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Fact Sheet

Baltic Sea Centre
Stockholm University

Understanding MSY

MSY stands for *Maximum Sustainable Yield*, and can be understood as the largest annual harvest that a fish stock can produce in the long term. Although there is criticism of the concept, MSY is important to understand for everyone involved in fisheries management, as is the alternative concept of MEY, *Maximum Economic Yield*. This fact sheet describes the concept of MSY and discusses alternatives.

Reaching MSY by 2020 is the main objective of the 2013 reform of Common Fisheries Policy (CFP) of the European Union. For depleted fish stocks, this means letting the stock recover to the level that will support catches according to MSY. Decisions under the CFP, such as annual decisions on total allowable catches, should be taken in line with this objective.

At the same time, it is difficult to calculate MSY. MSY is a theoretical concept and not always easy to apply in practice, and has rendered much criticism over the years. Nevertheless, MSY still plays a fundamental role in today's management of EU fisheries, and is a must-know concept for decision-makers and others involved in fisheries and fisheries management.

MSY – What is it good for?

MSY is basically a harvesting model used to calculate how much one can fish from a certain stock without depleting it. Its purpose is to define the largest catch (yield) that can be taken from a fish stock, over an indefinite period, while still leaving enough fish in the sea to ensure a sustainable stock development (i.e. enough mature fish to reproduce the maximum level year after year).

Calculating MSY for a fish stock is all about finding this "ideal" or optimal level of exploitation. It is very difficult to calculate MSY, as there are a number of factors that determine MSY, and as the interrelations between these factors are not always well known. Calculations of MSY should therefore be seen as estimates, which often are rather uncertain.

Biomass

To understand MSY, one must understand how to estimate biomass. Biomass is measured as the total weight of a stock. The main factors that increase or decrease biomass in a fish population are growth, reproduction and mortality, as outlined in Figure 1.

The natural factors can vary substantially between different fish

In the long term reduced fishery could be gainful for all: for fishers the yield would increase, the marine environment would be in a better state, taxpayers would have to pay less in subsidies, and European consumers would have a more secure fish supply.

species. For example, growth of the individual fish over time can be rapid (cod normally grow very fast), or slow (herring grow rather slowly).

Furthermore, some species breed a large number of offspring at each spawning occasion (cod, herring), while other (e.g. sharks) only breed a few. The reproductive success varies within stocks from one year to another.

The life-span of different species also varies tremendously. Consequently, unfished populations may have a quite stable biomass over time or the biomass might vary a lot. Short-lived, highly reproductive species such as lesser sandeels have highly fluctuating biomasses, whereas cod, although spawning a large amount of offspring, are rather stable in stock size.

The biomass of an unfished stock can also depend on factors such as environmental changes (in particular temperature), the prevalence of predators or the availability of food. The availability of food may in turn be influenced by the level of hatchings or recruitment (that is, the number of fish surviving to a particular stage).

For a fished population, on the other hand, the most significant factor affecting the overall population biomass is almost always the level of fishing mortality, i.e. how many fish that are caught (or otherwise killed by fishing activities), especially of the adult part of the population. However, even on a fished population, sometimes individual growth is just as important as the incoming number of recruits to the stock. This is the case for the eastern Baltic cod stock which, at the moment, suffers from reduced individual growth. In sum, the biomass of fish stocks varies greatly and is influenced by a number of factors, as listed in the box on the last page.

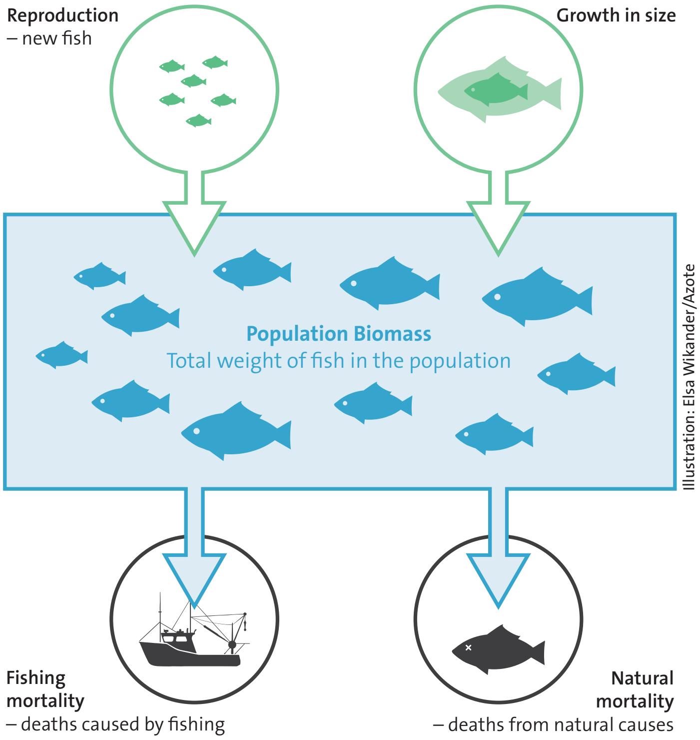

Figure 1. The main factors that increase or decrease biomass in a fish population are growth, reproduction and mortality. From Ministry of Fisheries, New Zealand (2006).

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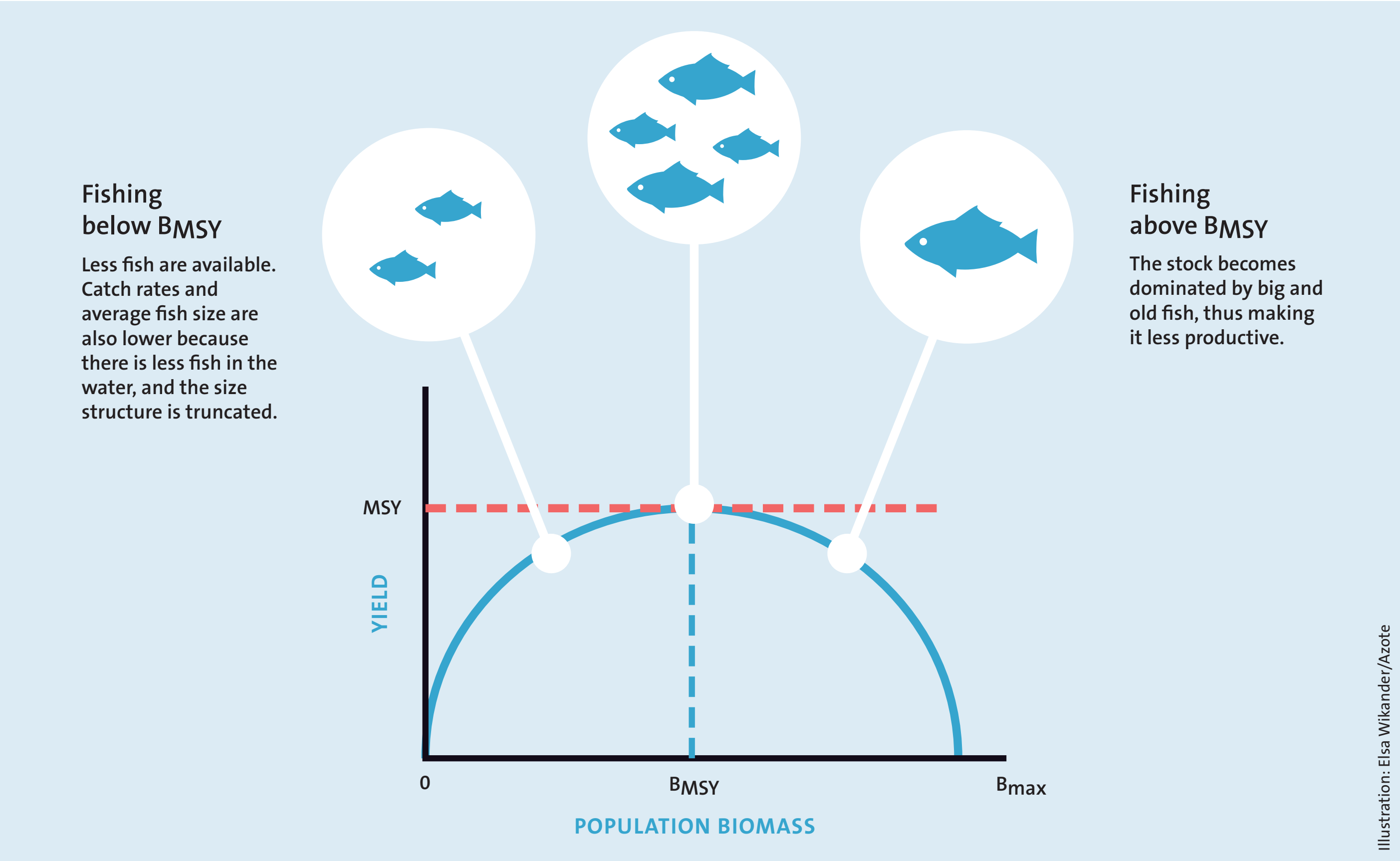

Figure 2. The productivity of the stock determines the actual level of yield. If the stock is overfished (left-hand side of B_{MSY}) the yield will become lower and if the fishing continues at this level, the stock might be depleted. If the stock biomass decreases – so should the catches. From Ministry of Fisheries, New Zealand (2006).

B_{MSY} - the biomass that gives MSY

The MSY biomass (B_{MSY}) is the stock biomass that can support harvest of the maximum sustainable yield. According to the basic version of MSY, the surplus production (that is, net growth, taking natural mortality into consideration) is highest when the level of biomass is at 50 % of the virgin (unfished) biomass (B_{max}). This means that the B_{MSY} will be 50% of B_{max}. These relationships are illustrated in Figure 2.

The productivity of the stock determines the actual level of yield. If the stock is overfished (to the left of B_{MSY} in Figure 2) the yield will become lower. It is the size of the biomass (the total weight of fish in a certain stock) that determines how much fish that can be harvested from that stock in order to obtain MSY. If the stock biomass decreases – so should the catches.[1]

Fishing when below B_{MSY}

If the biomass is below the B_{MSY} level (left side of Figure 2, where the yield curve is under MSY), fewer fish are available, and not as many can be sustainably caught. Catch rates (or catch per unit effort) and average fish size are also lower because there is less fish in the water, and the fish tend to be smaller.[2]

[1] B_{MSY} can also be understood as the biomass that the stock will achieve after having been fished at a low enough rate for a long enough time. See also: ICES, Acronyms and terminology http://www.ices.dk/community/Documents/Advice/Acronyms_and_terminology.pdf.

[2] Stocks can be harvested sustainably even if the biomass is lower than B_{MSY} as long as reproduction is unharmed and fishing mortality not systematically increased. Many times in mixed fisheries one has to accept that some stocks are on "the left side" (below B_{MSY}) and some on "the right" (above B_{MSY}) since it is impossible to catch several stocks at the same time and adjust fishing mortality for all of them to get maximal yields.

At moderate levels of overfishing, the yield becomes lower than at MSY but the stock is not jeopardised. At high levels of overfishing the stock becomes so small that reproduction decreases and is eventually impaired.

Fishing when above B_{MSY}

If the biomass is above the B_{MSY} level (right side of Figure 2, where the yield curve is under MSY), then catch rates, availability and the average size of fish can be expected to increase. The yield open for exploitation then decreases. This is because the stock becomes dominated by big and old, slow-growing fish, thus making it less productive. Also, competition between members of the stock increases as the stock becomes more dense. At no fishing, losses due to natural causes will equal production (B_{max} in Figure 2).

Problems with MSY

Although MSY is widely used by agencies regulating fishing, it has come under heavy criticism by ecologists and others. Fishing according to MSY is not always easy in practice. Estimation problems arise due to poor assumptions in some models and lack of reliability of the data. For example, biologists do not always have good enough data to correctly estimate population size or growth rate. Calculating the point at which the rate of growth of a population begins to slow from competition is also very difficult, and nearly all sorts of density dependent relationships are simply ignored. The MSY approach also tends to ignore variation in stock productivity.

As a management goal, the static interpretation of MSY (i.e. MSY as a fixed catch that can be taken year after year) is not fully appropriate because it tends to treat the environment as unvarying, and ignores the fact that fish populations undergo natural fluctuations in abundance.

FACTORS AFFECTING MSY

There are several important factors that influence the calculations of MSY for a single fish stock:

- How fast the individual fish grow.
- When and how the fish reproduce.
- How fishing is conducted (e.g. if the gear does not catch fish above or below a particular size, the size of the gears, the speed of the boat, the amount of time spent fishing, the amount of fish that is discarded at sea or damaged by the fishing, if all fish caught are reported, the time and place of fishing etc), which influences the size and age distribution of the catch, i.e. selectivity, and if the fish has been able to reproduce that year or not.
- The natural death rate of the fish (natural mortality, which is often very difficult to estimate and therefore based on assumptions).

Beyond the factors included in the MSY calculation, in the real marine environment there are a number of additional factors that can have strong impacts on a fish stock:

- Fluctuations in non-living (abiotic) factors (e.g. water temperature, salinity, oxygen conditions).
- Fluctuations in living (biotic) factors such as feeding conditions and predation, i.e. food web interaction between stocks and species (i.e who eats who, prey/ food availability and quality) and parasites.

All these factors vary over time, and in relation to each other, which adds to the complexity and difficulty of determining MSY for a specific fish stock at any given time.

MEY – the cheaper alternative

In recent years, alternatives to MSY have been presented in different scientific and management contexts. The concept of Maximum Economic Yield (MEY) is one of the most well-known. MEY defines the level of catch of a stock that gives the largest net economic profit (i.e. the largest positive difference between total revenues and total costs of fishing).

The fishing mortality rate (i.e the death rate in a fish stock due to fishing) at MEY is always slightly below the fishing mortality rate at MSY, resulting in marginally less yield than the maximum sustainable yield. However, much less fishing effort is needed, often in the range of a 50 % decrease, with lower costs as a result.

With less fishing mortality comes higher biomass levels, which in turn leads to more stable fishing opportunities and reduced risks of overfishing. From an economic as well as ecological perspective, MEY is an attractive option since it can be a cheaper way of ending up with almost the same amount of caught fish.

In conflict with multi-species managment

However, there is also interest in multi-species management. That is, given the interactions between different species, there is reason to consider those interactions in fisheries management.

The combination of a multi-species management and the rigid use of an MSY approach inevitably leads to conflicts. Not all species can be fished at MSY levels at the same time – some stocks will be partially overfished and some underfished. This illustrates the limits of a rigid MSY approach and the importance of weighing in other factors, in particular that all species should have viable levels and be able to fulfill their functions in the ecosystem.

No pain, no gain?

Clearly, there are many losers if the current fisheries management turns out to be unable to stop overfishing and depletion of fish stocks. The current situation for the eastern Baltic cod is a good example of that. Fish stocks won't recover unless there are major changes, and fishers will have even less fish to catch, resulting in more job losses and hardship.

Business as usual management will also have several ecolocial repercussions, besides the fact that food security is harmed on a European level. On the other hand, with some short term pain in terms of reduced fishery, there could be gain for all: for fishers the yield would increase, the marine environment would be in a better state, taxpayers would have to pay less in subsidies, and European consumers would have a more secure fish supply.

FURTHER READING

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