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International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive summary

The ICES Study Group on Risk Assessment and Management Advice (SGRAMA) met at the ICES Headquarters, Copenhagen, Denmark 1–5 December 2008. This was the third meeting of the study group. The Study Group is still struggling with low participation despite "Risk Assessment" forming a part of one theme session at the Annual Science Conference in Halifax. The report is structured according to some elements in the group's Terms of Reference (ToR).

The use of the word "risk" as meaning the likelihood or probability of a (negative) event is still rather widespread within the ICES community. This will have to change if risk assessments are to be used as tools in developing multi criteria fisheries advice and to move beyond the very limited use of an often poorly defined Blim as a basis for advice. The word "risk" should relate to both the likelihood of and the consequences of an event or impact. Examples of such can be growth overfishing and discards or even multispecies interactions.

The last review of qualitative approaches was based on a presentation made by Gottfried Pestal. This presentation was made using a Skype® connection to Canada. The approach is similar to the approaches previously reviewed by the SGRAMA (2007), but the ambition of the work is reduced to produce results useful to prioritize research effort. The presentation included a brief demonstration of a software tool developed to aid communicating information to stakeholders.

A new item had been added to the ToR for this meeting of the Study Group:

> *c) develop operational guidelines for setting precautionary biomass limit reference points, taking the broader concept of risk into account.*

Keeping in mind the limitations of advice based solely on biomass limit reference points the Study Group came up with a set of guidelines presented in Section 5.4. These guidelines "comment" upon the setting and validation of a B_{lim} and B_{pa} including the use of B_{loss} as a B_{lim} value. The guidelines are also addressed the not uncommon situation of poor data and lack of resources.

The work of SGRAMA overlaps with different research projects. A short description of the EU-funded PRONE (Precautionary risk methodology in fisheries) project is given in Section 6. Of particular interest is Section 6.2 which describes an approach to estimate the cost of gaining new insight/knowledge.

1 Opening of the meeting

The Chair opened the meeting at 10:00 on 1 December 2008. The list of participants and contact details are given in Annex 1. The venue was the ICES headquarter in Copenhagen. The meeting facilities are well suited for such a meeting, and especially if more than one group with overlapping interests are meeting within the same period. The Study Group had a joint session with ACOM which turned out very constructive.

2 Adoption of the agenda

There was no formal agenda for the meeting. The Study Group started the meeting with a range of presentations and discussions related to the different elements of our ToR. The work was then organized in a "traditional" way with Study Group members drafting subsections of the report before these were reviewed and accepted in plenary.

2007/2/RMC09 The Study Group on Risk Assessment and Management Advice [SGRAMA] (Chair: Knut Korsbrekke, Norway) will meet at ICES Headquarters, Copenhagen, 1–5 December 2008 to:

- a) on the basis of the SGRAMA report from 2007 (in particular the framework described in the report), input from WGFS and experience gained elsewhere, develop operational guidelines for risk assessment by:
  - i) identifying potentials for measuring or estimating consequences and probabilities.
  - ii) relating indicators to negative consequences and developing management procedures based upon such indicators.
  - iii) considering pseudo quantification methods (Multi-criteria decision analysis, fuzzy, Bayesian) and other qualitative approaches;
  - iv) considering risk analysis methods;
  - v) reviewing implementations;
- b) consider and report on training needs and possible modalities for training to disseminate knowledge of risk assessments to members of ICES expert groups;
- c) develop operational guidelines for setting precautionary biomass limit reference points, taking the broader concept of risk into account.

3 Management plan evaluations

3.1 Some comments to the SGMAS report (SGMAS 2008)

In its update of guidelines (SGMAS, 2008) addressed the issue of management plan evaluation in relation with PA limit reference point as there is the request, from managers, that management plan needs to be shown to be in accordance with the Precautionary Approach. In this evaluation process, the approach recommended by SGMAS can be summarized as follows:

1) Management plan need to be developed with the aim of avoiding an unacceptable situation with a high probability. In the ICES context, B_{lim} is considered to be the appropriate biological limit reference point to be avoided although SGMAS recognizes that some alternative suitable point could be selected.

2) Regarding probability limits, the value of 5% seems to be reasonable.

3) If the risk is defined as the percentage of simulated populations that go below B_{lim} at least once in a 10 year period, then a plan would be defined as precautionary if the risk (of SSB<B_{lim}) was less than 5% in both first and second and ten year periods. If the aim is for a long-term plan and risk was less than 5% in the second period but not the first due only to uncertainty in the starting values the plan could also be accepted. If risk (of SSB<Blim) is below 5% in the first ten year period but risk in the second period is significantly higher than in the first, this suggests long-term deterioration and the plan should only be precautionary in the short term.

Based upon these recommendations, the following points were raised within the SGRAMA:

It was first noted that risk in SGMAS context is limited in scope as it is "simply" defined as the probability of an event (e.g. SSB<Blim) although SGRAMA uses the term risk in a broader manner consisting both in likelihood of the event and the severity of the consequences of the event (like multispecies interactions, economic and social impacts, etc.).

It was then mentioned that a unique limit of 5% may be problematic as, depending on the simulation model used and the way uncertainty is addressed/incorporated into it, the outputs may not be comparable. Clearly stating the assumptions of each models used is crucial in such case. Furthermore, the 5% limit relates to B_{lim} which may not be well defined. Mäntyniemi *et al.* (2008) note that ICES stock assessments commonly use Monte Carlo simulation to project forward stocks starting from the recent estimates of the current status of the stock. For example, HAWG uses the STPR3 program for medium term projection. Within this program, some parameters such as natural mortality and carrying capacity need to have fixed values, whereas some other parameters are assigned probability distributions e.g. natural variability in recruitment is modelled using a lognormal distribution and uncertainty about the initial stock status can be expressed either by providing a bootstrap sample or point estimates with a covariance matrix. However, uncertainty is also conditional on the historical data, assumptions and expertise of the working group. The key question is would you get different results if uncertainty is dealt with in an alternative way particularly would the choice of HCR change.

SGMAS limited its analysis to biomass reference points although it mentioned the possibility to choose alternative ones. Cadrin and Pastoors (2008) showed that for most of the stocks assessed by ICES, there are no PA points defined and this group felt that it may be important to investigate other criteria to be used for risk assessment in management plan evaluation such as, for example, avoid growth overfishing by improving selection pattern and reducing discards.

3.2 Accounting for structural uncertainty

3.2.1 Northern Hake example

Recent tagging studies on northern hake have led to estimates of growth that differ by a factor of two compared to estimates based on otoliths. Assessments for northern hake have thus been carried out for each of these growth scenarios (ICES-WGHMM 2007). The faster growth scenario (tagging) implies a stock that is smaller historically, with lower recruitment and subjected to higher values of F than implied by the slower growth scenario (otoliths). Nevertheless, recent perceptions for trend, and stock status relative to reference points (using the same rationale for these reference points for each scenario) are similar (Figures 3.2.1.1 and 3.2.1.2).

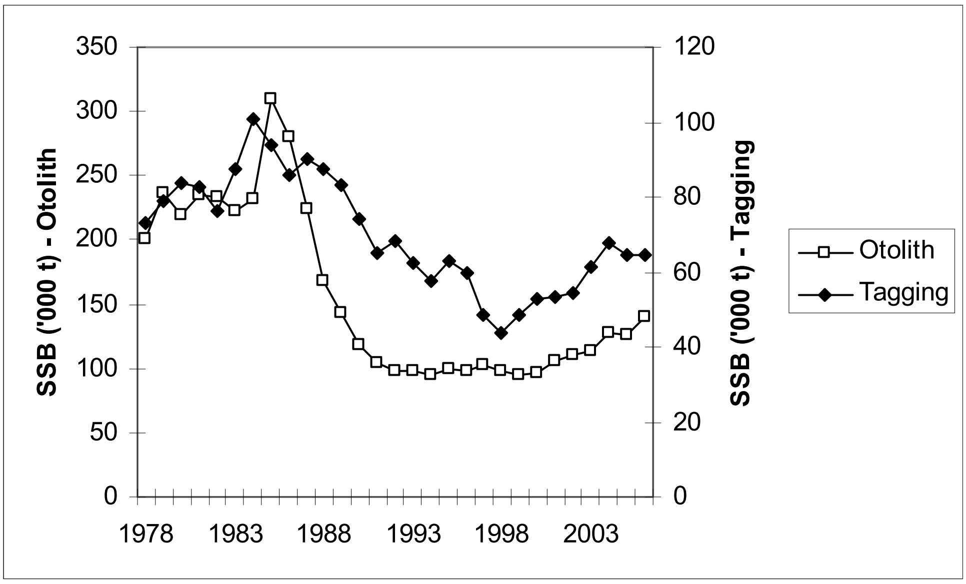


Figure 3.2.1.1. Comparison of trends in SSB from two assessments based on different growth rate.

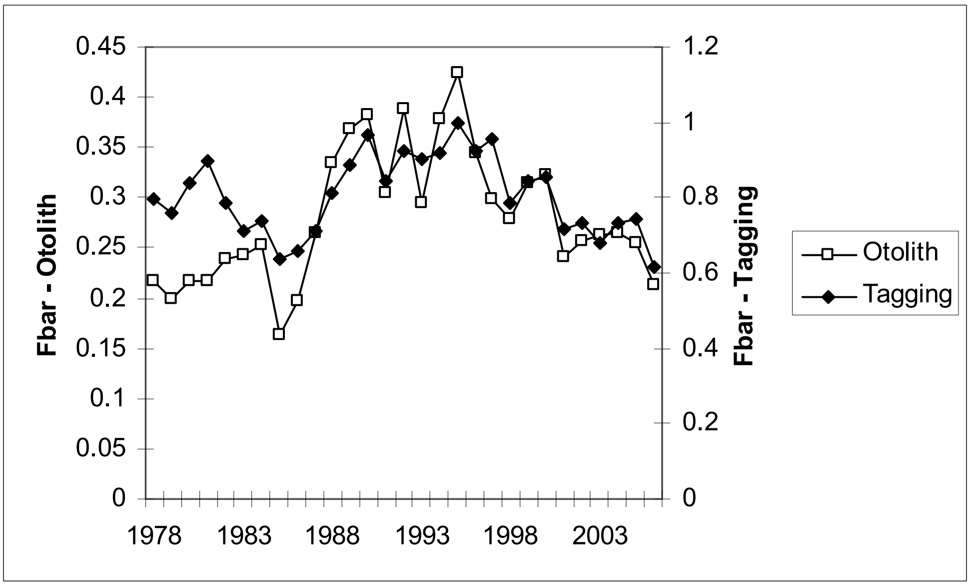


Figure 3.2.1.2. Comparison of trends in F from two assessments based on different growth rate.

However, short-term projections based on assuming Fsq, lead to different estimates of landings and SSB (higher for the faster growth scenario, Figure 3.2.1.3), and YPR analyses also indicated differences (higher YPR but lower Fmsy for the faster growth scenario, Figure 3.2.1.4; Bertignac and de Pontual, 2007).

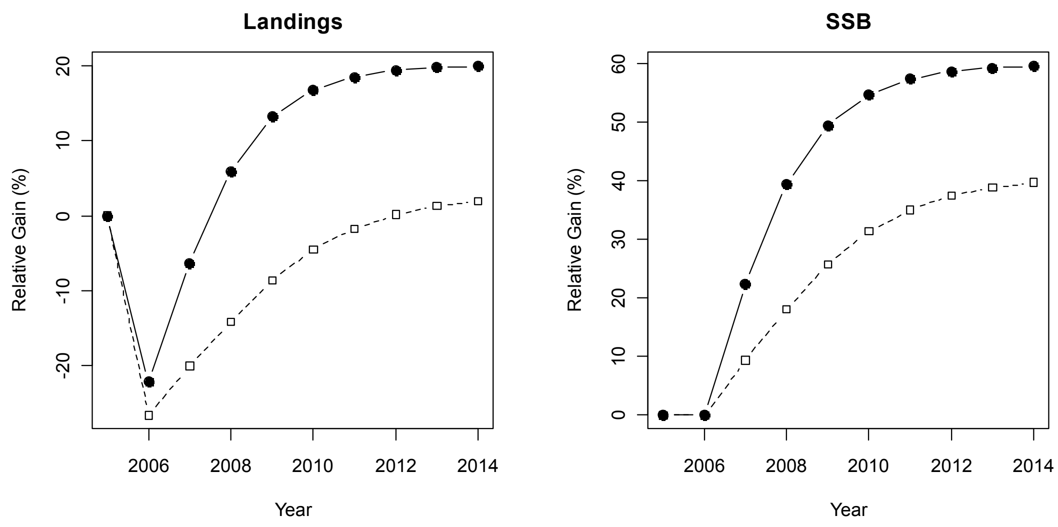


Figure 3.2.1.3. Short term projections under two hypothesis on growth rates. (otolith: white square and tagging : black circles).

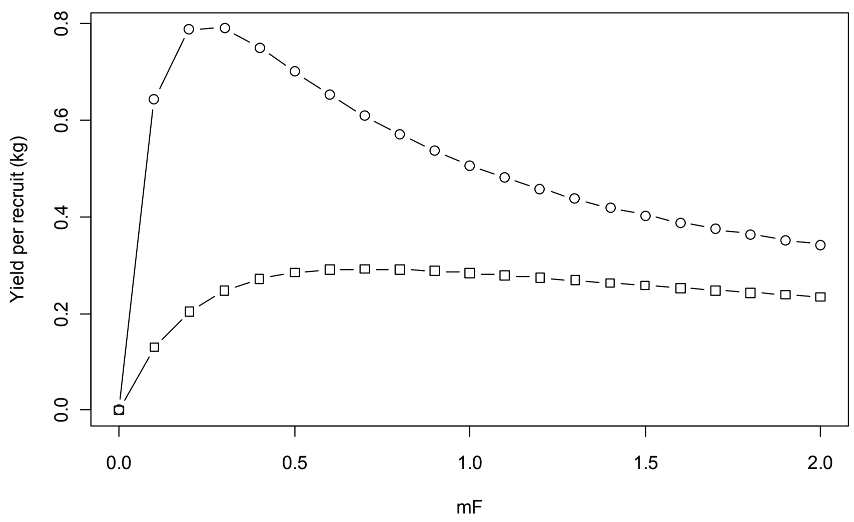


Figure 3.2.1.4. Yield per recruit less than two hypothesis on growth rates. (otolith: white square and tagging: white circles).

The alternative growth scenarios also have implications for what values to assume for natural mortality, although this issue has not been pursued to date (a fixed value of 0.2.year^{-1} is currently assumed for both growth scenarios) A further source of uncertainty for northern hake is discarding, currently ignored in the assessment because of the lack of discard data.

There is potential of exploring the impact of these three sources of structural uncertainty (growth, M and discarding) on the performance of management plans for northern hake, by including them as alternative hypotheses within a management strategy evaluation (MSE) framework. All three of these sources of uncertainty affect our perception of stock productivity, and hence our assessment of the efficacy of proposed management plans in meeting management objectives.

A further important source of structural uncertainty for both northern hake and North Sea cod (and for several other ICES "stocks") is that of stock structure uncertainty. The ICES assessment of northern hake covers a large area, potentially containing several substocks, and there remain questions about the boundary separating the southern and northern hake stocks.

3.2.2 North Sea Cod Example

North Sea cod, it has been hypothesized that cod exhibit meta-population structure consisting of subpopulations with low rates of mixing (Heath *et al.*, 2008), a hypothesis supported by a genetic study using microsatellite DNA markers, which found four genetically distinct populations in the North Sea (Hutchinson *et al.*, 2001). Currently both species are assessed as single unit stocks.

The consequences of ignoring stock structure uncertainty could be severe for substocks. For example, the aggregate fishing mortality on several substocks may appear to have declined, implying a relaxation of fishing pressure, but what could instead be happening is that one or more of the substocks undergo a collapse, contributing high fishing mortality just before the collapse, but then no longer contributing to the overall fishing mortality following the collapse.

3.2.3 Consequences of making wrong assumptions (North Sea Cod)

When evaluating proposed North Sea cod recovery plans (ICES-AGCREMP 2008), the MSE approach that was used considered situations where the recovery plans made wrong assumptions about underlying dynamics (i.e. the assumptions in the recovery plans, which included sampling data from the operating model, applying a stock assessment model to these data, performing a short-term forecast and applying a harvest control rule, contradicted those in the operating model). The question arises about whether this matters for the overall performance of the recovery plan.

Figure 3.2.3.1 illustrates the trade-off between two summary statistics (probability of SSB exceeding Bpa and median Yield were used for illustrative purposes) for two recovery plans subject to two operating models (reflecting alternative hypotheses about additional mortality). For each recovery plan, adjustments were made reflecting what changes were needed to remove retrospective bias in the assessment (modify catch, modify M or make no adjustment – the latter option effectively ignores the retrospective bias problem). These adjustments were sometimes consistent with the operating model hypothesis (larger symbols in Figure 3.2.3.1) or sometimes contradicted it.

There are several features to be noted in this example. The first was the operating model assumptions (reflecting uncertainty about what was causing a retrospective bias in assessments of North Sea cod) had a greater impact on the performance of each recovery plan in terms of the trade-offs shown, than the actual adjustment made (or not made) to account for retrospective bias in the recovery plan (i.e. there was more variability between operating model groups of points in Figure 5 than within each group). The second, counterintuitive feature was that making the correct adjustment in the recovery plan to account for retrospective bias did not necessarily result in improved performance in terms of either of the performance statistics considered. In the case of the EU Rule in Figure 3.2.3.1, the "m" adjustment resulted in marginally higher P(SSB>Bpa) but lower median Yield, and the "wg" option (no adjustment) in lower P(SSB>Bpa) but higher median Yield, with the "catch" option lying between these, regardless of the operating model. The Norway rule showed the same behaviour for the "m" and "wg" options, but the "catch" adjustment appears to deliver improved performance for both summary statistics relative to the "m" adjustment in 2012 and the "wg" option in 2015, regardless of whether this "catch" adjustment is correct or not.

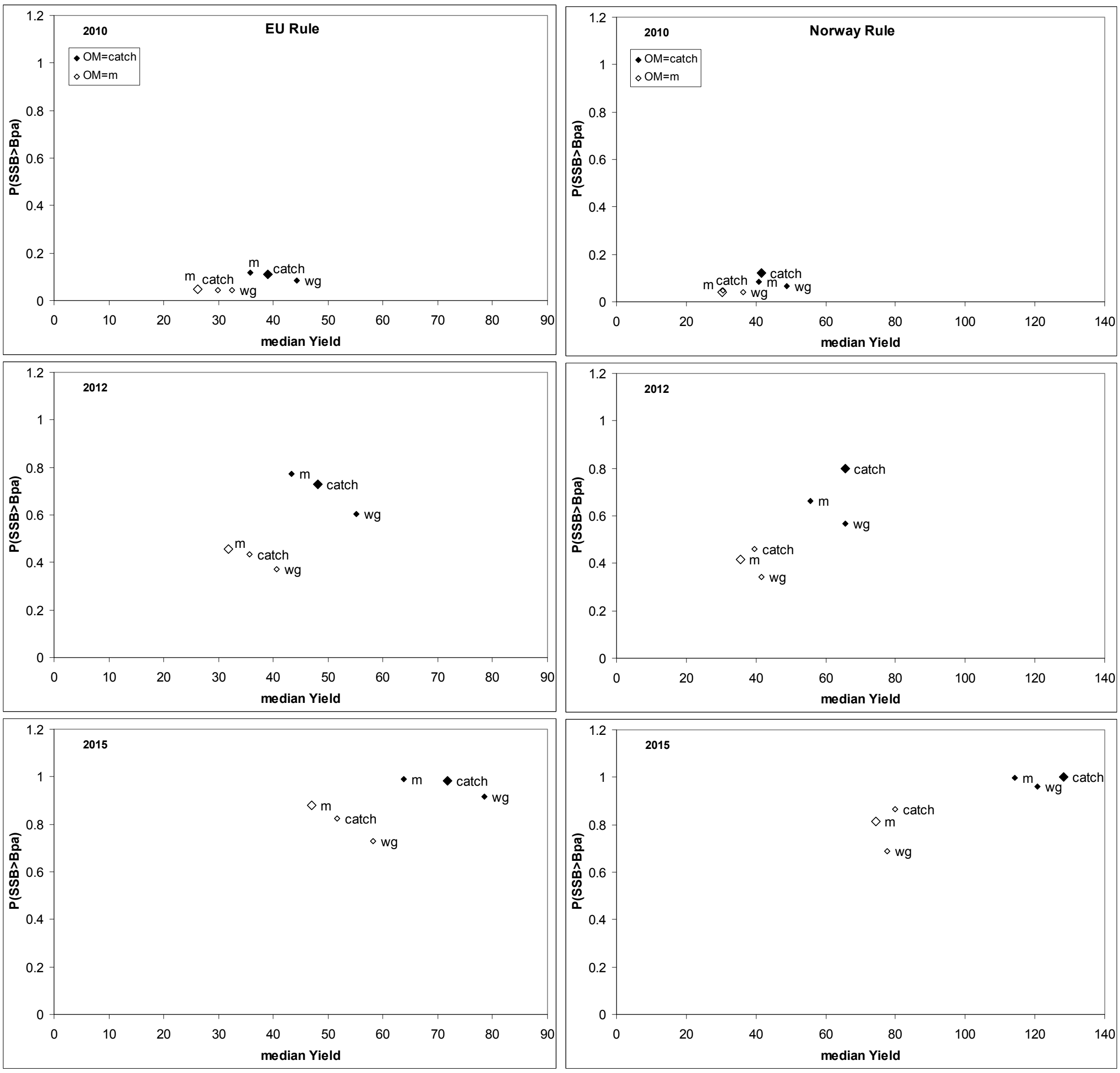


Figure 3.2.3.1. Comparing the performance of two cod recovery plans (EU proposal on the left, and Norwegian proposal on the right) in terms of summary statistics "P(SSB>Bpa)" (probability of SSB exceeding Bpa; vertical axis) and "median Yield" (horizontal axis) for the years 2010, 2012 and 2015, based on results from ICES-AGCREMP (2008). Solid diamonds indicate the operating model assumed additional mortality was due to catch misreporting ("catch"), and open diamonds due to additional natural mortality ("m"). The recovery plans either adjusted for catch misreporting ("catch"), or additional natural mortality ("m"), or made no adjustment ("wg"). Larger symbols indicate that the recovery plan makes the correct adjustment (i.e. consistent with the operating model).

3.2.4 Plausibility of alternative hypothesis

The Intergovernmental Panel on Climate Change defined three main types of uncertainty i.e. unpredictability, structural uncertainty and value uncertainty (Intergovernmental Panel on Climate Change 2005).

Unpredictability is due to human behaviour not being easily amenable to prediction or chaotic components of complex systems. Structural uncertainty is due to inadequate models, incomplete or competing conceptual frameworks. Value uncertainty is due to missing, inaccurate or non-representative data, inappropriate spatial or temporal resolution or poorly known or changing model parameters.

A way to deal with such uncertainty is to use scenarios as part of an MSE that spanning a plausible range, clearly stating assumptions, limits considered, and subjective judgments made. However this means that there will potentially be a range of values of Blim from ensembles of model runs, in this case a robust HCR would be one that met the 5% evaluation criteria for all plausible runs. Alternatively a Bayesian approach could be used for example to include alternative S-R functions for which posterior probabilities are estimated.

Accounting for scientific uncertainties when conducting MSEs requires that system dynamics be projected forward under the management strategies being considered, not only for the model that best reflects system dynamics, but also for models consistent with a broad range of alternative plausible explanations of the available data (ICES-SGRAMA, 2007). For acceptability, management strategies should demonstrate reasonable robustness in performance measures related to achieving management objectives (e.g. in the above example, maximizing both P(SSB>Bpa) and median Yield) over the range of plausible alternative hypotheses about system dynamics.

Under the MSE framework, arguments shift away from "which model is best?" and towards the plausibility of alternative hypotheses, and appropriate methods for allocating weights to each alternative. Such methods could be statistically based (e.g. using Bayesian methods) or could rely on expert judgement. An approach developed within the IWC for incorporating plausibility weights (IWC 2005), with potential application to fisheries, is for experts to categorize, by consensus, hypotheses as having "high", "medium" or "low" plausibility. Hypotheses that could reasonably be argued to have "high" plausibility but for which there is no consensus, are accorded "medium" plausibility, although hypothesis accorded "low" plausibility are not considered further. The next step in this process is then to require candidate management strategies to meet more stringent risk criteria for the "high" weight hypotheses than for the "medium" weight ones.

Once a set of alternative hypotheses with "high" or "medium" plausibility has been defined, an MSE could be used to demonstrate the benefits of incorporating additional knowledge that could help exclude some of the hypotheses considered (De Oliveira *et al.,* 2008). Examples would be focussing research on resolving the cause of the retrospective bias in the North Sea cod assessment, or on resolving which of the growth scenarios is most appropriate to northern hake. In these cases, the number of hypotheses for which management strategies need to demonstrate robustness is narrowed down, so that for the same level of risk to the stock, management strategies could be tuned to deliver higher yields.

4 Qualitative Risk Assessment

4.1 Review: Using Qualitative Risk Evaluations to Prioritize Resource Assessment Activities for Fraser River Sockeye, G. Pestal and A. Cass

The presentation covered a detailed example of a specific case of using risk assessment to produce an overview of the state of knowledge concerning the fishery and identify research priorities for Fraser River Sockeye Salmon, with an indication of the more general principles and lessons learned.

The goal of the work was "to establish a consistent, transparent framework that translates general policies and objectives into practical guidelines for prioritizing assessment projects." As a first step towards this the analysis was focused on identifying where to prioritize future research to provide the greatest benefit, and the methodology has not yet been implemented for management issues. The Fraser River Sockeye is a single species, but split into a large numbers of stocks, spawning groups and "conservation units" (one or more populations that are closely connected and function independently of other populations). Management is focused on optimizing the fishery (which is mostly on a small fraction of these stocks), but also driven by a policy requirement to preserve biodiversity. There is therefore a need to produce an assessment of the status of each conservation unit. There is a wide variation in the quantity and quality of the nature of data over the whole fishery. The large number of conservation units with highly variable data across the system is in some ways analogous to a mixed fishery impacting targeted and non targeted species, giving the results of this exercise broad applicability.

The procedure was broadly similar to that described in SGRAMA 2007 (Section 4, Australian and South African approaches), with meetings with a broad range of stakeholders (scientists, fishers, local groups, managers) to identify and rank issues, and produce a synthesis providing guidance for prioritizing future research. As reported in previous SGRAMA reports the authors found genuine involvement of the stakeholders to be an important and non-trivial issue. The aim was to produce a picture of the state (level and uncertainty) of the different stocks, and therefore rather than focusing on risks the process focused on assessing and combining different indicators for each conservation unit.

The range of stocks, issues and data sources led to a qualitative approach, with ranking (in one and two dimensions) the different possibilities, rather than performing a quantitative approach on any of them. This allowed for a consistent treatment across all conservation units, despite the disparity of data availability. It also allowed for similar approach to describing various risks, and the status of each conservation unit.

The ranking exercise assigned both probability ("how uncertain") and severity ("how bad") to the different indicators. An additive system was used to combine these two into a single number (rather than the multiplicative scheme used in Australia and South Africa), with an additional category of "insufficient data to make a judgment" given the highest weight. Results from individual indicators were then combined into a stock status (level and uncertainty) for each conservation unit. The results were presented in a similar format to that for the individual indicators, providing a consistent format to use in communicating with stakeholders. This gave five different categories for each stock status. These categories retained both severity and probability explicitly:

1) insufficient information

2) status probably poor, but little information
3) status poor, high confidence
4) status probably good, high uncertainty
5) status good, high confidence.

Based on the ratings for each conservation unit advice could be given on situations where research could be prioritized. A software tool was developed to aid communicating this information to the stakeholders.

4.2 Qualitative risk assessments in fisheries management

A process of qualitative risk assessment can be used as a tool for producing ecosystem based assessments by identifying areas of greatest concern and thus allowing for scarce resources, data gathering and analytical, to be prioritized (Section 4.1 above, SGRAMA 2007, Smith *et al.,* 2007). The process uses a broad range of stakeholders to identify and rank risks within the system. By keeping this analysis qualitative (splitting likelihood and severity of each risk into a number of ranks) a broad range of issues, and wide variety of data sources, can be incorporated. The risk assessment process allows for detailed quantitative scientific modelling work to be focused towards the areas perceived as being of the highest priority, and provides a forum for the results of that modelling to be presented back to managers and stakeholders.

The work presented from the Fraser River uses similar methodology to assess the state of knowledge of a large number of different ecosystem components within a fishery. This approach provides an indication of where increased research is likely to provide the highest benefit. The work also retains both the uncertainty and severity components of each risk and stock status. As such it provides a possible step forwards in handling quantitative and qualitative data in a single framework, allowing less reliable data to be utilized without losing track of that unreliability.

5 Limit reference points in relation to risk

5.1 Introduction

ToR c) of the Study Group on Risk Assessment and Management Advice [SGRAMA] addresses the specific problem of providing a firm basis for the precautionary reference points, and is related to the process of setting precautionary biomass limit reference points in particular.

To implement the precautionary approach guidelines for setting up reference points for fisheries management have been first published by Caddy and Mahon (1995). To translate these FAO guidelines into a standardized and transparent ICES framework the ICES Study Group on the Precautionary Approach to Fisheries Management (SGPA) has been founded during the mid-1990s of the last century. This group was in charge for doing this until 2002 when it dissolved. Based on this and the work of the Study Group on Precautionary Reference Points for Advice on Fishery Management (SGRPP) the ICES precautionary approach to fisheries management advice is build on limit reference points (LRPs) reflecting stock status and precautionary reference points (PRPs) reflecting the uncertainty as illustrated by Figure 5.1.1.

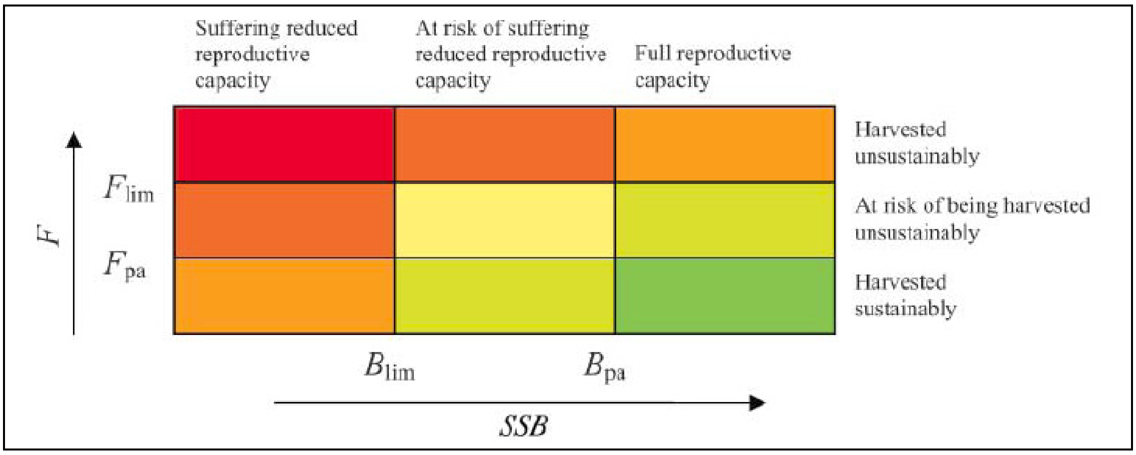


Figure 5.1.1. An overview of the status of fish stocks in relation to reference points, the basic idea being that, to have a high probability of avoiding a stock ending up in the red area (below B_{lim} and above F_{lim}), decisions on management targets should be constrained within the green area (above B_{pa} and below F_{pa}; from Hauge *et al.*, 2007).

Along these lines, the idea of the ICES approach is that for stocks and fisheries to be within safe biological limits, there should be a high probability that spawning-stock biomass (SSB) is above a limit $\mathbf{B}_{lim}$ below which recruitment becomes impaired or the dynamics of the stock are unknown. However, although the concept sounds appealing there are serious inconsistencies in the estimation and use of reference points and a tendency to underestimate uncertainty. One reason is that obviously the translation of the complexity and diversity of natural and human interactions into simple concepts leads to problematic standardization. This is also reflected by the B_{pa} values for diverse fish stocks in Table 5.2.2.1 below that are derived and approximated, respectively, in various ways.

5.2 Brief overview of the current approximation procedure(s) related to B_{pa}

5.2.1 The framework to derive B_{pa} as proposed by SGPA and SGPRP

The definition of the reference points assumes that information is available that allows the establishment of a SSB level (B_{lim}) below which recruitment is impaired, i.e. that the medium-term average recruitment is lower than has been observed at higher levels of SSB. Therefore, the definition requires implicitly that a Stock-Recruitment relationship exists and that there are observations available that shows where this lower recruitment occurs. Also, this concept is developed on the assumption that an assessment and a projection procedure (e.g. an analytical assessment) is available and that this assessment includes an estimate of the precision of the assessment. The buffer considerations also require that a method is available to allow the calculation of the buffer zones for F and SSB.

As summarized by SGPRP (ICES, 2003) the general ICES PA framework requires an analytic estimation method to be used for exploration, discrimination between types and to estimate reference points in those cases where this is appropriate, i.e.

a) a revised framework for estimating reference points, starting with Blim, and leading on to the estimation of Flim, Fpa, and Bpa.

b) the methodology for estimating Blim, using segmented regression

c) a methodology for estimating Flim from Blim deterministically d) a proposed new methodology for estimating Fpa and Bpa in order to evaluate assessment uncertainty

e) clarification of the risks to be accounted for in this framework

The procedure above is illustrated by the path diagram in Figure 5.2.1.1. The implementation of the precautionary approach by ICES emphasizes the aim of preventing stocks from being seriously harmed due to recruitment overfishing. SGPA (ICES, 2002) therefore proposed that the cornerstone of the reference point framework is to identify Blim as the SSB below which recruitment becomes impaired in a stock–recruitment scatterplot, because this point has an intrinsic biological meaning. Blim should then be used as the basis for deriving the other reference points. Thus Flim should be estimated as the fishing mortality corresponding to Blim, whilst to be sure that a stock is above Blim or that fishing mortality is below Flim, the operational reference points Fpa and Bpa must be estimated in a way that takes into account assessment uncertainty.

In this context, SGPRP (ICES, 2003) used the term assessment uncertainty to mean the combination of measurement error, model error and estimation error and described the various sources of error in stock assessment as follows:

- natural variation in dynamic processes (e.g. recruitment, somatic growth, natural mortality), also termed process error.
- measurement error, generated when collecting observations from a population
- model error, mis-specification of a model parameter (e.g. natural mortality), or the model structure
- estimation error, arises from any of the above errors and is the inaccuracy and imprecision in the parameters estimated by the model during the assessment process,
- implementation error, arising because management actions are never implemented perfectly, whether because the management plan does not correspond to the advice fully, or because compliance with the intent of the management plan is imperfect.

However, SGPRP (ICES, 2003) felt that in practice it is not easy to distinguish between measurement error, model error and estimation error, and therefore used the single term assessment uncertainty for their combined effect. Implementation error was not considered in this framework.

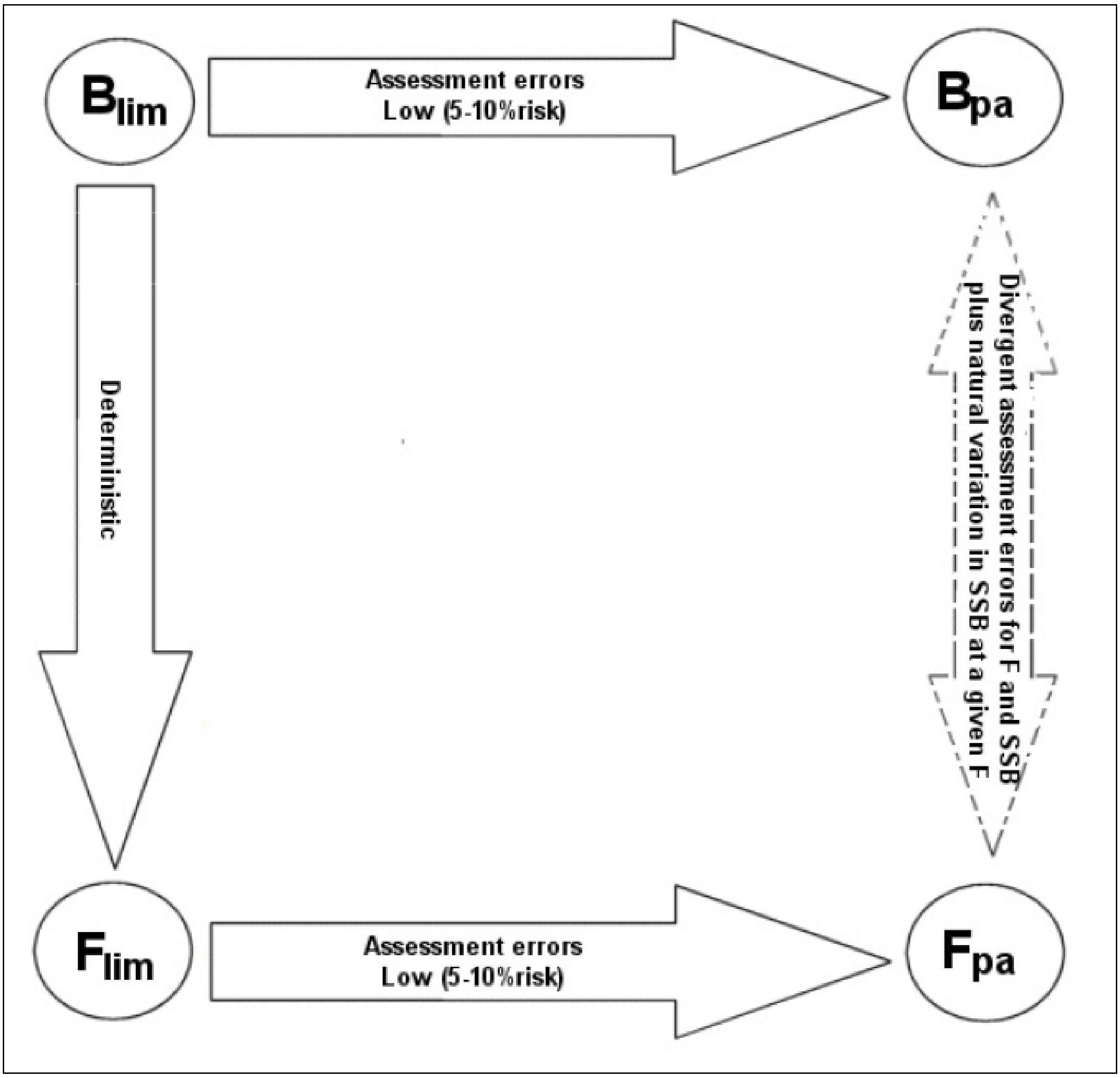


Figure 5.2.1.1. "The links between reference points, and the related sources of uncertainty and risk." (Figure taken from SGPA report ICES, 2003a. Please note the use of the word "risk")

5.2.2 The current procedures to estimate B_{pa} as proposed by SGPA and SGPRP

Different methods were proposed and applied by SGPA and SGPRP to approximate $\mathbf{B}_{pa}$. These methods are case specific and mainly depend on the specific type of the SSB/R scatterplot as specified in Figure 5.2.2.1. Table 5.2.2.1 summarizes the different cases how $\mathbf{B}_{pa}$ has been approximated by stock. This heterogeneity indicates that there is always some caution needed when using these values as proxies for $\mathbf{B}_{pa}$ as this implies that there is not only one consistent way to go. The major three methods are:

- The "magic formula"
- Retrospective analysis based method of assessed SSB values
- $\mathbf{B}_{loss}$ as a proxy for $\mathbf{B}_{pa}$

5.2.3 The" magic formula"

Most precautionary reference points (PRPs) have been calculated from a statistical formula based on general considerations of assessment uncertainty. This links PRPs to limit reference points (LRPs) such that $\mathbf{B}_{pa} = \mathbf{B}_{lim} \exp(1.645\ s)$ and $\mathbf{F}_{pa} = \mathbf{F}_{lim} \exp(-1.645\ s)$. The value 1.645 corresponds to a probability of 5% in a normal distribution with s=CV. The value of s (the measure of the uncertainty in the estimates of SSB and F) is usually decided by expert judgment.

5.2.4 Retrospective analysis based method of assessed SSB values

SGPA (ICES, 2002) and SGPRP (ICES, 2003) proposed to derive $\mathbf{B}_{pa}$ from $\mathbf{B}_{lim}$ by comparing the SSB estimated in previous assessments (SSB_{assm}) to the SSB estimated in the most recent reliable assessment (SSB_{conv}). SGPA (ICES, 2002) noted that the comparison can be made in either the assessment year, or in the forecast year, and concluded that the assessment year should be used since that was the value that was used to compare with the reference point value in giving the advice. However, at the present meeting SGPRP concluded that to be consistent with the estimation of assessment uncertainty, the observed SSB should be that forecast for the end of the TAC year.

Over the range of terminal years, retrospective analysis will give a set of $\{SSB_{assm}, SSB_{conv}\}$ pairs. Values of the ratio SSB_{assm}/SSB_{conv} are plotted against SSB_{conv} as the independent variable. A line is drawn through the origin so that α% of the points are above and (100-α)% are below the line, where α is the acceptable risk. This may be 10% or less, depending on the availability of the data. If the number of pairs is small, the highest line passing through a point should probably be used, unless this is a clear outlier. The slope β of the line is the ratio between $\mathbf{B}_{pa}$ and $\mathbf{B}_{lim}$, thus $\mathbf{B}_{pa} = \beta * \mathbf{B}_{lim}$.

5.2.5 B_{loss} as a proxy B_{pa}

In many cases the historical stock–recruit data indicate that the point of poor recruitment has either not yet been reached, or is very close to the left hand edge of the stock and recruit plot. In these cases a fit of a model with a change point (such as segmented regression) is not informative as the change point estimate will not be based on actual information from reduced recruitment. In such cases the most useful information which can be extracted is an estimate of the lowest SSB for which information is available on the population dynamics of the stock i.e. the lowest observed spawning-stock biomass, $\mathbf{B}_{loss}$ being more formally

$$\mathbf{B}_{loss} = \min \{SSB \mid \text{available time-series}\}$$

In cases where the stock is heavily exploited, and it appears that the stock–recruitment plot covers a wide dynamic range, SGPA (ICES, 1997; 1998) adopted the rationale that it is not precautionary to allow the stock to enter the domain where the stock dynamics and the risks are unknown, and $\mathbf{B}_{loss}$ was therefore proposed and used as a proxy for B_{lim}.

In cases where the stock is lightly exploited, or where the range of data in the stock–recruit plot is limited, and in particular where R appears to be increasing as SSB decreases, SGPA (ICES, 1997; 1998) proposed and used $\mathbf{B}_{loss}$ as a proxy for B_{pa}.

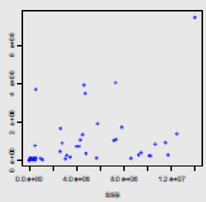
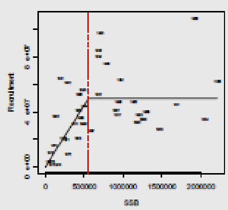
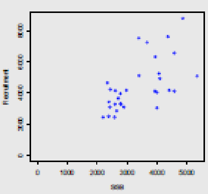
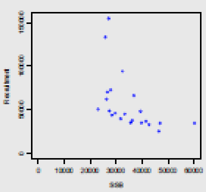
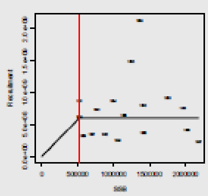
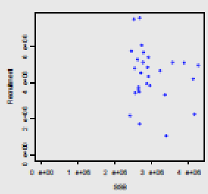
Stock characteristics			Limit point estimation options dependent on data and specific stock information		
Stock type	S/R plot characteristics	Sample S/R plot	B_{lim} estimation possible according to standard method	B_{lim} estimation possible on basis of stock-specific method or judgement	B_{lim} estimation not possible
1 Data poor situation	Not available				
2 Short-lived 1-time spawners				(B_{loss})	
3 Spasmodic stocks – occasional large year classes				Mortality based reference points such as F_{loss} based on normal recruitment situation.	
S/R signal	4 Clear change point (slope line and plateau)		B_{lim} = Segmented regression change point		
	5 Relationship between S and R, no clear change point (there seems to be a positive slope but the plateau is not evident)			B_{lim} may be close to highest SSB observed. Decision dependent on evaluation of historical fishing mortality	Present alternative basis for advice
	6 Inverse S/R relation (there seems to be a negative slope)		No LIMIT point, only PA point. (B_{loss} candidate for PA point)		
No S/R signal,	7 Distinct plateau (wide range of SSB)		B_{lim} = B_{loss}		
	8 No apparent plateau (narrow range of SSB)			No LIMIT point, only PA point (B_{loss} is candidate for PA point dependent on considerations involving historical fishing mortality)	

Figure 5.2.2.1. Summary of reference points and stock types from SGPRP (ICES, 2003).

SGPRP (ICES, 2003) proposed that the distinction between a "narrow" and a "wide" range of stock–recruit data should relate to the information which is considered available in the data – whether the data indicate a stock recruitment signal in the form of a plateau of recruitment over a range of biomass values or whether the data do not indicate any relationship at all, when the stock–recruitment scatterplot basically appears to be a shotgun shot. If there is a plateau $\mathbf{B}_{loss}$ should be used as $\mathbf{B}_{lim}$, when there is no signal or an inverse relationship $\mathbf{B}_{loss}$ should be used as $\mathbf{B}_{pa}$.

SGPRP (ICES, 2003) suggested further that Bloss may also be relevant in relation to stocks where the historical data exhibits an inverse relationship between stock and recruitment. In this case it is suggested that Bloss is used as Bpa.

5.3 Issues regarding risk terminology and the procedure as used to derive B_{pa}

Based on Hauge *et al.* (2007) the issues of estimating and approximating $\mathbf{B}_{pa}$, respectively may be summarized as follows.

With respect to terminology, it seems that the unwanted state that the PA framework is set up to avoid is defined loosely and inconsistently. The various terms used to describe such a state seem to be chosen rather arbitrarily. If their use is intended, at least the differences should be adequately explained.

Some terminological ambiguity relates to the risks and uncertainties that $\mathbf{B}_{lim}$ and $\mathbf{B}_{pa}$, respectively, are supposed to reflect. As $\mathbf{B}_{lim}$ represents a risk of impaired recruitment, $\mathbf{B}_{pa}$ represents the risk of a risk of impaired recruitment, which presumably is somewhat unclear to both advisors and their customers. This ambiguity is amplified by the belief expressed by ICES (2005) that the phrases "risk of reduced reproductive capacity" and "suffering reduced reproductive capacity" are "entirely equivalent".

Regarding the magic formula above it has been shown that it underestimates the implied forecast uncertainty as expert judgment in working groups has tended to underestimate uncertainty by only considering part of the overall errors (Bertelsen and Sparholt, 2002).

In the context of $\mathbf{B}_{loss}$ SGPA (ICES, 2002) did not provide clear rules as to what constitutes a "narrow" or "wide" range of stock–recruit data. Except in the case where the R-SSB relation is inverse, it may be difficult to decide whether $\mathbf{B}_{loss}$ should be $\mathbf{B}_{lim}$ or $\mathbf{B}_{pa}$. The rationale adopted in each case should therefore be specified individually.

Within the rest of the group of pragmatic approaches for devising PRPs, three types can be distinguished which itself underlies the inconsistency of deriving and using $\mathbf{B}_{pa}$ and is reflected by Table 5.2.2.1. None of them correspond to the PA framework, because they are not based on evaluations of uncertainty of predicted stock status relative to $\mathbf{B}_{lim}$.

1) First, the formula has been used inversely to calculate LRPs from PRPs (e.g. $\mathbf{B}_{lim}$ for sole in the Skagerrak and $\mathbf{F}_{lim}$ for Faroe Plateau cod; ICES, 2005).
2) Second, $\mathbf{B}_{pa}$ is sometimes based on a SSB/R relationship. The rationale for selecting the specific $\mathbf{B}_{pa}$ for North Sea cod has been that SSB values below that level have been associated with "signs of impaired recruitment" (ICES, 2005), which actually appears to confound the definition of the two reference points.
3) Third, if recruitment shows a decreasing trend with increasing SSB (e.g. plaice, *Pleuronectes platessa*, in the Skagerrak and Kattegat), $\mathbf{B}_{pa}$ has been set

equal to $\mathbf{B}_{loss}$. PRPs are usually presented as constants and the uncertainties accounted for are based on sorts of historical averages. An exception is the Barents Sea capelin (*Mallotus villosus*; ICES, 2005), for which a probability analysis is carried out annually, taking into account fluctuations in predation by cod. In this case, the advice allows a 5% probability of crossing $\mathbf{B}_{lim}$, and the uncertainty accounted for from different sources may vary between years. In practice, this is the same as changing $\mathbf{B}_{pa}$ from year to year. Of course, reference points may also be changed when data or parameter estimates are revised or when an assessment model is replaced, because such changes can alter our perception of historical time-series.

Although a few PRPs are designed to reflect prediction uncertainty, the majority appear to reflect assessment uncertainty, or it is largely unclear which of the two (or maybe both) is implied. Whereas this conceptual problem represents an obvious shortcoming of the PA framework as currently applied, it also emphasizes a tendency to underrepresent the uncertainty in the advice. This view is supported by Bertelsen and Sparholt (2002), who questioned whether the PRPs take the uncertainty in the advice sufficiently into account. After evaluating the ICES TAC advice for 33 stocks, they concluded that the uncertainty reflected in the PRPs for most stocks is considerably less than the implied uncertainty in the catch predictions on which the advice is based. There also is a tendency to confuse past and present uncertainty, for instance in providing a standard figure that supplies the historical trajectories of SSB and F relative to PRPs (ICES, 2005). Here, past and present uncertainties are mixed when a stock trajectory indicating that SSB has been below $\mathbf{B}_{pa}$ (but above $\mathbf{B}_{lim}$) is taken to imply non-precautionary management.

The PA framework clearly needs general revision to clarify its interpretation regarding past, present, and future uncertainty.

The findings of Hauge *et al.* (2007) suggest that the PA framework faces some challenges to enhance consistency and transparency, at both conceptual and operational levels. Nevertheless, there may be limits to the extent to which conceptual clarity can be matched with operational clarity:

a) First, each stock is to some extent unique, and what we know about its SSB/R relationship refers to a specific period characterized by a specific set of environmental conditions. Our knowledge may not apply when conditions change.

b) Second, data collections for different stocks are heterogeneous in form and quality.

c) Third, there may be practical dilemmas regarding which uncertainties should be included in the advice, for instance those pertaining to illegal catches or discards.

Taken together, these three issues imply that the potential for handling uncertainty in a standardized way will not be without limits.

Table 5.2.2.1. Table taken from Annex II of SGPRP report 2003.

PA point	Technical basis SGPRP report (ICES, 2002)	Stock	Ref. point used in SGPRP report (ICES, 2002)
Bpa	**B**loss	Anglerfish VIIb-k VIIIab (*L. budegassa*)	22000
Bpa	**B**loss	Anglerfish VIIb-k VIIIab (*L. piscatorius*)	31000
Bpa	**B**lim exp(1.645*σ) σ=0.25	Blue whiting	2.25 mill.
Bpa	Withdrawn - Previous MBAL	Cod 22–24	23000
Bpa	MBAL	Cod 25–32	240000
Bpa	Examination of stock–recruit plot	Cod, Arctic	500000
Bpa	Not defined	Cod Coas	Not defined
Bpa	Blim exp(1.645*σ), assuming a _ of about 0.40 to account for the relatively large uncertainties in the assessment	Cod Faroe Plateau	40000
Bpa	Not defined	Cod Iceg	Not defined
Bpa	**B**lim*exp(1.645*0.3)	Cod Kattegat	10500
Bpa	Previous MBAL and signs of impaired recruitment below: 150 000 t	Cod N. Sea	150000
Bpa	Previously set at 25 000 t at which good recruitment is probable. Reduced to 22000 t due to an extended period of stock decline	Cod VIa (West of Scotland)	22000
Bpa	Previous MBAL with signs of reduced R	Cod VIIa (Irish)	10000
Bpa	Historical development of stock	Cod VIIe-k	10000
Bpa	Not defined	Flounder 24–25	Not defined
Bpa	Not defined	Greenland halibut V+XIV	Not defined
Bpa	**B**lim*1.67	Haddock, Arctic	80000
Bpa	2 std above **B**lim but reduced based on S-R plot	Haddock Faroe	55000

PA point	Technical basis SGPRP report (ICES, 2002)	Stock	Ref. point used in SGPRP report (ICES, 2002)
Bpa	Not defined	Haddock, Icelandic	Not defined
Bpa	1.4***B**lim	Haddock N. Sea	140000
Bpa	**B**lim*1.4	Haddock VIa (West of Scotland)	30000
Bpa	1.4***B**loss	Haddock VIb (Rockall)	9000
Bpa	Not defined	Haddock VIIa (Irish)	Not defined
Bpa	1.4***B**lim	Hake, Northern stock	165000
Bpa	**B**lim x 1.64	Hake, Southern stock	33600
Bpa	Not defined	Herring 25–29+32 ex GoR	Not defined
Bpa	**B**lim *exp(1.645*0.2)	Herring, Bothnian Sea (30)	200000

5.4 Guidelines for setting precautionary biomass limit reference points

The stocks for which ICES gives advice may be broadly categorized into those where there is a reasonable degree of biological knowledge and time to conduct analyses (summarized here as "data rich"), and those where data, knowledge and resources are more limited (referred to as "data poor"). Different procedures are obviously required in each case, there is not likely to be a "one size fits all" approach that can be suggested. Some detailed guidelines are suggested for "data rich" stocks below, and then a section on how risk assessment can be used to improve understanding and management of "data poor" situations.

5.4.1 Setting B_{lim}

As mentioned above, one key goal of fisheries management is to preserve reproductive capacity of a stock by preventing it falling below a point at which recruitment is impacted. SSB[1] is taken as a proxy for reproductive capacity, and staying above some $\mathbf{B}_{lim}$ becomes the goal. In many cases SSB is a good proxy for reproductive capacity, and $\mathbf{B}_{lim}$ is a useful management objective. However this approximation may not be appropriate to all stocks. Issues such as sexual dimorphism or higher reproductive success of large fish may mean that reproductive capacity can be impaired even if the overall biomass remains above $\mathbf{B}_{lim}$.

SGRAMA recommends that a risk assessment be conducted to identify the risks involved in using B_{lim} in stocks where SSB may be a poor proxy for overall reproductive capacity.

[1] Calculated as the sum of stock numbers times mass times proportion mature at age

5.4.2 Validation of B_{lim}

Even if $\mathbf{B}_{lim}$ is a good proxy for reproductive capacity there are a number of issues in setting the level which arise, both over the actual level of $\mathbf{B}_{lim}$ and of our estimation of it. $\mathbf{B}_{lim}$ is defined as a cut-off point which management should to remain above to avoid negative consequences. In reality $\mathbf{B}_{lim}$ is one point on a sliding scale of impairment of reproductive capacity. Not only is the level of "harm" that is selected for $\mathbf{B}_{lim}$ subjective, the shape of the distribution around that point may be highly variable. In some cases "harm" may accumulate rapidly as the stock falls below $\mathbf{B}_{lim}$, in other cases harm may accumulate much more slowly. However, very seldom do we have data that allows us to estimate the form of the stock and recruitment curve near the origin whereas there may also be alternative plausible stock recruitment relationship (structural uncertainty).

In addition it is not clear that $\mathbf{B}_{lim}$ will in fact be constant over time. In particular fish stocks can fluctuate extensively over a range of scales independent of human exploitation (Hjort, 1914; Cushing, 1995) due to processes such as recruitment, growth, predation or migration (e.g., Lehodey *et al.*, 1997; Bailey 2000; Köster *et al.*, 2005). Such fluctuations could lead to **B**lim varying over time. Modelling variability in recruitment assuming that variability is short-term random noise around a long-term constant would be a potentially serious model mis-specification.

One approach to dealing with such uncertainty is to use scenarios as part of an MSE that spans a plausible range of hypotheses about the stock dynamics, clearly stating assumptions, limits considered, and subjective judgments made. However this means that there will potentially be a range of values of $\mathbf{B}_{lim}$ from ensembles of model runs, in this case a robust HCR would be one that met the 5% evaluation criteria for all plausible runs. Alternatively a Bayesian approach could be used for example to include alternative S-R functions for which posterior probabilities are estimated.

SGRAMA recommends that great attention be paid to the selection and validation of the Blim **levels, considering a range of plausible alternatives.**

5.4.3 Using B_{loss} as a value for B_{lim}.

Provided that there are reasons for believing that the observed $\mathbf{B}_{loss}$ is a level at which there has not been a serious impairment of reproductive capacity (see above) then setting $\mathbf{B}_{lim}$ to **B**loss is a precautionary measure. It is unclear how setting $\mathbf{B}_{pa}$ to $\mathbf{B}_{loss}$ can be considered precautionary, because stock behaviour below $\mathbf{B}_{loss}$ is, by definition, unknown. However in many stocks the lowest observed spawning-stock biomass has occurred at levels at which reproductive capacity may have been impaired. In such cases using $\mathbf{B}_{loss}$ as a limit reference point is likely to be inappropriate. There are also stocks which have high natural variability and which may naturally vary to levels below $\mathbf{B}_{lim}$. In such cases using $\mathbf{B}_{loss}$ as a reference point is also likely to be inappropriate.

SGRAMA recommends that where $\mathbf{B}_{loss}$ is used as a limit reference point then a risk assessment be conducted to assess if this is precautionary.

5.4.4 Setting B_{pa}

Setting $\mathbf{B}_{pa}$ is a different problem from setting $\mathbf{B}_{lim}$ in that $\mathbf{B}_{pa}$ is a limit that ensures that $\mathbf{B}_{lim}$ is avoided with high probability. Therefore it should always be borne in mind that, at best, a $\mathbf{B}_{pa}$ level can only be as good as the $\mathbf{B}_{lim}$ on which it is based. In risk terms there is no severity associated with $\mathbf{B}_{pa}$, only the likelihood of avoiding $\mathbf{B}_{lim}$.

The severity of the impact of selecting an incorrect $\mathbf{B}_{pa}$ are do with the severity of the consequences of falling below $\mathbf{B}_{lim}$.

Selecting an appropriate $\mathbf{B}_{pa}$ involves various sources of uncertainty (e.g. how well we can estimate SSB and set a target F depends on estimation and implementation error respectively). The current techniques for setting $\mathbf{B}_{pa}$ are outlined in the introduction to this section (above).

Whatever method is selected the priority is to analyse the appropriateness of that level. This can be done on a case specific basis using Management Strategy Evaluation or a Bayesian approach to evaluate the effectiveness of the $\mathbf{B}_{pa}$ under a range of different models and assumptions.

In a situation where management is based on a harvest control rule then there may be several different trigger points at which fishing behaviour will change rather than a single $\mathbf{B}_{pa}$ value. However the issues and uncertainties involved in setting these trigger points remains the same.

SGRAMA recommends that, in situations where resources permit, the appropriateness of existing and alternative $\mathbf{B}_{pa}$ /harvest control rules should be assessed using Management Strategy Evaluations or the Bayesian Approach.

5.4.5 Data and resource poor situations

Cadrin and Pastoors (2008) noted that of the 137 ICES management units for which advice is provided by ICES only 17% actually had the necessary estimates to implement the precautionary control rule and 61% had no estimates of reference points at all. While for stocks managed under the Common Fisheries Policy (CFP) stock status is unknown for 80% of stocks and only 3% are considered to be exploited consistently with MSY. This failure to implement management plans on a case specific basis means that there is a need to have a general risk identification and assessment to determine where action is needed and what form it should take.

In "data poor" situations there is generally a lack of data and a scarcity of resources for analysing the different stocks. There is therefore a need to identify where resources (data collection and analytic) can best be prioritized. There is generally some information available about each stock (data on CPU and landings, biological knowledge,…). The available information can be used to identify which stocks are the ones where there may be cause for concern. Classifying the potential vulnerability of each stock to fishing pressures, and identifying where the fishery related impacts are, should provide an indication of which stocks which may be being fished at levels that their biology cannot support. These stocks should then become a priority for further research (data gathering and/or analytic) and management actions. The work presented on the Fraser River Sockeye Salmon (Section 4.1) can be seen as an example of this process. A number of data-poor modelling approaches are in existence or in development which could provide some information on species identified as being at risk. Additionally where a large number of stocks are to be assessed then there may be general approaches or insights that can be derived.

SGRAMA recommends that in "data poor" situations a broad risk assessment be conducted to identify which stocks are most vulnerable to fishing, and prioritize work to improve understanding and management of these stocks.

6 PRONE and SGRAMA

PRONE (Precautionary risk methodology in fisheries) is an EU-funded research project whose main aim is to improve the Assessment, Management and Communication of risk in fisheries management and to provide an integrated approach including biological, economic and social objectives. The project revolves around a number of objectives intended to increase the capacity to understand and better incorporate risk in fisheries management decisions in particular to:

- Review the current state-of-the-art, identifying knowledge requirements and link these to the ability to reach management objectives using the available control tools.
- Link together the biological, economic and social elements to be used in fisheries advice.
- Suggest a risk framework for European fisheries management and advice on the adaptation of it to advisory systems and international agreements.

There are four main elements to the risk framework proposed by PRONE i) identification ii) assessment iii) management and iv) communication and a report making final recommendations will be produced next year in time for the next meeting of SGRAMA.

Work has concentrated in a variety of areas; summaries of some were presented to the SG.

6.1 Risk identification with Stakeholder

PRONE conducted evaluations of how perceptions of risk affect divergent categories of stakeholders involved in the fishing industry. These stakeholders were grouped into seven main categories, the fishing industry, fishers (inshore and offshore), governments and regulators, consumers (fish aware and unaware) and scientists. A mental modelling methodology was used in four countries: Iceland, UK, Faroe Islands and Greece with different management regimes and focused on fisheries management systems and their impact on risk perception among fishers in the four countries. The main questions addressed were whether the regulatory fisheries management in the European Community and Iceland based upon total allowable catches (TACs) and individual transferable quotas (ITQs) lead to different perceptions of risk among inshore and offshore fishers compared to the in Faroe Islands where management is based upon effort control and the Mediterranean which has no quota system. In particular, risks related to fish stocks, economic factors, scientific knowledge and climate change were analysed.

6.2 Value-of-information

To look at the value of knowledge in management a decision theoretic approach to fisheries management using a Bayesian approach to integrate the uncertainty about stock dynamics and current stock status was taken. Management objectives were expressed in the form of a utility function. The value of new information, possibly resulting in new control measures, is high if the information is expected to help in differentiating between the expected consequences of alternative management actions. Conversely, the value of new information is low if there is already high certainty about the state and dynamics of the stock and/or if there is only small difference between the utilities attached to different potential outcomes of the alternative management action. The approach can therefore help when deciding about the allocation of resources between obtaining new information and improving management actions. In our example we evaluated the value of obtaining perfect knowledge of the type of stock recruitment function of the North Sea herring population.

6.3 Risk classification

Following the adoption of the precautionary approach (FAO, 1996) fisheries management requires a formal consideration of uncertainty based upon limit and target reference points and control rules. Subsequently the World Summit on Sustainable Development (WSSD; COFI, 2003) committed signatories to maintain or restore stocks to levels by 2015 that can produce the Maximum Sustainable Yield (MSY). However, Cadrin and Pastoors (2008) noted that of the 137 ICES management units for which advice is provided by ICES only 17% actually had the necessary estimates to implement the precautionary control rule and 61% had no estimates of reference points at all. While for stocks managed under the Common Fisheries Policy (CFP) stock status is unknown for 80% of stocks and only 3% are considered to be exploited consistently with MSY.

This failure to implement management plans on a case specific basis means that there is a need to have a general risk identification protocol that bodies such as STECF and ICES can use to determine where action is needed and what form it should take. One deliverable is a proposal of a transparent way to classify stocks with respect to their sensitivity, susceptibility to fishing and our ability to control them.

The sensitivity of a stock can be defined by its productivity (Cortés *et al.*, 2008), equivalent to r the intrinsic rate of increase of a population, which also defines a limit to exploitation. While susceptibility is the probability or likelihood that a stock will be exposed to a pressure to which it is sensitive (Zacharias and Gregr, 2005) and can be expressed as the product of the conditional probabilities of availability, encounterability, selectivity, and post-capture mortality (Walker, 2005). Controllability is related to whether a desired state can be achieved using only permissible manipulations, e.g. recovery of fish stocks often depends upon incoming recruitment but the main management tool is to reduce fishing effort or catches and these are not directly linked.

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Annex 1: List of participants

NAME	ADDRESS	TELEPHONE/FAX	EMAIL
Michel Bertignac	IFREMER Lorient Station 8 rue François Toullec F-56100 Lorient France	+33 298 224 525 +33 298 224 653	Michel.Bertignac@ifremer.fr
Joachim Gröger	Johann Heinrich von Thünen-Institute, Institute for Sea Fisheries Palmaille 9 D-22767 Hamburg Germany	+49 4038905266 +49 4038905263	joachim.groeger@vti.bund.de
Daniel Howell	Institute of Marine Research PO Box 1870 N-5817 Bergen Norway	+47 55 23 86 79	danielh@imr.no
Laurence Kell	Centre for Environment, Fisheries & Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk UK	+44 1502 562244 +44 1502 513865	laurence.kell@cefas.co.uk
Knut Korsbrekke *Chair*	Institute of Marine Research Nordnesgt 33 PO Box 1870 N-5817 Bergen Norway	+47 55 23 86 38 +47 55 23 86 87	knut.korsbrekke@imr.no
José De Oliveira	Centre for Environment, Fisheries & Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk UK	+44 1502 527 727 +44 1502 524 511	jose.deoliveira@cefas.co.uk

Annex 2: SGRAMA terms of reference for the next meeting

2008/2/RMC12 The **Study Group on Risk Assessment and Management Advice** [SGRAMA] (Chair: Knut Korsbrekke, Norway) will meet in (venue to be decided) from (November–December 2009) to:

a) on the basis of the previous SGRAMA meetings and reports, input from WGFS and experience gained elsewhere, continue to develop operational guidelines for risk assessment as a part of the fisheries management advice process by:

i) identifying potentials for measuring or estimating consequences and probabilities;

ii) relating indicators to negative consequences and developing management procedures based upon such indicators;

iii) considering different approaches to risk identification;

iv) considering risk communication as a part of traditional fisheries management advice;

v) and in further detail suggest what elements or phases of a risk assessment is best suited for expert groups only.

b) present previous reports and proposed guidelines and framework to scientists outside SGRAMA and incorporate comments and suggestions;

SGRAMA will report by 1 March 2010 for the attention of SCICOM and ACOM.

Supporting Information

Priority:	The work is essential to ICES to progress in the development of its capacity to provide advice on fisheries and marine management which includes considerations of risk. Such evaluations are necessary to fulfil the requirements stipulated in the MOUs between ICES and Commissions
Scientific justification and relation to Action Plan:	[Action numbers 3.2, 3.4, 3.5, 3.12, 4.2, 4.3, 4.5, 4.11.2, 4.13, 4.15, 7.2] The SGRAMA report is a first step in establishing guidelines for production of risk assessments and inclusion of considerations of risk management in the advice. Risk assessment and risk management is an important field in several branches of science. The SGRAMA aims at drawing on the experience from other branches of science, and to include that experience in the development of risk assessment and risk management in fisheries science. The field covered by the SGRAMA is close to the field of the WGFS. The **ToR a)** is coordinated with a ToR for the WGFS, to ensure a rational division of labour, where the SGRAMA concentrates on technical aspects supporting risk decision-making **ToR a)** The guidelines shall outline the kind of information needed required for a risk assessment. They shall describe the process of identifying risk including how these relates to existing conservation and target limits, and with an overall focus on the ecosystem effect of fishing. The guidelines shall furthermore contain references to methods of quantifying risk including pseudo quantification methods and other qualitative approaches to risk analysis An important part of the guidelines will be a description of both risk identification processes and risk communication (how to communi-

	cate the findings in the assessment to managers in a way that facilitates decisions).
Resource requirements	
Participants:	Experts with qualifications regarding assessment and institutional aspects of risk assessment and management. Effort should be made to attract participants with experience in risk assessment and management outside the fisheries sector.
Secretariat Facilities:	Secetariat support
Financial:	No extra costs for ICES
Linkages to advisory committees:	ACOM
Linkages to other committees or groups:	WGFS, AMAWGC and Assessment WGs ToR c) relates directly to the WKREF, and WGEIM under SCICOM
Linkages to other organizations:	This work serves as a mechanism in fulfilment of the MOU with EC and fisheries commissions. Coordination should be assured as a number of participants in EU-funded projects such as JAKFISH are expected to participate.