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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive summary

WKFRAME III met for 4 days in January to develop the table used to provide advice for “data poor” species. ICES has used an empirical approach to giving advice for stocks which have no population estimates and thus no short term forecasts. This empirical approach is based on expert judgement of whether the stock is being harvested at a rate greater than the rate which would be sustainable in the long term, and augmenting the catch advice based on the trend in the stock response to the fishing pressure. In its original form as used in 2010, ACOM found it difficult to clarify what was meant by “trend in stock development”, and for 2011 the reference to rates of change was removed and the table simplified. However the changes created further issues regarding the suitability of the framework for various scenarios of short term perturbations to the demographics of the stock and catches. It was in response to these issues WKFRAME III was asked to develop the empirical approach proposed by ACOM.

Three primary developments are proposed in this report; the empirical basis is given a generic expression $C_{y+1}=Catch_{recent}*b*r*f*\theta$, where $Catch_{recent}$ is the average catch over some period, b an evaluation of whether the stock is at risk of productivity impairment given by $\min[1,b_{current}/MSYB_{triggerproxy}]$, r is the trend in development of the stock (normally SSB), f is the ratio of $F_{msyproxy}/F_{current}$ and θ is an expression of the uncertainty of the information where θ=1 where b,r & f are computed, otherwise $\theta=0.9^{\text{number of unknown or negative states}}$ (where 0.9 is an arbitrary number requiring input from managers).

The generic expression is also presented in a tabular form, which categorises different conditions of productivity status, trend in stock development and exploitation status. Two tables are presented, the first which is intended for use where there is some numerical estimation of b or r or f, and a second table where more than one of these parameters is unknown or not enumerated. There is some elaboration in the report about what is meant by “trend in development of the stock”, and $Catch_{recent}$ which can be related to the life history dynamics, and the development of the fishery.

The further development of the ICES empirical approach to giving an advice on “data poor” species is the introduction of a precautionary factor θ. The θ in the generic expression represents the number of unknowns (it is 1 where there are numerical estimates for all the other parameters). The use of this factor allows the inclusion of the PA in a quantitative way in the advice framework for “data poor” stocks. In the tables θ is represented by pb and/or pr and/or pf to link it directly to the stock pressure or state indices in the formulation. Although simple in concept, it is recognised that θ represents an element of risk evaluation, and whilst an arbitrary figure is proposed in this report (0.9) this value needs to be established by fishery managers.

The development of the empirical approach is presented here as an option for the basis for advice for “data poor stocks” in 2012, and the shortcomings of this approach are also discussed in the report. These shortcomings imply that the tables should be used with circumspection, and that other issues such as the frequency of the management action need to considered. Whilst such issues are beyond the scope of this report the catch advice framework presented here should be considered a “work in progress”, while other work such as the development of species specific HCR’s (which can be applied to situations of limited data) may provide a more appropriate longer term solution.

1 Introduction

1.1 Background context

ICES has implemented an MSY policy for advice since 2010, which is described in the Generic Introduction to the advice (see ICES Advisory book 1, Section 1.2). This change in the advice basis has been in response to ICES clients needs and in the wider context of International agreements. ICES MSY advice is generated by an HCR which has the basic form given in the figure below. In effect this means that advice for medium to long-lived stocks aims at harvesting the stock at F_{msy}, unless the stock biomass falls below some size (which would not be expected when fishing at F_{msy}); and under this circumstance the fishing mortality is adapted to less than F_{msy} given by the ratio $B_{current}/MSYB_{trigger}$. For short lived species the aim is to leave sufficient biomass after harvesting to be able to produce sufficient recruitment in the following year ($MSYB_{escapement}$).

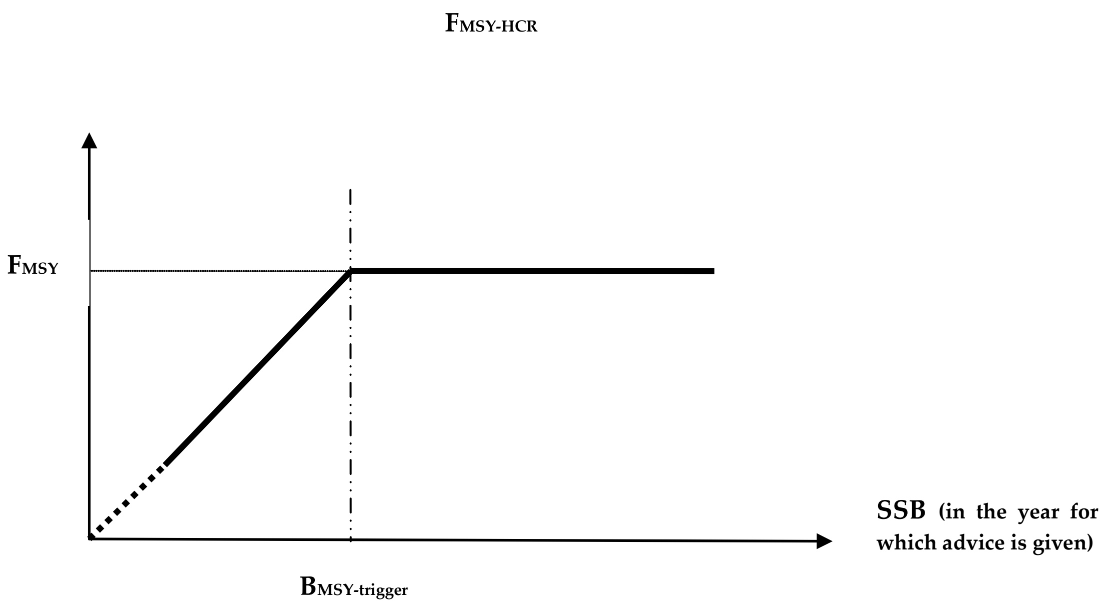

Fig 1.1 ICES MSY HCR for medium to long-lived species.

One of the issues which has arisen in advising under this policy is how to give an equivalent advice when either the biomass trigger and/or the fishing mortality target are not computed, or there is no population forecast from which to derive a harvest at the given exploitation rate. In 2010 WKFRAME (ICES, 2010) suggested for the situation where no population forecasts existed, "that advice should be generated (in relation to the putative targets) which is aimed at moving the exploitation rate towards the target, by specifying an applicable longer term catch rather than specifying an exact harvest rate in relation to the current stock status and expected short term development of the stock." ACOM then applied a decision table for these circumstances. In 2010 this decision table was in the form as given below:

Section 1.2 – ICES advice book 1, 2010

Stocks without population size estimates

For many fish stocks, the data available are inadequate to estimate the current population size and the catch resulting from fishing at a desired F. However, other data may be available to allow ICES to assess the desirable intensity of fishing.

For stocks without population estimates, ICES practice has been to base advice on recent average catches when there is no quantitative or qualitative evidence of declining abundance. The ICES MSY approach calls for a determination of the status of exploitation relative to F_{MSY} (overfishing or no overfishing) and consideration of the stock trend. The following table is the framework for advice for stocks without population size estimates.

	No Overfishing	**Overfishing or Unknown Exploitation Status**
Decreasing stock trend	Reduce catch from recent level at rate of stock decrease	Reduce catch from recent level at rate greater than the rate of stock decrease
Stable stock trend	Maintain catch at recent level	Reduce catch from recent level
Increasing stock trend	Increase catch from recent level at rate of stock increase	Maintain catch at recent level

Fishery catch per unit effort data or resource survey abundance information may be used to assess population trends, taking uncertainty into account. Age or size composition data are often useful for assessing the status of the fishery relative to F_{MSY}. However, there are situations where even this type of information is not available. In such cases, it might still be possible to give advice but the basis for this advice cannot be prescribed in advance. This approach is intended to move in the direction of MSY, but this is unlikely to be achieved without additional or more complete information.

In 2011, the table was adapted and a footnote was added:

Section 1.2 – ICES advice book 1, 2011

Updated table + footnote

	No overfishing	**Overfishing or unknown exploitation status**
Decreasing stock trend	Reduce catch	Reduce catch
Stable stock trend or no trend information	Do not allow catches to increase.	Reduce catch [1]
Increasing stock trend	Do not allow catches to increase	Do not allow catches to increase.

[1] In cases where catches are already very low, instead of a reduction, ICES advises that no increase of the catch should take place unless there is evidence that this will be sustainable. For other stocks, 2011 is the first year ICES collated and analysed data. For new stocks where there is insufficient information to evaluate the status and exploitation, ICES advises that catches should not be allowed to increase in 2012

When the first of these decision tables was used to provide annual advice in 2010, comments were made that this was not an MSY advice, and questions were raised about how to compute the rates referred to in the table. In 2011 WKFRAME II (ICES, 2011) further commented that this table should not be seen as an equivalent MSY advice, in that the yields arising from the application were more likely to be sustainable in the longer term rather than equivalent to a maximum sustainable yield. In addition WKFRAME II commented that "[the] above approach presumes a relationship between catch and F. In the short term this relationship may be perturbed by [for e.g.] recruitment which deviates from the mean. Thus advice generated from the current ICES approach should be seen as directional and not sensitive to short term variability. Should there be a short term consideration which would significantly affect the annual advice, e.g. a large recruitment event, this should of course be taken into account and as suggested in section 3.5.3, the framework should not be applied mechanistically."

The table was modified during the advice drafting process in 2011, to remove the references to trends (which had proved difficult to apply consistently in 2010). The result was the second decision table presented above, which was used to provide advice in 2011.

However this still proved unsatisfactory as many of the other factors on which the advice was based were not considered by the simplified table; in addition there was no option for increasing catch in underexploited populations with increasing abundance. WKFRAMEIII was tasked to further develop the empirical framework to produce a generic catch advice, consistent with the available scientific information and in the context of MSY and PA considerations. How the ToR's have been addressed is elaborated further in Section 1.2 below.

With regard to the future development of the advice framework for data poor stocks: the issues of how the advice is intended to be implemented and the limitations to this kind of generic basis for generating catch advice, needs to be clearly understood and communicated to clients. To be explicit, what is meant here (for situations where there is no population forecast) is that when measures of stock response are enumerated or informed by expert judgement, any putative response of the stock to a management action may not be measurable (or be able to be judged to have responded or not) within the cycle of 1 year (i.e. that this advice is not by default an annual basis for providing catch options). In addition as the advice (produced by the application of the framework provided in this report) is based on the modulation of the recent catch, there is a potential decoupling of the putative action and response logic, should the recent catch be affected by conditions other than the management response. This decoupling of the cause and effect logic is a limitation to the approach, which calls for an even greater need that the approach not be applied mechanistically. Finally, where the overriding issues of concern for fisheries management are related to a multispecies nature of the fisheries, it goes without saying that the single stock advice (provided by this framework) does not effectively address those fisheries management needs. Therefore it should be considered that the advice framework for data poor stocks presented in this report is a "work in progress", and that the development of a Harvest strategy standard should be considered, where such a standard would clearly link the technical aspects of advice provision with the management context of policies being used to govern the harvesting of marine resources.

1.2 How the terms of reference have been addressed

This report presents how WKFRAME III has addressed the following ToR's

a) Further develop the trends table* to be applied in situations where no quantitative projections are available taking into account;

   i) Life history traits

   ii) Exploitation characteristics (for example bycatch/targeted species)

   iii) Historical recovery trajectories

   iv) Changes in distribution and fisheries (for example changes in effort)

Determine the merits of having one single table or multiple tables that take account of the information.

b) Identify the criteria to be used in determining the trends in biomass or abundance (for example the time period over which to assess trends);

c) Develop the approach to provide quantitative advice on the basis of the(se) table(s) by identifying the rates of decrease/increase to be applied taking into account a) and b). In addition, propose conditions under which a zero catch advice is appropriate.

The workshop made some efforts to further develop the advice framework for data poor stocks (notwithstanding the limits of this approach outlined above). These developments included the elaboration of the table to deal with situations of under as well as over exploitation (in relation to long term sustainability), and the creation of a "precautionary factor" to deal with increasing uncertainty in either the reproductive capacity, development (i.e. trends) or exploitation of the stock. In this regard some of the terms of reference under ToR a) have only been dealt with in passing (see section 3 for further details). With regard to ToR b), the workshop was unable to be prescriptive short of providing some general guidelines, and elaborating a little on what implied by "trend in biomass or abundance" from the point of view of the catch rule applied in the table. It was felt that further exploration in any general guidelines would be better informed by a meeting of suitable experts, for example WGISDAA (ICES, 2012).

2 Data poor initiatives in other jurisdictions

Managing fisheries with limited data is not a situation unique to ICES member countries. By some standards the situations which ICES treats as "data poor" are not data poor at all. In any event many countries globally have adopted guidelines for harvest strategy policies which accounts for the situation that not all fisheries have sufficient data from which they can be assessed and managed with precision.

2.1 Australia

Australia has a policy and guidelines for harvest strategies (Anon, 2007) which has been adopted since 2007. The policy and guidelines set out a tiered approach to harvest strategies which acknowledge that many stocks will not have target and limit reference points which can be applied directly. In such cases there is an acceptance that scientifically defensible proxies need to be specified, and the precautionary approach is applied to account for uncertainty where the quantification if risk is unavailable.

In the case of the southern and eastern scalefish and sharkfish fishery (which has 34 species in the catches), there are 4 tiers defined as follows;

- Tier 1: robust quantitative assessment
- Tier 2: preliminary quantitative assessment
- Tier 3: estimates of F from catch curves (age/length data)
- Tier 4: trends in CPUE

The target exploitation rates will decrease as the tier increases, i.e. the TAC's for lower tier levels will be a percentage (less than 100%) of the higher tier levels.

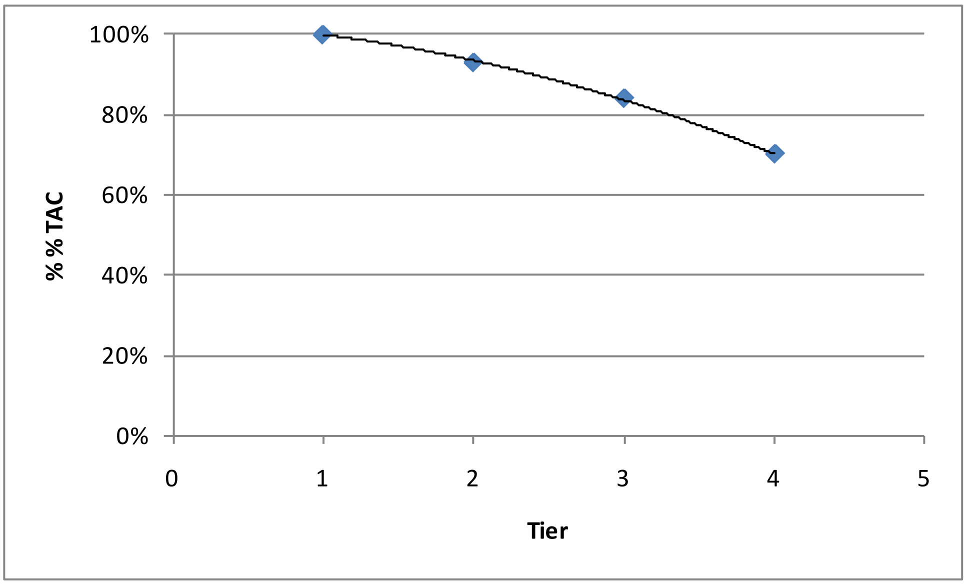

Fig 2.1. Theoretical example of the relationship between the TAC for higher Tier Levels as a percentage of a Tier 1 (high information) TAC.

For **Tier 3** species the advice is based on the empirical rule

$Catch_{y+1}=Catch_{current}*D$

where D can vary between 0 and 1.2 depending on F/M, and $Catch_{current}$ is the average catch (including discards) over the past 4 years.

For **Tier 4** the empirical rule is

$Catch_{y+1}=Catch_{current}*(1+b*slope)$

where the slope reflects the trend in CPUE over the past 4 years, or longer if the CPUE is cyclical.

It is interesting to note that in this Australian fishery, the differentiation between a Tier 1 and Tier 2 approach is expressed in the exploitation level applied (the value of F that would lead to 50% of unfished biomass in the long term for Tier 2, as opposed to 40% of unfished biomass for Tier 1). This means that where they have an assessment which they consider even preliminary they use the quantitative output for setting the harvest, albeit at a more conservative level.

2.1.1 Productivity and susceptibility Analysis (PSA)

Productivity and Susceptibility analysis is a risk assessment process, part of the Ecological Risk Assessment of the Effects of fishing (ERAEF) methodology. This method was developed in Australia (Hobday *et al*, 2007) as a response to the requirement to identify and prioritise the risks posed by fisheries to the marine ecosystem. The risk assessment framework enables available scientific resources to be focussed on the most pressing ecological problems and the most urgent need for information. Productivity and Susceptibility analysis is a semi quantitative process which examines the relative risks posed by fishing to the affected ecosystem components. These components can be stocks or stock proxies. In most data poor situations the stock structure is unknown, therefore the stock proxy is a species within a given geographical area. With suitable scoring systems, it can also be applied to habitats. Those components at highest relative risk can then be examined in more detail.

Productivity is scored using such attributes as growth, maximum age, maximum size, fecundity and reproductive strategy. High risk attributes, such as slow growth and low fecundity, score more highly in terms of risk, the scale is from 1 to 3. Susceptibility, is analogous to fishing mortality and is derived from scoring (again on a score of 1 to 3) attributes such as the geographical availability of the stock to the fishery, whether the stock is likely to encounter the gear, and scores for selection and survival post encounter.

There are various scoring schemes, see Cotter and Lart (2011), for further information. The requirement of a scoring framework, is to pick attributes that are as independent as possible, but can be estimated for the components being compared. To make the assessment as precautionary as possible, where the score for an attribute is unknown a default high risk level is scored.

The idea behind PSA is that the Productivity and Susceptibility attributes of a component are a useful measure of its capacity to sustain the type of fishing under consideration. When plotted on a Productivity v's Susceptibility graph (Figure 2.1.1), the overall risk to the species can be estimated by the Euclidean distance from the origin obtained by Pythagoras' theorem.

The scheme for PSA is illustrated diagrammatically in Figure 2.1.1. It is not a substitute for stock assessment. However, within one analysis, PSA should be consistent across the components in a relative sense and, therefore, give a comparative risk assessment to the effects of fishing, which enables resources to focus on specific stocks, stock proxies or habitats.

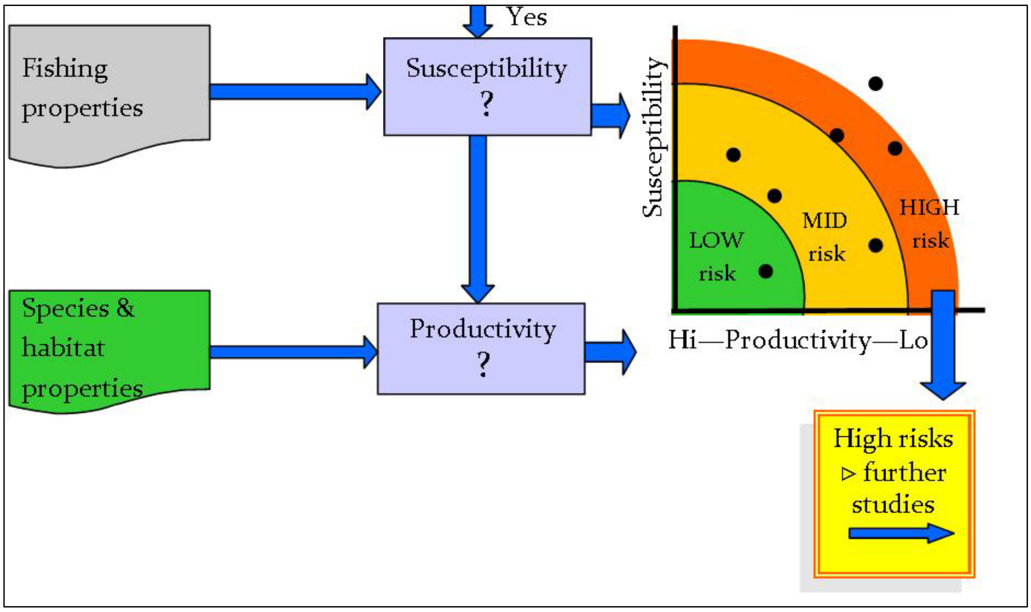

Figure 2.1.1 Illustration of Productivity and Susceptibility analysis; modified from Cotter and Lart (2011). Each point on the graph represents a stock or stock proxy affected by fishing. Note; Productivity is plotted from high to low on the horizontal axis (hence from low risk to high risk, when moving from left to right on the horizontal axis); Susceptibility from low to high on the vertical axis (hence from low risk to high risk, when moving upwards on the vertical axis). A similar process may be undertaken for habitats on a separate plot. Those in the top right hand section of the graph (highest Euclidean distance from the origin) represent components at highest risk due to the effects of fishing and, therefore, should be prioritised for further analysis.

2.2 New Zealand

New Zealand has produced technical and implementation guidelines for their Harvest strategy standard (Anon, 2008). As with Australia the harvest strategy standard is produced in the context of a Fisheries Management Act (fisheries act of 1996), which outlines the objectives and principles behind the utilisation of the fisheries resources in New Zealand waters. Although a tiered approach has not been formally adopted, New Zealand recognises the range of data available across their different fisheries, and this is reflected in their harvest strategy standard which states: "The Harvest Strategy Standard specifies that targets should be based on MSY-compatible reference points[1] at the minimum."

For some data poor species an MCY (maximum constant yield) is adopted, which uses equilibrium assumptions about MSY for the stocks and is modified to account for data deficiencies (e.g. MCY=MSY*f where f<1). Where proxies for F and B reference points are to be used, there is a classification of productivity (into high medium and low) based on life history characteristics. Based on this classification of productivity, simplified guidelines are given on how to set default Fmsy and SSB reference points.

PRODUCTIVITY LEVEL	%B0	F%SPR
High productivity	**25%**	**30%**
Medium productivity	35%	40%
Low productivity	40%	45%
Very low productivity	45%	50%

Roles and responsibilities are defined for both Scientific and Management working groups, where the Scientific groups provide best estimates or range of estimates of MSY reference points and provide the limit reference points and the Management working groups set the targets. It is interesting to note that in New Zealand an evaluation of whether overfishing is occurring is based on a three to five year running average of exploitation levels.

2.3 USA

In the USA NOAA produced technical guidelines on setting catch levels for data poor stocks (Berkson *et al* 2011). The USA has a tiered approach based on the quantity and quality of information available. In the USA the purpose of the scientific working groups is to define the Acceptable Biological Catch (ABC) and Overfishing limits (OFL) which is required under the Magnusson Stevenson Act (MSA), and the responsibility of the Fisheries management Councils (FMC) to set the Catch limits. It is interesting to note that the authors of the technical guidelines document include both fisheries scientists and fisheries management professionals. The approaches outlined by Berkson *et al* (2011) range from analytical methods which use time series of catches and stock response metrics (such as depletion based stock reduction analysis and depletion corrected average catch; see WKFRAME, 2010, for more information) to scalar approaches as the MCY approach in New Zealand and empirical approaches

[1] MSY-compatible reference points include those related to stock biomass (i.e. B_{MSY}), fishing mortality (i.e. F_{MSY}) and catch (i.e. MSY itself), as well as analytical and conceptual proxies for each of these.

based on PSA categorizations (the so-called "Methot table"). Berkson *et al* (2011) advocate a hierarchical approach, i.e. to use various methods depending on the data available, noting that "Lower tier methods are designed to provide catch advice so that the fishery will be sustainable, but the optimality of the derived catch and the probability of overfishing are not known." This is essentially the conclusion of the various WKFRAME workshops which have superficially looked at this issue and concluded that advice generated for data poor species (on the basis of limited biological information and catch data) should be seen as moving exploitation in the direction of what is sustainable rather than delivering an MSY based advice on an annual cycle.

2.4 Other Jurisdictions

The summary provided above is not meant to provide a review of the approaches globally, and there may be some novel ideas from other areas which have not even been considered here (one could think of investigating the approaches used in e.g. South Africa and Canada). Such a comprehensive review would be an important reference for ICES in trying to work with its clients in providing fisheries advice which suits their needs. In all the examples looked at in WKFRAME III the issue appears to have been tackled jointly by managers and scientists, and it is likely that a satisfactory arrangement for ICES member countries would employ the same approach.

3 Development of the advice framework for "data poor" stocks

3.1 Primary limitations in 2011

In 2011 the decision table for data poor stocks was adapted to reflect the lack of resolution of the issue of determining rates in trends in stock development. References from the 2010 table to '*the rate of stock de/increase*' were deleted in 2011 because it was judged that these rates could not be quantified in a consistent way. The table then took the form given below:

	No overfishing	**Overfishing or unknown exploitation status**
Decreasing stock trend	Reduce catch	Reduce catch
Stable stock trend or no trend information	Do not allow catches to increase.	Reduce catch [2]
Increasing stock trend	Do not allow catches to increase	Do not allow catches to increase.

This modification had the unintended consequence of limiting catch advice for stocks with no population estimates to a maximum of the most recent catch, even under the condition where the stock could have been lightly exploited (below F_{msy} proxy) and its abundance increasing. Whilst this approach may have some utility in terms of a cautious short term action to take under the expectation that there would be a more precise evaluation of the stock in the near future, it does not deal with the reality that many stocks will remain imprecisely evaluated, due to the nature of either the fishery or species biology. As per ToR a), we have tried to elaborate on the original table to take this into account.

Some of the problems in adapting the table used for the advice in 2011 stem from the fact that it seems to have been implicitly adopted by ICES that all stocks for which an advice is to be given and for which there may be no population estimate, have to be advised upon according to this table and on an annual cycle. WKFRAMEIII again stresses its original intention that advice for data poor stocks should be seen as directional and implemented in a stepwise fashion which requires a stock response to be ascertained. Given that this stock response may take more than a single year to be determined, it may be more appropriate to give advice for some of these stocks on a multi-annual basis, in line with the time it may take to measure the effect of implementing the advice.

Finally there are invariably exceptional conditions arising which may merit a different form of advice to that prescribed in the table. We have tried to deal with some of the more obvious of these cases (section 3.2.2) and suggest that these and other factors should be considered before attempting to classify the advice according to the table. Again WKFRAME III stresses that the framework proposed here is meant to provide guidance, and that it should not be applied mechanistically.

[2] In cases where catches are already very low, instead of a reduction, ICES advises that no increase of the catch should take place unless there is evidence that this will be sustainable. For other stocks, 2011 is the first year ICES collated and analysed data. For new stocks where there is insufficient information to evaluate the status and exploitation, ICES advises that catches should not be allowed to increase in 2012

3.2 ICES generic MSY HCR and the Empirical Harvest Control Rule for "data poor" stocks

It is proposed that the ICES advice is based on a generic approach starting from the ICES MSY HCR which is then adapted to achieve sustainable exploitation by changing the catch recursively in response to two features:

- The state of the stock in terms of the level of exploitation and the response of the stock in terms of its reproductive biomass.
- The quality of information on the state of the stock

This adaptation requires a change in the way information is used; from the model output based MSY HCR to an empirical approach for the "data poor stocks". The following situations and associated rules for advice are considered:

3.2.1 Full analytic assessments and forecasts:

Rule 1: When full analytic assessments and quantitative forecasts are available, the ICES MSY HCR (described in section 1.1 of this report) applies (unless the species is managed by an escapement strategy).

3.2.2 Not full analytic assessments and forecasts

In 2010, WKFRAME (ICES, 2010) concluded that for stocks without a population estimate and forecast, advice should be generated (in relation to the putative targets) which is aimed at moving the exploitation rate towards the target, by specifying an applicable longer term catch rather than specifying an exact harvest rate in relation to the current stock status and expected short term development of the stock. Because the cause and effect is not precisely enumerated in the situation where you are measuring the response of the stock to the fishery in terms of trends in abundance, it takes longer to detect changes in the system response, and this needs to be considered in the way in which advice generated in this way is applied in terms of a management action (see discussion in section 3.6). For some stocks (without a population forecast), a generic approach based on the ICES MSY HCR may not apply. These include:

i) Short-lived stocks, for which F-based reference points may not be relevant.

ii) Stocks exploited in a newly developing fishery (for which there may be no historical catch record or information on abundance trends), for which an HCR based initially on the precautionary approach alone may be developed.

iii) Stocks where there is a continuing observation of a critically low biomass condition, this defaults to a zero catch advice where this has been previously advised.

For other stocks, the following rule should apply:

Rule 2: When there is not a full analytic assessment including a forecast, an empirical HCR scales the recent catch (not TAC or not necessarily landings, see section 3.5) according to the ratio of target(F_{msy}proxy)/ current exploitation (this ratio will be called f from here on in this report) and the change in reproductive biomass, as measured by the trend of an appropriate index (see section 3.4), whilst having a protection rule against a low biomass condition which could impair the reproductive capacity of the stock.

The recent catch can be an average over some years, and the pressure on the stock (f) is given by some average of the fishing mortality rate measured annually over the same period relative to an F_{msy}proxy. The stock reproductive biomass arises from a number of factors: ***a***) changed numbers of fish in each cohort due to natural and fishing mortality and ***b***) individual growth of those fish, and ***c***) additions to the SSB from maturity. Although it is ***a*** you are trying to manage by proxy using the measurement of "stock response", both ***b*** & ***c*** are produced from the demographics of the stock and not "caused" directly by the mortality. For example: If exploitation was exactly at the long term equilibrium (e.g. $F=F_{msy}$), you would expect the SSB to have no trend over time. However, you could expect there to be short term fluctuations in stock biomass due to recruitment variability. If the catches were fixed at the long term equilibrium yield, you could expect the exploitation rate to fluctuate according to the short term changes in the SSB caused by recruitment variability. Therefore, you could expect to see short term changes in f created by short term changes in stock biomass, even if the catches were set at the long term equilibrium yield. For this reason an evaluation of the stock response to a volume of catch should look at a time period which "smooths" out as much of the short term perturbations as possible. In that regard what you are looking for is the (potential) trend in the SSB over a period of (relatively) stable catches. If the recent catches have a trend, then you have to assume an "averaged" response in the SSB to the "average" exploitation resulting from the catch. If there is no trend in the recent catches then the variability in catch is just another piece of "noise".

3.2.3 Pressure and State can be assessed relative to proxies and a stock trend is available

Rule 2a: when proxies (for exploitation targets and low biomass triggers) exist and state relative to them can be enumerated (even based on expert judgement), a HCR can be applied according to the state of the stock relative to the proxies and the trend in the abundance index. The following HCR is applied:

$Catch_{y+1} = Catch_{current} * r * f * b$

where

r is the stock response rate (r>0)
(see section 3.4 below)

f is a proxy for $F_{msyproxy}/F_{current}$ (f>0)
(if the proxy measure is very variable (noisy) the range value for this parameter could be limited to avoid large interannual changes)

b is the smaller of 1 and some proxy for $B_{current}/MSYB_{trigger}$ ($0<b\leq 1$).
In cases where biomass is very low (*e.g.* when b<0.3), which may result in a high probability of negatively affecting the stock reproductive capacity, the option of giving zero catch advice should be considered.

3.2.4 Pressure and/or State cannot be assessed relative to proxies and/or a stock trend is not available

Rule 2b: In situations where even a proxy cannot be proposed, there is an expression of the equivalent condition, having due regard for the precautionary principle (*e.g.* treating $F_{msyproxy}/F_{current}$ unknown as if $F_{msyproxy}/F_{current} < 1$). A precautionary reduction factor is applied to the advised catch. This factor becomes smaller when more information is missing by implementing it as multiplicative according to the number of unknowns. Thus, the principle of the way in which the generic HCR proposed for this situation works is still as Rule 2a, with an additional multiplicative penalty factor θ:

$Catch_{y+1} = Catch_{current} * r * f * b * \theta$

where

θ = pf or pb or pr or any combination of these, and where there is more than one θ factor they are multiplicative (see details below),

f, b, and r are defined as in Rule 2a, but

r is *replaced* by 1 when its value is not enumerated, and "pr" (a value < 1) is introduced to logically implement the precautionary principle as a cautious response to lack of information.

f is *replaced* by 1 when its value is not enumerated, in which case "pf" (where pf=1 if it is known that f≥1, and pf<1 if it is known that f<1 or f is entirely unknown) is introduced to logically implement the precautionary principle as a cautious response to lack of information.

b is *replaced* by 1 when its value is not enumerated, and "pb" (a value < 1) is introduced to logically implement the precautionary approach as a cautious response to lack of information.

In the simplest practical context, all 3 penalty factors may be chosen to be equal (we suggest on an arbitrary basis that pb=pr=0.9 and pf = 1 or 0.9 depending on the situation, as explained above). Thus when r, f and b are all known, then θ= 1, otherwise

$\theta=0.9^{\text{number of unknowns and/or unquantified negative states}}$

where the "unquatified negative state" refers to f not enumerated but known to be <1.

The practical application of the generic rules 2a and 2b is given in the tables in section 3.4 below.

3.3 Accounting for species vulnerability.

Stocks with low productivity (i.e. those with high age of maturity, high longevity, slow growth rates or low fecundity) and high susceptibility (liability to capture and death) tend to be less resilient to fishing. Productivity and Susceptibility analyses (PSA; Cotter and Lart, 2011) can be used to quantitatively rank species according to vulnerability criteria. Using the PSA score, critical life history characteristics could be implemented in the generic HCR as an extra PA factor, for e.g. if the PSA score is larger than a certain threshold. Implementing this would require a thorough analysis of the PSA scoring mechanism, and this would need to be addressed by an Expert Group. So although this is a nice idea the necessary background work is unlikely to be available in the short term (see discussion in section 2.1.1).

3.4 Definition and computation of "stock response rate" (r):

The index used for computing the "stock response rate" in the advised catch should represent the reproductive population. In principle this should represent the spawning biomass, therefore an SSB index would be the obvious choice. However, if such an index is not available any other measure which is a proxy for the SSB could suffice; e.g. an abundance index. Note, however, that an abundance index which is dominated by recruitment would not have desirable properties in this respect.

To compute the stock response rate, *n* index years must be selected, starting from the most recent year available. The quantity "stock response rate", in essence, approximates the ratio of the index values in any two consecutive years within the selected *n* year period. For example, a stock response rate of 1.15 would mean $I(t+1)/I(t)$ = 1.15 (*i.e.* a 15% annual increase), approximately, for any years *t* and *t+1* in the selected range of years. The "stock response rate" factor to be used in calculating the advised catch would then be r=1.15. Similarly, if $I(t+1)/I(t)$ = 0.85 (i.e. a 15% annual decrease), approximately, for any years *t* and *t+1* in the selected *n* year period, then the "stock response rate" factor used in the advised catch would be r=0.85.

The number of years *n* used for the computation should be big enough to be able to reflect the consequences of management actions (*e.g.* an increasing stock trend after some years of lower fishing mortality) and, hence, it should be related to the species longevity and productivity. Larger values of *n* should be used for longer lived and less productive species. As an arbitrary default, we suggest *n*=5. This is an ad-hoc proposal and if there is an accepted rationale to use a different value of *n*, then that value should be used when accompanied by the rationale.

The calculation of the stock response rate is case-specific and depends on how the index time series looks. It will often be easier to examine the series in logarithmic scale, *i.e.* to base the analysis on ln($I(t)$) instead of $I(t)$. If the index series in logarithmic scale looks fairly linear, then simple linear regression could be applied to estimate the slope. The "stock response rate" to be used in the advised catch would then be r=exp(estimated slope). More sophisticated methods (time series or filtering techniques) could be required, depending on the shape of the time series or, *e.g.*, to deal with the uncertainty associated with the index values in different years. With *n=5* years, calculating the "stock response rate" as the index average in the 2 final years divided by the index average in the 3 immediately preceding years could also be sensible. Irrespectively of the method applied, the result should be a value that approximates the ratio $I(t+1)/I(t)$ during the years selected.

In order for the generic HCR to work (logically) the same method (in calculating the stock response rate) should be applied the next time the data is analysed for the purpose of providing an advice.

In data poor situations, it is often very difficult to separate signal from noise, particularly if there is only one index series available. Analytical stock assessments models act as "filters" that extract signals from the data, but when working with only indices, there will typically be more noise which could potentially lead to very large inter-annual changes in advised catch. As a practical way to avoid advising extremely large changes in catch that may not reflect population changes, it is proposed that the "stock response rate" (r) used for the advised catch is restricted by an interval. We suggest on an arbitrary basis that such an interval could be 0.5-1.5, *i.e.* that the maximum change permitted (arising from potential trends in the index series) does not exceed 50%.

3.5 Proposed table based on the generic HCR

The generic HCR proposed in 3.2.2 (see also 3.2.3 and 3.2.4) above has the form:

$Catch_{y+1} = r * b * f * Catch_{current} * \theta$

If only landings are known, and are thought to be different from the actual catches, then the term 'catch' could be changed to 'landings' in this formula. However if there is a large component of the catch discarded, then the changes in landings given by the HCR will not have the intended effect on mortality and, thus, on the stock response.

The term "current" refers to the recent period for which the information is used. This period might include the most recent year only (for short lived stocks), but will more commonly be a longer period of years.

Example 1: Terminal catch year is 2011 and a only one year (2011) only has been chosen to define "current". Then b is simply the (relative) stock size in 2011 and f is a proxy for F_{msy}proxy/$F_{current}$, where $F_{current}$ is a proxy F in 2011. $Catch_{current}$ is the catch weight in 2011. The stock response rate (r) must reflect the change in the stock index from 2010 to 2011.

Example 2: Terminal catch year is 2011 and a 3 years period has been chosen to define "current". Then b must make use of annual estimates or expert judgement about it for the years 2009-2011 (e.g. to calculate a simple average of the three values). Similarly, $Catch_{current}$ is the (e.g. average) catch weight within the period 2009-2011 which corresponds to the (e.g. average) $F_{current}$ in the period. A higher weighting of the most recent information might be appropriate. The stock response rate, r, must be estimated over the same "current" period as well.

The period of the $Catch_{current}$ may need to be given further consideration; for example what is the effect on the performance of the HCR where there is a trend in the recent catch and variable ranges of years can give variable values for $Catch_{current}$ which would significantly affect the advice for $Catch_{y+1}$?

The following two tables describe the catch multiplier calculation for stocks with regard to the trend and state in biomass and the exploitation rate. The first table gives the multipliers where numerical estimates are available (even if these numerical estimates are proxies based on expert judgement); the second table is suggested where categorisation of the state of the stock (b) or exploitation rate (f) can only be done qualitatively.

Table 3.5.1. Catch multipliers to obtain $Catch_{y+1}$ from for $Catch_{current}$ in cases where there exist numerical estimates of ratios to corresponding MSY proxies of at least one of stock size (b) or exploitation rate (f). In other words, numerical values for at least one of b or f exist. When pf is used in this table, pf=1 if it is known that f≥1 (i.e. that the exploitation rate is below F_{MSY} proxy even if a numerical value for f cannot be determined) and pf<1 otherwise. When pb and pr are used in this table, they are always < 1.

		Exploitation rate			
Response: Stock trend	**Stock size**	Below F_{MSY} proxy	At or close to F_{MSY} proxy	Above F_{MSY} proxy	Unknown
Decreasing	**above trigger**	r * 1 * f	r * 1 * 1	r * 1 * f	r * 1 * pf
	below trigger	r * b * f	r * b * 1	r * b * f	r * b * pf
	unknown	r * pb * f	r * pb * 1	r * pb * f	Use Table 3.5.2
No change	**above trigger**	1 * 1 * f	1 * 1 * 1	1 * 1 * f	1 * 1 * pf
	below trigger	1 * b * f	1 * b * 1	1 * b * f	1 * b * pf
	unknown	1 * pb * f	1 * pb * 1	1 * pb * f	Use Table 3.5.2
Increasing	**above trigger**	r * 1 * f	r * 1 * 1	r * 1 * f	r * 1 * pf
	below trigger	r * b * f	r * b * 1	r * b * f	r * b * pf
	unknown	r * pb * f	r * pb * 1	r * pb * f	Use Table 3.5.2
Unknown	**above trigger**	pr * 1 * f	pr * 1 * 1	pr * 1 * f	pr * 1 * pf
	below trigger	pr * b * f	pr * b * 1	pr * b * f	pr * b * pf
	unknown	pr * pb * f	pr * pb * 1	pr * pb * f	Use Table 3.5.2

Table 3.5.2. Catch multipliers to obtain $Catch_{y+1}$ from $Catch_{current}$ in cases where there exist only soft (categorical) estimates of the ratio between the stock size and/or exploitation rate, and their MSY proxies. In other words, numerical values for b or f do not exist. When pf, pb and/or pr are used in this table, they are always < 1.

		Exploitation rate			
Response: Stock trend	**Stock size**	Below F_{MSY} proxy	At or close to F_{MSY} proxy	Above F_{MSY} proxy	Unknown
Decreasing	**above trigger**	r * 1 * 1	r * 1 * 1	r * 1 * pf	r * 1 * pf
	below trigger	r * pb * 1	r * pb * 1	r * pb * pf	r * pb * pf
	unknown	r * pb * 1	r * pb * 1	r * pb * pf	r * pb * pf
No change	**above trigger**	1 * 1 * 1	1 * 1 * 1	1 * 1 * pf	1 * 1 * pf
	below trigger	1 * pb * 1	1 * pb * 1	1 * pb * pf	1 * pb * pf
	unknown	1 * pb * 1	1 * pb * 1	1 * pb * pf	1 * pb * pf
Increasing	**above trigger**	r * 1 * 1	r * 1 * 1	r * 1 * pf	r * 1 * pf
	below trigger	r * pb * 1	r * pb * 1	r * pb * pf	r * pb * pf
	unknown	r * pb * 1	r * pb * 1	r * pb * pf	r * pb * pf
Unknown	**above trigger**	pr * 1 * 1	pr * 1 * 1	pr * 1 * pf	pr * 1 * pf
	below trigger	pr * pb * 1	pr * pb * 1	pr * pb * pf	pr * pb * pf
	unknown	pr * pb * 1	pr * pb * 1	pr * pb * pf	pr * pb * pf

3.6 Discussion

The tables presented above are an attempt to explicitly describe the decision rules used (tacitly or otherwise) by ICES in providing catch advice for situations where there is no population forecast. The tables implement in a formal way the Precautionary Approach with the objectives of the MSY approach and give a basis for the enumeration of a catch figure for the advice.

The decision rules include a set of precautionary (penalty) factors. Based on expert knowledge ICES could set the factor values for the individual stocks based on the biology of the species. However, the time needed for a stock recovery is a function of (amongst others) the risk taken during the recovery period and this is not entirely a scientific prerogative. Therefore fishery managers should have an input to the values of the θ factors also. The θ factor could be used to include all sorts of risk considerations (for e.g. it could include some metric of whether the catch applied exceeded the advice), but it is not trivial to work out values which could be applied in a generic sense, and any proposals should be backed by simulations.

There are a series of properties to the above decision rules which would merit further investigation. Firstly, there is no feedback for continued unknowns, which may be trending in a negative direction, it is not known what the consequence of this scenario is and it is likely to be case specific. Secondly, WKFRAME III is acutely aware that, although the rules appear logical in moving exploitation towards or maintaining a sustainable exploitation level, the rules have not been tested by simulation, and we suspect that (under certain scenarios) they may have undesirable properties of driving the catch advice to very low fractions of the starting values in the medium to long term (see section 3.7 below). WKFRAME III therefore suggests that the decision rules presented above be considered as a temporary measure until a more stock (fishery) specific solution is available. Thirdly, WKFRAME III stresses that despite best efforts to apply the decision rules in a considered way, the resulting catch advice will likely in many cases, be subject to short term noise in the pressure (f) and state (b) indicators. Such noise (created either by measurement error or short term stock demographic perturbations) may create large fluctuations in the catch advice. As a means to counter this, WKFRAME III suggests that limits to the current catch multipliers could be considered. The logical effect of applying such limits would be analogous to a TAC constraint in a stock specific HCR. However, in the case of a stock specific HCR the risk arising from a TAC constraint is managed by altering the other parameters, all of which are specific to the stock/fishery and many of which are specific to certain life history parameters (e.g. productivity): it is a considerable challenge, therefore, to make generic catch advice constraints which have the properties of both managing risk and suppressing noise. Finally, because of the delay between action (change in catch) and response (state of the stock (b), trend in stock development (r) and pressure from fishery (f)) the advice from these tables should not be assumed to be applicable as an annual advice.

The basic principle that a higher level of uncertainties should lead to lower level of TAC is sound and in accordance with the Precautionary principle. However, the very specific formulation of the approach here will likely mean that it will not be applicable in all cases. To this extent we have provided some obvious considerations which would preclude the application of the table (see section 3.2.2). The proposed rules need to be evaluated further by both stock specific implementations and by extensive simulation. While such work may take a considerable time to undertake, the question could be asked whether effort would be more effectively deployed in developing fishery specific HCR's.

3.7 Further considerations in the use of generic HCR for data poor species

In the development of the proposed generic HCR, similar approaches were presented. The methodology described below has much in common with the proposal. However, whereas the approach above is empirical, the generic HCR's explored here are derived from the catch equation (i.e. C=B*F, where C, B and F denote catch, biomass and fishing mortality, respectively).

In the world of data poor stocks we do not have enough data to make an analytical assessment. We do, on the other hand, have time series of landings and, hopefully, catches, as well as one or more indices of stock abundance. In some cases we might also have more data.

The ICES MSY harvest control rule based on analytical assessment is to fish at $F_{msy} min(1, \frac{SSB}{B_{trigger}})$. In the world of non-analytical assessment this rule could be changed to a rule based on an index I_y and a proxy for fishing mortality

$$F_{proxy,y} = \frac{C_y}{I_y} \qquad (1)$$

In fishery science, we conduct an assessment in a year Y to give advice for year $Y + 1$. When we conduct the assessment, catch data are only available up to year $Y - 1$ but and index may exist up to year Y or $Y - 1$, depending on when during year Y the survey is conducted compared to the assessment. We do, therefore, have a delay in the advisory system that can be bad for stocks that change rapidly. If the catches are stable and the stock is managed effectively then the catches in year Y can be assumed to be close to the TAC in that year (as advised in year Y-1) but the value of F_{proxy} at year Y will of be different from what was assumed about it in year Y-1.

In year y, the catch we want to advise for year $y + 1$ is

$$C_{y+1} = min(\frac{I_{y+1}}{I_{trigger}}, 1) * F_{msy,proxy} I_{y+1} \ (2)$$

but as we do not know I_{y+1} we should use $I_{pred,y+1}$

$I_{pred,y+1}$ can be predicted from I_{y-1} and earlier years, or from I_y and earlier years. One option is to assume that the index is unchanged. Another option is to calculate the rate of change in recent years and assume that the same rate will continue. Indices of recruitment and other information about size of fish can be used in the forecast of I_{y+1} using time series models or delayed difference models. Of course, at this point it could be asked if we really have a data poor stock when we have multiple data to help in the prediction of the index.

The delay in information does not matter for many stocks but has negative consequences for others. In those cases the advice might be updated when I_{y+1} is available. Occasionally, the delay might even be advantageous, for example if a large part of the index consists of fish that will recruit to the fisheries in the next years.

So in the end the rule we end with is

$$C_{y+1} = min(\frac{I_{pred,y+1}}{I_{trigger}}, 1) * F_{msy,proxy} I_{pred,y+1} \qquad (3)$$

A smoother version of the rule would be:

$$C_{y+1} = C_{y-1} \frac{F_{msy,proxy}}{F_{y-1,proxy}} min(\frac{I_{pred,y+1}}{I_{trigger}}, 1)^{\delta} \qquad (4)$$

Another rule worth investigating is

$$C_{y+1} = C_y(\alpha_0 + \alpha_1(\frac{I_y}{I_{y-1}} - 1))min(1, \frac{I_y}{I_{trigger}})^{\gamma} \qquad (5)$$

where α_0 is usually 1.

The trigger action $min(1, \frac{I_y}{I_{trigger}})^{\gamma}$ is recursive, so if the power γ is too high the fisheries will soon close when the values of the index are below $I_{trigger}$. A typical value of the factor γ is 0.1, although the exact value depends on the longevity of the fish.

The rule discussed in section 3,2 is essentially an empirical analogue of

$$C_{y+1} = 1\beta_y PA_y C_{y-1} \qquad (6)$$

But as we are predicting 2 years it would become

$$C_{y+1} = 2\beta_y PA_y C_{y-1} \qquad (7)$$

β_y is trend in the indices estimated at year y and PA_y is year's y model of the PA factor. The 2 is because the trend is per year and is applied for 2 years. The PA factor has some default value, for example 0.9.

If equation 7 is applied without the PA factor it has an implicit goal of keeping the stock size constant if $F >> M$, else the factor β_y would have to be replaced by $\beta_y + (\beta_y - 1)\frac{M}{F}$ or $0.95 + (0.95 - 1) = 0.9$ if the downwards trend is 0.95. This means that 10% reduction in F is required to get 5% reduction in Z if $F = M$. The PA factor is also applied for 2 years so the PA value of 0.9 is just enough to keep stock status stable when $F = M$. A PA factor less than 0.9 means looking for increased stock size.

Equation 5 has the inherent goal of reaching $I_{trigger}$ in few years and when we reach $I_{trigger}$ the catches might already be low and the stock go above $I_{trigger}$. The behaviour above $I_{trigger}$ is somewhat random, but low vales of α_1 lead to stable catches. This rule can be suitable to apply for some years with not too high value of α_1 and $I_{trigger}$ somewhat where we have been in recent years. Compared to the rule shown in equation 7 it has at least a goal of reaching some biomass.

The proxy version of ICES MSY HCR (equation 3) can be made to do similar things as equation 7 by setting the goal that the stock will be unchanged over the next years. $F_{msy,proxy}$ in equation 7 would then be replaced by the mean F_{proxy} in the period that the trend was calculated over, multiplied by $\beta_y + (\beta_y - 1)\frac{M}{F}$. A PA factor would mean that the goal was to increase the stock and mean F in the period would be replaced by $\beta_y PA + (\beta_y PA - 1)\frac{M}{F}$

Simulations conducted in recent years indicate that rules based on ratios of indices and/or accumulated ratios between I and $I_{trigger}$ have problems when starting from low values, i.e well below $I_{trigger}$. When the trigger is reached the fishing mortality is already very low and above the trigger only the ``ratios'' work and are not able to increase the catches. Making the rule in equation 5 acting both above and below $I_{trigger}$ helps, but still the overshoot can be quite large. The rule might, though, work well for few years. The F_{proxy} version of the ICES MSY HCR seems to be the best of the poor data HCR's investigated in terms of long term stability, but requires smoothing to avoid unnecessary interannual changes in catches.

Noise and nonlinearity in the relationship between survey indices and stock are things that need to be considered in evaluation of HCR's based on indices. In quite many cases a smoother will have to be applied to the HCR, for example by smoothing the indices or putting a catch stabilizer on the HCR. A famous (notorious) example of a smoother is what is called assessment. But there are also more than one way to calculate survey indices, depending on how they are going to be used. If indices are going to be used directly to give an advice, a GLM model, winsorisation or other stabilizing mechanisms should be used when the indices are compiled.

4 Case studies applying the revised “data poor tables” framework

4.1 Lemon sole in Sub area IV and Divisions IIIa and VIId

The advice from ICES for 2012 and 2013 on the basis of precautionary considerations is that catches should not be allowed to increase. There is insufficient information to determine fishing mortality and stock size is estimated to be stable.

Interpreting this information on face value this would correspond to no change in stock trend, unknown stock size, and unknown exploitation rate. According to the framework proposed in Section 3, the advice would be

$Catch_{y+1}= Catch_{current}*pf*pb$

$Catch_{y+1}= Catch_{current} *0.9*0.9 = Catch_{current}*0.81$

If further information was used the advice could be different. For example: Catch-per-unit-effort (CPUE) in numbers derived from IBTS is shown in Figure 4.1.1. CPUE has increased since around 1980. This indicates that recruitment has not been impaired during this period. Spawning stock biomass (SSB) indices derived from the IBTS (Figure 4.1.2) show a slight decline in SSB over the period. The red line in the figure is the mean SSB index for the period with no impaired recruitment and is suggested as a candidate for $MSYB_{trigger}$. The SSB trends were smoothed using a 5 year average because it is expected that the total mortality is modest and the SSB consists of several year classes; the age at first maturity is 3-5 years. The original and smoothed trends are shown in Figure 4.1.3.

The stock appears to be stable in the last 5-10 years which places the stock in the ‘no change’ category. However, the stock size in the terminal year of the time series is below the candidate $MSYB_{trigger}$ (Figure 4.1.2). Using this additional information the stock is now classified as stable stock trend, known stock size and unknown exploitation rate. According to the table the advice would be;

$Catch_{y+1}= Catch_{current} *pf*b$, where b = 0.85

$Catch_{y+1}= Catch_{current} *0.9*0.85 = Catch_{current}*0.77$

A five year average was used for calculating stock trends. This suggests that a five year average should be used for $Catch_{current}$.

Implications

The additional information concerning stock size in relation to $MSYB_{trigger}$ will result in advice for slightly less catch in year y+1 than if b was treated as unknown. The period between catch adjustments is crucial. If the stock responds with an increase, it will occur on a timescale related to the species’ characteristics. For this species we cannot expect to find major changes in SSB within 1 year. This species characteristics (age at maturity 3-5 years) implies that advice should be updated at around 3 to 5 year intervals.

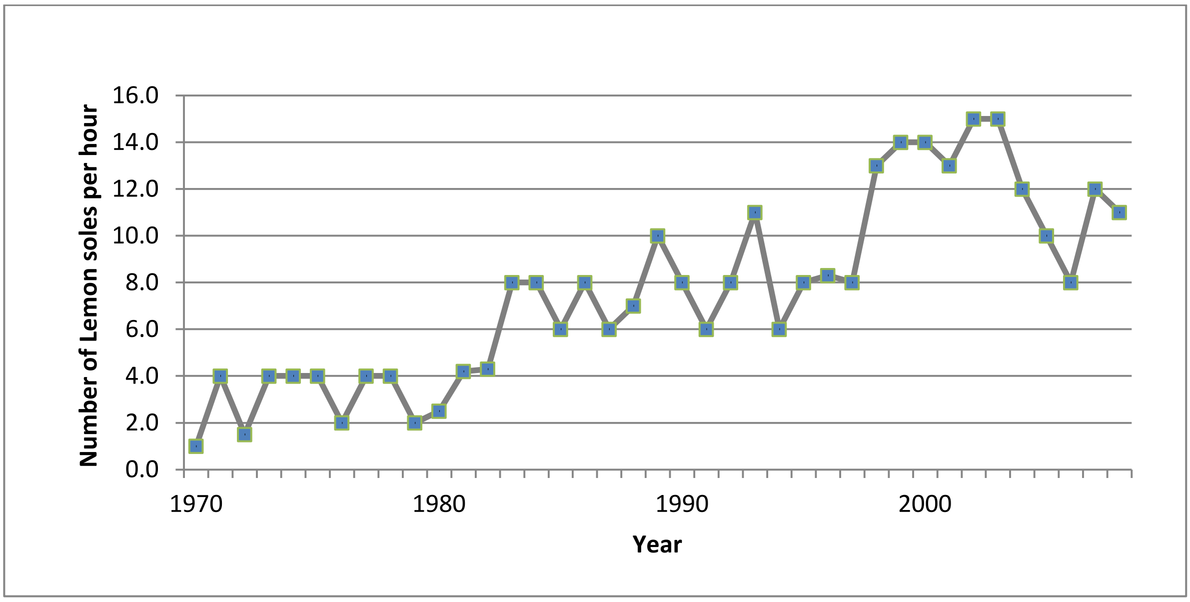

Figure 4.1.1 Time series of catch per unit effort from IBTS survey; quarter 1 data.

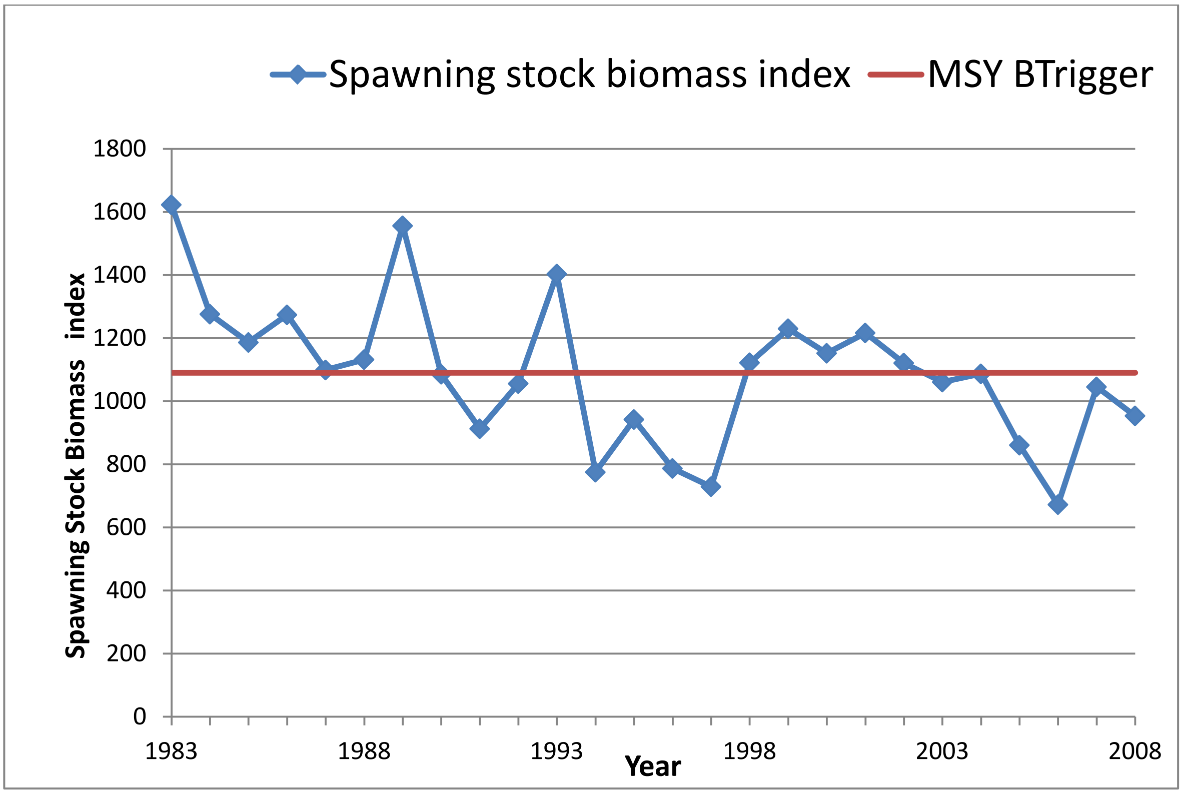

Figure 4.1.2 Time series of spawning stock biomass; the Spawning Stock Biomass Index was the total catch of mature lemon soles in kg caught in each survey, standardised to the final year (2008) of the survey. Thus in 1983, 1623 kg of mature lemon sole would have been caught by the survey, had the survey effort been the same as in 2008 when 954 kg were caught.

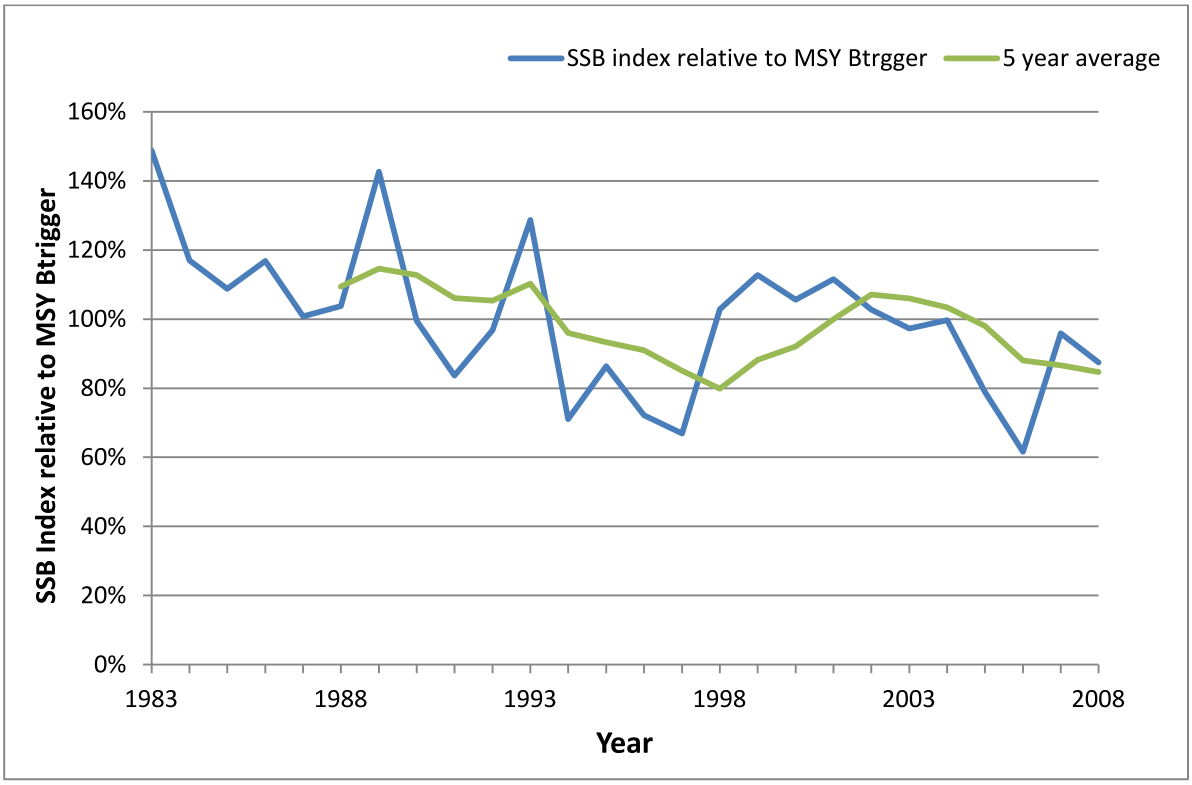

Figure 4.1.3 Spawning stock biomass relative to MSYB$_{trigger}$ with original data blue, 5 year average green

4.2 Baltic Flounder

The drafted framework (section 3) was also tested with Baltic flounder. All information used originated from the ICES advice for 2012 (ICES, 2011) and the Report of the Baltic Fisheries Assessment Working Group (WGBFAS) (ICES CM 2011/ACOM:10). Flounder is taken as bycatch in demersal fisheries and, to a minor extent, in a directed fishery. The only information available are commercial landings in numbers at age from Sweden, Latvia, Poland and Germany. It is estimated that discards of flounder are five to ten times greater than the amounts of landed bycatches of flounder in the cod trawl fishery. Also survey data from the Baltic International Trawl Survey (BITS) are available. It is also worth noting that the advice is based on the entire stock complex that might consist of 11 potentially separate population units.

For the years 2000 to 2011 ICES did not give an advice for this stock. The ICES advice for 2012 concluded that the stock has been stable in recent years and exploitation was considered to be low or moderate. Due to the lack of appropriate data, no analytical assessment and no detailed management options could be presented for this stock by ICES advice. Using precautionary considerations and the stable but noisy stock trend, ICES advised that catches should be reduced, but without giving a figure for the amount of the reduction. When using the revised table drafted during this workshop for stocks with "qualitative info only", and using the same conclusions as in the ICES advice for 2012, the following result was obtained:

Parameter	ICES Advice 2011	Row/cell chosen from Table 2
Stock trend	Stable (based on survey data)	No change (r=1)
Stock size	Stable (qualitative evaluation, absolute level unknown)	Unknown (b unknown)
Exploitation rate relative to MSY	Low to moderate (qualitative evaluation, green o.k. mark, meaning below Fmsy)	Below possible Fmsy proxy (numerical value of f unknown, but f≥1)
		Result: $Catch_{current}$ *1*pb*1

In the case for Baltic flounder, based on official landings of 16 582 tonnes and using a value of pb=0.9 this would mean an advice for a catch of 14 924 tonnes for 2012. However, one should note that when calculating this figure, no information about discards was considered. Also, there is currently no TAC set by the EU for flounder in the Baltic.

4.3 Boarfish in the NEA

The advice from ICES for 2012 on the basis of precautionary considerations is that catches should not be allowed to increase. Fishing mortality is less than natural mortality, and the stock is relatively large and widely distributed. Survey data suggests that recruitment has increased since 2005. The advice included under management considerations a suggested TAC based on the average landings over the past 3 years on the basis that the stock did not appear to have been overfished for this period. The trend and absolute biomass state are unknown.

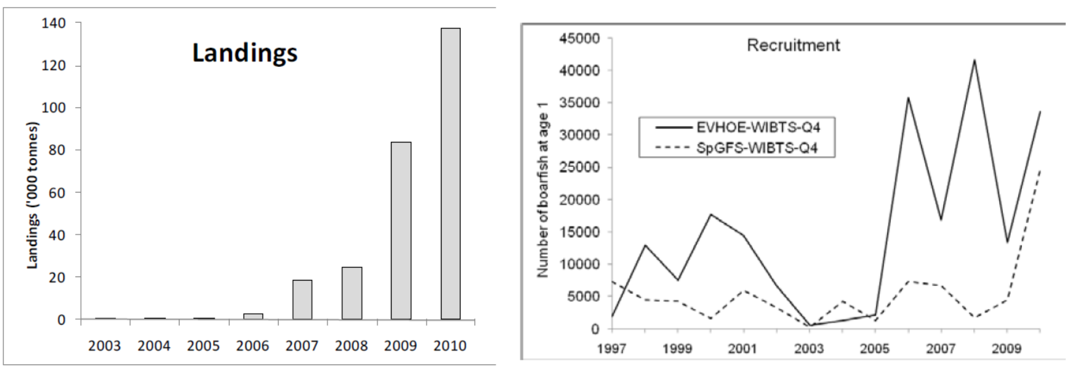

Figure 9.4.22.1 Boarfish in the Northeast Atlantic. Landings (000 tonnes) (left panel). Recruitment estimates (age 1) from two surveys: EVOE-WIBTS-Q4 and SpGFS-WIBTS-Q4 (right panel).

Interpreting this information at face value, would imply using Table 3.5.2 as no estimates of F proxies or proxies for reference points were presented in the advice. An interpretation of $Catch_{current}$ is required. Using the most recent year of catch data for $Catch_{current}$ (137 kt in 2010) would be problematic as there has been a strong increasing trend in the catch. Applying an average of the catch in the 3 most recent years (the same basis that was used in the 2011 advice) would imply

$Catch_{y+1} = Catch_{current} * pr * pb * 1$

$Catch_{y+1} = 82\ 000 * 0.9 * 0.9 * 1$

$= 65\ 600$

If additional available information was used, the advice could be different. For example: the 2011 WGWIDE produced a table of F estimates based on an assumed M and catch curves. See the table below.

	Z	F (Z-M)	Landings
2007	0.17	0.01	18 387
2008	0.23	0.07	24 683
2009	0.27	0.11	83 688
2010	0.28	0.12	137 503

Furthermore WGWIDE proposed a proxy for Fmsy based on some stochastic YPR analyses. On the basis that the increasing catches in recent years have not overexploited the stock, the catch and the F estimates could be averaged over the last 3 years, this would imply

$Catch_{y+1} = Catch_{current} * pr * pb * f$

$= 82\ 000 * 0.9 * 0.9 * (0.13/0.10) = 82\ 000 * 1.05$

$= 86\ 346$

As with the lemon sole example above, given the life history of this species it is unlikely to exhibit major changes in SSB within 1 year. This implies that advice should be updated at around 3 year intervals.

4.4 Discussion

These examples highlight a number of issues which will arise when trying to provide a catch advice when using this framework.

- The period of catch used to calculate $Catch_{current}$ matters, particularly where there is a trend in catches, and/or where the catches are affected by factors other than a direct management response to the perceived state of exploitation.
- The period (number of years) to which the same catch advice should apply could be variable between stocks.
- Other factors, such as the nature of the fishery (target or bycatch) or the extent of unaccounted catch (whether through discarding or other means), are not directly accounted for by the framework, but may require consideration.
- A different catch advice can be derived by making expert judgement for proxies for $MSYB_{trigger}$ and $F_{msyproxy}$, and making expert judgements on the exploitation pressure and stock state relative to these. This implies that the advice will depend on the scientific argumentation put forward to support an expert judgement.

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