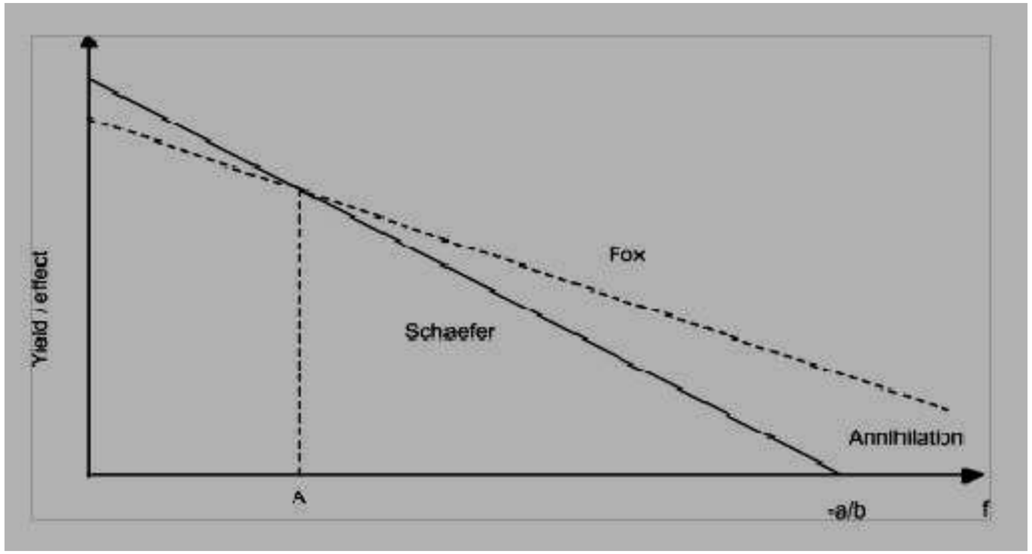
This model gives a curved line when ‘Y/f’ is plotted directly on ‘f’. But a straight line is obtained when the logarithms of ‘y/f’ are plotted on effort.

$$\ln [y(i)/f(i)] = c + d \cdot f(i) \qquad (2)$$

The above equation could also be written as

$$Y(i)/f(i) = \exp(c + d \cdot f(i))$$

Schaefer model plot on ‘Y/f’ on ‘f’ gives a straight line and in Fox model plotting of ‘Y/f’ on ‘f’ gives a curved line which approaches zero only at very high levels of effort without ever reaching it.



The figure depicts another basic feature of the two models. When effort (f) is close to zero, ‘Y/f’ takes the maximum value and also the biomass, because Y/f = q. B and ‘q’ is constant. The biomass corresponding to f = 0 is called virgin biomass or the unexploited biomass. This is denoted by ‘Bv’. In the equation of Schaefer and Fox, the ‘Y/f’ can be replaced by ‘q’. ‘Bv’. as follows:

q * Bv = a or Bv = a/q (Schaefer)

q * Bv = exp. (c) or Bv = exp.(c) / q. (Fox)

In both models, the unexploited biomass (Bv) is the same. When the effort (f) is increased to level of A (see above Fig.), the two curves (Schaefer and Fox curves) are approximately equal. But increasing the effort to the right of A, the differences become larger. Thus, one can use any one model and it becomes important only when relatively large values of ‘f’ are reached.

Procedure

(i) Collect data on yield of a stock.

(ii) Collect effort data (Number of standard vessels) employed to catch the stock in question.

Collect these two data for a number of years. For Schaefer model, effort f(i) is taken as X and Y(i)/f(i) (catch per unit effort) is taken as Y.

For Fox model, effort f(i) is taken as X and ln [Y(i) / f(i)] is taken as Y variable.

In Schaefer model,

MSY = - 0.25 . a^2/ b

FMSY = - 0.5 * a / b

In Fox model,

MSY = - (1 / d) * Exp. (c-1).

FMSY = - 1 / d.

(Note : The constants ‘a’ and ‘b’ for Schaefer model should be replaced by ‘c’ and ‘d’ in Fox model)

Uses of the surplus production model

The advantage of surplus production model is that it can also be used to estimate a first approximation of the sustainable yield from fisheries operating on multiple stocks in a well defined area, treating them all as a unit stock. Careful examination of time series data on catch and effort would help in identifying the successive phases in the growth of a fishery from its origin to peak and then down to decline. These phases could be indicated in the relative and absolute yield curves by appropriate identification marks for each phase so as to make the model more meaningful and readily usuable as a tool for management and development decisions. This model will also serve as an excellent tool for ready estimation and judicious allocation of optimum yield and effort to solve intersectoral and interstate conflicts which are very common in the Indian fishery industry.

Relative to the Schaefer model of surplus production, the Fox model seems to be more realistic when a fishery undergoes transition from traditional to mechanized state or when mechanized fleet is added on to the existing traditional fleet, when there are changes in yield and effort in quantitative and qualitative terms.