Fish Stock assessment models and ICES reference points

Introduction

Fish populations are divided into 'stocks' for management and assessment purposes. The biological unit stock, which is the normal unit in which fish stocks are assessed is considered to be a self-contained biological population and is the unit discussed here. Management stocks may be combinations of biological stocks and are used as management units. Ideally the biological and management stocks should coincide however this is not always the case. This note explains the basis of the analytical methods used by ICES and other scientific organisations to assess fish stocks and the reference points used to assess their status against.

Stock Assessments

Fish stock assessments calculate:

- Spawning Stock Biomass (SSB); which is a measure of the reproductive capacity of the stock, measured in tonnes.

- Fishing mortality (F); the rate at which fish are removed from the stock by fishing

In order to help managers manage each stock has a designated set of reference points against which is the stock is assessed. This document explains the basis of the reference points, and the ways in which they are presented in the Ecoregion descriptions.

Analytical stock assessment models use estimates from catch data and research vessel surveys, of the growth, recruitment, fishing and natural mortality of a stock. The inputs and outputs into the stock are modelled as shown diagrammatically below;

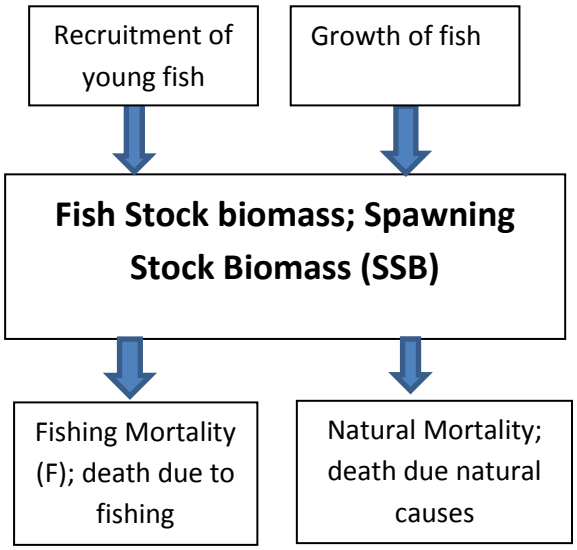

Figure 1 illustrates a simple model of a fish stock, modelled on a single stock basis

To keep the stock at equilibrium growth and recruitment of young fish must at least balance the outputs due to death from fishing and natural mortality. The scientists can make predictions of what the likely effects of different management options (for example total catches, selectivity measures) would be on the fish stock biomass. The Spawning Stock Biomass is calculated as the proportion of the fish stock biomass which is in breeding condition

Spawning Stock Biomass reference points

Current ICES advice on stocks is given on the basis of Maximum Sustainable Yield (MSY) and the Precautionary Approach (PA). MSY means fishing at a level that takes the maximum catch (yield) that can safely be removed from a fish stock, on a continuous basis, whilst maintaining its long-term reproductive capacity. This is achieved by keeping the Spawning Stock Biomass (SSB) above the biomass action points **MSYBtrigger** and/or **Bpa.** The Precautionary Approach is aimed at keeping the stock in a state where fishing is not affecting reproduction. When this occurs it is described as 'recruitment overfishing'.

Figure 2 illustrates this concept. This curve represents the potential catches (yields) on a long term basis for a stock at equilibrium. At high Spawning Stock Biomass (the green section to the *left hand side* on the schematic in Figure 2), the stock is in good condition and can potentially be exploited at Maximum Sustainable Yield; this reference point is known as **BMSY**. It corresponds to the equilibrium stock size where the stock at its most productive in terms of growth and reproduction. It is not always easy to define **BMSY** and it is not always defined for ICES stocks. However, even if the stock is not at this optimum size it can still reproduce itself provided it is in the green section of Figure 2. If the SSB is low (to the *right hand side* on the schematic in Figure 2) the stock is 'recruit overfished' and is in the red section, that is below **Blim**, there is insufficient reproductive capacity to produce enough recruits to sustain a fishery; the stock is outside Safe Biological Limits and risks collapse.

Because there is uncertainty in the estimate of SSB the stock is considered *at risk* of being outside Safe Biological Limits when it is below **Bpa** and/or **MSYBtrigger**, (that is in the yellow section in Figure 2). **MSYBtrigger** and **Bpa** are action points; when the SSB is below this level managers expect to take measures to reduce fishing mortality aiming at exploiting the stock at MSY.

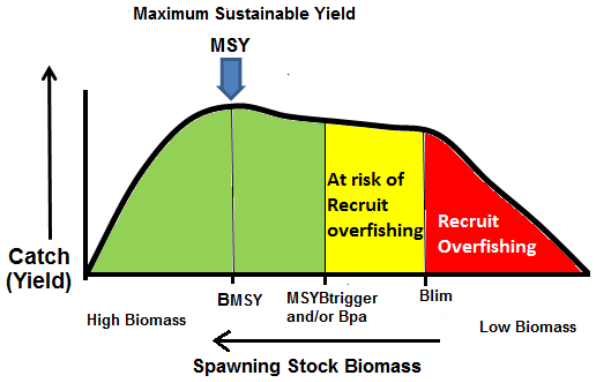

Figure 2 Schematic showing spawning stock biomass reference points in relation to Maximum Sustainable Yield

Fishing Mortality reference points

The Biomass reference points described above have corresponding Fishing Mortality reference points. If the stock is exploited at a given fishing mortality it will, in the long term, result in a corresponding Spawning Stock Biomass (SSB).

These concepts are illustrated in the schematic (Figure 3), which shows how catches from an unfished stock would increase in line with exploitation (= fishing mortality, F), up to a point where the total mortality on the stock causes so many fish to be caught at a relatively small size (and discarded or landed) that the potential production of the stock due to growth of individual fish is not realised ("growth overfishing"). The peak of this curve represents MSY and indicates where $\mathbf{F_{MSY}}$ lies.

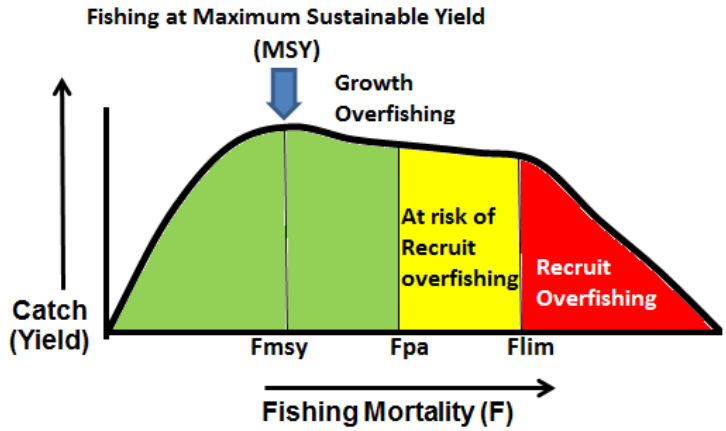

Figure 3 Schematic for Fishing Mortality reference points in relation to Maximum Sustainable Yield

However, providing sufficient fish survive to become adults and spawn, they may still have the reproductive capacity to replace themselves. There is a risk stock collapse occurring when fishing mortality reaches a level (**Flim**) such that removals from a stock are so high, and its spawning capacity is so diminished, that fewer and fewer juveniles are produced. So, not only is the size of the stock being reduced by too high a level of exploitation, but there are fewer juvenile fish to replace those that are caught, and stock levels are likely to fall even lower ("recruit overfishing"). The yellow area between the green (inside safe limits) and red (outside safe limits) zones in the schematic represents levels of F or SSB (see Figure 2) that management should seek to avoid to ensure that the stock has a high probability of remaining sustainable; when it is in this area it is considered 'at risk'.

Comparing stocks in relation to Maximum Sustainable Yield (MSY) reference points

The location of each stock in relation to these references can be calculated by dividing the Fishing mortality (F) in 2014 by F_{MSY} ; F/F_{MSY} and the Spawning Stock Biomass by MSYBtrigger; SSB/MSYBtrigger; see Figure 4

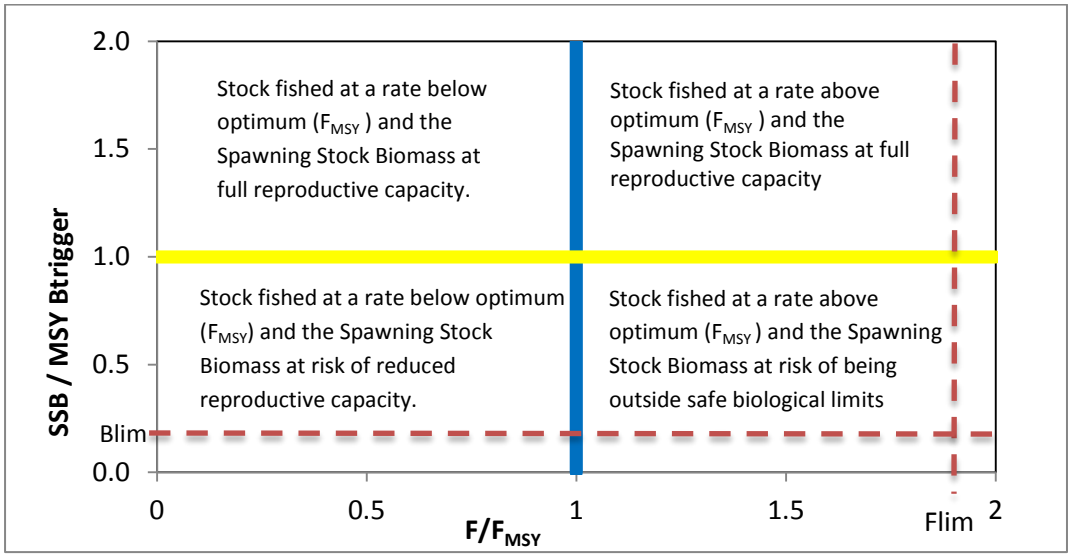

Figure 4 Explanation of Maximum Sustainable Yield reference level plots

These plots are used in the Ecoregion descriptions to compare the locations of each stock in relation to F_{MSY} and MSYBtrigger. Flim and Blim cannot be plotted where multiple stocks are compared because the ratio between F_{MSY} and Flim, and MSYBtrigger and Blim varies between stocks. However they are located approximately as in the dotted lines in Figure 4.

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