1.2 Advice basis June 2013

1.2.1 General context of ICES advice

ICES advises competent authorities on marine policy and management issues related to the impacts of human activities on marine ecosystems and the sustainable use of living marine resources.

Overarching international agreements on exploitation of living marine resources

An important part of ICES advice regards *the management of the exploitation of living marine resources*. The context for this part of ICES advice is set by several international agreements and policies:

- United Nations Convention on the Law of the Sea (UN, 1982 (known as UNCLOS)), which includes a call for a maximum sustainable yield (MSY) approach to managing fisheries;
- United Nations Conference on Environment and Development (UN, 1992a (known as UNCED)), including Chapter 17 of Agenda 21 which highlights a precautionary approach;
- United Nations Straddling Fish Stocks Agreement of 1995 (UN, 1995 (known as the UN Fish Stocks Agreement or UNFSA)) and the FAO Code of Conduct for Responsible Fisheries (FAO, 1995), both of which call for a precautionary approach;
- Convention on Biological Diversity (UN, 1992b (known as CBD)), which calls for conservation of biological diversity through an ecosystem approach;
- Johannesburg Declaration of the World Summit on Sustainable Development (UN, 2002 (known as WSSD)), which calls for an ecosystem approach and rebuilding fisheries to maximum sustainable yield.

In addition, ICES advice responds to the policy and legal needs of ICES member countries and multinational and intergovernmental organizations that use the advice as the scientific basis to manage human activities that affect, and are affected by, marine ecosystems. Some applicable policy and legal instruments are:

- The Common Fisheries Policy of the European Union (EC, 2002)
- Communication from the European Commission on Implementing Sustainability in EU Fisheries through Maximum Sustainable Yield (EC, 2006)
- The Marine Strategy Framework Directive (EC, 2008)
- Norwegian Marine Resources Act (Lovdata, 2008 (Lov om forvaltning av viltlevande marine ressursar)),
- Russian Federal Law on Fisheries and conservation of biological resources in the waters. N 166-P3 20/12/2004 (Anon., 2004)
- Icelandic Fisheries Management Act (No. 38, 15 May 1990) (Anon., 1990)
- Faroe Islands Fisheries Management Act (Løgtingslóg nr. 28 um vinnuligan fiskiskap frá 10. mars 1994) (Anon., 1994)

ICES provides advice in the context of these agreements.

Impacts of human activities on marine ecosystems

Almost all ICES member countries have policies that address *the impacts of human activities on marine ecosystems which have been developed under the above international agreements*. These policies may explicitly be framed as an implementation of an ecosystem approach. An important example is the Marine Strategy Framework Directive (MSFD) of the European Union (EC, 2008), which is a comprehensive framework for achieving good environmental status (GES) for European marine ecosystems. The Directive calls for scientifically-based indicators and standards for eleven descriptors of GES such as Biodiversity, Non-indigenous Species, Commercially Exploited Fish and Shellfish Stocks, Foodwebs, and Sea-floor Integrity.

The Regional Seas conventions have a role in ensuring the cohesion of assessments within their regions. Both OSPAR and HELCOM have established specific coordinating platforms for the regional implementation of the MSFD, striving for harmonized national marine strategies to achieve good environmental status and implementing their overall agreed commitment to an ecosystem approach.

The ICES scientific community and ICES advisory services have played a key role in providing scientific guidance to define GES indicators and standards. The process of developing these indicators and standards at the European level is ongoing and the process is now being continued by revising current monitoring activities and developing programmes of measures. The MSFD is an important challenge for the scientific community, and ICES welcomes the MSFD as an opportunity to apply an ecosystem approach.

Marine spatial planning is envisioned as a key mechanism in achieving GES. The idea is to integrate planning and management actions across human activities (e.g. fisheries, renewable and non-renewable energy development, mineral extraction, transportation, tourism, recreation, etc.) to take into account the cumulative impact of all of these activities on ecosystems. This will require more spatially resolved data on more types of activities, and a better understanding of how these activities impact ecosystems. It will also require integrated ecosystem monitoring systems where ICES has special experience to offer in particular on the fisheries surveys side. A draft EU Directive on establishing a framework for maritime spatial planning and integrated costal management has been released in March 2013.

An ecosystem approach to marine environmental policy, a precautionary approach and an MSY approach regarding living marine resources are prominent themes of the agreements and policies that set the context for ICES advice. A compilation of acronyms and terminology used in the ICES advice is available at http://www.ices.dk/advice/icesadvice.asp as acronyms_and_terminology.pdf.

1.2.1.1 An ecosystem approach to management of the marine environment

An ecosystem approach is intended to contribute to sustainable development. Sustainable development is defined in the Brundtland Report (WCED, 1987) as development that

> "meets the needs of the present without compromising the ability of future generations to meet their own needs."

An ecosystem approach has been defined in various ways but mainly emphasizes a management regime that maintains the health of the ecosystem alongside appropriate human uses of the environment, for the benefit of current and future generations. For example, the 1992 UN Convention on Biological Diversity (UN, 1992b) defines an ecosystem approach as

> "ecosystem and natural habitats management" to "meet human requirements to use natural resources, whilst maintaining the biological richness and ecological processes necessary to sustain the composition, structure and function of the habitats or ecosystems concerned."

The Reykjavik Declaration (FAO, 2001) forms the basis for using an ecosystem approach in the management of the marine environment:

> "… in an effort to reinforce responsible and sustainable fisheries in the marine ecosystem, we will individually and collectively work on incorporating ecosystem considerations into that management to that aim."

The World Summit on Sustainable Development (UN, 2002) indicated that States should:

> "(30.d) Encourage the application by 2010 of the ecosystem approach, noting the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem[1] and decision V/6 of the Conference of Parties to the Convention on Biological Diversity".

An ecosystem approach is expected to contribute to achieving long-term sustainability for the use of marine resources, including the fisheries sector. An ecosystem approach serves multiple objectives, involves strong stakeholder participation, and focuses on human behaviour as the central management dimension.

ICES is in the process of regionalizing its advice and building the scientific foundation for regional ecosystem advice. The methods needed to allow ecosystem advice are being developed by working groups on integrated ecosystem assessments and will support summaries of ecosystem state and pressures documented in "ecosystem overviews". These overviews will focus on ecosystem processes in order to enable ecosystem drivers to be incorporated into traditional fish stock assessments and to enable operational advice to be given regarding possible measures. This process is necessary for ICES to provide robust, contextual and relevant advice on ecosystems. ICES will work closely together with the regional seas commissions (RSCs), European Environment Agency, and EU/DG Environment, to ensure that our efforts are supplementing on-going activities.

[1] "While it is necessary to take immediate action to address particularly urgent problems on the basis of the precautionary approach, it is important to advance the scientific basis for incorporating ecosystem considerations, building on existing and future available scientific knowledge." Source: Reykjavik Declaration, appendix I, pg. 107. (FAO, 2001).

1.2.1.2 A precautionary approach in fisheries management

A precautionary approach (PA) is described in the UN Fish Stocks Agreement (UN, 1995) as follows:

> "States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures."

Annex 2 of the UNFSA contains guidelines for applying a precautionary approach within an MSY framework. To quote:

> "The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield, and that the biomass does not fall below a predefined threshold. For overfished stocks, the biomass which would produce maximum sustainable yield can serve as a rebuilding target."

In addition, the guidelines indicate:

- Precautionary reference points should be used to guide management;
- Target reference points are intended to achieve management objectives;
- Precautionary reference points should take account of reproductive capacity, the resilience of each stock, and the characteristics of fisheries exploiting the stock, as well as other sources of mortality and major sources of uncertainty;
- Management strategies shall seek to maintain stocks at, or restore stocks to, levels consistent with previously agreed precautionary reference points. Such reference points shall be used to trigger pre-agreed conservation and management action. Management strategies shall include measures which can be implemented when precautionary reference points are approached;
- Fishery management strategies shall (a) ensure that the risk of exceeding limit reference points is very low, (b) initiate actions to facilitate stock recovery for stocks below precautionary reference points, and (c) ensure that target reference points are not exceeded on average; and
- When information for determining reference points for a fishery is poor or absent, provisional reference points shall be set.

Although some aspects of the guidelines are not entirely clear (e.g. the relationship between precautionary and limit reference points is unclear) or consistent (the fishing mortality rate to achieve MSY is referenced as both a target reference point and a limit reference point), it is most useful to recognize that MSY and a precautionary approach are complementary, and this is the spirit in which ICES applies these concepts.

Populations need to be maintained within safe biological limits according to a precautionary approach to make MSY possible. However, within safe biological limits, an MSY approach is necessary to achieve MSY. Lack of scientific information should not be an excuse for postponing management action to maintain populations within safe biological limits and/or to delay implementing a strategy to attain MSY. In a sense, a precautionary approach is a risk-averse concept intended to avoid unproductive situations while an MSY approach is intended to make the best use of the ecosystem productivity. A precautionary approach (PA) is a necessary, but not a sufficient condition for MSY. The ICES precautionary approach (including the methods for estimating PA reference points) is described in more detail in the introduction of previous volumes of ICES advice (e.g. ICES, 2009b).

1.2.1.3 The maximum sustainable yield concept

Maximum sustainable yield has been a widely accepted objective for fisheries management for many decades. The United Nations Convention on the Law of the Sea (UN, 1982) notes

> "…State(s) must set an allowable catch, based on scientific information, which is designed to maintain or restore species to levels supporting a maximum sustainable yield (MSY)."

This policy was reaffirmed by WSSD (UN, 2002) which called on States to

> "Maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015".

Maximum sustainable yield is a broad conceptual objective aimed at achieving the highest possible yield over the long term (an infinitely long period of time). It is non-specific with respect to: (a) the biological unit to which it is applied; (b) the models used to provide scientific advice; and (c) the management methods used to achieve MSY. 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. For reasons discussed later, implementation of the MSY concept by ICES will first be applied to individual fish stocks, but even on a single-stock basis MSY can only be reached in a healthy environment.

In practice, MSY depends on:

- The production of the unit, which describes the relation between productivity and the size of the unit (e.g., population biomass), which in turn depends on the growth rates, natural mortality rates, and reproductive rates of the members of the production unit;
- Interactions of members within the production unit and interactions with other production units (intra- and inter-specific interactions);
- Environmental conditions (e.g., climate, environmental quality), which affect production, and intra- and inter-specific interactions; and
- Fishing practices and fishery selectivity that determine the size and age composition of the catch (both the landings and the discards).

Many of the models (mathematical and conceptual) used to estimate MSY and associated parameters typically assume that factors not explicitly included in the models remain constant or vary around a long term mean. Thus, MSY estimates are generally conditional on current conditions and assumptions. This assumption is reasonable as long as the analysis does not attempt to project changes which are very different from the prevailing conditions, or from conditions which have been observed historically. Marine ecosystems are, however, dynamic and fish stocks will not only change in response to the fisheries directly targeting them but also to changes in fishing patterns and fishing pressures on their prey or their predators. ICES considers MSY estimates as applicable only in the short-term and they should be subject to regular re-estimation. This has implications for the further development of the MSY approach as discussed in the context of incorporation of ecosystem considerations in ICES advice below (Section 1.2.2.5).

1.2.1.4 ICES approach to fisheries advice: Maximum sustainable yield within a precautionary approach

The ICES approach to fisheries advice integrates a precautionary approach, maximum sustainable yield, and an ecosystem approach into one advisory framework. The aim is, in accordance with the aggregate of international guidelines, to inform policies for high long-term yields while maintaining productive fish stocks within healthy marine ecosystems. ICES recognises that although the advice is based on stock objectives, the method is through the management of fisheries and changes in stock size are the result of both the changes in the fishery and the environment.

ICES provides fisheries advice that is consistent with the broad international policy norms of the precautionary approach, MSY, and an ecosystem approach while also responding to the specific needs of the management bodies requesting advice. A precautionary approach has been recognised as an important basis for fisheries management in all the jurisdictions advised by ICES. ICES notes that in the past the fisheries for which it provides advice have generally not been managed with MSY as an objective. The current European Commission policy (EC, 2006) calls for EC fisheries to be managed according to MSY by 2015. Therefore, the nature of ICES fisheries advice is evolving. The evolution includes options for a transition process to attain full implementation of an MSY approach by 2015. Ecosystem limitations on fisheries have typically not yet been identified in management policies in the ICES area. However, as the EU MSFD is implemented, such limits will be recognized to achieve environmental objectives, especially regarding biodiversity, sea floor integrity, and food webs. Therefore, harvests may be further modified in consideration of potential fishery impacts on marine ecosystems beyond the impact on target fish stocks.

ICES considers that a precautionary approach, an ecosystem approach and maximum sustainable yield, are not alternative strategies but are nested boundaries for the harvesting of living marine resources, where the outer boundary is defined by a precautionary approach to maintain fish stock productivity (Figure 1.2.1). Considerations of wider ecosystem impacts and interactions may further modify harvest strategies and not all fishing strategies within these precautionary limits will lead to the largest long-term yields as MSY is constrained by the prevailing ecosystem considerations.

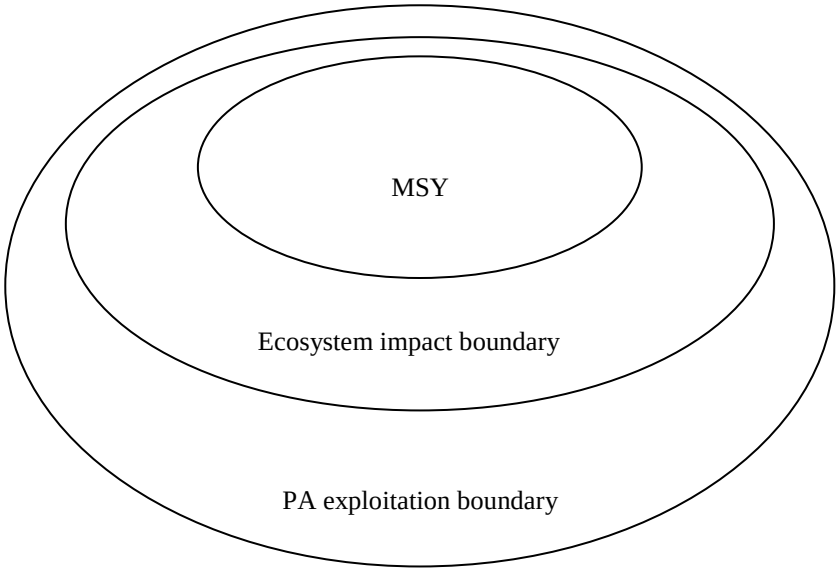

Figure 1.2.1 Limits to the exploitation of living marine resources that arise from a precautionary approach regarding single-stock exploitation, an ecosystem approach and an MSY approach, as an integrated framework of nested boundaries

1.2.2 The Technical basis of the ICES advice

Fisheries management under the above philosophy may be carried out using a variety of approaches involving the specification and control of both input (numbers of vessels, days at sea) and outputs (catches, landings). Within the currently agreed European allocation scheme and regulatory framework the primary measure is the output or removals from the stock. Thus, ICES is typically requested to provide catch advice on a stock-by-stock basis, as fisheries on most of the stocks for which ICES provides advice are managed using stock-specific total allowable catches (TACs). In practice most fisheries in the ICES area are currently managed through constraints on landings. Those landings figures could be deduced from the catch advice based on the assumption that discards will remain a stable incremental factor (as observed in the recent past) additional to the landings. In many cases, other fishery management measures are used as well, such as technical regulations (e.g. closed areas, mesh sizes, days-at-sea limitations and minimum landing sizes). To support the European stock by stock management system, the ICES framework for fisheries advice needs to be applicable to individual stocks. This does not obviate the need to modify stock-specific advice to take account of technical interactions (e.g. bycatch in mixed-species fisheries) or of biological interactions (e.g. predator–prey relationship), but the structure for ICES fisheries advice remains the individual fish stock.

1.2.2.1 Maximum Yield and the Precautionary Approach

Fisheries affect fish stocks through catches which can be expressed in a proportional way as the fishing mortality rate (F) applied to these stocks. Production of a fish stock is the sum of the population weight (biomass) augmented by the young each year (recruitment or incoming year class) growth in weight of existing year classes minus the loss of

numbers of individuals from natural mortality. Production can be highly variable but, on average, it is related to stock size (often expressed as spawning-stock biomass or SSB), which in turn depends on F. That is, for each F, there is a long-term average production and an average stock size. The relationship between F, production, and stock size is called the production function. Surplus production at a given F is the catch that can be harvested without changing the average stock size in the long term. The peak of the production function is MSY, and the fishing mortality generating this peak is F_{MSY}. Figure 1.2.2 gives a hypothetical production function versus F and Figure1.2.3 shows surplus production versus spawning-stock biomass.

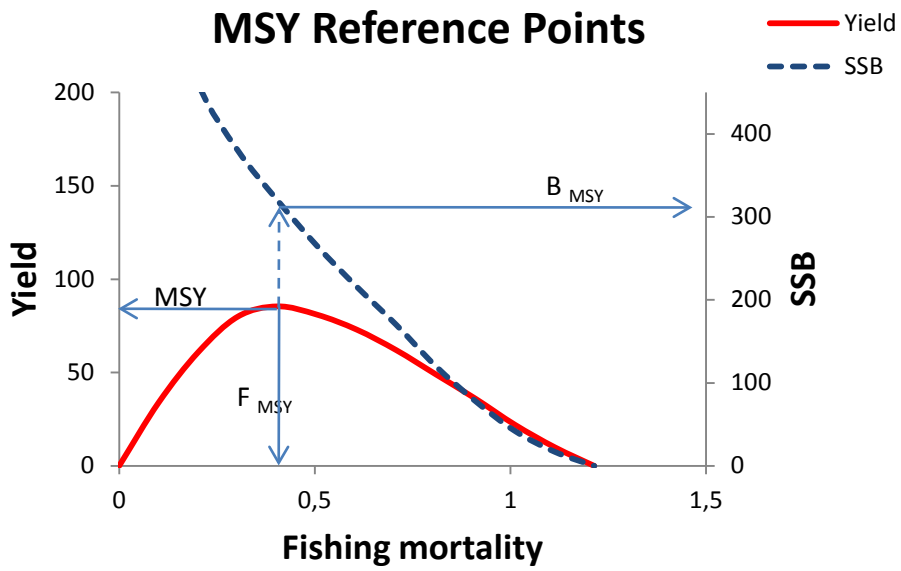

Figure 1.2.2 Example of a yield (production) versus fishing mortality (F) for a hypothetical fishery. SSB: spawning-stock biomass.

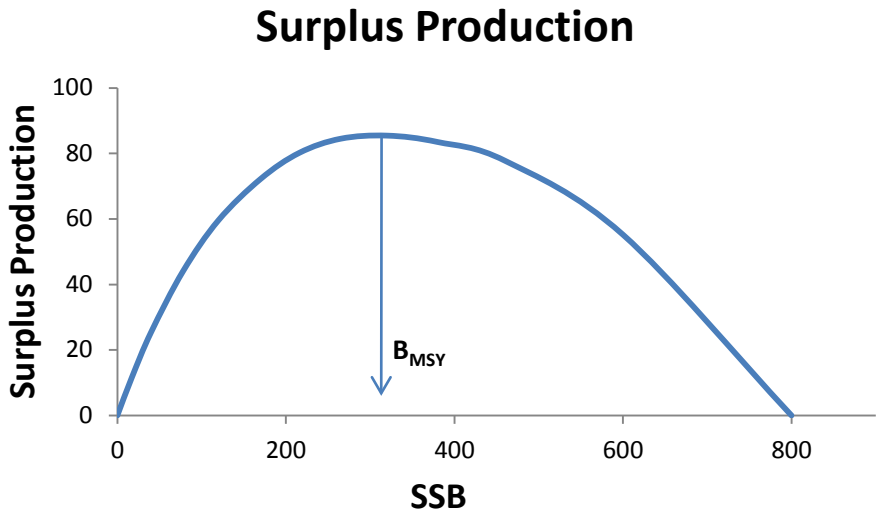

Figure 1.2.3 Example of surplus production versus spawning-stock biomass (SSB) for a hypothetical stock. The theory is that harvesting around 80 units when the stock is at B_{MSY} would keep the stock in full reproductive state at an SSB capable of delivering MSY. On the stock at the carrying capacity (800 units of SSB) there is no surplus production, all the production is needed to support the high stock size. If a fishery begins on a stock at carrying capacity (i.e. the virgin state), the SSB is reduced and surplus production is generated.

Fishing mortality (F) is the only variable in the production function that can be directly controlled by fisheries management. Fisheries management cannot control SSB, it can only influence it through F. SSB is also subject to

natural variability that on a year-to-year basis can overwhelm the influence of F. MSY is a long-term average, and the maximum constant yield that could be taken sustainably would be lower than MSY. Fisheries that harvest variable yields in response to the natural variability in stock size will be on average nearer to the long term MSY.

Due to the natural variability in SSB, beyond the influence of F, there may be situations where the spawning stock is so low that a significant risk exists that reproduction is impaired. A precautionary approach implies that fisheries management in such situations should be more cautious. For stocks where quantitative information is available, a reference point B_{lim} may be identified as the stock size below which there may be reduced reproduction resulting in reduced recruitment. A precautionary safety margin incorporating the uncertainty in ICES stock estimates leads to a precautionary reference point B_{pa}, which is a biomass reference point designed to avoid reaching B_{lim}. Therefore, when SSB is above B_{pa} the probability of impaired recruitment is expected to be low. For short-lived species, the biomass can fluctuate over the full range between years. A precautionary approach in this situation implies that a minimum stock size, $B_{escapement}$, should remain every year in the sea after fishing (Figure 1.2.4).

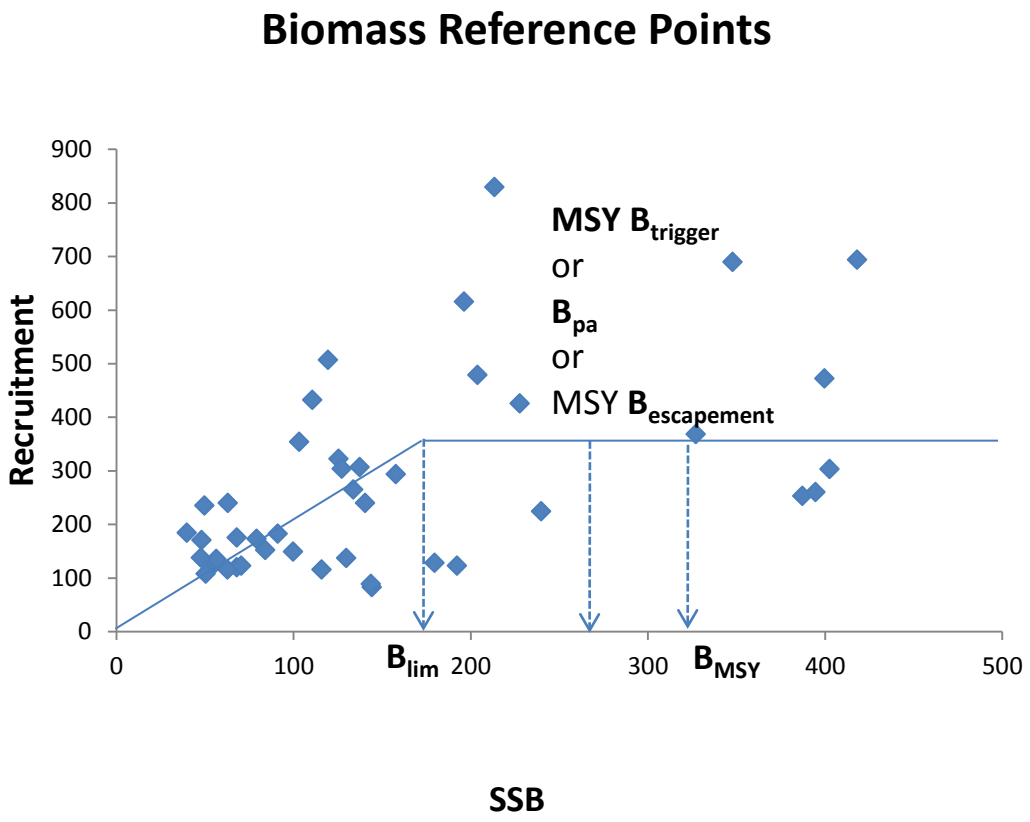

Figure 1.2.4 Illustration of biomass-based biological reference points. B_{lim} and B_{pa} are precautionary reference points related to the risk of impaired reproductive capacity, while MSY $B_{escapement}$ often equal to B_{pa} is used in the advice framework for short-lived species. MSY $B_{trigger}$ is the parameter in the ICES MSY framework which triggers advice on a reduced fishing mortality relative to F_{MSY}. B_{MSY} is the average biomass expected if the stock is exploited at F_{MSY}. Diamonds show the variable recruitment verses SSB that have been observed over the years. Recruitment can be seen to be generally lower below B_{lim}.

The ICES framework for fisheries advice recognizes that the characteristics of fish stocks are different, and the information available on individual stocks also varies.

The ICES approach uses both fishing mortality rates and biomass reference points. In general, F_{MSY} should be lower than F_{pa}, (a precautionary buffer to avoid that *true* fishing mortality is at F_{lim} the rate associated with long term stock decline and ultimately crash) and MSY $B_{trigger}$ should be equal to or higher than B_{pa}. This is appropriate since a precautionary approach is a necessary boundary to ensure sustainability, but not sufficient, condition for achieving the maximum sustainable yield implied by the MSY framework.

Although most of the stock for which ICES provides advice are considered in terms of exploitation using fishing mortality rates, for a very small number of stocks, such as Icelandic cod and saithe and some Nephrops stocks, ICES

advises based on harvest rates (HR) a slightly different measure of exploitation. The HR is defined so that the recommended catch is a fraction of a reference biomass. The reference biomass can be based on total stock biomass, SSB, biomass above a minimum size or minimum age. The choice is tailored to the most suitable biomass for the stock concerned. In these cases the fishery may legitimately catch ages or sizes outside the reference range but the HR is still defined in terms of the selected reference. The HR can also be defined directly on the size or ages selected in the fishery, in this case the reference biomass is described as the fishable biomass. In stable fisheries with relatively stable recruitment F and HR can be related directly to one another. If recruitment is very variable or age or size selection changes in the fishery the relationship can change. Advising using a HR is most suitable for fisheries that exploit intermittent year-classes such as haddock or where age information is not available such as Nephrops.

1.2.2.2 ICES stock categories

ICES recognise six main categories of stocks, and application of the ICES framework to each of these categories is discussed below. ICES has used the following biological and information based categorizations:

Category 1 – Stocks with quantitative assessments

This type of stock can be considered in two sub categories a) stocks with several year classes contributing to the fishery that includes stocks with full analytical assessments and forecasts as well as stocks with quantitative assessments based on production models.; and b) short lived species stocks with quantitative assessments. These are the stocks that have short life cycles with catches dominated by single year classes. They are not considered data-limited and this category includes stocks with full analytical assessments and forecasts as well as stocks with quantitative assessments based on production models.

Category 2 – stocks with analytical assessments and forecasts that are only treated qualitatively

This category includes stocks with quantitative assessments and forecasts which for a variety of reasons are considered indicative of trends in fishing mortality, recruitment, and biomass.

Category 3 – stocks for which survey-based assessments indicate trends

This category includes stocks for which survey indices (or other indicators of stock size such as reliable fishery-dependant indices; e.g. lpue, cpue, and mean length in the catch) are available that provide reliable indications of trends in stock metrics such as total mortality, recruitment, and biomass.

Category 4 – stocks for which only reliable catch data are available

This category includes stocks for which a time-series of catch can be used to approximate MSY.

Category 5 – Landings only stocks

This category includes stocks for which only landings data are available.

Category 6 – negligible landings stocks and stocks caught in minor amounts as bycatch
This category includes stocks where landings are negligible in comparison to discards. It also includes stocks that are part of stock complexes and are primarily caught as bycatch species in other targeted fisheries. The development of indicators may be most appropriate for such stocks.

1.2.2.2.1a Long-lived stocks with population size estimates

For stocks with population size estimates, ICES can calculate the catch that will achieve a desired fishing mortality rate. For most stocks with population size estimates, ICES can also forecast future stock size as a function of catch (i.e. for a range of catch options). In stocks naturally having several age groups, future stock size is not overly dependent on recruitment because many older animals exist in the population (unless the stock age composition has been truncated due to high fishing mortality). When population projections are too dependent on recruitment, projections are less reliable because recruitment can be variable and difficult to measure or predict.

For long-lived stocks with population size estimates, ICES bases its approach on attaining a fishing mortality rate at, or below, F_{MSY}.

Annex 2 of the UN Fish Stocks Agreement (UNFSA; UN, 1995 see Section 1.2.1) states that “The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For

stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield, and that the biomass does not fall below a predefined threshold." The World Summit for Sustainable Development (WSSD, Johannesburg; UN, 2002) states that "To achieve sustainable fisheries, the following actions are required at all levels: (a) Maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks on an urgent basis and where possible not later than 2015." The first statement refers to F_{MSY} as an upper limit to fishing mortality. From a starting point of excessive exploitation (until recently this was the case for many stocks in the ICES area), the latter statement can be considered as an intermediate step towards fulfilling the UNFSA requirements as it establishes an intermediate target for fishing mortality at F_{MSY}, so that stocks are restored by 2015. Competent authorities advised by ICES have based their implementation on the WSSD and the interpretation that fishing mortality should be reduced to F_{MSY} by 2015 where possible (e.g. EC, 2006). The ICES MSY approach is thus based on this interpretation.

In this approach, both fishing mortality and biomass reference points are used; these reference points are F_{MSY} and MSY $B_{trigger}$. The approach does not currently use a B_{MSY} estimate. B_{MSY} is a notional value around which stock size fluctuates when $F = F_{MSY}$. Recent stock size trends may not be informative about B_{MSY} (e.g., when F has exceeded F_{MSY} for many years or when current ecosystem conditions and spatial stock structure are, or could be, substantially different from those in the past). B_{MSY} strongly depends on the interactions between the fish stock and the environment it lives in, including biological interactions between different species.

MSY $B_{trigger}$ is considered the lower bound of SSB fluctuation around B_{MSY}. It is a biomass reference point that triggers a cautious response. The cautious response is to reduce fishing mortality to allow a stock to rebuild and fluctuate around a notional value of B_{MSY} (even though the notional value is not specified in the framework). The concept of MSY $B_{trigger}$ evolves from the PA reference point B_{pa} that ICES has used as a basis for fisheries advice since the late 1990s (see Figure 1.2.4). B_{pa} is derived from B_{lim} based on the precision of the assessment, often taken as a standard value such that is in most cases $B_{pa} = B_{lim}*1.4$. The evolution in the determination of MSY $B_{trigger}$ requires contemporary data with fishing at F_{MSY} to identify the normal range of fluctuations in biomass when stocks are fished at this fishing mortality rate.

The ICES approach as specified in a hypothetical Harvest Control Rule (HCR)),) which shows how the target F should change with SSB is depicted in Figure 1.2.5.

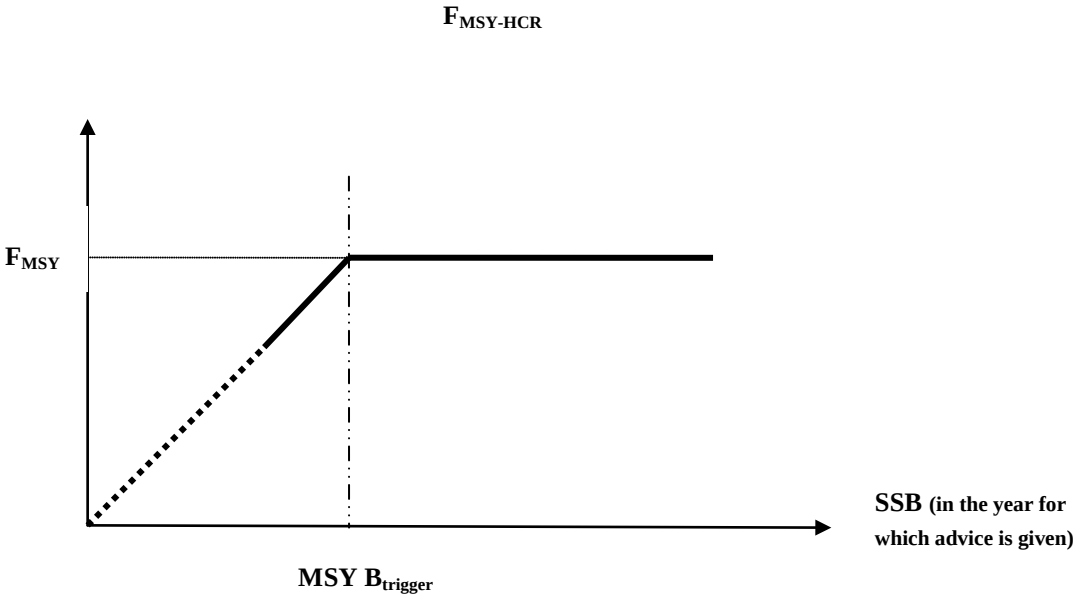

Figure 1.2.5 Approach shown in the ICES harvest control rule. Vertical axis is fishing mortality (F). Horizontal axis is spawning-stock biomass (SSB). Dotted section indicates stock below B_{lim}

Conceptually, SSB in the HCR is the estimated SSB at the beginning (or at spawning time) of the year to which the advice applies (advice year). For example, for an assessment performed in 2012 using data through 2011, the reference SSB will be the projected SSB at the beginning of 2013. $F_{MSY-HCR}$ is the fishing mortality rate used to calculate a catch

option for the advice year. However, it may not be possible to project SSB to the beginning of the advice year, or the projections themselves may introduce so much additional uncertainty that it would be better to use a current SSB estimate. In such cases, the SSB used in the HCR will be the most recent reliable estimate.

Since MSY $B_{trigger}$ is intended to safeguard against an undesirable or unexpected low SSB when fishing at F_{MSY}, the trigger reference point should be based on the natural variation in SSB and the assessment uncertainty, once F_{MSY} has been reached. Ideally, F_{MSY} should take account of selectivity, recruitment, growth, and natural mortality under current or recent ecosystem conditions, and be derived through stochastic simulations of target F in the context of a harvest control rule. However, recruitment functions are typically very noisy and poorly defined. It is therefore common to use proxies for F_{MSY}, such as F_{max}, $F_{0.1}$, M, and $F_{20\text{-}40\%SPR}$[2] (Figure 1.2.6). Thus F_{MSY} is used as a generic term for a robust estimate of a fishing mortality rate associated with high long-term yield. These proxies do not take into account the full range of stock dynamic directly but attempt to give good approximations to F_{msy} where insufficient data is available to carry out a fuller evaluation. ICES will generally indicate when the advice is based on proxies. Conceptually these proxies have the following properties

F_{max}: The maximum yield point without accounting for the dependence of recruitment on SSB or its annual variability. Some stocks have a well defined F_{max} at low F that is a good approximation for F_{msy}. For other stocks the peak is either poorly defined at high F or not defined at all and the value is unsuitable. Fmax is sensitive to changes in the selection pattern / selectivity.

$F_{0.1}$: The point where the increase in yield with increasing F is 10% of the rate at very low (around zero) F. This point is often stable and well defined potentially giving a small reduction in yield relative to F_{msy}, but may be quite close to F_{msy} once dependence of recruitment on SSB and is annual variability is included. It is not suitable for stocks with higher natural mortality.

M: F_{msy} taken equal to natural mortality (M). Most suited to stocks with high natural mortality

$F_{20\text{-}40\%SPR}$ The fishing mortality that reduces the life time reproductive output of a year class to 20–40% of the reproductive output without fishing. It is based on a study of a wide range of stock biology. It has characteristics similar to $F_{0.1}$ but is sensitive to assumptions of natural mortality as it depends on the unexploited biomass.

Changes in selectivity, growth, natural mortality implies a re-estimation of those reference points.

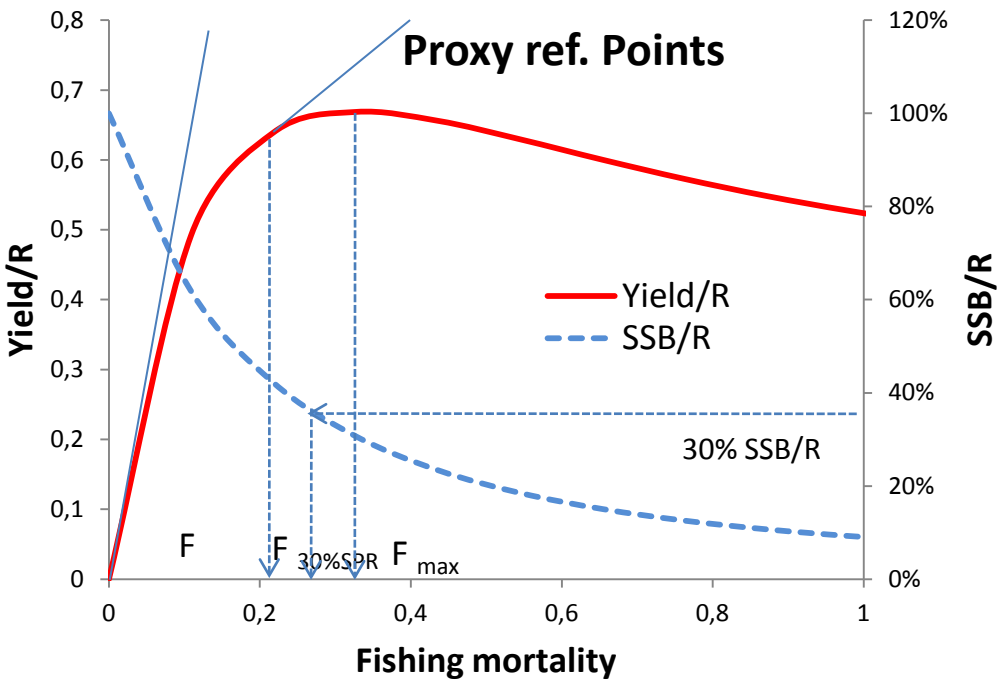

Figure 1.2.6 Illustrations of various proxies for F_{MSY}. For SSB/R 100% is at F = 0. Other numerical values are illustrative only and will vary from stock to stock.

[2] $F_{20\text{-}40\%SPR}$ are fishing mortalities that reduce the life time reproductive output of a year class to 20–40% of the reproductive output without fishing.

As an initial option, MSY $B_{trigger}$ is set at B_{pa} when this reference point is available, unless there is a sound basis for using a different value. In the future when there are sufficient observations of SSB fluctuations associated with fishing around F_{MSY}, the MSY $B_{trigger}$ should be re-estimated to correspond to the lower bound of the range of stock sizes associated with MSY. In general, re-estimated values of MSY $B_{trigger}$ will be higher than B_{pa} because B_{pa} forms a lower boundary under the precautionary approach.

The ICES harvest control rule (Figure 1.2.5) is designed to promote recovery of the stock to the normal range of stock sizes associated with F_{MSY} when the stock is below this range (i.e. when it is below the MSY $B_{trigger}$). For most fisheries, recovery should theoretically occur at a fishing mortality of F_{MSY}[3]. The likelihood and speed of recovery is increased by reducing F whenever the stock is below the stock size range associated with fishing at F_{MSY}. However, at very low stock sizes, the normal tendency for stock recovery at F less than or equal to F_{MSY} may not hold. In these cases, the fishing mortality rate derived from the HCR is likely to be so low that fishing may cease anyway. Nevertheless, when the stock size is so low that recruitment failure is a concern (e.g. well below B_{lim} as estimated for a precautionary approach), additional conservation measures may be recommended to prevent a further decline. The special consideration given at low stock sizes is depicted by a broken line in Figure 1.2.5.

Competent authorities receiving ICES advice have adopted several management plans in the spirit of the harvest control rule described above. When these plans are considered consistent with the precautionary approach and if no competent authority with a legitimate interest rejects a plan as the basis for the advice, the advice on the first page of the ICES advisory document will be based on the management plan. Other options will be also included in the body of the advisory report.

The transition to advice based on reaching F_{MSY} in 2015

Based on policy documents of management authorities and discussions with managers, there is general agreement that fisheries on the stocks for which ICES is requested to provide advice should be managed according to an MSY approach by 2015, but the transition should be gradual. Significant progress has been made in recent years developing and implementing precautionary management plans. Most of these plans are already developed based on delivering high long term yield and are conceptually similar to exploitation under MSY. These plans should not be jeopardized but they can, if necessary, be revised to be consistent with an MSY approach (as well as being precautionary). Over the next few years, ICES will advise on options that take account of this evolving situation.

Although the World Summit on Sustainable Development (UN, 2002) called for stocks to be restored to levels that can produce MSY by 2015 where possible (which requires that overfishing relative to MSY be ended well in advance of 2015, but for many stocks it is already too late), this is not the policy of the European Commission (see EC, 2006). The EC and other management bodies that request advice from ICES have indicated they favour a gradual transition to implementing an MSY approach. Currently MSFD requires meeting Good Environmental Status (GES) which included $F < F_{msy}$ by 2020.

Direct application of the ICES MSY approach

In 2010 ICES introduced an MSY framework for fisheries advice. ICES provides catch options by direct application of the ICES HCR to give catch for F_{msy} and where necessary catch options consistent with the MSY transition scheme. During the transition period (for advice in 2011–2015) where F is above F_{MSY} and/or current biomass is below MSY $B_{trigger}$, ICES applies a stepwise transition to reach F_{MSY} by 2015. The transition is in equal steps beginning with the year in which the transition was initiated.

[3] The theory is that fish populations compensate for fishing by increasing their production per unit stock size as stock size decreases. This type of response is known as compensatory. Production functions typically exhibit compensation. However, it is possible that at low stock sizes, production per unit stock size decreases as stock size decreases. This type of response is known as depensatory. It is difficult to observe (in part because there are few observations of stocks at very low stock sizes), but there are mechanisms that potentially result in depensation. Depensation has the potential to lead to extinction of a population.

Transition scheme

If an estimate or a proxy of F_{MSY} was available, the transition began in 2011 and F was to be reduced in five equal steps. Consequently, the catch option for 2014 will be:

$$F_{MSY\text{-}HCR\text{-}transition}(2014) = \text{Min}\{0.2 \bullet F(2010) + 0.8 \bullet F_{MSY\text{-}HCR}(2014); F_{pa}\}$$

whereas for 2015:

$$F_{MSY\text{-}HCR\text{-}transition}(2015) = \text{Min}\{0.0 \bullet F(2010) + 1.0 \bullet F_{MSY\text{-}HCR}(2015); F_{pa}\}$$

where F (2010) is the current year estimate of the fishing mortality in 2010 and $F_{MSY\text{-}HCR}(2014)$ is according to the ICES HCR in Figure 1.2.5, being equal to F_{MSY} if SSB in 2014 is at or above MSY $B_{trigger}$ and reduced linearly if SSB is below. The $F_{MSY\text{-}HCR\text{-}transition}$ values are capped at F_{pa} to maintain consistency with a precautionary approach. The plan for transition to MSY recognizes that managers requested a gradual transition, although they have not formally agreed to such a plan.

However, there may be situations where a gradual transition is not appropriate because stock size is low (e.g. below B_{lim}) and unless fishing mortality is reduced more rapidly the outlook is for a further decline (e.g. as a result of low recruitment). In such cases, ICES advises on a more rapid transition or application of the $F_{MSY\text{-}HCR}$ as soon as possible.

1.2.2.2.1b Short-lived stocks with population size estimates

The future size of a short-lived fish stock is very sensitive to recruitment because there are only a few age groups in the natural population. Incoming recruitment is often the main or only component of the fishable stock. In addition, care must be given to ensure a sufficient spawning-stock size as the future of the stock is highly dependent on annual recruitment. For short-lived species, estimates or predictions of incoming recruitment are typically imprecise, as are the accompanying catch forecasts.
For most short-lived stocks, the ICES MSY approach is aimed at achieving a target escapement (MSY $B_{escapement}$, the amount of biomass left to spawn, see Figure 1.2.4), which is robust against low SSB and recruitment failure and includes a biomass buffer to account for recruitment uncertainty. The yearly catches corresponds to the stock biomass in excess of the target escapement. No catch should be allowed unless this escapement can be achieved every year.

For some short-lived species, assessments are so sensitive to incoming recruitment that the amount of biomass in excess of the target escapement cannot be reliably estimated until data obtained just prior to the fishery (or during the fishing year) have been analyzed. Therefore, an adaptive framework may be applied as follows:

1. Set a preliminary TAC that ensures a high likelihood of the target escapement being achieved or exceeded. This preliminary TAC is likely to be considerably below the final TAC (step 3).
2. Assess the stock just before or during the fishing year, typically based on a survey or an experimental fishery.
3. Adjust the TAC based on the assessment in step 2, ensuring that escapement is at, or above, the target.

The MSY $B_{escapement}$ should be set so there is sufficient biomass to provide the ecosystem services of a forage fish species and a low risk of future recruitment being impaired, similar to the basis for estimating B_{pa} in a precautionary approach. For short-lived species, where most of the annual surplus production is from recruitment (not growth), MSY $B_{trigger}$ and B_{pa} might be expected to be similar. Therefore B_{pa} is a reasonable initial estimate of MSY $B_{escapement}$.

1.2.2.2.2 Stocks without population size estimates

Of the more than 200 stocks for which ICES provides advice, ICES (2012a) determined that approximately half do not have population estimates from which catch options can be derived using the existing MSY framework. Up to and including 2011, ICES provided qualitative advice regarding the future exploitation of such stocks for which there is either limited knowledge about their biology or lack of data about their exploitation. Advice recipients have, however, expressed a strong interest in ICES developing quantitative advice based on the information available. In 2012, ICES has therefore developed a framework for quantitative advice regarding such stocks. This framework will, as other advice approaches, be refined in the future.

The principles underlying this framework is that the available information should be used, that the advice to the extent possible should be based on the same principles as applied for stocks with analytical assessments and catch forecasts, and that a precautionary approach should be followed. The latter implies that as information becomes increasingly limited more conservative reference points should be used and a further margin of precaution should be adopted when

the stock status is poorly known. The margin of risk tolerance is a management prerogative, but in the absence of any proposal by managers ICES has applied values which are given below.

Unlike the classic fishery management problem of estimating maximum sustainable yield (MSY), fishery analysis on stocks without quantitative assessments must estimate a yield that is likely to be sustainable. The overall approach adopted by ICES has been developed under WKLIFE (ICES 2012a) and WKLIFE2 (ICES, 2012c) and is explained in ICES report on the implementation of RGLIFE advice on Data Limited Stocks (ICES, 2012c). The majority of the data-limited stocks have more information available than merely either catch or landings. The starting point for this analysis is therefore a categorization of the stocks according to the data and analyses that are available. The categorization of stocks is intended to reflect the decreasing availability of data, and thus the conclusions on the fishing pressure and state of the stock are likely to be less certain as one goes down the categories.

As a consequence, a precautionary approach implies that exploitation rates advised for stocks below the data rich stocks (Category 1) will be more conservative than F_{MSY}. Here we provide only a basic overview of the 5 additional categories that have been defined.

Category 2 – stocks with analytical assessments and forecasts that are only treated qualitatively

A quantitative assessment is available, but for a variety of reasons the information from the assessment has been used only as a description of trends such as fishing mortality, recruitment, biomass and future catches, rather than as an analytical assessment. Previously such analytic assessments were presented without Y-axis values. This approach uses a modification of the HCR from De Oliveira, J.A.A. et al., (2010). The general approach is to apply $F_{0.1}$ as a robust and generally precautionary proxy for F_{MSY} to account for the additional uncertainty associated with an assessment that cannot reliably estimate the size of the stock.

Category 3 – stocks for which survey-based assessments indicate trends

Surveys or other relative abundance or biomass indices are available for these stocks and they provide reliable indications of trends in total mortality, recruitment and abundance or biomass, but no quantitative, analytic assessment is available for the stock. The general concept of survey-based catch advice is based on Russell's (1931) non-equilibrium definition of overfishing, in which catch exceeds biological production and causes a reduction in the stock. Therefore, decreasing surveys suggest catch should be incrementally decreased and vice versa.

Category 4 – stocks for which only reliable catch data are available

Only catch or landings data are available, and the data may not be continuous or consistent over time for a variety of reasons. The approach is to use estimates of Depletion-Corrected Average Catch (DCAC) to give approximations of stock depletion over the catch time series, it requires the ratio of F_{MSY}/M and M. It assumes that the average catch has been sustainable in the past if abundance has not changed. Depletion Corrected Average Catch is an approximation of MSY. However, a catch advice based on MSY is only appropriate for stocks near B_{MSY} (See Figure 1.2.3). For situations in which DCAC is much greater than recent catch, stock size may be less than B_{MSY} and if F is decreased catch advice should increase slowly toward DCAC. Decreases or increases in catch are incremental and slow.

Category 5 – Landing only stocks

In the rare situation that only landings data are available, and no relevant life-history or fishery information can be gleaned from similar stocks or species in the eco-region or beyond the first approach should be to compile as much additional information as possible on fishery and survey data to transition to another category. However, in the meantime a Productivity and Susceptibility Analysis (PSA) risk assessment is used to evaluate the risks.

Category 6 – negligible landings stocks and stocks caught in minor amounts as bycatch

This category includes stocks where landings are negligible in comparison to discards. It also includes stocks that are part of stock complexes and are primarily caught as bycatch species in other targeted fisheries. The development of indicators may be most appropriate for such stocks.

For each of these categories, methods have been employed to provide quantitative advice in 2012.

Category one accounts for a precautionary approach through the use of PA reference and limit points. In order to apply a precautionary approach for categories 2-6 the framework for these stocks includes the following considerations regarding uncertainty and precaution have been applied in sequence:

- As the methodologies used to estimate stock status, trends, and forecasts, due to the limited data available, are expected to be more susceptible to noise than methods used to produce forecasts for data-rich stocks, a change limit of ±20% (uncertainty cap) has been applied in the advice. This change limit is relative to the reference on which it is based and may be, e.g. recent average catches or a projection of a trend.
- A principle of an increasing precautionary margin with decreasing knowledge about the stock status has been applied:
    - The reference points for exploitation used have, when proxies could be identified, been selected on the lower margins of F_{MSY} – either at the lower range of an interval as $F_{0.1}$ or similar.
    - A precautionary margin of −20% (precautionary buffer) has been applied for those cases when the stock status relative to candidate reference points for stock size or exploitation is unknown. Exceptions to this rule have been made in cases where expert judgement determines that the stock is not reproductively impaired, and where there is evidence that the stock size is increasing or that exploitation has reduced significantly – for instance, on basis of survey indices or a reduction in fishing effort in the main fishery if the stock is taken as a bycatch species.

This approach is intended to move in the direction of sustainable exploitation, having due regard for the species' biological characteristics and uncertainty in the information. This implies that advice is applicable to a time-frame which is compatible with a measurable response in the metrics used as the basis for the advice; i.e. in the simplest case, and where the least information is available, this would imply a multi-annual constant catch advice. Where least information is available, including cases where the 20% precautionary margin has been applied, ICES therefore considers that the advice is not expected to be changed for a fixed and determined period such as, for example, three years, unless important new knowledge emerges regarding a stock which may justify a revision of the advice.

1.2.2.3 Frequency of advice and updates in 2013

In 2012 most stocks were allocated to categories and advice was provided. Many of these stocks have little new information on an annual basis and the advice can be used for two or more years.

The 2012 advice will generally not be updated in 2013 if:

- Biennial advice was provided in 2012 (e.g. elasmobranches, deep sea species and nephrops).
- Only landings data are available and changes are negligible (categories 5 and 6 stocks).
- The advice in 2012 was for lowest possible landings or zero catch advice (e.g. some elasmobranches, Irish sea cod) and there are no changes in the perception of the stock.
- The PA buffer has been applied in 2012, except Pandalus in IIIa and IVa East for which an inter-benchmark process is underway and for anchovy in IXa which is a short-lived species.
- The DCAC method (category 4) was applied.
- The advice has been the same for the last 3 years or more and the stock index has changed by less than 10%.

The 2012 assessment and advice may be updated in 2013 if:

- The PA buffer has not been applied and the stock index has declined by more than 10% compared to that used as the basis of advice in 2012.
- There are doubts about the method applied in 2012 and a more appropriate method can be put forward.
- Benchmarks have been held

1.2.2.3 Ecosystem considerations in fisheries advice

The move toward an ecosystem approach to management (UN, 1992b, 2002; FAO, 1995) implies that human activities should be managed such that the overall health of the marine ecosystem is not placed at risk. This means that management of fisheries must consider not only the direct effects on fishery targets, but also the impacts on biodiversity, marine ecosystem structure, functioning, marine habitats and interactions between the fish populations.
The advice must also be based on the best available knowledge about the interactions between the fish populations and their environment, be it other fish populations, other organisms, or the physico-chemical environment.

A first step is to incorporate knowledge about the interactions between the various fish populations, for which advice is given. Two types of interactions should be considered in fisheries management, as described below.

One type of interaction (referred to as "technical interactions") results from the non-selective nature of many fishing operations. That is, the fishery captures a mixture of species and it is not entirely possible to control which species and how much of each is caught. For a mixed-species fishery, it may not be possible to achieve the single-stock MSYs (translated into TACs) of all the stocks simultaneously. Either the recommended maximum catches for some stocks will be exceeded in trying to catch the TACs of other stocks, or the TACs for some stocks will not be caught in order to

prevent recommended maximum catches of other stocks from being exceeded. ICES has developed a mixed-species fisheries model (ICES, 2009a, 2010). The full value of this model (and future models of this type) will be realized with input from managers and stakeholders on trade-offs between species in the catch. The choice among different trade-offs and whether to fish only below or also above F_{msy} for the different species in the fishery is not a scientific but a societal issue. However, ICES does consider that the precautionary approach and F_{pa} forms an upper bound for exploitation under these conditions.

Estimates of MSY reference points depend on the size and age selectivity of the fishery. In many cases, both a higher yield and a larger stock size can be obtained by changing fishing practices (e.g. mesh size, fishing area and season) to achieve more favourable size and age selectivity. However, changing fishing practices to favour one species may put other species at a disadvantage in a mixed-species fishery. In the future, mixed-species fisheries advice should provide information to inform trade-offs between species in terms of changes in fishing practices that influence selectivity.

As in 2012 ICES provides catch options in 2013 that incorporate technical interactions regarding demersal fisheries in the North Sea. The options are given as scenarios and not as the basis for the advice as single-stock management plans are currently in force, and mixed-fisheries advice would require an agreed policy for mixed-fisheries management by the relevant authorities.

Another type of interaction results from 'biological interactions': some fish eat other fish, which means growth for the predator and mortality for the prey: fish populations also compete for food or habitat. Such interactions mean that as populations of one species increase by higher numbers and increased growth, populations of other species are likely to decrease because their mortality increases due to predation. It also means that as a population of fish increases one cannot expect that growth and mortality for that species remains constant as there will be increasing competition for food and habitat within that population. This is what is referred to in ecology as 'density-dependence' and is the reason that it is not realistic to assume simple projections of the growth of biomasses from low population sizes as the fishing pressure is reduced, for instance towards F_{MSY}. This is also the basic reason for ICES to refrain from defining rebuilding targets based on a B_{MSY} concept and the reason B_{MSY} is not a part of the ICES approach to MSY.

The implication is that all of the predicted increases in stock size based on applying an MSY approach on an individual stock basis are unlikely to occur simultaneously. Some stocks will increase substantially, but biological interactions may prevent other stocks from increasing as much as anticipated, and there may even be stocks that decrease in abundance as they are predated on by larger predator populations or are exposed to increased competition for food or habitat.

ICES has for a number of years incorporated such multispecies considerations in the single-species framework by applying natural mortality or growth rates that are derived from models of species interactions using size, age, and stomach data for several species in Baltic, Barents Sea and North Sea. ICES has routinely incorporated short term changes in growth and maturation in short term projections in order to account for competition and food supply. ICES also expects to update MSY reference points regularly (typically as part of the benchmark process) again to reflect current dynamics.

These aspects are a first step toward incorporating species interactions in fish stock assessments and advice and helps in making short-term predictions, where the surrounding ecosystem can be considered constant for a few years relative to the stock in question, more accurate. The utility of this approach is, however, very limited when it comes to medium-term forecasts or the exploration of long term reference points in an ecosystem context because the populations of all the various fish species are expected to change with changing fishing regimes and the interactions can therefore not be considered to be constant.

This means that a full-fledged MSY approach cannot be implemented on a stock-by-stock basis. Basic MSY reference points such as F_{MSY}, B_{MSY}, and MSY $B_{trigger}$ are conditional on a variable surrounding ecosystem and the other predator or prey fish populations living in it because growth and natural mortality, both of which are influenced by other fish populations, are determinants of these reference points.

This means that the references to MSY reference points in UNFSA (UN, 1995) and other international agreements ultimately must be interpreted as features of the fish community or even the ecosystem rather than as constant parameters of a fish stock.

Although biological interactions thus are important in terms of the response of stocks to a change in fishing pressure within a MSY approach, there are relatively few situations where the response of a multispecies community of fish to changes in fishing mortality can be reliably predicted. In the few cases where such predictions are possible, multispecies fishing mortality strategies can be developed to achieve MSY on a multispecies basis and to evaluate trade-offs between species based on preferences from managers and stakeholders. In situations where predictive models accounting for biological interactions are not reliable, it will be necessary to adopt a stock-by-stock MSY approach based on the

observed response of these stocks once they have been fished at F_{MSY}. As very few stocks have a history of exploitation at MSY target reference points, biomasses reference points can be expected to evolve as more and information become available.

As in 2012 ICES provides considerations in 2013 on options to incorporate biological interactions between herring, sprat, and cod in the Baltic in advice and fisheries management. The options are not presented as the basis for the advice as there are single-stock management plans in force, and multispecies fisheries advice would require an agreed policy for relevant authorities to consider biological interactions in fisheries management. Where relevant ICES indicates which options are considered precautionary.

Achieving single- or multi-species MSY is not necessarily sufficient to assure all aspects of a healthy ecosystem and may need to be supplemented with measures to mitigate undesirable impacts on ecosystems. This need for supplementary measures is also considered in ICES advice. Reducing fishing mortality or changing selectivity should also reduce: (a) bycatch of non-target and sensitive species; (b) impacts on habitat and biodiversity; (c) the risk of truncated age structure; and (d) alterations that could possibly affect ecosystem functionality.

In some cases, advice has included considerations of the impacts of fisheries on other components of the ecosystems. An example is the advice regarding sandeel, which is based on an escapement strategy to ensure that there is sufficient sandeel biomass to support populations of other biota that feed on sandeel.

Where specific marine environmental management policies exist that require the regulation of fisheries to achieve their objectives, the fisheries advice will be restricted within the limitations required to achieve these objectives. In the EU context, this may be the case regarding fishing impacts on habitats relative to the Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora), and fisheries impacts on biodiversity, sea floor integrity, and foodwebs relative to the Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy). In the NEAFC context, advice has already been provided on fishing practices and fishing limitations to protect habitats of cold-water corals.

1.2.2.4 Management plan evaluations

Recovery, or long-term, management plans have already been agreed for a number of fish stocks or fisheries within the ICES area, and new plans are being proposed. ICES has evaluated such management plans according to their compliance with a precautionary approach regarding risks to maintenance of reproductive capacity, and now also evaluates them according to the likelihood that high yields will be produced in the longer term. Stakeholders and authorities may raise other issues that may also be addressed in a specific management plan evaluation, such as stability of yield and risks under specific recruitment regimes.

ICES has adopted one precautionary criterion for all medium/long lived stocks and a second similar criterion for short lived species.

- ***Medium or Long lived*:**

  Management plan is precautionary if the *maximum* probability that SSB is below B_{lim} is ≤ 5%, where the maximum (of the annual probabilities) is taken over all years in the plan (i.e. short and long terms), accounting for modification for recovery plans or initial recovery phases within long-term management plans.

- ***Short lived***

  (a) If under natural conditions of no fishing the long-term annual probability of SSB being below B_{lim} is ≤ 5%, then the same criteria as for medium or long lived species is used.

  (b) If under natural conditions of no fishing, the long-term annual probability of SSB being below B_{lim} is > 5%, then the management plan is precautionary if the maximum probability that SSB is below B_{lim} is ≤ 5% (after the fishery) in any year when a fishery takes place. In all other years the fishery should be closed. Accepted plans with the above or more stringent criteria should not imply an increase of the long-term annual probability of SSB being below B_{lim} by more than a factor of 2 compared to natural conditions of no fishing.

The management plans in place by 2012 were generally agreed prior to the introduction of MSY in the ICES advice, and on the basis of plan compliance with a precautionary approach. Some plans have since been evaluated with regard to generating high long-term yields, and these plans are considered also to be in accordance with an MSY approach.

While the probability of avoiding a limit point should be less than 5%, ICES considers that a target point is reached if the associated probability of being above or below is 50%.

It is generally anticipated that in the future competent authorities will aim at management plans (or replacement of management plans) being consistent with MSY. Management plan evaluations will be conducted to determine how plans perform in terms of long-term average catch, average stock size, average fishing mortality rate, and the statistical distributions of these variables. The ICES HCR will be used as a reference in comparing plan performance, although ICES does not expect that this HCR is superior to other HCRs, as it is selected to provide a simple approach with only the magnitude of yield as a consideration. Unless managers agree on specific performance criteria, the management plan evaluation can only be comparative; that is, ICES would not recommend one plan over another and would have no basis for rejecting a management plan if it is consistent with an MSY approach and it does not violate the precautionary approach.

1.2.3 ICES processes to provide stock status and single-stock advice

ICES uses specific terminology and symbols or pictograms to describe the status of stocks. The wording aims at using a nomenclature which is less prone to misinterpretation, but at the same time allows for a match to the legal description, which still uses "safe biological limits". ICES discontinued the use of this wording in 2008 as "safe biological limits" has in some cases misled the recipients of ICES advice and other stakeholders to consider stocks described as being "outside safe biological limits" to be biologically threatened (i.e. close to extinction).

The terminology now uses different wording for the description of the stock status for biomass and fishing mortality and for the comparison to reference points based on an MSY approach, a precautionary approach, and existing and implemented management plans. The structure and the associated symbols and text are given below in Table 1.2.1 and 12.2.2 for MSY and precautionary approaches:

Table 1.2.1 Symbols and text for MSY status

MSY reference points	Explanation	Sign	Text
Fishing mortality (F_{MSY})	$F < F_{MSY}$ and		Appropriate
	$F <<< F_{MSY}$ (~ 0)		Below target
	$F > F_{MSY}$		Above target
	No reference point		Undefined
	Stock status unknown		Unknown
Biomass (MSY $B_{trigger}$)	SSB = MSY Btrigger or SSB > MSY Btrigger		At trigger or Above trigger
	SSB < MSY Btrigger		Below trigger
	No reference point		Undefined
	Stock status unknown		Unknown

Table 1.2.2 Symbols and text for precautionary status

Precautionary reference points	Explanation	Sign	Text
Fishing mortality (F_{pa},F_{lim})	F =< Fpa		Harvested sustainably
	Flim > F > Fpa		Increased risk
	F > Flim		Harvested unsustainably
	No reference point		Undefined
	Stock status unknown		Unknown
Biomass (B_{pa},B_{lim})	SSB ≥ Bpa		Full reproductive capacity
	Blim < B < Bpa		Increased risk
	SSB < Blim		Reduced reproductive capacity
	No reference point		Undefined
	Stock status unknown		Unknown

In the case of management plans, the terminology changes depending on the characteristics of a specific reference point; namely, if the reference point is considered a target or a limit. If considered a target, this reference point would usually come with a target range, which means that a green symbol can be used when the stock is within the estimated or defined range, although for most of the stocks a range has not been defined. It is necessary to identify whether the reference points are defined as targets or as limits for each individual plan.

Table 1.2.3 Symbols and text for status of stocks fished under management plans.

Management plan [4] reference points	Explanation	Sign	Text
Fishing mortality (F_{MP})	F< F mgt target / limit	✓	Below target /Below limit
	F within defined range	✓	At target or Within target range
	F>F mgt target / limit	✗	Above target / limit
Biomass (SSB_{MP})	SSB > target, limit or trigger biomass	✓	Above target/limit/trigger
	SSB within defined range	✓	At target or Within target range
	SSB < target, limit or trigger biomass	✗	Below target/limit/trigger

In situations where very limited information is available and the stock status table is filled with grey question mark symbols, ICES provides additional, qualitative information where available. For example, this information could be based on survey information and give an indication of stock status or trend.

Table 1.2.3 Symbols and text for stocks with limited information.

Qualitative evaluation	Explanation	Sign	Text
Fishing mortality or exploitation rate	If there is **an** idea of the exploitation of this stock in relation to any possible reference points:		
	If F is very high i.e. F > possible reference points	✗	*Short description*
	If F is very low i.e. F < possible reference points	✓	*Short description*
Biomass	If there is **an** idea of the state of this stock in relation to any possible reference points:		
	If SSB is very low, i.e. SSB < possible reference points	✗	*Short description*
	If SSB is very high i.e. SSB > possible reference points	✓	*Short description*
If only trends are known	If parameter increases	↗	Increasing
	If parameter decreases	↘	Decreasing
	If trend is stable	→	Stable

The production of ICES advice can be separated into four distinct temporal phases (Figure 1.2.7):

- The first phase is the assembly of data up to December 31st of the year preceding the assessment year.
- The second phase is the assessment of the state of the stock at 1 January of the assessment year, This phase is looking at the past only and dealing with the stock status.
- The third phase between the assessment and the forecast is the assessment (interim) year. As incomplete data are available for this year (the year is not over yet), ICES has to make a number of assumptions on the fishery and biology. Some of these so-called interim year assumptions can significantly influence the catch forecast for the next year, but these assumptions are uncertain. If these assumptions prove to be markedly different from reality in subsequent assessments, stock status may be different than that forecasted.
- The fourth phase is the prognosis (forecast) on catch options to be taken next year (the year for which advice is given) and the state of the stock resulting from the different options.).

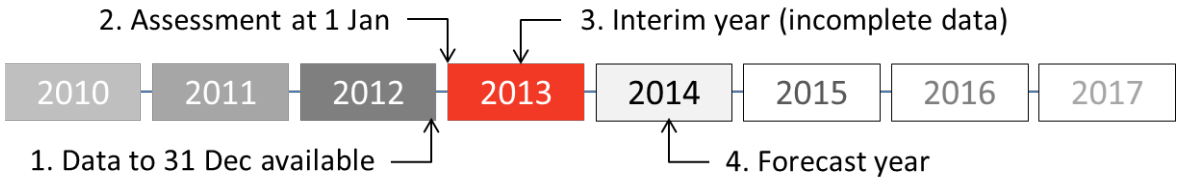

Figure 1.2.7 Timeline of the production of ICES advice

In some cases where stocks are short-lived (see above) this three phase approach is compressed into two years with catch options provided for the current year for in year management.

[4] Only included when plan is considered consistent with PA by ICES and agreed on by all relevant clients

The framework for the statement regarding future fisheries (third phase) has been developed in consultation with the relevant competent authorities. From among the range of catch options presented ICES provides a single main advice option which is based on the following principles:

1. If competent authorities with an interest in the stock have agreed that a management plan can be the basis for advice and this management plan has been found to be precautionary, this management plan will be the basis for the ICES advice.
2. If this does not apply, the advice will be based on the ICES MSY framework.
3. If there is no basis for giving MSY-based advice, advice will be based on precautionary considerations (see introductory section to the 2009 advice report).

1.2.4 Advice to inform an ecosystem approach to marine management

At the 13th Dialogue Meeting between ICES and the Clients (ICES 2004), the ICES plans for the introduction of an ecosystem approach into the advice were discussed.

In 2008 ICES provided ecosystem overviews for the different sea regions (ICES, 2008). In 2012, these reviews will be updated starting with the Baltic Sea region. A new approach will be included in which an ecosystem description is combined with long-term trends in specific species or groups of species, and with long-term trends in drivers of ecosystem change such as climate and fishing pressure. Depending on the availability of long-term data, these overviews will be made available for the different ecoregions during 2013 and 2014.

The organisation of the advisory report in ecoregions facilitates an ecosystem approach to marine management which is currently narrowly focussed on fisheries management. In future, non-fisheries parts of the trophic chains will be considered and integrated into advice going beyond fisheries management; e.g. aspects of eutrophication in the Baltic Sea linked with the abundance of the top predator cod.

Our understanding of the functioning of the ecosystems is confined to certain ecosystem components. Work is underway to expand the number of ecosystem components beyond fisheries that are included in the ICES advice. However, this understanding is not uniform among ecosystems; some ecosystems have more data and the critical processes are understood better than in other ecosystems.

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