SEAFISH
the authority on seafood

Industry Guidance Note

March 2011

Maximum Sustainable Yield (MSY)

This industry guidance note explains the concept of MSY, how it applies to individual fish stocks and the ICES approach.

What is Maximum Sustainable Yield (MSY)?

Maximum Sustainable Yield (MSY) describes the largest average catch or yield that can continuously be taken from a stock under existing environmental conditions.

Fishing at MSY levels means catching the maximum proportion of a fish stock, that can safely be removed from the stock while, at the same time, maintaining its capacity to produce sustainable returns, in the long term.

In the case of a small stock, the annual yield potential is limited because there are too few adult fish producing too few young fish that can contribute to the renewal of the stock concerned. At the same time, when a fish stock is too large, the annual reproduction is low and growth slows down due to lack of food and the production of younger fish may decrease due to competition between them.

Between these extremes is a stock size at which the sustainable catch is at the highest practicable level. This is the stock size that can produce the maximum sustainable yield.

The ICES MSY approach is based on a long-term strategy whereby catch rates are fixed, enabling fish stocks to reproduce so that exploitation can occur in sustainable economic, environmental and social conditions.[1,2]

Applying MSY to individual fish stocks

- The sustainable yield of any fish stock is the amount that can be fished annually without decreasing the stock's ability to yield fish in future years. This is determined by calculating the population weight or biomass that is added every year through recruitment and the growth of young fish, and then deducting its natural mortality.
- Yield can be highly variable but is related to growth of fish, stock size, the size of the parent stock or Spawning Stock Biomass SSB, recruitment of young fish, and to the proportion of the stock harvested by fishing (fishing mortality rate or F).
- The aim is to determine the optimum catch which can be harvested from a stock – the catch should correspond to a fishing mortality that maximises the yield from the stock. This is defined as the MSY, and the fishing mortality rate that generates this is F_{MSY}.
- Factors such as variation in recruitment and natural mortality, can affect the 'natural' level of biomass of a stock. This can make deciding what the fishing mortality at MSY should be difficult for some stocks so a range of fishing mortalities is proposed. Since biomass varies from year to year, catches at MSY are also likely to vary from year to year.

The EU commitment to MSY[1,2]

Over the years a number of international conventions have urged governments to work towards the goal of MSY. At the World Summit on Sustainable Development in Johannesburg, in September 2002, EU Member States called for an ecosystem approach to limit fishing to sustainable levels by maintaining or restoring stocks to levels that can produce the MSY. For depleted stocks, this should be achieved urgently, and where possible not later than 2015. Community fisheries management should be based on MSY. This is to be achieved through the creation of long-term management plans for the different EU fisheries, marking a major step away from the traditional approach of annual planning.

Why it is necessary to apply the MSY principle in EU waters[1,2]

In 2006 the International Council for the Exploration of the Sea (ICES) analysed the fishing mortality rate for a number of fish stocks in the North East Atlantic and adjacent waters in relation to high long-term yields. The results showed that 81% of the stocks assessed were subject to fishing mortality higher than MSY, with some exceeding that level by a factor of five. The Commission considers that the time has come for Community fisheries management to be handled differently.

The MSY approach is designed to work towards maximising the long-term yield; it implies aiming for improved yields beyond those obtained from recovered depleted stocks. Several scientific studies have shown that management based on maximum sustainable yield (MSY) could restore 80% of the European fish stocks currently affected by overfishing.

THE ICES APPROACH TO MSY[3,4]

ICES is typically asked to provide catch advice on a stock by stock basis as most of the stocks on which ICES advises are managed using stock specific total allowable catches (TACs).

ICES advice is intended to be consistent with the broad international policy objectives of the management bodies requesting the advice. In the case of European fisheries the intention is to manage stocks on a ‘single stock’ MSY basis by 2015 - so the nature of ICES advice is evolving to comply with this; see European Commission (2010). It is likely that ICES advice will evolve towards an ecosystem and multi-species approach over the coming years.

The MSY concept can be applied to an entire ecosystem, an entire fish community, or a single fish stock. The choice of the biological unit to which the MSY concept is applied influences both the sustainable yield that can be achieved, and the associated management options.

Aiming for MSY is not necessarily sufficient to assure some aspects of a healthy ecosystem, it may need to be supplemented with other measures aimed at this goal. There are a number of approaches which may be used to evaluate the risks to ecosystems and the possible mitigation measures.[5]

ICES implementation of MSY approach

ICES will first apply the MSY approach to individual fish stocks. Figure 1 shows an artificial example (from ICES 2010) of the yield of a stock and spawning stock biomass plotted against the fishing mortality. In essence as the fishing mortality rate increases, the yield of the stock increases to MSY. As the fishing mortality increases above this level the yield starts to decrease; and the stock would be described as 'overfished'; this does not necessarily mean that the stock is in danger of depletion; just that its exploitation is not optimal.

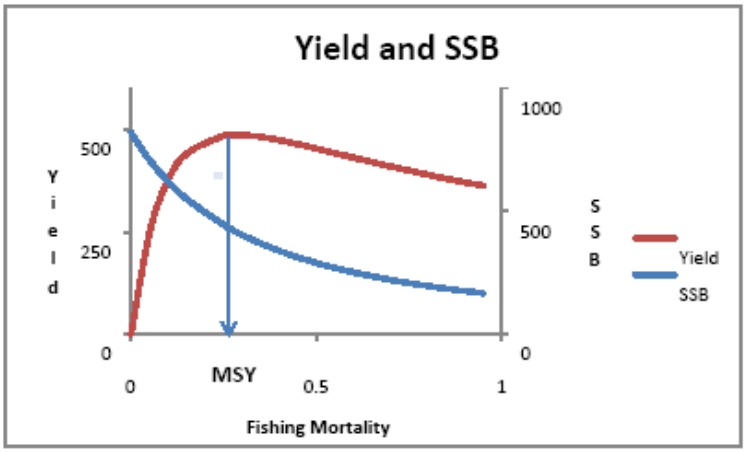

Figure 1. Idealised graph of yield and Spawning Stock Biomass (SSB) for a stock against increasing fishing mortality (from ICES 2010).

Different approaches

To cope with variability in the characteristics of fish stocks and the information available ICES has adopted different approaches to long-lived and short-lived stocks where population estimates are available.

- **Long-lived stocks**

For these stocks ICES advises what the fishing mortality rate for MSY should be, but does not specify a biomass reference point at which MSY should be achieved. This is because the natural level of biomass for a stock is difficult to determine. Instead ICES suggests a fishing mortality rate which is consistent with MSY. However, as a precaution, when the biomass drops below a pre-specified or **action level**, called $\mathbf{B_{MSY\text{-}trigger}}$, a more cautious response is advised and a decrease in fishing. The concept of $B_{MSY\text{-}trigger}$ evolves from the precautionary approach reference point B_{pa}, which is a reference point above which there is a low probability of the stock being depleted.

This approach is described in Figure 2 as a Harvest Control Rule or HCR; so called because it defines the rate of harvest advised under different conditions. The idea is that stocks with low stock sizes will not be subject to high fishing mortalities, but once they are above $B_{MSY\text{-}trigger}$ advice on

fishing mortality will be consistent with MSY. When the stock size is very low (see broken line in Figure 2) special consideration may be given to the advised rate of fishing mortality, since a stock may not reproduce in a normal way when it is very low, or outside safe biological limits under the precautionary approach.

Setting up the $B_{MSY\text{-}trigger}$ reference point for each stock will require knowledge of each stock. In most cases the precautionary approach limits (B_{pa}) will be used for now.

The implications of this change are:

1) Stocks which are above $B_{MSY\text{-}trigger}$; for most stocks this will be inside precautionary levels or above B_{pa}. They will be subject to advice which will be consistent with fishing mortality estimated to lead to F_{MSY}.

2) Those stocks below $B_{MSY\text{-}trigger}$; the advice on fishing mortality will be related to how far below $B_{MSY\text{-}trigger}$ the stock is estimated to be as in Figure 2. This approach represents a gradual approach to a reduction in catches, rather than a 'stop fishing' recommendation.

3) For a minority of stocks where there is evidence of impaired recruitment at low stock sizes advice may be different; this is depicted by the dotted line in Figure 2; it corresponds to stocks being outside safe biological limits.

This means that advice given for stocks will be to achieve gradual recovery to levels above $B_{MSY\text{-}trigger}$, rather than advise that fishing stops. However, advice under the precautionary approach will also be given.

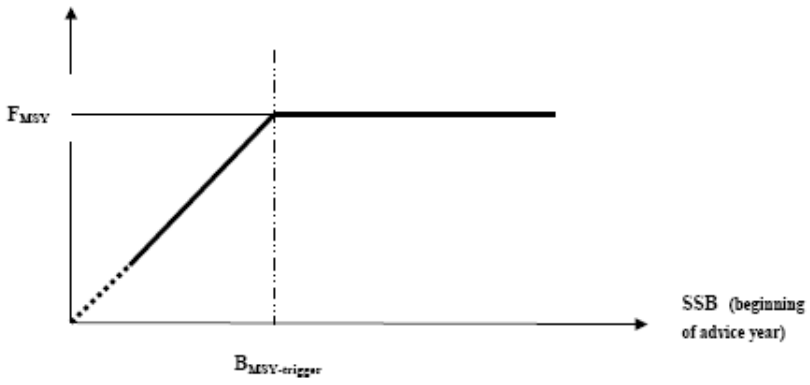

Figure 2. Harvest Control MSY approach (from ICES 2010).

- **Short lived species**

Stocks of these species are characterised by only a few year classes in the fishery. They are therefore very dependent on recruitment of young fish into the population. The data on these stocks is not likely to be sufficient to produce models such as those shown in Figure 1. For these species the ICES MSY approach is aimed at achieving a **target escapement** to ensure that there

are adequate fish left to spawn, and in cases where the fish are considered to be important food fish for other species, sufficient fish to provide food for these species. The ICES approach assesses stock size at the start of the year, and then allows a harvest which means the biomass of the stock should not decrease below a level set as $\mathbf{B_{MSY\text{-}escapement}}$. For most stocks the biomass used is B_{pa} or at the precautionary level.

- **Stocks without population size estimates**

For these stocks ICES will use available information to assess population trends, for example, research vessel catch per effort trends, such age or size composition data that is available. Stocks will be classified as either: increasing, stable, decreasing or overfished. The approach is intended to move in the direction of MSY, but this is unlikely to be achieved without additional or more complete information.

Transition to MSY

When stocks are overfished advice will be given to bring them to fishing mortality levels that correspond with MSY. This results in a reduction in catch in the short-term with the expectation that catch will increase in the longer-term. In order to avoid instability, many stocks are being managed under long-term management plans designed to bring them to MSY over a number of years. For stocks where there are no long-term plans the European Union intends to move toward MSY by reducing fishing mortality in four equal steps from 2011 to 2014, with the aim of achieving fishing mortality corresponding to F_{MSY} by 2015. Dependent on the response of the stock, it may take some time before the stocks show an increase in yield and therefore catches.

Mixed fisheries and multi species interactions

The only variables that can be directly controlled by fisheries management are adjusting fishing mortality (F) levels and changing the size of the fish at first capture through such measures as gear selectivity or spatial management. In principle, for each size at first capture there is an optimum fishing mortality corresponding to MSY and *vice versa*. However, in mixed fisheries different species may have different optima, and also some scenarios may be outside the range for which predictions can be safely made. ICES has been developing a mixed fisheries model which is intended to explore the trade-offs between species, the full value of which will be realised with inputs from managers and stakeholders.

There are also likely to be biological interactions between species such as predator-prey interactions or competition between species. This means that as one species increases another may decrease. The implications are that improved catches of all species may not be achieved through working towards MSY for individual species; as one species increases, others may decrease. At present there are relatively few examples where these effects can be predicted.

MSY Reference Points

Fish stocks may be classified into five categories under the MSY approach:

1. Inside safe biological limits and fished at Maximum Sustainable Yield When a stock is of a sufficient size to reproduce and support a commercial fishery, and is also fished at MSY
2. Inside safe biological limits but fished below Maximum Sustainable Yield When a stock is of a sufficient size to reproduce and support a commercial fishery, but not fished at MSY. Fishing could be increased to achieve MSY.
3. Inside safe biological limits but fished above Maximum Sustainable Yield When a stock is of a sufficient size to reproduce and support a commercial fishery, but corrective action is required to reduce fishing to levels that are consistent with MSY.
4. Stocks below the Biomass action point $B_{MSY\text{-}trigger}$ There is concern that the stock needs to be rebuilt and fishing mortality (proportion of the stock captured each year) is reduced to allow the stock to be rebuilt.
5. Stock outside safe biological limits The stock is in a condition where there is concern that reproduction may be impaired. Action should be taken appropriate to each stock to further reduce fishing mortality and encourage stock rebuilding.
Conditions 1 to 3 will result in a recommendation for catches consistent with fishing levels which would result in a maximum sustainable yield. Conditions 4 and 5 will result in advice to rebuild stocks through a reduction in fishing or other measures.

References

1.http://europa.eu/legislation_summaries/maritime_affairs_and_fisheries/fisheries_resources_and_environment/l66037_en.htm
2.http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/06/268&format=HTML&aged=0&language=EN&guiLanguage=en
3. ICES Advice 2010, Book 1; Section 1.2 pages 1-10.
http://www.ices.dk/committe/acom/comwork/report/2010/2010/Introduction%20for%20Advice.pdf
4. European Commission 2010; Consultation on Fishing Opportunities for 2011. COM (2010) 241 final.
5. Cotter, J and W. Lart 2011. A Guide for Ecological Risk Assessment of the Effects of Commercial Fishing (ERAEF) SR644, Seafish, Grimsby.

For further information contact:
Bill Lart on **T:** 01472 252323 **E:** w_lart@seafish.co.uk

18 Logie Mill, Logie Green Road, Edinburgh EH7 4HS

t: 0131 558 3331 f: 0131 558 1442
e: seafish@seafish.co.uk w: www.seafish.org SIN: http://sin.seafish.org