ICES SGMAS REPORT 2008

ICES ADVISORY COMMITTEE

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Report of the Study Group on Management Strategies (SGMAS)

17 - 21 November 2008

Lisbon, Portugal

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

SGMAS met in Lisbon on the 17-22 November 2008. It considered lessons learned from recent work with management strategies in general and harvest control rules in particular, as well as input from other Expert Groups. That led to updates of the guidelines for ICES' handling of management strategies. The inventory of suitable computer programs for evaluation of management strategies was also updated.

Examination of recent evaluations revealed inconsistencies in methods used to parameterise errors and in the use of the risk concept. SGMAS now provides extended guidelines for carrying out evaluations, with indications of the minimum levels of complexity ICES should require. Also included are guidelines for the standards of software, emphasising quality checking of the code and highlighting critical aspects of the conditioning of models, in particular how uncertainties are specified, and how risk in relation to the precautionary approach should be evaluated.

SGMAS maintains its view that dialogue between science, industry and managers is essential in developing management strategies that are relevant and accepted. The amount of time and work needed in that process is substantial, and underestimating that effort delays and frustrates the process. The experience so far has been a learning process for all parties. For science in particular, it is considered essential that it is well prepared before entering a dialogue, for example by having adequate biological and error models running at the start. ICES should also recognise that different managers have different ways of relating to both science and industry, and that the form of the dialogue has to adapt to the kinds of conflicting interests that are present. For example, the dialogue will be different for 'domestic' and 'international' stocks, where for the latter different managers are also negotiators, who may perceive open participation as not in their interests.

SGMAS considered recent work by WGSAM, WKEFA, SGFIAC, WGMD, SGMIXMAN and WGFS, recent experience by the American Fisheries Society, and recent studies on generic harvest rules in STECF. Points of importance for the SGMAS guidelines include: Multispecies interactions lead to different perceptions of achievable objectives, but may mostly be dealt with by influencing parameters in single species evaluations until such interactions are better characterized. Moderate transfer of quotas between years has in itself minor effects. Environmental drivers have clear effects on stock productivity, but since predictions of such drivers in themselves are highly uncertain, management strategies have to be developed to be robust to plausible changes in the environment rather than being driven by predicted changes. Fishery-induced evolutionary changes still have to be proven, but their potential for influencing stock dynamics calls for a precautionary attitude. Tools to simulate harvest rules in a mixed fisheries context have matured considerably, and should be used when appropriate. In particular current mixed fisheries work can provide guidance on the kind of strategy that is likely to fail in its objectives, but it will require more development before providing guidance for optimal solutions that have a high probability of working.

SGMAS briefly considered management in data poor situations, highlighting the relation between stock dynamics, variance and delays in measures of the state of the stock and the dynamics of manager's response as the key factors to be considered when developing plans in such situations.

SGMAS has updated its inventory of simulation software with recent developments.

The field of management strategies is still rapidly developing, SGMAS can see a number of ways forward, by a continuation of SGMAS in its present form or by other EG structures in ICES. There is a need for some stronger coordination, as currently the standards being applied across evaluations are too inconsistent. Experience suggests that good evaluations are carried with work over several months, and involving a number of meetings with stakeholders. If this link to stakeholders is to be continued a management plan working group charged with developing multiple plans seems unlikely to be successful. Thus it seems more productive for ICES to have a small group to oversee a template giving guidance and to review work against that template.

1 Introduction Chairs

1.1 Terms of reference

The Study Group on Management Strategies [SGMAS] met in Lisbon (Portugal), 17–21 November 2008 to address the following terms of reference Council resolution 2007/2/ACOM24).

a) Examine current developments of harvest control rules in particular and management strategies for inter alia NEA Mackerel, North Sea flatfish, North Sea haddock, Blue whiting, North Sea herring and IIIa herring, western Horse mackerel, Northern hake, southern hake and *Nephrops*, Norway pout, sandeel and anchovy, and the North Sea cod recovery plan. More generally to assemble experience for further revisions of guidelines for developing and evaluating for such processes;

b) assemble results from ongoing work in other Expert Groups related to management strategy development and evaluation, including this year SGRAMA, WGMG, WKEFA, SGFIAC and WGSAM. and including finding from internationally coordinated research projects such as EFIMAS, COMMIT, PRONE, and make recommendations on appropriate methods to evaluate management plans.

c) explore feasible management strategies that do not rely solely on regular analytic stock assessments;

d) update the inventory of methods and software to evaluate harvest control rules, taking into account evaluations of such methods by WGMG.

SGMAS will report within four weeks from the meeting 2008 for the attention of ACOM.

The group was co-chaired by John Simmonds (UK Scotland) and Dankert Skagen (Norway). The list of participants is in Annex 1.

1.2 Background

SGMAS was created in 2005 to provide guidelines for evaluating management strategies in general and harvest control rules in particular. The incentive was the growing numbers of requests for evaluating such rules and the unclear standards for such evaluations. The SGMAS report from 2006 provides such guidelines. A further meeting was held in 2007 to summarize experience and to broaden the scope towards assisting in the development of rules rather than just evaluating proposed rules. This led to suggestions for improving the dialogue processes with managers and stakeholders some of which have been applied in the development of several plans in the last year.

Prior to 2007 the guidelines from SGMAS had been criticized for not taking into account insight from other Expert Groups that might be relevant. In particular, the impact of environmental research on fisheries management was examined through a workshop, WKEFA, which was set up in 2007 specifically to provide SGMAS with insight on that aspect. This group considered the scope of including a wide range of physical drivers and the potential for bringing in biological interaction into management. This year, ToR b was included with the intention that SGMAS should take account of the work by other ICES EGs, and incorporate them in the guidelines as relevant. In addition, the intention was to summarize the experience from recent work with management strategy development and evaluation both within and outside ICES and amend the guidelines accordingly, to further extend the guidelines for 'non-standard' stocks and to maintain the inventory of available software.

1.3 Structure of the report.

Each term of reference is dealt with in a separate section. Hence, ToR a is dealt with in Section 2, ToR b in Section 3, ToR c in Section 4 and ToR d in Section 6. Section 5 is an update of the guidelines, which should be regarded as an extension of those presented by SGMAS in 2006.

1.4 Future of SGMAS.

The future of SGMAS was discussed by the group. ICES has a clear need for instruments that can handle the growing number of requests that it receives. SGMAS has never considered itself as a 'computation group', but concentrated on giving guidelines for those who shall do the actual work and those who shall review it. The field of management strategies is still rapidly developing, SGMAS can see a number of ways forward, by a continuation of SGMAS in its present form or by other EG structures in ICES. The experience (Section 2) does suggest that there is a clear need for some stronger coordination, as currently the standards being applied across evaluations are too inconsistent. However, experience also suggests that good evaluations are carried with work over several months, and involving a number of meetings with stakeholders. If this link to stakeholders is to be continued as a method for developing management plans a working group charged with developing multiple plans seems unlikely to be successful. Thus it seems more productive for ICES to have a small group to oversee a template giving guidance and to review work against that template.

2 Review of management existing plans

In this section we briefly document a number of management plans that have been proposed and in many cases agreed. In section 2.1 we describe the background and general information on the organisation of the plan, where it is documented and some comments on content and process. In section 2.2 we draw a number of conclusions from the process of management plan development. In Section 2.3 we provide some updates on plans under development.

2.1 Overview of plans ICES and STECF plans

2.1.1 Sandeel

background	The AGSAN was set up to implement a real time monitoring system for the North Sea sandeel stock in 2007. The primary aim of the meeting was to agree on the implementation procedure for a previously established harvest control rule. The overall objective of the HCR was to ensure that fishing was limited in 2007 so that SSB in 2008 would be above Blim with a high (95%) probability. Fishing in 2007 would depend on the size of the 2007 year class. The estimate of the 2007 numbers was to be derived from real-time monitoring using a regression between historical CPUE observations and “bias-corrected” stock numbers at age 1. This report gives a summary of the agreed methodology and the procedure for combining data from the Norwegian and EU monitoring fisheries. A time table of when data and model estimates would be made available is given. In addition to that year’s management advice the group was asked to consider feasible options for future management arrangements. The group agreed that it is essential to account for substock structuring in future management. This is because the past management regimes have failed to avoid local depletion in many areas and account for regional differences in productivity and catch rates. The Ad hoc Group was not in the position to come up with a definite proposal for future management plans because of limitations in the knowledge base, although ongoing research is addressing this.
period	27-28 February 2007
organization	ICES AGSAN 2007
method	No evaluation of the proposed HCR. Only provided the parameters for N – CPUE regression.
expertgroup	AGSAN 2007 ICES CM 2007/ACFM:38 (ICES 2007e)
review	http://groupnet.ices.dk/advice2008/adgsan/default.aspx
advice	6.3.3.4 Harvest control rules and long term management strategies for sandeel in the North Sea and Skagerrak. (ICES 2007g)
comments	No formal evaluation of the management plan. Long input into future management plans using categories like: Management objectives, Extended effort regulation, Area closures, Indicator based management, Fixed quotas, Self-regulation.

2.1.2 Sandeel

Background	The AGSAN2 was set up in 2008 to address a request dealing with sandeel in the North Sea and Skagerrak. The EC and Norway requested ICES to provide further advice on a long term management strategy for sandeel fisheries that ensures sustainable fisheries, that allows Maximum Sustainable Yields to be achieved and is consistent with the precautionary approach; that prevents local depletion of sandeel aggregations and takes into account the function of sandeel in the ecosystem. Past meetings of the group agreed that it is essential to account for sub-stock structuring in future management because management regimes have failed to avoid local depletion in many areas and to account for regional differences in productivity and catch rates. AGSAN2 considered long term management strategies in terms of an effort control component, a TAC component and area closures. The potential to use stochastic short-term projections for estimating the 2009 TAC setting was considered and a plan proposed. The various objectives of closed areas were considered and in the short term, emergency measures to promote recovery of commercially extinct grounds were considered to have the highest priority and would also be the easiest to implement. It was not possible for AGSAN2 to currently recommend a full suite of operational tools to change sandeel management to a more sustainable system, but the group proposed changes in the procedures, tools and data bases over the next few years that would eventually lead to this goal.
Period	25-30 August 2008
Organization	ICES AGSAN 2008
Method	No evaluation of HCR.
Expertgroup	AGSAN 2008 ICES CM 2008/ACOM:59
Review	http://groupnet.ices.dk/advice2008/adgsan/default.aspx
Advice	6.3.3.8 EC and Norway request on long term management strategies for sandeel in the North Sea.
Comments	No formal evaluation of the management plan. Management should take into account the spatial structure of sandeels.

2.1.3 Southern hake and Nephrops in VIIIc and IXa

Background	The Southern Hake and Iberian Nephrops stocks are in a severely depleted state and ICES has advised that a recovery plan should be developed and implemented to assist the recovery of these stocks (SGMOS, 2003). A Subgroup on Management Objectives (SGMOS) of the EU Scientific, Technical and Economic Committee for Fisheries (STECF) was formed to address the topic of Recovery plans of Southern hake and Iberian Norway lobster stocks. The subgroup met from 9 – 13 June of 2003 at IPIMAR Headquarter in Lisbon. The aim of the meeting was to establish the scientific framework for recovery plans for southern hake stock and Iberian Norway lobster stocks (FU 26-30 and FU 25-31). The subgroup proposes a recovery target for Hake of 23 000 t, reducing F towards F0.1 (0.15) without catch constrain. The implemented plan set a SSB target of 35 000 t Bpa, decreasing F 10% annually towards 0.27 (Fmax) and a TAC constrain of 15%. Nephrops follow the same F reduction than hake. Recovery plan is in force from 2006 (EC Reg. nº 2166/2005). Southern hake: Goal: SSB = 35000 t (Bpa=Blim*1.4) in two consecutive years by 2015 Tactic: decreasing F a maximum of 10% annually until F=0.27 (Fmax) (TAC, effort control and closed areas) Constrain: annual change in TAC less than +- 15% Nephrops in VIIIc and IXa: Goal: rebuilding the stocks to within safe biological limits by 2015 Tactic: TAC shall be set at a level that will result in the same relative change in its fishing mortality rate than South hake. Constrain: annual change in TAC less than +- 15%
Period	2006-2015
Organization	STECF
Method	Stochastic projections
Expertgroup	SGMOS-03
Review	No evaluation of plan yet ("The Commission shall, on the basis of advice from ICES and STECF, evaluate the impact of the recovery measures on the stocks concerned and the fisheries on those stocks in the second year of application of this Regulation and in each of the following years" Art. 3 in EC Reg nº 2166/2005)
Advice	
Comments	ICES did not evaluated the recovery plan although it is enforce since 2006. ICES advice in 2008 is: "ICES has not evaluated the recovery plan in relation to precautionary limits. ICES continues to advise according to the precautionary limits; no landings should therefore be allowed in 2009." The same advice than in the previous three years. This advice has been ignored by EU that sets hake TACs based on the recovery plan rules and short term projections carried out by ICES. WGMAS suggest the need of an evaluation of this plan. This evaluation should have to take into account the bayesian stock assessment, accepted by ICES in 2008, a revision of reference points and the main sources of uncertainty in the assessment: stock unit definition, growth and ageing and discards.

2.1.4 Northern Hake

Background	Following concern over the status of the stock, technical measures were introduced in 2002 followed by a recovery plan in 2004. The situation of the stock has now improved so long term management plan has been proposed by EC. Scientist have been requested to analyse the plan. Industry has then been asked to give its feedback opinion over various possible measures of the plan (How to reduce F, how to improve selection pattern/reduce discards and protect juvenile etc.).
Period	4-8 June 2007, Lisbon (Management plan) 3-6 December 2007, Brussels (Impact assessment) February and May 2008 (NWWRAC meetings)
Organization	STECF
Method	FLR (full feedback) + EIAA
Expert Group	SGBRE-07-03; SGBRE-07-5
Review	by STECF plenary
Advice	by STECF plenary
Comments	SGBRE-07-03. The objectives of the plan are based on Johannesburg agreement: Fmsy = Fmax = 0.17 (from historic assessments). No reference is made to precautionary approach or probability above Blim so the working group decided to use 50% for the P(SSB< Bpa) and 0% for the P(violating the 15% yearly TAC change). Initial attempts were made to address fishing mortality by "metier" (fishery units): computed from total F at age, the F at age for various FU and/or gear categories. Multi-species evaluations with megrim and anglerfish have been attempted. If no discards are included in the assessment then there is not much differences in equilibrium yield between Fsq and Fmax. However, SSB level is higher at Fmax so more stability for the stock. With discards included in the assessment, there are much higher yields at Fmax than at Fsq. Furthermore, if reduction in F is coupled with improvement in selectivity pattern, a lower reduction in F is needed to get to Fmax. SGBRE-07-05 During the economic impact analysis: EIAA model by member state was used. Based on results of the FLR simulations; No dynamic link between biology and economy. Similar conclusions as in the first meeting. RAC meetings Presentation of the results of the management plan evaluation and of the "non paper" from the EU Commission to the industry. The plan should be implemented in 2009. No participation of Industry and/or scientist in the initial development of the plan. For the moment, not much support nor "real" acceptance from stake-holders (This may imply a lack of ownership of the results).

2.1.5 Greenland Halibut (NAFO)

Background	This case was chosen as a recent example outside ICES area. A rebuilding plan for the 2+3KLMNO Greenland halibut stock developed by NAFO Fisheries Commission (FC) has been in effect since 2004. Under the plan ad hoc TAC reduction steps were specified until 2007. There was no scientific basis for this, and the NAFO Scientific Committee (SC) was not consulted. SC subsequently reported in research documents that the approach was not PA-Compliant and unlikely to work. Recent assessment of this stock indicates that the rebuilding plan has been ineffective in initiating any recovery. Fishing mortality is still at high levels and spawner biomass has remained at very low levels. At the NAFO meeting in 2005 a renewed commitment was made to rebuild the Greenland halibut stock based on scientific principles and the Precautionary Approach. This encouraged NAFO Scientific Council to form a study group to evaluate rebuilding options for the stock using a Management Strategy Evaluation approach.
Period	2007-2008
Method	FLR (full feedback). A reference set of 20 operating models was specified. Five Management Strategies were investigated, as full MSE against four of these OMs and as deterministic projections on the other OMs.
Organization	NAFO SC created a study group (NAFO Study Group for Rebuilding Strategies for Greenland halibut) to develop the MSE. A Wiki was established to garner input and the Study Group met in Vigo in February 2008 to review progress and to suggest further development. This meeting was attended by scientists from NAFO member countries, fishing industry representatives from Canada and the EU, fisheries managers and invited independent experts. No ENGOs had been invited at the Workshop.
Expert Group	http://nafo-mse-ghal.wikidot.com
Review	
Advice	Since the FC did not endorse the evaluation process, no advice has been given following the scientific work.
Comments	During its September 2008 meeting, The NAFO FC has rejected the SC proposal to introduce MSE into the management of the Greenland halibut stock, so the "ad hoc" approach from the 2003 Rebuilding Plan still prevails.
References	Miller, D.C.M. and Shelton, P.A.,2008. Risk management within an RFMO – The case of Greenland halibut and NAFO. ICES CM 2008/O:13 MILLER, D.C.M., P.A. SHELTON, B.P. HEALEY, W.B. BRODIE, M.J. MORGAN, D.S. BUTTERWORTH, R. ALPOIM, D. GONZÁLEZ, F. GONZÁLEZ, C. FERNANDEZ, J. IANELLI, J-C. MAHÉ, I. MOSQUEIRA, R. SCOTT and A. VAZQUEZ. 2008. Management strategy evaluation for Greenland halibut (Reinhardtius hippoglossoides) in NAFO Subarea 2 and Divisions 3LKMNO. NAFO SCR Doc., No. 08/25, Ser. No. N5225.

2.1.6 North Sea herring

Background	Request from EC to evaluate management plans agreed by EU and Norway.
Period	Feb-May 2008
Method	STPR3a (Skagen 2008a). FLhms, and a deterministic management tool evaluation package implemented in SAS. The majority of the analysis was performed using STPR3a, with the other packages being used to complement and extend this work where appropriate.
Organization	ICES WKHMP workshop; 2 stakeholder-observers present at the workshop
Expertgroup	http://groupnet.ices.dk/wkhmp2008/default.aspx
Review	during North Sea review 2008.
Advice	6.3.3.4 EC requests on NSea herring management plan.doc
Comments	Method and conditioning as for previous evaluations for this stock Criteria for precautionary nature of plan: Not more than 5% probability of SSB < Blim in any of 20 years. ICES has accepted that a harvest rule as such is in accordance with the precautionary approach as long as it implies a low risk to Blim, even if other reference points may be exceeded occasionally. When a rule is regarded as precautionary, and the rule is followed, ICES gives its advice according to the rule. Within this framework, other precautionary reference points generally will be redundant. However, the precautionary reference points are also used to classify the stock with respect to 'safe biological limits', which may lead to a conflict that is still unresolved. Stakeholders present in the workshop; worked well. Ownership of results by stakeholders.
Problems In Evaluation	The evaluation was restricted to simulations necessary to address the request, using software and conditioning similar to previous practice for this stock. However, the result was very sensitive to the initial settings, and small changes in that would have altered the conclusions, because many projections were marginally precautionary.

2.1.7 Western Baltic herring

Background	Request from EC to evaluate management plans agreed by EU and Norway, for both North Sea herring and Western Baltic herring
Period	Feb-May 2008
Method	HCS
Organization	ICES WKHMP workshop; 2 stakeholder-observers present at the workshop
Expertgroup	http://groupnet.ices.dk/wkhmp2008/default.aspx
Review	during North Sea review 2008.
Advice	6.3.3.5 EC requests on management plan for herring in Division IIIa and western Baltic
Comments	Evaluation still at a early stage, and only preliminary results obtained, since the WKHMP took place before the benchmark assessment revision in march 2008. Therefore, the analyses should be re-run and expanded. Other approaches and further exploratory analyses have been suggested by the WG, including possibilities for area-based TAC. Stakeholders present in the workshop; worked well. Ownership of results by stakeholders. This stock will be further dealt with within the FP7 research project JAKFISH (2008-2011), including collaborative and participatory modelling with Pelagic RAC and Baltic RAC, so improved analyses are expected to take place in 2009.
References	ICES. 2008. Report of the Workshop on Herring Management Plans (WKHMP), 4–8 February, ICES Headquarters Copenhagen. ICES CM 2008/ACOM: 27. 2 pp. Report of the Herring Assessment Working Group for the Area South of 62°N, 11–19 March 2008. ICES CM 2008/ACOM:02.

2.1.8 Western Horse Mackerel

Background	Initial paper on use of Egg survey (Roel and De Oliveira 2007) Intensive timetable of activities during 2007 between Pelagic RAC and consortium of scientists with the compliance of EC. Produced an agreed report and recommendation by Pelagic RAC in June 2007. Request to ICES by EC: The ICES is requested to evaluate the consequences of implementing the "management plan for western Horse Mackerel" as prepared by the Pelagic RAC in July 2007. The evaluation should include assessments of: a) the likely trends in landings, stock size and fishing mortality rates; b) the risks of transgressing relevant precautionary reference points; c) the likely inter-annual variability in catches; d) any added provisions in plans that ICES may consider desirable. ICES was specifically requested to advise whether the plan conforms to the precautionary approach and to the implementation plan of the World summit on Sustainable Development (Johannesburg, 2002), especially in respect of conformity with maximum sustainable yield.
Period	September 2006 - September 2007
Organization	Pelagic RAC-Science partnership; ICES
Method	FPRESS, bespoke Fortran application
Expertgroup	Pelagic RAC-Science partnership
Review	http://groupnet.ices.dk/ACFM2007/OCT/rgwd/default.aspx
Advice	9.3.2.9 EC Request on evaluation of management plan for Western horse mackerel (ICES 2007) "Based on the current perception of the stock dynamics ICES considers that the plan is consistent with the precautionary approach for a period of 3 years. The current plan is not precautionary in the longer term, because the risk of the stocks falling below SSB in 1982 (~Blim) increases towards the end of the simulation period."
Comments	The objectives of all stakeholders involved were identified and accepted early in the process. An iterative process with regular updates and feedback from all parties involved kept the parties engaged and informed of the status of the development of the management plan. Over the period of the process the presentation of the simulation results was refined in order that the final statistics were presented in a manner stakeholders could readily and comfortably understand. Dialogue was constructive and non-judgemental throughout the process. There was a lack of manager involvment until later in the process when the Commission were present at one of the later meetings. At this point they outlined that for them to adopt the plan the management and TAC areas would have to be harmonised and all fisheries would have to be included under the TAC. A harmonisation of the management and TAC areas is proposed for 2009. The FPRESS model was used exclusively for the final HCR evaluations. Both models should have been used throughout the process for verification purposes. The documentation was lacking with the original report not publicly available (WD to WGMHSA07 (ICES 2007f)), although it was made available for the review process.

2.1.9 NEA mackerel

Background	Request from EC for evaluation of management plan. Other coastal states not involved in the request.
Period	April 2007-May 2008
Organization	ICES; series of workshops (April 2007, web conference July 2008, sept 2007, dec 2007, april 2008) Implemented the SGMAS approach: attempted to involve stakeholders and managers. Two workshops open to stakeholders; no interest from managers.
Method	Three methods: • FLR (a very slow version; used for sensitivity testing, parameterising observation errors (Magnitude, correlation and age structure), testing differences between rules (F, HR, constant TAC regimes) under realist implementation of assessment and STF errors), FRS Aberdeen • F-PRESS (R-code); fast. specifically for fixed TAC strategies. MI, Ireland • HCM (~STPR like): Harvest Control rules for Mackerel; IMR Norway Stock operating model based on 1000 populations each with separate S/R relationships and stochastic components based on H-S Normal (41%) H-S Log (29%) Ricker Normal (23%) Ricker Log(8%). Models chosen using Bayesian analysis and probabilities based on work of Micheilsens and MacAlister (2004).
Expert Group	http://groupnet.ices.dk/NEAMackerel2007/default.aspx
Report	Report on NEA mackerel long-term management scientific evaluation (ICES CM 2008/ACOM:54).
Review	http://groupnet.ices.dk/ACFM2007/OCT/rgwd/default.aspx
Advice	9.3.2.1 EC request on evaluation of management plan for mackerel.doc
Comments	Criteria for evaluating precautionary nature of plan explicitly discussed. Threshold used: "ICES interprets "consistent with (or conform to) the precautionary approach" for NEA mackerel to mean less than a 5% probability that the SSB is below 1.7 Mt during the simulation time periods", and "risk of less than 5% of SSB being below 1.7 Mt at any time during 11 years of simulation period." Reference points found to be inconsistent and re-evaluated during the HCR development. Problems of formulating S/R relationships required extensive exploration. Stakeholders present through initial stages of the process; Work on final report without stakeholders. Interaction with stakeholders and managers with 3 meetings and reworked data outputs to obtain clear presentation of tradeoffs. Final meetings increased acceptance of results though ownership of results by stakeholders, was reduced, partly because process was initiated by only one of managers (EU). The different objectives of different managers and the interactions among managers through negotiation process to set a TAC resulted in some difficulties in providing explanation of results. This necessary part of the process interferes with open and transparent idealized concept for stakeholder participation.

2.1.10 Blue whiting – coastal states science group

Background	A Working Group is established by the Blue Whiting Coastal States with the following terms of reference: To advise, by means of simulation studies, on the long-term consequences in terms of yield, stability of yield and conformity with the precautionary approach of implementing the following alternative elements in a longterm plan before 1 May 2008. Second request to ICES to evaluate a specific agreed plan wrt. …….
Period	26-30 May 2008
Organization	Coastal states working group
Method	Harvest Control rule Simulation (HCR, Dankert Skagen, Norway), modified to accommodate the rule for gradual reduction of fishing mortality. Conditioning bases on assessment with SMS: Initial numbers, weight and maturity from short term prediction input. Stochastic terms: Observation model: Noise as product of random term (CVs of assessment uncertainty by age) and year term, to give CV of SSB in the first year as in the assessment. Initial numbers: Using the observation model. Stock-recruitment: Hockey stick with lognormal random variation, based on years before the period with high recruitments. No implementation error included. SMS with similar conditioning was used for validation.
Expertgroup	Coastal states science group (ad hoc),, Anon 2008. Morten Vinther, Denmark (chair); Høgni Debes, Faroe Islands; Jesper Boje, Greenland; Manolo Meixide, Spain; Afra Egan, Ireland; Dankert Skagen, Norway; Frans van Beek, the Netherlands; Sergey Belikov, Russia; Asta Gudmundsdottir, Iceland. Second request: WGWIDE (ICES 2008 xx).
Review	none
Advice	1. included in the expert report, 2. 9.3.2.9 EC/Faroe Islands/Iceland/Norway request on long-term management of blue whiting (ICES
Comments	Known experts but intransparent process. Specific focused request from managers, feasible parameters in a pre-defined rule. No review. Report not published but available on request. Precautionary approach: Less than 5% probability for 'true' SSB < Blim in every year 2008-2028 was considered to be in accordance with the precautionary approach. No stakeholder involvement in the work. The simulations were repeated by WGWIDE in September 2008, after new assessment. The previous advise to reduce the F by at least 30% annually did no longer meet the precautionary criteria. Indicates that the recruitment model did not cover recent poor recruitments sufficiently.

2.1.11 NS flatfish – ICES

Background	The European Commission has established a multi-annual plan for fisheries exploiting stocks of plaice and sole in the North Sea (Council Regulation (EC) No 676/2007 of 11 June 2007). ICES advised in October 2007 that it has not been in a position to review the management plan, and could therefore not conclude on the precautionary nature of the plan. An evaluation of the management plan was documented by Machiels et al. (April 2008), based on a range of scenarios concerning stock dynamics, technical interaction between sole and plaice fishing, and interpretation of the regulation itself. This will be referred to in subsequent text as the "evaluation report". ICES has requested an independent review of the evaluation report. The stated objective of the review is to "ascertain that the evaluation of the (agreed) flatfish management plan has been carried out appropriately and whether the management plan is in accordance with the precautionary approach."
Period	April-May 2008
Organization	ICES
Method	FLR; dedicated model developed. Long code.
Expertgroup	No expert group. Report produced by IMARES, Netherlands http://groupnet.ices.dk/wgnssk2008/Working%20documents/Forms/AllItems.aspx?RootFolder=%2fwgnssk2008%2fWorking%20documents%2fPlaice%20and%20sole&View=%7b85C98B95%2d2584%2d4A79%2d81BB%2dFAF0258429EA%7d
Review	Two independent reviewers by correspondence. Bundled with a summary during ADG. Document: Review of flatfish plan_combined.doc
Advice	No separate advice. Included in the advice sections for North Sea plaice and sole.
Comments	Two independent reviewers did not agree on the conclusions of the report. Plan for one stock was accepted as provisionally precautionary; for the other it was.inconclusive. Criteria for precautionary nature of plan: "ICES does not appear to provide an explicit statement of what criteria need to be satisfied before the flatfish management plan is considered precautionary. For example is a moderate probability of SSB < Blim acceptable in the short term if the management plan evaluation indicates a very low long-term risk (as the evaluation report indicates)? ICES ACFM advice for Irish Sea cod in 2007 stated that a precautionary recovery plan must include an adaptive element. Specifically, ICES wanted the possibility of closing the fisheries on a severely depleted stock until an initial recovery of SSB is proven. The provisions of Article 18 of the Council Regulation for the flatfish management plan allows a larger annual reduction in TACs and fishing effort limits than specified in Articles 7-9, if the stock has reduced reproductive capacity (this would be defined by ICES as SSB < Blim). This may be considered enough to make the plan precautionary, independent of any simulation studies, if it is interpreted as allowing fishery closures until stock recovery is proven. The application of Article 18 is not simulated in the evaluation report."

Problems In Evaluation	The management plan could not be interpreted in one clear way. E.g. How should F's in the intermediate year be defined. The managers could not comment on this either. The management plan could not in total been implemented into a simulation routine since some decisions in the management plan rely on expert judgment. The results obtained from the simulation exercise did not fit to the observed values from assessments. This might mainly be due to the fact that the simulation model simulates a fleet fishing on both sole and plaice at the same time, while assessments assess each species separately. This setup is unique in its kind in ICES areas. Another problem arose when estimating uncertainty of different processes in the simulation. Estimating uncertainty is probably uncertain as well. Therefore strict rules should apply to indicate what type of uncertainty should be used. A final problem in the simulation was the choice of the stock recruitment relationship. It has already been shown by other studies that this relationship can determine the major part of the behavior of the simulation model, and hence its outcomes.

2.1.12 North Sea Saithe

Background	Request to ICES 2007: ICES is requested to evaluate the management plans agreed between Norway and the European Community concerning saithe of North Sea origin (Subarea IV (North Sea), Division IIIa (Skagerrak), and Subarea VI (West of Scotland and Rockall) with particular respect to : a) achieving the highest yields long-term from these stocks; b) ensuring conformity with the precautionary approach; c) achieving yields as stable as possible, consistent with achieving a high yield from the stocks and achieving conformity with precautionary principles.
Period	March 2007 – April 2008
Organization	ICES WGNSSK 2007 and chair of WGNSSK
Method	CS_HCR (modification of CS4), FLR full feedback model (XSA assessment) FLR attempted but failed due to lack of time.
Expertgroup	ICES received the request from the EC and Norway in March 2007. ICES addressed the request through a subgroup of the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) (ICES 2007c)
Review	ADGMP (31 March – 1 April 2008)
Advice	6.3.3.3 Norway and EC request on management plan for North Sea saithe (ICES 2007b) "Ensuring conformity with the precautionary approach: Medium-term stochastic simulations at F = 0.30 indicate that equilibrium SSB will remain stable just above Bpa, with ~50% probability of being below Bpa. Exploitation with reduced F or a higher upper SSB threshold would give equilibrium SSB above Bpa and low probability of being below Blim. A management plan based on a target F of 0.3 when SSB is above Bpa with a linear reduction to F=0.1 at Blim and a 15% constraint on interannual changes in TACs is consistent with the precautionary approach in the short term (<4 years). Because of a lack of manpower, it was not possible to carry out an evaluation which included full consideration of measurement and implementation errors."
Comments	The plan has been in operation since January 1 2005. The evaluation and review described here is a scheduled re-evaluation. The evaluation was conducted by a subgroup of WGNSSK 2007 and insufficient resources were allocated to the task. The evaluation is contradictory, with one of the reviewers commenting "I concur with the author's conclusion that '[r]eal uncertainties are much larger than those represented here. The model should not be used to estimate absolute probabilities but to compare strategies'. Therefore, the analyses do not indicate that the management plan is in accordance with the precautionary approach, as described in the second question above. One cannot conclude from these analyses that the MP results in a low probability that SSB will fall below Blim or that F will exceed Flim. This is different than the 5th conclusion in the report, 'the HCR is therefore considered appropriate to maintain the stock within precautionary levels'." The reviewers raised a number of concerns with the evaluation and the review group concluded that "the limited treatment of measurement and implementation errors in the assessment and implementation errors in the fishery, the HCR should be reviewed again within 4 years. In the longer term, discussions between ICES scientists, managers, and stakeholders should be initiated to further refine the management plan "

	The period allocated for the review of the evaluation was inadequate (1 week). No additional work has been carried out since the review. The interpretation of 'consistent with the precautionary approach' is not specified. There are issues with the interpretation of some clauses in the management plan.

2.1.13 North Sea haddock

Background	The European Community and Norway have agreed to exploit the stock of North Sea haddock on the basis of a TAC consistent with a fishing mortality rate of no more than 0.3 for appropriate age-groups (2-4). However, scientific advice from ICES has led to unexpectedly large variations in the forecast catch that corresponds to this fishing mortality rate, partly because of the selected age range interacting with transient dominant yearclasses. It is also relevant that for the stock the stability of catches (according to ICES estimates) may be substantially greater than the stability of the adopted TACs. The detailed request was as follows: Develop and evaluate the consequences of alternative options and methods to provide improved stability in TACs, while maintaining the fishing mortality rate on the stock on average close to the level decided by managers, and avoiding a high risk of depletion of the spawning biomass outside safe biological limits. ICES should develop these options and alternative methods on its own initiative, but should also evaluate the consequences of applying a 15% limit on inter-annual variation in TACs."
Period	2006
Organization	WGNSSK 2006
Method	FLR full-feedback model The simulation model consists of an operating model and a simulated management procedure. The operating model simulates the underlying "true" haddock population. The simulated management procedure consists of the stock assessment process and the management decisions that are taken on the basis of the perceived states of the stock. Fifty iterations of 20 years have been simulated for each HCR. Each of the iterations had a different simulated recruitment time-series. Within each HCR, iteration and year, the assessment incorporated uncertainties on measurements of catch (CV = 0.1), and on the relationship between survey data and true stock size (CV = 0.2). Code was written for this purpose specifically. No external review of the code
Expertgroup	WGNSSK 2006 + additional work after the ACFM meeting.
Review	First review in North Sea review group (no documentation). Additional work not reviewed.
Advice	6.3.3.3 Harvest Control Rules for North Sea haddock Released after post-ACFM work. ICES evaluated options through simulation studies. A target F = 0.3 with TAC constraint ±15% leads to a low risk (5%) of B < Blim over 20 years. The simulations are sensitive to the target F used and increasing the target F increases the risk.
Comments	Precautionary criteria: 5% risk of B < Blim over 20 years. No specification of how the risk is calculated (thought to be % of populations per year averaged over 20 years) Only modest fluctuations in stock size observed despite full-feedback model. Very poorly documented evaluation Further developed to evaluate banking and borrowing of 10% of TAC. Variability may depend on the use of simple average F over ages 2-4.

2.1.14 North Sea cod – recovery plan

Background	EC (DG MARE) requested ICES to evaluate an EC proposal and a Norwegian proposal for a cod recovery plan.
Period	August 2008 – November 2008
Organization	ICES AGCREMP 2008
Method	FLR using full-feedback model. Stock perception was modelled through XSA (even though assessment WG uses BAdapt. Stock size trajectories, fishing mortality rates and yields were simulated for 2008–2025. The results for 2015 are considered most informative for evaluating the Plans because they are far enough into the future so that stock recovery is an achievable objective, but they are not so far into the future that simulated stock sizes are outside of the observed range. Several different scenarios were considered to address sources of uncertainty in assessments, mainly related to unaccounted mortality. In addition, the performance of the Plans was evaluated for a "standard" recruitment model that reflects the long term relationship between spawning stock size and recruitment, and for a "low" recruitment model that reduces recruitment by 50%. The latter reflects the recent situation.
Expertgroup	http://groupnet.ices.dk/AGCREMP2008/default.aspx
Review	http://groupnet.ices.dk/advice2008/adgcremp/default.aspx
Advice	6.3.3.7 Request on Cod Recovery Management Plans
Comments	There was no formal usage of precautionary criteria. Because of the full-feedback model, there was no equilibrium situation during the course of the simulations. Instead, the simulations indicated a cyclic behaviour in stock and perception. That prevented a clear expression of the risk to Blim in the medium or long term. The simulation model was set up using FLR. The code was generated just prior to the meeting. During the AGCREMP meeting (3 days), an initial check process was carried out and a number of inconsistencies were discovered. This lead to alternative versions of the code after the meeting and eventually being finalized around mid September. During additional work for a French request in November 2008, more inconsistencies in the code were discovered, some of which had substantial influence on the results. The interpretation of the management plan=harvest control rule proved to be non-trivial. Because of the intricacies of the HCR, it took a number of iterations to make sure the code was doing what it supposed to do. Conclusion is that insufficient time was allocated for coding complex rules.

2.1.15 Baltic cod

Background	A multi-annual plan for the two cod stocks in the Baltic has been implemented since the 1st January of 2008 (EU Commission 2007). These plans are based on a gradual reduction by 10 % each year in fishing mortalities ('adaptive F approach') until reaching a targeted F level compatible with low risk to of recruitment failure and high long-term yields as proposed by ICES in 2005 (i.e. 0.3 for the eastern stock; 0.6 for the western stock). Before the plan implementation in 2006, A STECF reporting was requested by the EU commission to set technical aspects of the plan and conduct short-term prediction under some F scenarios. Investigation of the relative outcomes of setting the HCR with a 'moving' F (the last assessed one) versus a 'fixed' reference value for F was conducted and the report concludes that the fixed F should be chosen for the plan (STECF 2006). The plan is however implemented at this stage using the 'moving' F alternative. No formal evaluation of the plan has been requested (MSE) in order to explore the long term performance of the implemented HCR as well as its robustness against process and implementation errors. However, to the knowledge of the present WG participants, two independent scientific evaluations have been carried out over the year 2008 on the Eastern Baltic cod plan conditioning on WGBFAS 2007 data.
Period	mid 2007 – mid 2008
Organization	None
Method	SMS model and FLR model (FLR2M)
Expertgroup	Independent scientific works, (i) Köster F., Vinther M., Kraus G., and Plikshs M 2007 Baltic cod management plan evaluation. UNCOVER workshop, Tenerife, 13-16 November 2007 (ii) inside EU CEVIS project: Francois Bastardie, F., Nielsen, J.R., and Kraus, G. (in submission). Management Strategy Evaluation framework for the Eastern Baltic cod fishery to test robustness of management against environmental conditions and fleet response scenarios.
Review	still have to be reviewed
Method	(i)The first method uses the SMS model (Köster et al. 2007) in a single species way to run long term projections of the agreed recovery management plan until reaching equilibrium. Simulations were done using two recruitment models (low / high recruitments) related to the Atlantic inflow of saline and oxygenated water from the North Sea. Choice of a moving F versus a fixed F was also fully supported. The robustness of the TAC HCR is evaluated against bias in assessment, TAC settings (i.e. TAC bounds) and implementation error. (ii) The second method was designed to focus on the evaluation of the plan against some presumable fleet response scenarios (implementation error). A FLR full-feedback model was developed (FLR2M model; Bastardie et al. in submission) accounting for the response of fishermen in terms of misreporting, spatial effort reallocation and technical improvement. A fleet dynamic OM holding heterogeneity of fishing practices across the Baltic nations participating in the cod fishery, together with population dynamic OMs (recruitments function of stochastic inflow/stagnation years) were conditioned to project forward the evolution of the stock under a range of management options in isolation or not (effort HCR; TAC HCR; spatio-temporal closure) including the agreed plan combinations (effort HCR and closure).

Advice	None
Comments	The main results of the SMS runs showed that the HCR is able to rebuild the stock at low level of uncertainties (CV < 0.35). Adding additionally an assessment bias of 1.2 (consistent 20% overestimation of the stock) and an implementation uncertainty of 0.1 are the limiting conditions at which the harvest control rule can be considered precautionary. The F target at 0.3 (half of the Fpa) was shown sufficient to get rid of uncertainties effect in the HCR. The implementation error is shown having a big effect in reaching the target; The MSE conducted by the full FLR feedback model showed that the recruitment is the dominant factor in driving the performance of the plan. The simulations showed cod recovery inside the 10 years time horizon under the agreed plan if (and only if) some possible inflow years occur (P inflow = 0.2). Under continuous adverse conditions, the gradual reduction driven by the effort HCR should initiate the stock recovery as far as misreporting on effort is inexistent. This recovery seems to be robust enough against the tested scenarios in changing the spatial fishing pattern from effort displacement (in these cases, recovery is delayed). The hypothetical TAC HCR is strongly impaired by the misreported landings while the agreed plan should limit or remove this effect as the TAC is only use to supplement the effort HCR. There has been no evaluation of the plan by ICES, but the concerns of STECF regarding the method for calculating F suggest the plan is not robust to errors in the assessment.

2.2 Common experience from recent work

Types of requests

Except for North Sea flatfish, most of the evaluations that have been carried out recently have been of harvest control rules in the strict sense for single stocks and fisheries. The main reason for this narrow scope is that the processes have been driven by manager's requests to obtain answers for single species issues. One may consider if ICES should take on a more active role in developing management plans in the broader sense as outlined by SGMAS (2006), including at least the knowledge base and the implementation of the harvest rule. However, this should not be done without clear indications that the scientific capacity to do the necessary substantial amount of work is available.

The cases studied here differ considerably in the way they have been initiated, which may in itself have had a strong impact on the process. A few cases have been triggered primarily by science, where scientists have had insight that they considered promising, which has been conveyed to managers and stakeholders. Often such ideas have evolved within the ICES Working Group environments. The Western horse mackerel plan and the early phase of the NEA mackerel case may be examples. In many cases the ICES advice (on a depleted stock) has been the background for starting to consider management strategies. In these cases ICES as an organization did not take initiative to develop management strategies, however, but responded to requests from its formal customers. In a number of other cases, the initiative has come from managers, wishing to have a firmer basis for their tactical decisions,. Occasionally cases have been generated by the industry, in particular the EU RACs. Here plans have been developed in collaboration between industry and science, while managers and ICES have been brought into the process at a relatively late stage.

In some cases, relatively specific harvest rule has been proposed by managers, and the task has been to advice on feasible parameters of the rule (e.g. North Sea herring, Western Baltic herring). These cases have either been revisions of existing management plans or plans with pre-decided lay-out according to a more or less standard template. These evaluations have required modest work once the simulation framework including conditioning of the model was in place. However, cases where the conditioning of the biological model was inadequate (e.g. Blue whiting) have led to questionable advice.

In other cases, the requests have been far more open, asking for exploration of a wide range of alternatives and searching for something that may satisfy more or less specific objectives (e.g. NEA mackerel, Western Horse mackerel). In such cases, ICES has attempted to follow the dialogue policy outlined by SGMAS (2006, 2007). This has led to long, but fairly productive processes, which has been learning processes for all parties.

Dialogue with managers and stakeholders

In its 2007 report, SGMAS highlighted that the development of harvest rules, and of management strategies in general, requires a dialogue process where managers, stakeholders and science takes part. ICES has attempted to follow that advice. The experience from recent evaluations is that the kind and level of interaction has varied, as has the satisfaction by the stakeholders.

Figure 2.2.1 which summarizes the experience with the dialogue process by one stakeholder representative from the Pelagic RAC (Olesen WD 2008), is a useful illustration of how the process can be perceived by a stakeholder representative. Several of the points made here are further discussed below.

	Initiator	EU Actors involved			ICES/ Others	All relevant managers	All relevant industry	Precautionary - test	MSY-test	Satisfaction EU actors			result
		M	I	S						M	I	S	
Blue Whiting (1)	I	1	1	0	-	Y	Y	N	N	☺	☺	😐	6
Blue Whiting (2)	M	1	0	1	O	Y	N	Y	N	☺	☹	☺	6
NEA Mackerel (2)	M	1	1	1	I	N	N	Y	Y	☺	☺	☺	8
Horse Mackerel	S	0	1	1	O	N	Y	Y	Y	☺	☺	☺	8
Herring - WBSS	M	?	?	?	?	?	?	?	?	?	?	?	?
Herring - North Sea (2)	S	0	1	1	I	N	N	Y	N	?	?	?	?
Herring - West of Scotland	M/S	1	0	0	-	Y	N	Y	N	☺	☹	😐	4

Figure 2.2.1. A stakeholders perception of success and failure factors in various aspects of harvest rule developments. (M = managers, I = industry, S = Scientists, numbers in 1st column 1,2 refer to versions of the plans)

The Western Horse mackerel case may be the most successful in terms of stakeholder interaction. Here, the process was to a large extent been driven by the RAC in close cooperation with a small group of scientists. Important success factors were regular meetings, sufficient capacity on the science side to enable both the close cooperation and to perform the work, and presentation of results in a way that addressed the RACs questions and problems directly. For NEA mackerel, only by the second version of the mackerel plan had satisfaction been achieved. Considerable difficulty was encountered in parameterising the biological operating model leading to an extended process and dissatisfaction until extensive efforts were made to explain the results. It should also be noted that plans that involve increases in catch options may be easier to accept than those involving reductions.

The dialogue process has been less successful in other cases. Possible reasons have been:

1) Science has not been sufficiently prepared to do simulations interactively in the dialogue process. This has been due to the need to develop software, to condition the model properly, and general shortage of scientific manpower.

2) Presentation and explanation of results has been a learning process. The key to success seems to be the ability to communicate results in a way that addresses the stakeholder's questions and problems, which is different from presenting results in a scientific forum or trying to understand mechanisms and relations. Many stakeholders prefer condensed tables of carefully selected options, showing numbers that are important from their perspective rather than graphical output attempting to include as much information as possible. This requires interaction to allow appropriate selection of options.

3) Dialogue with stakeholders is far simpler when there is one representative stakeholder body to communicate with. Once there are conflicting stakeholder interests, science will have to be careful to avoid being too heavily influenced by one party. This is typically the case with stocks exploited and managed by several nations, including nations outside the EU.

With a few minor exceptions managers have generally not taken part in the dialogue process. For stocks where the final decisions are made in international negotiations, managers may prefer not to reveal their positions beforehand. In such cases, the main task for science is to provide common background information for the negotiators. Hence, science must attempt to ensure that sufficient ground is covered and ensure that it remains neutral to specific interests. Examples of such cases are e.g. Mackerel and Blue whiting.

Managers may also prefer to deal with stakeholders themselves, rather than leaving that communication to science, in order to control the balance between conflicting interests. Practice and attitudes vary considerably between nations in this respect. While the EU encourages direct communication between science and stakeholders in the development process, the interaction between managers and stakeholders may operate differently in nations outside the EU. Therefore, EU standards are not necessarily applicable in other parts of the ICES community.

Some lessons learned.

Assembling the experience from recent studies has revealed some points that need further consideration and improvement which we highlight here. The revised guidelines for evaluations, taking these experiences into account are presented in Section 5.

The methods used for evaluating rules has varied across stocks, and the justification for the choice is not necessarily clear. In general, the simulation tools have the standard elements:

- An operating model which projects a bundle of age structured stock trajectories forward representing a plausible range of 'true' stocks ,
- an observation model that derives noisy observations that are seen by the decision maker,
- a decision model which simulates the decision process and
- an implementation model that converts decisions to real removals form the operating model stock.

The tools used differ mostly in the observation model. Two approaches have been followed: A 'closed loop' approach, where the observation uncertainty is generated by running an assessment with noisy observations inside the projection loop, and a 'shortcut' approach where observation noise is generated as random numbers with specified statistical properties. The closed loop evaluations have typically used the FLR framework, while there are several programs of the 'shortcut' type. The choice between the two has to some extent been person dependent. This may be rational since modifications of software often is necessary, and modifying programs written by others is often problematic. Other reasons have been that the assessment procedure used by the assessment WG has not been implemented in the FLR framework, as well as the need for computation speed when screening over wide ranges of options.

Rules as presented by managers may have ambiguities, as discussed by SGMAS (2007). The way such ambiguities have been handled has varied. Such ambiguities may be deliberate, to give managers some space to adapt to the prevailing conditions, but the action to be taken has to be assumed in a simulation program. Usually, one choice has been assumed, and the results are presented as conditional on that assumption, there is a need for this to be dealt with more explicitly.

The concept of risk, i.e. evaluation of the rule according to the precautionary approach has varied greatly. This problem is further discussed in Section 5.3.

A common experience is that the conditioning of the model, in particular the assumptions about distributions of stochastic terms and about the choice of stock recruit relationships has a strong impact on the conclusions. Documentation and justification of these assumptions, as well as testing the robustness of the conclusions to these assumptions has varied, and has not always been satisfactory.

More generally, documentation of methods and assumptions has not always been satisfactory. This has made the review processes carried out by ICES difficult, and sometimes inadequate.

Software that has had to be developed during the process of formulating and evaluation a rule as caused problems on several occasions. Subsequently bugs in ad hoc modifications to programs have been encountered on several occasions, and the time needed to both develop and test the code has delayed dialogue processes and created frustration.

The time and workload needed in a development process is substantial. In particular, this is the case in the early phases of development, where time is needed both for ensuring proper conditioning of models, for programming and not the least for communicating with stakeholders. Clearly, developing a management strategy, and even just a harvest rule is a process, and not a routine run of a program. Hence, a critical success factor is that sufficient time and manpower is allocated to the task.

Only in cases where the principles of the biological operating model are well established, the task is limited to just evaluate a given rule with respect to the precautionary approach, and this can be done with existing software, may the task may be done rapidly. In most cases a major obstacle is the need to ensure that the model is properly conditioned, however, and this is not a trivial task. These requirements become more critical if stakeholders and managers wish to choose regimes that are close to the specified precautionary criteria.

On occasion the limit reference points proposed by ICES are incompatible with the population dynamics implied by the biological operating model for the stock. This may be because the reference points are based on a different assessment or a different range of dynamics. It is important to resolve these differences, and to ensure that the reference points are appropriate. This may mean proposing revisions, or it may imply testing multiple biological operating models to accommodate changes in dynamics.

2.3 Management plans under development

During the meeting two plans which are under development were discussed and the outcomes of the discussion are included below.

2.3.1 Development of Western horse mackerel management plan

Due to concerns raised during the review of the Western Horse Mackerel management plan evaluation, the plan was accepted by ICES as precautionary only in the short term. Furthermore, the plan is to be reviewed in 2009, prior to the next TAC setting.

The concerns of ICES centred on the following

- The recruitment model. It was felt that the recruitment time series warranted investigation with a view to the incorporation of autocorrelation in the simulations.
- The stability of the simulation outputs. Over the simulation period, the risk of SSB falling below the SSB_{1982} limit point rises.
- Inertia in the harvest control rule. Since the rule is based on a fit to the previous 3 egg survey results, would the HCR be able to respond with appropriate speed once a large year class has moved through the fishery?

The recruitment time series was analysed for autocorrelation and was found to have a significant correlation at a lag of 1 year which should be incorporated into future simulations. It was also proposed that 2001 should be considered a pulse recruitment and the plan, which already contains the principle of management of the stock from a low base i.e. disregarding of intermittent and unpredictable pulse year classes, should be evaluated in this context. The updated recruitment model will also be used to test whether the rule is sufficiently flexible to respond to a large year class moving out of the stock.

The minimum TAC that can result from the application of the current management plan is 80,250t, regardless of the state of the stock. It was proposed to address the increasing risk over the lifetime of the simulation by the incorporation of a protection rule in the harvest control rule to allow the rule to set TACs lower than this when applicable. Initial simulations have indicated that the activation of a protection rule based on SSB falling below a trigger point can introduce stability into the results. Additional formulations for the protection rule will be investigated as part of the review, including modified HCR parameters.

New information available includes the stock assessment conducted at WGWIDE08 (ICES 2008) which is considered to be quantitative rather than indicative of trends only, as was the case in recent years. This assessment has resulted in an increase in SSB. Additional applications of the assessment methodology are required before it can be used as a basis for conditioning of simulations. Future work will also address the issue of TAC overshoot whereby any overshoot of the TAC will be discounted from the following years TAC, as detailed in the management plan, and undershoot whereby a portion of the TAC can be carried into the following year.

2.3.2 Development of a management plan for sardine

Possible plans to manage the Iberian sardine are in a very early phase at present. The development of a management plan for this stock was recently re-visited by scientists involved in the assessment of the stock. Preliminary discussions were held during the 2008 WGWIDE meeting. The proposed development of a plan was discussed with the Portuguese fishing sector. A presentation reflecting these discussions was presented to the SG.

The sardine stock is not managed using a TAC. National management plans, including limitations to number of fishing days, seasonal closures, and annual quotas (allocated by the Producers Organization in Portugal) were implemented in 1998 by Spain and Portugal. This followed a request by the EU to decrease fishing mortality, following a decline of the stock (after seven years of low recruitment) and a crisis of the fishery in northern Spain. In Portugal, some of these regulations were discontinued when the stock was rebuilt to the historic average in the mid-2000s.

SGMAS supports the idea that a long term plan will facilitate management of this stock by setting rules that will trigger action in the event of prolonged low recruitment. Fishing mortality is presently low for this stock and has been relatively stable in the past decade, partially due to market constraints. However, the absence of harvest rules may lead to an escalating fishing mortality in a scenario of stock decline which is not immediately reflected in low yields, or if new market opportunities are found. The long-term declining trend in both the recruitment and SSB seen in the assessment is an additional concern to the sustainability of the fishery.

The nature of the recruitment to the stock is a fundamental feature that will require consideration in the development of a management plan, and should be amenable to implementation within a simulation framework. The SG suggested that this stock may benefit from a management plan that incorporates a HCR that is less rigid than the ‘classic’ three stage HCR.

The fact that sardine is caught in a well-organized and targeted fishery and that there are good relationships between stakeholders, scientists and managers provides a good opportunity for constructive dialogue on the development of a plan. It was also noted that up to now, most of the dialogue has been carried out within Portugal, although at the scientific level both Portugal and Spain are collaborating through ICES. Spanish stakeholders and managers must be involved in the dialogue as early as possible. A natural forum for the discussion would be the appropriate RAC or ICCAT WG.

3 Contributions of ICES Working and Study groups

In this section we bring together summaries of work relevant to SGMAS from a number of ICES study and working groups and draw this together in final part of this section (3.10). The conclusions are combined with those from Section 2 to give the guidance in section 5.

3.1 Contributions from WGSAM

Background:

WGSAM was asked, as described under its ToR a 2008, to explore the concept of Maximum Sustainable Yield (MSY) within a multispecies context. The group chose not to evaluate this concept on a simulation basis, as time and approaches for that were lacking. However, based upon studies on MSY performed within earlier studies, the following remarks were made:

e) The high yields predicted at low F by single-species models are almost certainly unrealistic, as these will be 'eroded' by predation pressure and density-dependent growth reductions.

f) Multi-species models tend to suggest that MSY is achieved at slightly higher fishing mortalities in comparison with single-species approaches.

g) It is impossible to attain the high yields predicted by single-species models for all stocks simultaneously, since achieving B_{MSY} for one species may result in stock declines for other species that are prey and/or competitors.

h) System-wide analyses suggest that the optimum strategy to maximise yield usually involves the elimination of top predators (ecosystem engineering).

i) Management objectives need to be very clear – to maximise overall yield (protein production), to maximise economic returns or to prevent the loss of any species (biodiversity objectives). These objectives are almost certainly mutually incompatible.

j) Predators might provide other 'services' in ecosystems which could be impacted if system-wide strategies are pursued to maximise yield.

Relevance for SGMAS:

Based upon these remarks, one main discussion point was raised within the SGMAS meeting.

- How to define a management strategy for multi-species interaction to work towards MSE

Under the Ecosystem Approach to Fisheries Management there is a growing need for multi-species management plans. However, as current detailed knowledge on feeding interactions is still lacking, SGMAS considers that the framework developed by SGMAS for management strategies cannot be adjusted to account for multi-species management. However, as the multispecies work can provide more realistic approximations of single species natural mortality rates, it is believed that studying multi-species management plans can also provide more insight into single species management strategies. SGMAS wants therefore to stress that action should be undertaken to formulate basic principles on how to manage populations in a multi-species context. It is very likely that these will deviate from the common concept used today in single species management, but in the short run will rather serve these management strategies than replace them.

Actions:

- Design a framework for multi-species management strategies.
- Evaluate this framework and identify where this can be used for single species management

3.2 Contributions from WGMG

Methods WG considered that perception of the impact of harvest-control rules (HCRs) on the underlying population can change with different levels of approximation in the MSE, particularly when considering the longer term. Figure 3.2.1 taken from the WG report illustrates this issue. The changes are not always obvious when considering only individual distributions of quantities of interest (e.g. SSB and landings yield). It is possible that, using an approximated MSE (e.g. omitting both the assessment and intermediate-year lag) could lead to perceptions of superior performance of one HCR relative to another in terms of summary statistics that would not be concluded if a full MSE were conducted. SGMAS considers that this evaluation is useful, but it would be helpful to know if the use of temporally correlated age structured error, along with a true timescale (intermediate year), similar to the approach for NEA mackerel would be sufficient to mimic assessment errors.

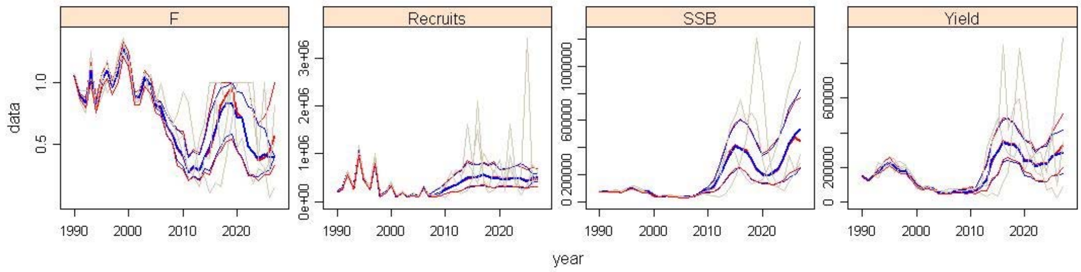
WG Methods considered that conducting an MSE can be approached in a two-step procedure.

- The first step would be done among the scientists, and would address the issue of model dimensionality—which factors are important, and how many levels and/or iterations should be retained for the 'final' MSE.
- The second step involves summarizing the information for managers and the general public, and this should be done graphically. All results of the MSE could be put into an appendix table for persons interested in the fine details.

Here SGMAS agrees that the first step parameterisation is generally the responsibility of scientists, but experience (Section 2) has shown the involvement of stakeholders in this process can improve communication and acceptance of the modelling. However, we consider that the second step cannot be carried out successfully in the way described. We consider that it requires extensive iterative consultation with stakeholders to establish criteria for selecting potentially suitable HCRs. Once these criteria are defined scientists should show how a small set are extracted and present a short set of tabulated results. Examples of this process are the final presentations to stakeholders of options from Western horse mackerel and NEA mackerel management plans.

MSE of the EU-Norway management plan for North Sea haddock was used to address the question of interannual quota flexibility, allowing countries 10% of next year's quota to be fished this year, or bank 10% of this year's quota to be fished next year. The evaluation concluded that there is very little change in risk if this facility is permitted. It is considered that the demonstrated insensitivity to the flexibility may be generic for stocks with similar or lower exploitation targets, but further evaluation may be needed for short lived stocks such as Norway pout, or sandeel.

a) 'Full error' MSE



b) MSE with random error in the estimates and no intermediate year

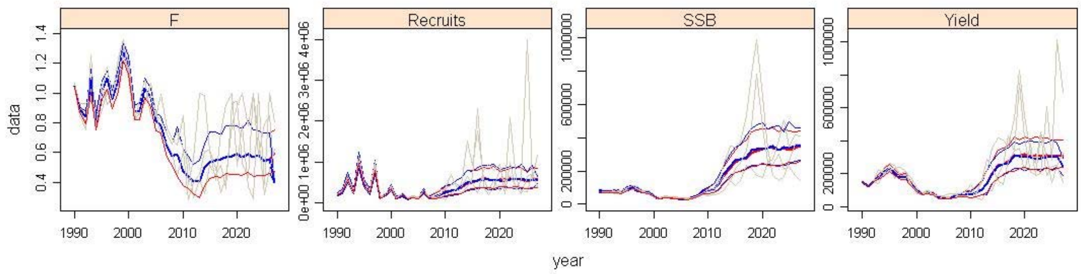


Figure 3.2.1. Comparison of Simulations taken from WGMG, showing differences between two different simulation methods for evaluating NS cod recovery plans, a) including XSA assessment and an intermediate year in the management cycle and b) simulating only random noise as a measurement error and no intermediate year.

3.3 Contributions from SGFIAC

The ICES study group on fisheries-induced adaptive change (SGFIAC) works on identifying and quantifying potential fisheries-induced trait changes in exploited fish stocks, as well as on assessing the consequences of such changes. Although the work on computational tools (e.g. probabilistic maturation reaction norms and eco-genetic modelling) is rapidly expanding in the scientific literature (REFS needed here), implementation of these methods in the ICES framework of giving scientific advice is still pending. To make progress in this direction, there are plans to integrate the estimation of probabilistic maturation reaction norms into the FLR framework and to apply this to North Sea flatfish.

SGFIAC is currently preparing two scientific papers relevant to SGMAS. The motive of the first paper, "Slipping reference points driven by fisheries-induced evolution," is that reference points are likely to shift when a stock's demographic characteristics are changing as a result of fisheries-induced evolution. The second paper, "Evolutionary impact assessment (EvoIA) in practice," builds on the publication "Managing evolving fish stocks" (Jørgensen *et al*. 2007) that resulted from SGFIAC's inaugural meeting. For EvoIA to be successful, it must work within the current management systems. When scientists have information on past trait changes in a fish stock, or when they can predict future trait changes under alternative management measures, the evolutionary impact should be assessed as the change in a stock's utility resulting from fisheries-induce evolution, thus accounting for various utility components such as yield, profit, ecological services, etc.

Some uncertainty will always remain as to whether any particular fish stock is actually undergoing fisheries-induced evolution. This is because evidence for life-history changes resulting from fisheries-induced evolution is necessarily indirect regarding its nature (evolution or not) and correlative regarding its driver (fisheries or not). Model-based results obtained by SGFIAC participants suggest, however, that the recovery time for depleted fish stocks that have experienced genetic trait changes can be significantly longer than for stocks that have experienced merely phenotypic trait changes. Therefore, SGMAS concurs that in applying the precautionary approach to fisheries management, precaution should extend to the possibility that fisheries-induced evolution is indeed occurring for a given fish stock.

SGMAS points out that SGFIAC is perhaps ICES' most productive study group: their first meeting produced a publication in the journal *Science* and their second meeting spawned two new plans for peer-reviewed papers. SGMAS commends the initiative of SGFIAC to use the ICES study-group framework to facilitate on-going collaborative work for the production of peer-reviewed papers and to bring innovative science closer to practical management. Indeed this might be a model worthy of being promoted for other ICES study groups.

3.4 Contribution from WKMIXMAN

Major progresses have been achieved in mixed-fisheries modelling since last year's meeting, and these are summarised here.

SGMIXMAN (originally WKMIXMAN) was established in 2006 with the short-term requirement of defining a framework for simple models of mixed fisheries which could be used to obtain consistency between management (TAC and/or effort) advice for species caught together. Previous trials in that field were mainly about the development of the MTAC approach (Vinther *et al*, 2004). But SGMIXMAN has promoted the development of another approach, the Fleet and Fishery Forecast approach (F^3 or Fcube, ICES_SGMIXMAN 2007, 2008, Ulrich *et al.*, 2008).

The basic structure of Fcube is the separation of fleets (i.e. the vessels) and their activity (the fisheries or métiers). Fleets (i.e. homogeneous groups of vessels) have a certain amount of effort each year which is allocated between different métiers. The fishing mortality that each fleet exerts on each of its target species is then derived from its total effort, the proportion of that effort allocated to each métier, and the catchability of each species within each métier. In this way the approach allows the impact of different fleet efforts and allocations to be modelled, through simple arrays of partial fishing mortalities. Alternative simple hypotheses about the behaviour of the fleets (for instance by assuming that all fleets will fish until all of their quotas are exhausted (the scenario of max. effort), or that they will fish up the quota of their most valuable species) can be used to show the misreported or discarded catches implied by these scenarios, and thus illustrate the extent to which the single species TACs are mis-matched.

Major developments in the methodology have taken place in 2007 and 2008, both during SGMIXMAN meetings and inter-sessionally within the EU-funded FP6 projects EFIMAS (www.efimas.org) and AFRAME (http://ec.europa.eu/research/fp6/ssp/aframe_en.htm). Two major works have been developed in parallel.

First, and in parallel with the general FLR development, Fcube has been translated and re-coded from an independent and self-contained R script to functions and methods compatible with the FLR framework. These are stored in a FLFcube function in the FLEcon package. As such, FLFcube is only dealing with the estimation of effort, while other usual FLR features are used for performing the traditional single-stock projections. This methodology was tested and used during SGMIXMAN 2008 on both North Sea mixed-fisheries and Northern Hake mixed-fisheries. An example of the results obtained is displayed on figure 3.4.1 for the North Sea, and detailed description and discussion is available in the SGMIXMAN 2008 report.

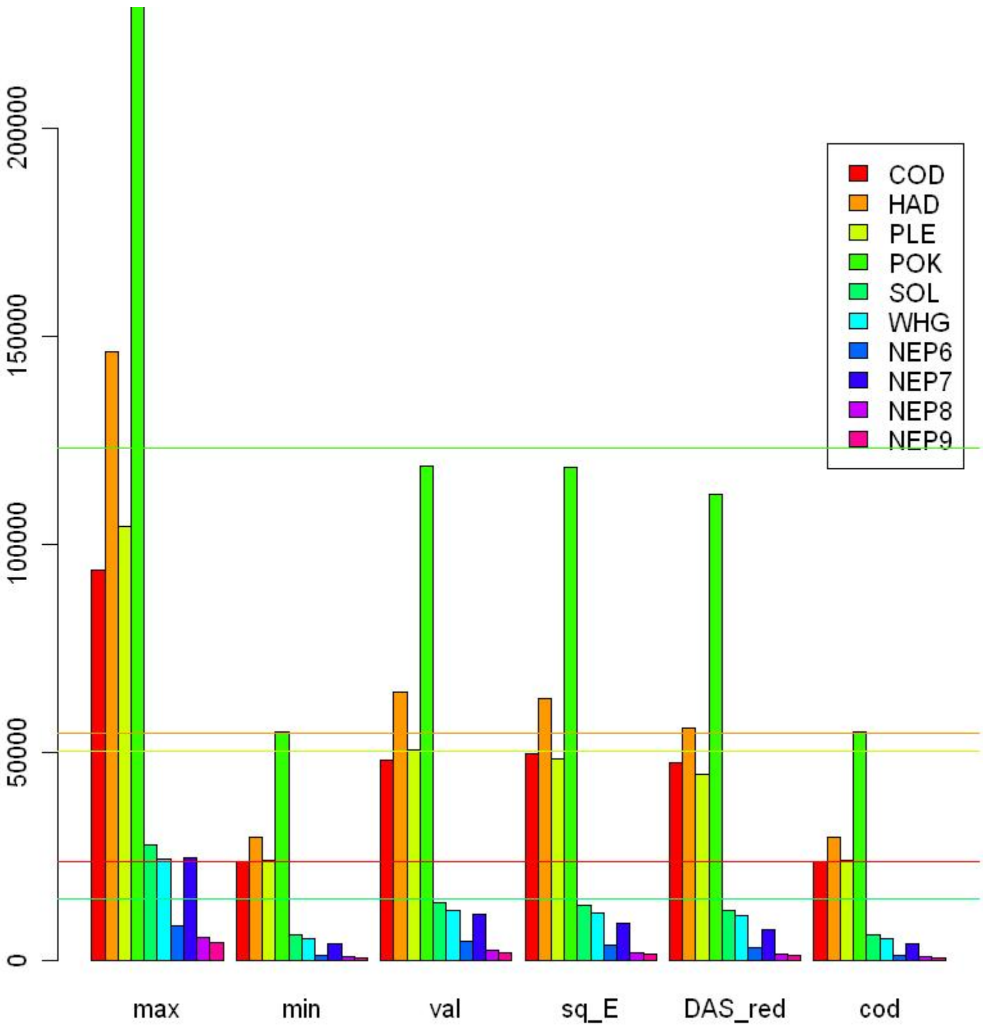


Figure 3.4.1 – estimated 2007 landings by stock for the various Fcube scenarios. Horizontal lines correspond to base case TAC for cod, haddock, plaice, saithe and sol respectively (whiting TAC being close to cod TAC level). (From SGMIXMAN, 2008)

The SGMIXMAN was very positive about the results of Fcube runs, as these were found to be fully consistent with qualitative and quantitative observations. They could thus be interpreted in the light of current knowledge on the state of the stocks and the expected effects of main management measures. There has long been evidence and claims from the industry about the negative effects of restrictive cod TACs, and this could be reproduced quantitatively with a fairly simple model based on usual logbooks data without complex age distribution by fishery and stock. The

SGMIXMAN thus considered that the method could potentially be used in the future to deliver timely mixed-fisheries advice.

Secondly, a complex full feed-back and stochastic mixed-fisheries MSE model has been developed with FLR (Hamon et al., 2007). Beside including some usual sources of single-species uncertainty, as well as some single-species HCR, mixed fisheries issues are considered through technical interactions between fleets and metiers. The dynamics of all stocks are calculated simultaneously at each time step of the MSE, depending on a level of effort by fleet and metier common for all stocks. In the current implementation, only North Sea cod and haddock are included, and only the simple scenarios “min effort” and “max effort” are considered (Figure 3.4.2). The results obtained showed that the recovery of cod, expected from a single-stock approach, would be dramatically jeopardised by the high quotas of haddock and the subsequent over-quota catches of cod.

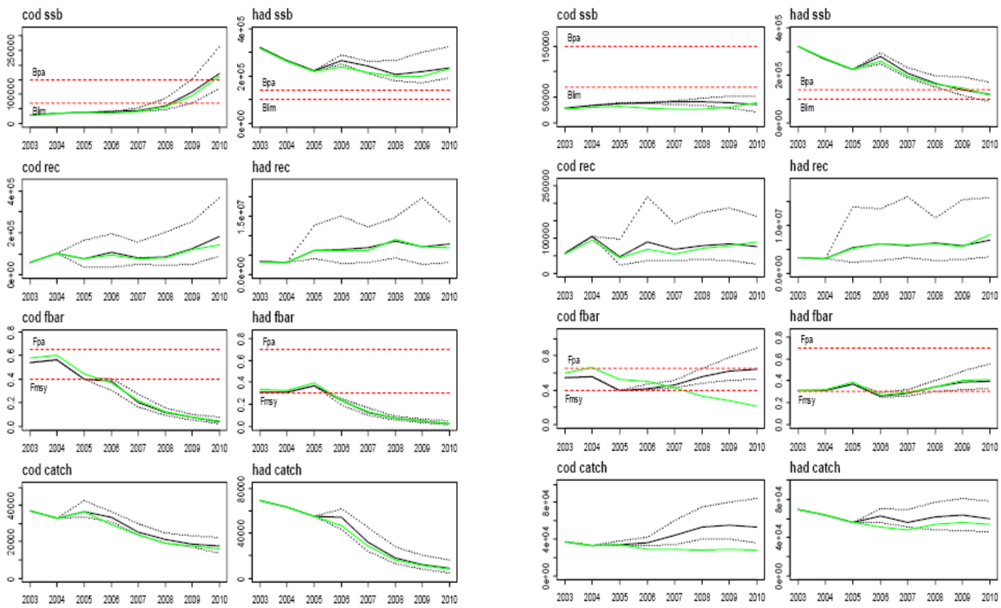


Figure 3.4.2. SSB, recruitment, Fbar and catches for cod (left) and haddock (right) over the period 2003-2010. Black lines represent the “truth”, and green the perceived system. Full lines correspond to the median values, and dotted to 25 and 75% quantiles. Left had panels represent the scenario ‘Minimum’ and right hand panels the scenario ‘Maximum’ (From Hamon et al., 2007)

These two approaches have been developed in parallel, using the same data and FLR objects, and with the ultimate goal of being merged. Current work now is to include FLFcube into the MSE model, in order to provide a full evaluation framework for the main North Sea demersal species. This will provide a very valuable tool allowing to propose ranges of consistent single-species TAC, and to evaluate their outcomes in the short, medium and long-term perspective. While this should not replace single-species approaches, it may complement them to ensure a better consistency among them, as well as providing direct linkages to economic considerations, and to implementation error (through the imperfect linkage between the parameter to be affected, the fishing mortality, and the parameter that can be managed, the fishing effort).

SGMAS welcomes this development, which should have the potential to bring the development of management strategies for mixed fisheries a major step forward. Furthermore, as previously noted by SGMAS in 2007, the concepts behind the approach, and in particular the need for routine incorporation of fleet and fisheries information in the assessment process, have a number of implications. By placing the focus on fisheries rather than on fish stocks, it becomes necessary to account for other components of the catches, and not just those species that are the subject of routine stock assessments. This might involve simpler models or indicator approaches, rather than the traditional age-based assessments. This in turns provides a natural link into the ecosystem approach to fisheries management. This link runs in two directions. Firstly issues with the impact of fisheries on other aspects of the ecosystem typically involve the use of specific gears in specific areas and thus involve fleet/fishery information. Secondly, indicator approaches designed for ecosystem considerations may also have applications within more fishery-related management contexts. Hence the routine incorporation of fleet and fishery information into the assessment and advice process would provide a way of bridging the gap between the traditional single species assessments and the ecosystem approach to fisheries management.

3.5 Contributions from WKEFA

Following a preparatory meeting in February which developed a strategy and identified a number of relevant case studies, the main workshop co-sponsored by ICES, EUR-OCEANS, and GLOBEC met from 18–22 June 2007. Fourteen cases studies involving a wide range of demersal and pelagic stocks, as well as some generic stock simulations were presented over the first two days. The main results from the case studies and the demonstrated influence of environmental change on the stocks are summarised in the report. Over the remaining 2½ days these cases were then used to discuss and formulate generic concepts for improving fisheries management strategies and advice considering interactions under four main aspects,

a) Entries and exits from populations (recruitment, natural mortality and migration)

b) Internal population processes, encompassing a range of aspects associated with growth maturation and reproduction.

c) Location and habitat (including such aspects as vertical and horizontal movement)

d) Multispecies interactions

The workshop considered that there was need to take account not only of stochastic variability but also trends and shifts in the environment as we develop scientific advice. Changes in physical drivers at many scales of space and time act together and this will result in changes in habitat. Through complex linkages these changes result in differences in fish location, growth, maturation and reproductive potential. These differences may then influence recruitment and abundance leading to changes in natural mortality due to different species interactions. The workshop concluded that the effects of environmental change on fisheries management are better addressed by separating variability according to the time-scale of the changes, where medium and longer term aspects are considered relevant to the development of management plans.

There are a number of instances where environmental drivers have been clearly shown to explain variability in recruitment, but once in use some have shown problems. This indicates that testing the utility of indicators in management simulations must be a requirement before they are formally applied, including developing implementation frameworks that are informative and robust to errors. As habitats changes, spatial distributions of fish change, both horizontally and vertically. These changes can interact with surveys, and fisheries leading to the requirement monitor and account for change in catchability in assessment tuning series.

Medium term change cannot be predicted in the same way as short term effects. The approach needs to follow two avenues. Where explicit relationships exist between stock and the environment the mean of stochastic projections can be modified accordingly. Such situations include average temperature dependence, species interactions and food availability for different exploited stocks. Where no explicit relationships exist or there is no basis for predicting environmental drivers into the future, advice should be based on plausible scenario testing, adding additional conditions to those already included in the guidelines of SGMAS management plans. However, given the scope of possibilities it is recommended that evaluations don't try to test everything now, just what is immediately plausible between now and next review of HCR.

Scenario testing with plausible scenarios to management HCR testing

- Include different S/R models for regime change (incl. habitat)
- Include potential changes in growth and maturation as scenarios.
- Testing robustness of HCR to such changes
- Where possible use of Multispecies models can be used to develop possible scenarios.

3.6 Contributions from WGFS

The main focus of WGFS is the fishery system and the role of scientific advice within that system. This year's meeting focused specifically on ways of dealing with uncertainty and risk in scientific policy advice, and communicating the uncertainties to multiple-interest stakeholders. At the time when SGMAS met, the final report of WGFS was not yet made available, and therefore could not be fully investigated. However, the main features of interest for SGMAS are summarized here.

The WGFS was set up as a dialogue between fisheries and non-fisheries experts representing different disciplines and working in the field of uncertainty and risk assessment. Based on presentations from the various fields, the WG developed ideas and methods for good governance in fisheries. There was a high consistency in the presented examples on how to tackle complex situations that involve high uncertainty with high stakes and risks, indicating that good practices guidelines are generically applicable to a wide range of situations. The lessons learnt were fully consistent with those discussed within SGMAS, in particular with regards to (i) the importance of involving all stakeholders in the analytical and decision making process, as early as possible, and (ii) the crucial importance of communication and presentation skills to effectively solve complex problems and to make interdisciplinary systems work successfully. On this second point, a major contribution was the presentation from J. van der Sluijs dealing with practical issues and good practices on reporting uncertainty information (cf also Kloprogge, van der Sluijs and Wardekker (2007), of direct implication for SGMAS).

A key aspect discussed in WGFS is the concept of "post-normal science", i.e. the acceptance that, despite a common belief that more research will reduce uncertainties, often it will rather increase them ("the more we know the more we know that we don't know"). Hence, one needs to accept that uncertainty is intrinsic to the system and must be worked with. The challenge is to find out what the uncertainties mean and how we can live with them, and this is why the involvement of the larger panel of stakeholders acts as an "Extended Peer-review Community (EPC)". The WGFS believed that the EPC approach is critical in a situation where fisheries managers are confronted with greater challenges, of greater complexity and uncertainty. The WGFS suggested a number of points for successful fisheries management, in particular the need to focus less on routine assessments, but to experiment new approaches more tailored to issues raised by the EPC.

Finally, the WGFS reflected on the role of scientists in this context. It concluded that scientists should not limit themselves to being passive providers of information; they need to be active but thoughtful participants in management discussions, and help shape management regimes that make realistic use of what they know.

3.7 Contributions from STECF HCR studies

STECF (STECF/SGRST-08-02) evaluated a set of rules proposed by the EC, developed to assure that future fishing opportunities will be sustainable. It further suggested changes in order to improve long-term yields, reduce costs, and to improve the stability of fishing operations and markets.

The evaluation was carried out within the MSE framework, testing different harvest rules scenarios to set TACs for: (i) two generalised fish stocks with different life history parameters "cod-oid" and "her-oid"; (ii) two S/R models, Beverton-Holt and Ricker, with two different steepness, 0.75 and 0.9; in (iii) three different exploitation situations, well managed, F<= FMSY & SSB>=BMSY, overfishing, F> FMSY but SSB>BMSY, and overfished, F <= FMSY and SSB<BMSY.

The scenarios evaluation was carried out considering two distinct situations regarding the information available, with and without analytical assessments. With analytic assessments robust rules could be suggested regarding the data poor situation the example of a model free HCR that was examined proved to be incapable of maintaining a well managed stock and so could not be recommended.

STECF suggested a rule that set a TAC in line with a fishing mortality rate of F0.1. This HCR is more reliable in terms of maintaining well-managed stocks and recovering stocks that had experienced overfishing or were being overfished. This recovery occurred even in the face of a retrospective bias (brought about by a linear increase imposed on catchability through time), although the improvements and level of rebuilding were often reduced. This HCR would often lead to a reduction in yields for the first few years after the introduction of management. However, the significant reduction in fishing mortality led directly to a significant reduction in costs so the profitability of each fishery tended to be maintained. The amount of benefits is likely to be dependent on the cost structure of the fleet.

The suggested rule was:

Consider y the last data year, y+1 the assessment year, y+2 the TAC setting year, α the limit on the proportional change in TAC permitted and Fsq = (Fy-2+Fy-1+Fy)/3.

1) Set target F & α

if Fy < F0.1 & SSBy > Bpa then rule 1) α = 0.25 & Fy+2 = F0.1

else if Fy ≥ F0.1 & SSBy > Bpa then rule 2) α = 0.15 & Fy+2 = F0.1

else if SSBy ≤ Bpa then rule 3) α = 0.20 & Fy+2 = max(F0.1, 0.7Fsq)

2) Check that (1- α)TACy+1 ≤ TACy+2 ≤ (1+ α)TACy+1

if TACy+2 < (1- α)TACy +1 then TACy+2 = (1- α)TACy+1

else if TACy+2 > (1+ α)TACy+1 then TACy+2 = (1+ α)TACy+1

3) If SSBy+2 < Bpa and SSBy+3 < SSBy+2 then set TACy+2 = 0.75*TACy+1

Branch 1) relates to the management response to the assessment, branch 2) relates to the constraints placed in the potential changes in TAC (different depending on stock status), and branch 3) relates to the stock recovery plan in the case where the stock in the TAC setting year and the year thereafter is below biological limits.

Regarding the scope of SGMAS the approach taken by STECF can be seen as a way to introduce and explore, at a moderate level of abstraction, distinct sources of uncertainty, allowing the scientific community to get more knowledge about its effects and relevance. Secondly, the HCR described by STECF can be used as base line against which specific HCR could be tested regarding their (i) precautionary performance, (ii) achievement of management objectives, and (iii) robustness to uncertainty both on the conditioning of the operating model and implementation of the management procedure.

3.8 American Fisheries Society annual meeting 2008, symposium on Harvest control Rules: Experiences in modelling and application

At the AFS annual meeting on August 21, 2008, scientists from different countries gathered to share and discuss experiences and new research on harvest control rules for fisheries management. This is a summary of highlights considered relevant for SGMAS compiled from the panel discussion among the symposium's presenters. [1]

Summary of Panel Discussion:

HCRs represent a platform on which different scientific specialties can contribute for the good of society and once a rule is made, all efforts must be focused on firmly keeping it in place with no "wiggle room" for interpretations. The Management Procedure (MP) template most commonly used in South Africa and Australia is generally superior to ad-hoc HCRs more commonly used in Europe and the United States as stock assessments are pre-agreed and the framework more rigid. Control rules as we know them can define a TAC, but it is up to the manager to allocate the TAC. A control rule that could include an allocation algorithm, for example, could have larger implications on the stock and fishers' behavior.

There is no overlying recipe for how HCRs should be created and implemented as each HCR is case-specific. This being said, one may generalize some HCR output, for example, focusing on changes in output signals as a metric of performance of an HCR. There is a broad range of control rules used globally, but many of these control

[1] The panel members included: Doug Butterworth (University of Cape Town), Laurence Kell (Cefas), Steve Cadrin (University of Massachusetts, Dartmouth, School of Marine Science and Technology and the Northeast Fisheries Science Center), Dorothy Dankel (Institute of Marine Research, Bergen, Norway), Jon Deroba (Michigan State University), Bjarte Bogstad (Institute of Marine Research, Bergen, Norway), Fiona Johnston (International Institute for Applied Systems Analysis, Leibniz-Institute of Freshwater Ecology and Inland Fisheries, Berlin, Germany and Humboldt-University of Berlin, Germany), Jim Bence (Michigan State University) and Ciaran Kelly (Marine Institute, Galway, Ireland)

rules are variations on a theme and tailored to a specific stock, so there's a high correlation amongst harvest rules.

In order for a HCR to work, stakeholder communication must be in place in order to identify objectives and rank different strategies. It is important for scientists to recognize that industry stakeholders can make "dangerous" short-term management requests and for this reason perhaps scientists should engage more frequently and directly with fisheries managers to encourage focus on long-term yields and to discourage short-term approaches from industry and "left field" proposals from maverick scientists.

But sometimes governments do not encourage stakeholder communication/interdisciplinary science in fisheries management. The Barents Sea capelin was presented as an example: scientists in Bergen had planned meetings with stakeholders (the stock collapsed some years ago and a fishing moratorium has been in place for some years but now the resource is recovering) in order to develop potential management strategies which may be acceptable to all stakeholders, but the government (ministry) apparently has put such plans 'on ice' for the time being. Another issue for all Barents Sea stocks (not only capelin) is that the resources are shared by Norway and Russia, so any stakeholder contribution has an international dimension.

Multi-species HCRs have a clear need and are a future of HCR research and a standard modeling approach should be identified. Some work in this area has been done regarding sardine and anchovy technical interactions in South Africa. It is not clear yet whether one could formulate and simulate a more complicated multi-species structure (like that found in the North Sea) in a multi-species HCR like a MSVPA, but this has been mildly attempted.

One thing is clear: it is important that society democratically chooses clear objectives in order for scientists to be able to evaluate management strategies that can fulfill these consensus objectives. However, the largest problem facing scientists is: Who will assimilate the different viewpoints as a democratic way to make the decisions for the resource? There is often no formal framework in place for all fisheries for consensus objective making. In order to take a proactive approach to ask stakeholders what they want out of a certain fishery, Johnston et al. (refer to talk in the symposium) sent out surveys to recreational anglers. From these surveys, Johnston et al. were able to quantify utility functions for each angler group in order to rank different management regulations. In Europe, the European Commission (EC) produces "non-papers" to stimulate discussion on fisheries issues. One of these non-papers is a policy statement in how fishing opportunities are proposed to be set by the EC. More recently these publications have included a set of rules which, when applied to the scientific advice, constitute a management procedure. This kind of insight to the views and stated policy of managers is very helpful to the establishment of objectives in any MP discussions. Typically, only the fishing industry is involved in the on-going management plan work in Europe (e.g. Western horse mackerel management plan, Northeast Atlantic mackerel management plan work-in-progress, (see section 2 of this SGMAS report). The panel agreed that it is very useful to have input from other stakeholders regarding what they want out of the system, so that the management plan could more fully reflect their objectives. The panel concurs that this is the only "real" way we can move towards the much hyped "ecosystem approach".

However, although we mostly live in a democratic society, there are often great issues with whose opinion/preferences hold more weight than others. Stakeholder's opinions are important, but when we start talking ecosystem management, the stakeholders may lack a basis to offer informed decisions, in some instances because ecosystem interactions are not understood properly. For example, in South Africa some stakeholders need to make decisions on the best trade-off between utilization of sardine or anchovy, while other stakeholders fail to consider the longer term adequately because they are concerned about the security of their property rights in the short term.

The discussion then took a somewhat philosophical turn by pondering the question "Should scientists advocate for certain management regimes?" The panel suggested that scientists should be careful not to lose objectivity, although one may debate if scientists are indeed stakeholders of the fishery system. On an ideological level, science (being objective) cannot be equal to a stakeholder's right (being subjective). Advocacy is possible when it comes to methods (i.e. an HCR is the best method for this management situation). But to understand stakeholders' views it may be helpful to identify a common ground; you may not get a consensus, but once a decision is made it needs to stay for a long time in order to establish trust. Scientists should advocate for best methods but also understand different stakeholder's views to help identify a common ground from which an HCR can be collaboratively developed. Scientists' role is to communicate the knowledge base of stock dynamics and as well as its limitations and how it affects the perception of biological risk. It can take a decade or so for people to get in the swing of looking at things in an HCR framework which has been the experience in both South Africa and in Europe (i.e. North Sea herring)

The panel was posed the question "What is the cost of an HCR?" The panel rhetorically asked in response "What is the cost of not having one?" or rather what is the benefit of having one? It is clear that the interdisciplinary nature of fisheries management strategies and their connections to sociology and economics as well as the biological/ecosystem repercussions is very broad and very important. Scientists are encouraged to be proactive in pursuing funds in order to further interdisciplinary research from their respective governments (like the EU) instead of waiting for things to happen.

Ongoing projects related to management strategies

A large number of EU funded projects have some relation to the development and evaluation of management strategies. In its previous report, the SGMAS found that it might be informative to get an overview of ongoing projects, without attempting to evaluate the content or progress in the projects

The idea of this section is to give an overview of some relevant projects that are somehow related to improving management strategies and/or policies and that are ongoing as part of the EU framework programmes (FPs), FP6 in particular. We have merely collected more general information about these projects, i.e. their research contexts, their concepts, scopes and foci, as well as their design implementations, to see what is done so far and how can we learn from them - specifically in the light that at this time no substantial outcome resulted from all of the projects being considered.

3.8.1 Overview

A good source of finding ongoing EU projects is the EU website itself. There are some important links that refer to EU projects sorted by themes and being linked to research in fisheries and aquaculture:

- http://ec.europa.eu/research/agriculture/projects/list_theme_13_en.htm
- http://ec.europa.eu/research/fp6/ssp/themes_en.htm#188

- http://cordis.europa.eu/fp7/projects_en.html

Under the first link about 50 fisheries related projects are listed in total of which 28 projects claim an improvement of management strategies; 13 of these are completed, 15 are in an ongoing stage. Under the second link 49 projects are listed of which 18 projects claim an improvement of management strategies. As this link exclusively refers to projects that are running under the 6th framework (FP6) and that are still in an ongoing stage, the following table summarizes all 18 projects by acronyms that claim an improvement of management strategies and that are attached to this link. For some of them, a specific website exists on the web and is given below (the list may not be exhaustive).

Acronym	Topic
AFRAME	Improved fishery management through fleet- and area-based assessments
BECAUSE	Improving multi-species fisheries assessment in five European regional seas
CAFÉ	Measurement of capacity, effort and fishing mortality
CEDER	Real-time monitoring of fishing activity
CEVIS	Evaluating alternative, participatory management models for EU fisheries http://www.ifm.dk/cevis/index.htm
COMMIT	Committing to tailor-made long-term fishery management strategies
EFIMAS	Evaluating scientific advice and decision-making processes in fisheries management systems www.efimas.org
EMPAFISH	Ecosystem conservation and fisheries management through Marine Protected Areas http://www.um.es/empafish/
FISBOAT	Taking reliable stock of fish numbers http://www.ifremer.fr/drvecohal/fisboat/
IBEFish	Better fishery management through meta-research
IMAGE	Integarting the ecosystem into fisheries management
IN EX FISH	Incorporating non-fishery influences into stock assessments http://www.inexfish.org/
INDECO	Developing environment indicators for assessing fishery management http://www.ieep.eu/projectminisites/indeco/index.php
ISTAM	Improving fishery data acquisition, management and analysis http://projet-istam.org/
POORFISH	Developing probability model applications in data-poor fisheries http://www.poorfish.eu/
PRONE	Assessing risk in fishery advice and management decisions http://prone-fish.eu/
PROTECT	Ecosystem conservation and fisheries management through Marine Protected Areas http://www.mpa-eu.net/
SAFMAMS	Scientific Advice for Fisheries Management on Multiple Scales http://www.ifm.dk/safmams/
UNCOVER	Developing more effective stock-recovery programmes www.uncover.eu

To give a structured and concise overview of topics, objectives and design of these projects, the EU web sites related to these projects are all organised in the same following way:

- Overview
- Contribution to policy development
- Project deliverables
- Dissemination

where the point "Contribution to policy development" always contains a statement on whether and how the project will affect or improve the current EU management strategy.

Most of these projects are now completed or in the stage of being completed, and it is the opinion of the SGMAS that these projects have contributed significantly to the development of tools and approaches for improved management strategies.

Finally, the third link refers to the new research FP, FP7, which started in December 2006. A search after "fisheries management" resulted in 8 projects, of which two appear of direct interest to SGMAS:

MEFEPO – Making the European fisheries ecosystem operational

JAKFISH – Judgement and knowledge in fisheries including stakeholders

MEFEPO had just started at the time when SGMAS met. MEFEPO will focus on how best to make current institutional frameworks responsive to an ecosystem approach to fisheries management at regional and pan-European levels in accordance with the principles of good governance.

JAKFISH was started half a year ago. It is a socio-biological project, whose main objectives are to examine and develop the institutions, practices and tools that allow complexity and uncertainty to be dealt with effectively within participatory decision making processes. The project will develop these institutions, practices and tools in respect to European fisheries and marine management via two linked strategies. Strategy One is to develop tools to facilitate participatory decision making processes based on recently developed bio-economic modelling techniques. Strategy Two carries out a sociological analysis of the practices and institutional forms that can most effectively involve the wider community in debates over developing science-based policies., and aims at involving stakeholders in some participatory modelling exercises for fisheries management plans.

These two projects focus on issues of marine and fisheries management in a context of good governance. In particular, the guidelines and good practice collected by SGMAS about stakeholders involvement sill serve as a useful starting point for the participatory modelling exercises to be conducted in JAKFISH.

In the previous report, it was decided to highlight features of three typical but quite different approaches that aim to improve management strategies or policies, and detail focus was given on the three following FP6 projects:

- EFIMAS
- CAFÉ
- PROTECT

These detailed descriptions have not been carried on again in the present report, but extensive documentation is available on the various project websites (cf above). In addition, main results obtained so far with the FP6 project AFRAME are reported under section 3.4for mixed-fisheries approaches.

3.9 Summary of conclusions from other groups

Both WKEFA and WGSAM recommend additional scenario testing for robustness to environmental influences on both single and multi-species responses. These should include

- Scenarios with different S/R models for regime change (inc habitat shifts)
- Scenarios examining potential changes in growth and maturation.
- Recruitment / growth / natural mortality scenarios due to multispecies interactions derived from multispecies models
- For systems with very limited species diversity such as Baltic and Barents Seas multi species management plan models may be run for several stocks together.

In addition to these tests for robustness the SGFIAC points out that there may be potential for fishery induced evolutionary change, even though this has not yet been shown to occur. In the context the precautionary approach for fisheries management, one should be precautionary towards potential negative events affecting fish stocks, for example fisheries-induced evolution which could retard stock recovery and affect economic potential.

The work reported in WGMIXMAN show a number of important single species management effects due to mixed species fisheries, leading to the following scenarios that need to be evaluated in testing the likely effectiveness of a single species HCR within a multispecies fishery.

- Single-species MP (including usual short-term TAC forecast) should be tested for potential unforeseen outcomes due to mixed-fisheries interactions. Ultimately, these single-species MP should be combined into a consistent management plan for a whole fishery in an area where mixed-fisheries interactions occur.
- A way to approach mixed-fisheries interaction is proposed by SGMIXMAN, through the use of the Fcube method. The data necessary are usual logbooks data of annual catch and effort by fleet and fishery. Detailed catch-at-age data by fishery are NOT a necessary pre-requisite to perform sensible analyses, since relative importance by species already provides valuable information. However, such data can be included if available.
- Mixed-fishery approach can help providing simple advice on other secondary and non-target species, thus helping bridging the gap between single-species management and ecosystem-based fishery management.

A number of points regarding the interactive consultative process required to develop management plans, these are drawn from diverse sources in Section 3 above.

- It is thought that some consideration should given to scientific advocacy i.e. it is possible when it comes to methods (such as an HCR is the best method for this management situation). However, SGMAS considers this should best be done carefully in the context of the educational iterative process of management plan development, because scientists need to be careful that they understand the diverse requirements of stakeholders and managers, and do not allow their own view of perception of objectives distort advice.

- To understand stakeholders' views it may be helpful to identify a common ground; you may not get a consensus, but the dialogue process itself is important.
- Once a decision is made on an HCR it needs to stay for a sufficient time in order to establish trust between managers, scientists and stakeholders.
- Some people might wonder whether an HCR is appropriate for a given situation. In such a case, it might be possible to examine the utility of an HCR by analyzing the costs and benefits occurring with and without an HCR in place.
- Communicating uncertainty is one important additional role for science --- again involving the dialog process

We draw these points together with those from Section 2, where there is some overlap, to develop the guidance we give in Section 5.

4 Data poor stocks

As an extension of the general ideas on indicator based management in last year's report, we here briefly outline some guidelines for developing management strategies for data-poor stocks. We also reflect on some recent work in the area of giving scientific advice to fisheries and describe an example where a data-poor stock has been managed successfully. The development of indicators based on surveys and catch attributes has been dealt with in a series of studies such as FISBOAT (EU 2007, Petitgas 2007, Cotter 2007, Woilleza 2007)

4.1 Guidelines:

Developing a management for a data poor stock will generally require more thought than just developing a harvest control rule, because the kind of rule that is possible depends strongly on the knowledge that is available. Therefore, the task typically will be to develop a management plan in the wider sense (SGMAS 2005), specific to the knowledge base and the possibilities for implementation, in addition to decision rules.

Data poor stocks here include all stocks where a harvest control rule requiring regular reliable assessments is not applicable. Management decisions will then have to be based on other kinds of information. The concept as used here includes a wide range of situations, from those where there is abundant information, although not what is needed for an analytic assessment, to those where there is hardly any information at all.

The reasons why a stock is considered data-poor are diverse. Commonly encountered cases include those where collecting sufficient information has not been a high priority, for example in small scale fisheries or with species with limited commercial interest. It also includes stocks that have only been exploited recently. Another category are those stocks where the information is unreliable because large parts of the fishery is unrecorded, as with **illegal, unreported and unregulated (**IUU) fisheries, but also may artisanal and recreational fisheries. The guidelines below apply mostly to where the information about the stock is insufficient for an analytic assessment, but where there still is some information relating to the biologic properties of the stock. Stock where managers actions are not effective, as when IUU fisheries dominate, are not further considered here.

There is still quite limited experience with development of management strategies for data-poor stocks, and the properties of candidate decision rules are still not well understood. Therefore, the guidelines given here necessarily are rather general, and should be regarded as an attempt to lead the work in a rational direction rather than a detailed recipe.

In general terms, to be precautionary the management of a stock must adjust the removals from the stock if the stock tends to develop outside the range where a full productivity can be expected. To achieve that, the strength and timing of management response must be adequate compared to the rapidity of change in the state of the stock. The crucial factors therefore are the dynamics of the stock, i.e. how fast its state can change, potential measures of the state of the stock and the link between such measures and the actual state of the stock in terms of signal to noise ratio. A management rule that responds strongly enough to the signal embedded in the information should have the potential to be successful. In this context strongly enough implies with sufficient effect and timeliness to avoid risks to the stock.

On the other hand, it must be assumed that the state of the stock is imprecisely known, therefore there is no scope for micro-management. Rather, one should think of decision rules providing stability of action where changes are only made if there appears to be a need for them. However, it also implies action is taken on the basis of weak information and that exploitation rates will inherently be lower in recognition of poorer information.

On this background, it is suggested that the development process should start with assembling insight in:

- Stock dynamics
    - The range within which the stock can be expected to vary with a sustainable exploitation ('bandwidth').
    - The turnover rate in the stock, as an indicator of how fast the stock can be expected to change.
- Potential measure of the state of the stock
    - The kinds of indicators or combinations of indicators that are or can be made available to provide measures of the state of the stock and trends in stock development
    - The link between stock and measures in terms of:
    - Statistical properties of the measure
    - Delay in recognizing changes in the stock

Some indications of both stock dynamics and possible range of variation can to a large extent be deduced from information about likely life-span, growth rates, fluctuations in historical catches, length distributions etc. If precise information about the stock is not available, some indications of plausible levels will still be possible to obtain, for example from known properties of other stocks or species with presumably similar properties.

The potential measures of stock abundance and fluctuations cover a wide range, from dependencies on hydrographic conditions via length distributions to CPUE data, and information from the fishing industry. Combinations of indicators, e.g. as developed in the FISBOAT (EU 2007) project, may be relevant to consider. What matters for the present purpose is to characterize the link to the population in a way that can be represented as a distribution of observation noise in a simulation framework.

The next step would be to set up a simulation framework with an operating model with stock dynamics (bandwidths and turnover rates) in a realistic range and an observation model with realistic links between stock and selected measures. This framework provides a workbench to experiment with possible management decision rules. The population part of such a simulation model could be designed according to the general outline where the 'bandwidth' and turnover rate can be adjusted through recruitment variation, growth rates and mortality level. The observation model should include realistic ranges of uncertainty in measures of the stock and allow evaluation of both delay and probability of false detection in recognizing changes in the stock.

Recognizing that micro-management is not a realistic option in such cases, a possible decision rule can be to keep either catches or exploitation rates at a fixed level unless there is reason to change them. Alternatively one may also consider rules where the exploitation is changed according to trends in indicators rather than their values.

The choice of regulatory tools depends on what is possible to implement and control. A fixed exploitation rate at a safe level can generally be expected to give higher average catches than a fixed catch regime because a safe fixed catch must correspond to the low range of catches under a fixed exploitation regime. However, a regime with fixed exploitation rate requires that the effective effort can be controlled, and that the fishery is controlled such that the exploitation rate is clearly regulated by effort control. On the other hand, a fixed catch regime requires that the actual removals can be controlled through TACs.

In brief, what matters for a management strategy to function is that it responds adequately to fluctuations in nature, preventing the exploitation from bringing the stock to a stage where its productivity is impaired. Even in a data-poor situations information about likely fluctuations in the stock can be inferred. Hence, efforts should be concentrated on these aspects. Using this information in a simulation framework as outlined should give the following

- indications of necessary and sufficient properties of managers decision rules,
- limitations to what can be achieved,
- a basis for selecting such rules taking into account other priorities and how decisions can be implemented.

According to the precautionary approach, the less one knows about the stock the more cautious management should be. As a general rule, the average catch for a data poor stock will always be lower than the average catch for the same stock if it was data rich, because the catches can be better adjusted to fluctuations in the stock productivity in a data-rich situation. Also as a rule of thumb for all fisheries one should avoid quick expansion of fishing capacity, even if the stock produces a positive signal (e.g. good recruitment).

Cadrin and Pastoors (2008) complied a review of stocks in the ICES and in the United States, and found that the stocks that have the least amount of knowledge are the ones whose management plans do not adhere to the precautionary approach. This "uncertainty paradox" needs to be confronted. The guidelines outlined here would probably be helpful in that respect.

4.2 STECF Working Group Report on Harvest Control Rules

A subgroup of the STECF (STECF/SGRST, 2008) was requested to evaluate the likely consequences of applying a set of harvest control rules in a range of biological stock situations currently encountered in Community waters, including stocks in data poor situation. To address the latter situation, it was assumed that only a time series of catch and effort were available from the fisheries, i.e. there was no absolute estimate of biomass or of exploitation level and the following rule was applied:

if recent CPUE decreases then a TAC is set consistent with an effort decrease and ,

if recent CPUE increases then a TAC is set consistent with an effort increase.

This HCR was found to be dysfunctional. Its effect was to increase fishing mortality leading to an initial increase in yields but this was quickly followed by accelerated increases in fishing mortality, reductions in SSB, yield, revenue and eventual stock collapse. The particular arrangement used in the HCR was clearly unsuccessful and alternatives are required. Insufficient time was available to explore alternative arrangements. However, the use of a constant multiplier on fishing effort (and hence fishing mortality) was obviously not sufficiently adapted to changes in observed CPUE levels. Implementing a variable multiplier to prevent run-away increases in fishing mortality may correct that failure and provide time for the CPUE to change and the HCR to adapt to changing conditions within the fishery.

4.3 On-going work on data poor stocks in other areas

Dankel *et al.* (2008) included some examples of current management conditions of different case studies of fish stocks from around the world, including some data poor, long-lived, low-fecund stocks like Southern bluefin tuna (managed by CCSBT) and Patagonian toothfish (managed by CCAMLR). For both of these stocks, IUU fishing is a major contributor to the data uncertainty that stands as a roadblock to sound management advice. Despite lack of biological knowledge for toothfish, rough stock assessments are carried out using production and recruitment models aid in setting catch limits in the CCAMLR area. (Dankel et al. 2008) But for toothfish, added uncertainty in the stock comes from whale predation after the fish are hooked by longlines, for example (Butterworth et al. 2008). The management plan for Southern bluefin tuna gives management advice on catch levels after assessing the stock by fitting a discrete age-aggregated Fox dynamic production model to historic CPUE and catch data from a section of the long line fishery. However, after realization of extensive IUU fishing, the MP was unable to move forward due to uncertainty in the stock and the management. For both these data uncertain stocks, management is severely compromised, mainly due to IUU issues directly related to the high market value of the species. (Dankel et al. 2008) These are examples of how scientists operating with internationally managed, biologically data poor stocks were able to produce some management advice. Unfortunately for these stocks, biological data poor sets are additionally hampered by IUU uncertainties, therefore making these stocks among the most difficult in the world to manage.

Butterworth *et al.* (2008) give a comparative example between "data rich" and a "data poor" generic stocks which demonstrates the advantages of additional information (CPUE data) when the mean length of catches is already known. The study perhaps most importantly shows that, except in the worst case scenario simulated, the minimum data (mean length of catches) was sufficient to control the decline in SSB and on average to generate recovery, at the expense of a 15% reduction in catch and increased catch variability. In relation to this study, one could point out that CPUE monitoring may perform better than monitoring mean length of catch for the important reason that if a population becomes severely depleted it is difficult to find enough fish to get a reliable mean length estimate, whereas at such low abundance the CPUE measurement is still reliable. This working paper is part of an international symposium in Berkley with other papers dealing with data poor issues which will come out in a special issue in AFS's Marine and Coastal Fisheries in 2009.

In 2005 an ICES working group (WGNEW) was founded to deal with several species for which ICES (with the exception of sea bass) had never previously provided management advice. However, the working group has only been able to summarize the information available on stock status and data collection programs. As there is the ambition to work towards more understanding of the status of these stocks, they requested the EU to provide financing to analyze available survey data. The EU recently responded by bringing out a tender for: "Improving the knowledge of the biology and the fisheries of the new species for management".

The EU has funded a 6th Framework project called POORFISH whose objective is to create an advisory system (assessment, advice, and/or management) approach based on methods able to deal with data poor systems (utilizing both expert knowledge and published information in addition to existing data sets). More information as well as specific case studies can be found on their project website: www.poorfish.eu.

In the United States there is a formal Data Poor Working Group based from NOAA's Northeast Fisheries Science Center who are also working on these types of issues. FAO has a long standing objective to further the research of fisheries management with data poor stocks. A useful overview of the world status of data-limited fisheries is contained in Vasconcellos and Cochrane (2003).

5 Update of guidelines.

In the 2006 SGMAS report provided detailed guidelines for the management plan development process. This section is intended to add to the landscape described in the 2006 report and to give operational guidance for development of procedures or plans and testing of suitable harvest rules. In particular here we address issues of complexity and the process of interaction of scientists with stakeholders and managers.

The development of plans involves many diverse activities and involves more than testing of harvest rules. It is expected that it will involve a dialogue process which is discussed in greater detail in section 5.4. Within section 5 we discuss the setting of objectives for a plan and the criteria for choosing between different plans.

Regarding the methods that can be employed for evaluation, we bring out a concept of providing a minimum standard approach and then advice on where more complexity may be required. We consider both the development of specific plans and the testing of these in a precautionary framework. We consider testing for robustness to give advice on the types of conditions that might cause a plan to fail.

Finally drawing on the experiences of the development of plans documented in section 2 we discuss the iterative process between scientists and stakeholders that is required to allow stakeholders to choose amongst a wide range of alternatives so as to develop plans that are precautionary but that best meet the needs of stakeholders.

5.1 Choosing plans to deliver different objectives

Choosing a suitable plan is an involved process. There are diverse objectives for a management plan, from biological objectives of maintaining a stock in a healthy state to economic objectives of revenue and profitability to social objectives of employment. Clarifying achievable objectives may not be possible at the outset, but early ideas of the types of requirements are extremely helpful for those trying to present options. Testing of rules in the final phase, can only be done on the basis of agreed procedures to be checked. Selecting the type of criteria that will be used is important as these help to inform the complexity of the evaluations that are required.

For plans that are to be evaluated on purely biological criteria such as mean long term yields these can be obtained from relatively simple approaches.

Information on year to year variability in yield requires more complex methods, specifically including the way restrictions on change are included. Care should be taken to show how different rules may give different magnitude of change up and down. If users require asymmetric changes, (faster increases than decreases, or *visa-versa*) this must be explicitly included by choosing and testing a suitable range of rules.

Expressing yields in terms of revenue may be relatively simple if assumptions of pricing are available. However, the extension of revenue to profitability may be much more complex. If evaluations are to give information on economic and social objectives, this may require development of new modelling methods, in collaboration with other disciplines and is outside the scope of this document.

5.2 Methods – when to use what

Here we discuss simulation methods, dealing with the different approaches. We describe how to select methods with sufficient complexity to give acceptable realism, while keeping the complexity to a minimum. While fully stochastic approaches are required for the main investigation, it may be possible to use simple approaches to evaluate whether the variability resulting from a range of potential variables is important for simulating the stock and fishery, or if fixed values are sufficient because the variability is swamped by more important factors. If extreme values do not influence the results then including this source of variability is not necessary. Here in this section we comment on methods, in Section 6 we discuss coding quality standards and provide information on software that can be used to implement these methods.

5.2.1 Conditioning models

We start by considering single species models, for mixed species fisheries, all the single fishery aspects need to be considered, along with implementation considerations in a mixed species context. If it is not possible to evaluate a mixed species fishery, but this is still considered important, robustness testing (Section 5.2.3) should be included to evaluate the possible consequences of fishery interactions.

Biological operating model

The biological operating model represents a collection of 'true' stocks with properties mimicking the actual stocks that are considered. The chosen simulations define how these 'true' stocks are considered to respond to the management measures. Therefore, conditioning the biological operating model is to create a sufficiently plausible range of realities, which are then tested to ensure that the majority of them behave in a satisfactory way. The key aspects of conditioning are discussed below.

Initialization: It is important to appropriately include information on the uncertainty in the initial state of the true stock being simulated. However, the problem is complex. There are three approaches:

1) Using assessment values with uncertainty derived from parametric bootstrap or Bayesian posterior distributions may lead to unrealistically large variability in the stock if the full range of observation error is then added in the following year.
2) The use of similar uncertainty to that implied into the future, by comparing errors at the start, middle and end of the simulation and assigning starting populations accordingly (perhaps the simplest method). Or starting the simulation from a number of years from the past to allow the model to converge to reasonable range of values for the starting year, though this may not reproduce the present very well.
3) Selecting a range of scenarios to test for sensitivity to starting assumptions.

Forward projection: The biological model must account for sufficient variability / uncertainty in future to provide a reasonable range of plausible biological outcomes.

A minimum standard is a single stochastic stock recruit model and a stochastic range growth and maturation to reflect potential variability. These can be obtained by fitting to data. Accounting for temporal dynamics (eg. autocorrelation, periodicity and occasional extreme values) is important if this is observed in the data even when not significant. Tests (such as S/R fits from FLR) should be presented to show that this has been checked. If a single S/R model explains the data well over the full range of biomass covered by the simulation it would be sufficient to continue on this basis. The stochastic component can be obtained through bootstrap of residuals or use of a fitted statistical distribution (truncated as necessary). If bootstrap methods are used care needs to be taken to ensure autocorrelation is included. Comparison of observed and simulated distributions should be provided.

If the choice of S/R model is uncertain or where growth may follow trends or density dependence this simple approach would not be sufficient to capture the necessary complexity. In this case a range of scenarios should be tested to cover a range of plausible possibilities by fitting alternative growth and S/R models and testing a range of HCRs under each circumstance. In particular if there is a great deal of uncertainty in the slope of the S/R relationship near the origin different options must be tested. If the HCR results are relatively insensitive to these choices one model may be chosen for further work.

If following this investigation it is found that the performance of the HCRs being tested are critically dependent on the choice of S/R or growth models, then multiple models with different parameters can be selected using for example the method of Michelsens and MacAlister (2004) and described in the NEA Mackerel evaluation (ICES 2008). This method provides a formal way of including uncertainty in the form of the S/R functional relationship, parameters and stochasticity in the evaluation, and can easily be used to provide a set of growth models. In this case simulated 'populations' should each follow only one of the selected models of the full duration of each evaluation.

If it is known that growth or recruitment are dependent on environmental drivers then a plausible range of possible scenarios should be included. If climate models with forecasts are available, then stochastic variability due to environmental drivers should be included in the growth or recruitment models. If climate models, without being able to provide forecasts indicate that major shifts in stock productivity, through carrying capacity, reproductive capacity or growth may occur, such alternatives should be included as robustness tests (See 5.2.4).

Limit Reference Points

The limit reference points, (Blim and Flim) should reflect appropriate SSB or F to be avoided with a high probability. To test if a plan is in accordance with the precautionary approach the precautionary Blim is particularly important (See Section 5.3). Its important that Blim (and Flim) are compatible with the operating model and any differences are resolved or understood in the early stages. In most cases Blim should be compatible with points of inflection on the S/R relationship(s) chosen for the S/R maturation and growth functions in the operating model, and Flim compatible with the slope to the origin. However, there may be occasions where multiple regimes are considered and in these cases the appropriate Blim may be the higher of those to be considered, or linked to transition between states. In any case Blim should be checked and if necessary an alternative proposed.

Fishery Operating model – Variation in selection

The fishery model must include sufficient variability or responsiveness (or lack of it) to management to be realistic. The action of the fishery model, in addition to total catch, is primarily through changes in selectivity of the simulated fishery. The role of selectivities is two-fold: To translate real removals in biomass into removals in numbers at age from the population model, and to translate fishing mortalities into biomasses in the managers decision process. The first may be regarded as part of the implementation model and the latter as part of the observation model, or one or both may be assumed *a priori*.

As with growth, the selectivity of catches may vary from year to year, and from year-class to year-class. Selectivity may be due both to process error, natural variability in the catching process (spatio-temporal distribution of the fishery, mean size at age of the fish) and to observation error in samples. This variability is combined in the assessment model (for example, some assessment models assume a fixed selectivity pattern (separability) in their fitting procedure while others estimate independent selectivity-at-age parameters).

Variability in the selectivity may potentially affect the outcomes of the simulations, since the TAC may not correspond anymore to the target F used in the short-term forecast, resulting in implementation error in a full feed-back model. Therefore, if the issue is considered important, it is suggested to use a single selection with some stochastic variability, for example by fitting a lowess smoother with stochastic variability (cf. example in Kell et al., 2005).

Observation error model

The observation model generates the basis for manager's decisions as a noisy representation of the true stock in the population model. Two approaches are being used:

1. An assessment is performed as part of the simulation loop. The observation error model generates the data that go into the assessment
2. The assessment is mimicked by adding noise to measures of the true stock with specified distributions. The observation error model then becomes a representation of the noise created by doing an assessment with uncertain data.

The first approach is necessary to evaluate extent to which the assessment (method and data) is adequate and to uncover unforeseen interactions between assessment and management actions. The second approach is often sufficient for screening over options in the development process, and may be adequate for a final evaluation if the stochastic properties of the assessment are sufficiently known, e.g. through parameterisation based on the use of the full feed-back in the preparatory phase.

Whatever approach is used, observation error must reflect sufficient and adequately error for all variables in a consistent way and mimic, as far as possible, the global observation uncertainty. In practice, this will require more complexity than adding unstructured random noise.

Minimum requirement in selecting variables to take into account are to include all abundance indices that are the main source of uncertainty in both initial state and any necessary short term forecasts.

Error model structure may be simulated under two different paradigms: frequentist or Bayesian. In the frequentist paradigm variable distribution may be defined with a parametric statistical model (normal, lognormal, etc) where parameters (mean, variance, etc) may be estimated from data or models, or with non parametric distributions from conditioned or non conditioned bootstrap. In the Bayesian paradigm variables distributions are direct sampled from posterior distribution. Statistical bias is also of main consideration dealing with non-linear models since it affects sampling distributions, their effect on frequentist methods have been studied and bias-correction solutions proposed. A full review on how to reproduce uncertainty in fisheries may be found in Patterson et al. (2002). Correlated errors will often be important and a Bayesian approach should give these directly, A frequentist approach may need additional terms to account for correlation.

When a full assessment is performed as part of the simulation loop, the variables that should be considered on the observation error model depend on the OM structure but should include: total catch and catch at age, natural mortality, indices of abundance, weight and maturity at age. For a full simulation of these variables the error structure should have to take into account also correlations among abundance at age, between abundance and biological parameters like weight or maturity, i.e. dense-dependent effects.

For methods where the assessment component is replaced by a distribution mimicking the error, this is likely to require age structured temporally autocorrelated approaches to error generation, such as those used in NEA mackerel. It is not recommended to use simple random errors to characterise observation error in an assessment.

Implementation error

Implementation error model reflect differences between management decisions and its practical implementation. As a minimum these include error and bias terms in the TAC taken. The HCR usually provides a requirement for the management year in the form of fishing mortality that is based on the "observed" population but applied to the 'true' population. For a TAC the magnitude of this implementation error should be based on historical observations of management decisions and the corresponding landings and catches from an appropriately selected number of years in the recent past fishery, since recent years probably reflect better what is expected to happen in the future. If the HCR is based on effort reduction implementation error takes the form of a stochastic F / effort relationship which may be non linear and varying with time. When misreporting and discarding respond to management actions in an unpredictable manner, this can be applied but it is extremely difficult to parameterise the uncertainty, yet this can be crucial in predictions. Identification of factors affecting the relationship between catch and quota assignment in TACs based fisheries may be critical for fluctuating stocks responding to changing recruitment. Understanding how these factors interact with each other may help to a better definition of implementation error model and their use for evaluating management plans.

Modelling Economic / social objectives

The use of economic modelling can add considerably to the relevance of management plan evaluations, the computation of revenues is encouraged as a indicator of the economic outcome of different management strategies. This indicator can also illustrate how the potential for socio-economic objectives may be eroded if the biological capability is exceeded or pushed to an unstable situation.

Where economic models are included SGMAS considers that a minimum level of socio-economic modelling should be implemented, computing economic metrics, like revenue or profit, based on simple and clear assumptions so that different economic outcomes for similar biological risks can be identified (STECF 2008), giving the stake holders the opportunity to choose from a set of possibilities.

Convergence of results

Convergence is a desirable property in a random variable when we make statistical simulations. Convergence may be defined as the approach of an infinite series to a finite limit. Translated to MSE simulations we could say that "true" value of performance measures are achieved with infinit iterations. These performance measures include two sources of errors: statistical error, coming from error model (observation, process, implementation), and simulation error, coming from sampling size simulation, i.e. number of iterations. Simulation error is reduced when iterations increases and disappear totally with infinite iterations. Since this is not possible a criteria to decide how many iterations to perform is needed. A simple approach is repeating your simulation with a different random seed and check you get the same results. But this can be done in a more conclusive way by performing a large number of iterations and checking that performance measures are stable at a level that does not compromise your conclusions. For example, with a MSE simulation with 5000 iterations, first, estimate the $Pr[SSB_{year}<B_{lim}]$ for the first 50,100,200 … 5000 iterations and then, plot these probabilities against iterations number. Looking at this plot we can see how stability is achieved as the number of iterations increase. We can decide the number of iterations needed to achieve the required stability. If the number of scenarios is large, this exercise should be done at least with some representative scenarios. During SGMAS some illustrative examples were presented and the plot functions proposed will be included in next version of FLR.

5.2.2 Robustness of HCR

The impact on results due to departures from the assumptions made to condition the operating model must be computed in order to have an indication of the sensitivity of the HCR being tested. Such an analysis will give information about how confident one can be regarding the underlying dynamics of the stock and the fishery and must be considered as first step before exploring alternative HCRs, but also as a series of final tests to establish conditions that the rules are not expected to deal with.

As a concluding step in an evaluation, the HCR must be tested regarding its robustness to violations of the assumptions about

1) the fleet dynamics in face of specific management actions, i.e. effort reduction schemes may not decrease fishing mortality as expected if implementation error is considered, Fleet dynamics in a mixed fishery may reduce the effectiveness by increased discarding, robustness to this can be tested,
2) unexpected events regarding the population dynamics, i.e. recruitment failure, changes in M.
3) Poor parameterisation. Parameters likely to be important for most stocks and/or fisheries are stability of discard practices, IUU catches, fisheries interactions (such as the type of technical interaction discussed in Section 3.4 - Mixman), extreme biological events and multispecies interactions (Section 3.1. - WGSAM and 3.5 – WKEFA)

5.2.3 Documentation and accessibility:

There are a range of minimum standards of reporting required to document an evaluation of a management plan.

The basis for the initial starting conditions should be provided, including:

- the specific stock assessment used
- how input data to the assessment are derived,
- uncertainties in the source of data that are regarded as known and
- characteristics of the uncertainty in starting conditions used in the simulations.

For each part of the simulated process, such as biological operating model, fishery model and observation model etc. the following should be provided:

- Full description of the method selected.
- Source of data used to parameterize the method.
- Software used to implement the method including version number and source of documentation, or a copy of the routine.
- An example using the method showing its performance.
- Sufficient information to allow somebody else to implement the method.

If there are any special cases; like handling of exceptions such as stocks that crash completely or assessments that do not converge, then it must be clearly explained how these are dealt with and how many such instances are encountered.

If multiple software approaches are used to evaluate HCRs, then results of a subset of comparable procedures should be compared.

If in the report subsets of the results are presented, for example in table form, the basis for selecting these subsets needs to be specified.

As an overall requirement it must be possible for others to reproduce the results.

5.3 Precautionary Approach

The SGMAS was established with the specific task to "define a framework based on long-term considerations for management strategy evaluations in a Precautionary Approach context".

The precautionary approach in fisheries management has been defined in two international instruments, the FAO Code of Conduct for Responsible Fisheries (CCRF); and the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNIA). The Precautionary Approach was summarised in the UN Straddling Fish Stocks Agreement (UN 1995) as follows: "States shall be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures."

In 1997, ICES was asked by its clients to suggest an approach for implementing the precautionary approach into fisheries management in the North East Atlantic. The precautionary approach suggested by ICES consists of a dual system of conservation limits (limit reference points) and a buffer to account for the uncertainty of the knowledge about the present and future states relative to the conservation limit (precautionary approach reference points). The reference points are expressed in terms of single-stock exploitation boundaries (limits on fishing mortality) and biomass boundaries (minimum biomass requirements). In practice the precautionary approach currently used by ICES is based on the following reference points (table from ICES 2007):

	Spawning stock biomass (SSB)	Fishing mortality (F)
Limit reference point	**B_{lim}**: minimum biomass. Below this value recruitment is expected to be 'impaired' or the stock dynamics are unknown.	**F_{lim}**: exploitation rate that is expected to be associated with stock 'collapse' if maintained over a longer time.
Precautionary reference point	**B_{pa}**: precautionary buffer to avoid that true SSB is at B_{lim} when the perceived SSB is at B_{pa}.	**F_{pa}**: precautionary buffer to avoid that true fishing mortality is at F_{lim} when the perceived fishing mortality is at F_{pa}.
	The buffer safeguards against natural variability and uncertainty in the assessment. The size of the buffer depends upon the accuracy of the projections (of SSB and F) and the risk society accepts that the true SSB is below B_{lim} and the true F is above F_{lim}. The accuracy of the projections depends on the magnitude of the variability in the natural system and of the accuracy of the population estimates.	

The PA points provide conservation points which are designed to be avoided, in contrast management plans provide targets to be achieved. The distinction between limit and target points is important as on occasions the limit reference points Bpa and Fpa, have sometimes been used as target reference points. If target points are chosen well they become desirable outcomes, such as MSY (ICES, 2008).

When advice on management plans is given by ICES in response to requests by managers this needs to be shown to be in accordance with the Precautionary Approach. While those standards are not, in themselves, scientific standards and should not be presented as such (SGMAS 2006), it is helpful to establish guidelines that are compatible with the current conservation reference points. In this context SGMAS recommends the following approach:

4) Selecting a point to be avoided: Management plans should be developed with the principal of avoiding an unacceptable situation with a high probability. In the ICES context of the PA system B_{lim} is the appropriate biological limit reference point to be avoided, but if necessary some alternative suitable could point could be selected.

5) Selecting probability limit: When considering the number of occasions in a simulation that populations fall below B_{lim} there are a number of factors that affect the numerical outcome, such as variability in recruitment, lifespan and target harvest rates. The simulations provide a set of plausible 'populations'. Counting the proportion of populations that are seen to fall below B_{lim} in a defined period provides a criteriumthat is reasonably comparable across stocks with different biological characteristics. This is because a count of populations collapses time and removes the need to account for correlation between years that is different for differing population and fishery dynamics. Average values over years derived from simulations of different populations with different dynamics may imply different probabilities of avoiding such an event over the period when a plan is in force. Evaluation of risk of SSB< B_{lim} against most main exploitation criteria such as yield of F show a sigmoid relationship. The 5% point on this sigmoid curve is usually well defined with a reasonable slope, in contrast lower values will be on a very shallow part of the curve and the outcomes will be very sensitive to the choice of value (see NEA Mackerel

report ICES 2008). Contrastingly a higher value would not provide the necessary high probability of avoidance.

6) Defining time periods: Accepting these criteria it is necessary to select a period of time over which to obtain the necessary value, and 10 years would seem an appropriate value, long enough to include a typical range of observations, and exceeding the duration of review periods of most plans. However, different situations would imply that different values should be considered. On occasions the initial starting values for a population used in the simulations, which may be very uncertain, may cause increased risk in the early years. For this purpose it would be helpful to evaluate the first few years (3-5 years) separately. Also separate values should be obtained for 1st and 2nd 10 year periods (years 1-10, 11-20), By comparing these it can be established if the HCR is causing increased or decreased risk with time. On a few occasions the biology of the stock may indicate different periods would be more appropriate, if so a case could be made for exceptions.

This leads to the following definition of a precautionary plan

Given that the documented evaluation of the plan can be judged to include sufficiently variable correctly parameterised operating, error and implementation models and given the definition of risk as the percentage of simulated populations that go below Blim at least once in a 10 year period, a plan would be defined as precautionary if the risk (of $SSB<B_{lim}$) was less than 5% in both 1st and 2nd 10 year periods. If the aim is for a long term plan and risk was less than 5% in the 2nd period but not the first due only to uncertainty in the starting values the plan could also be accepted. If risk (of $SSB<B_{lim}$) is below 5% in the 1st 10 year period but risk in the 2nd period is significantly higher than in the 1st this suggests long term deterioration and the plan should only be precautionary in the short term.

5.4 The dialogue process

Experiences documented in Section 2 have lead to a number of clear conclusions, which depend on the types of players in the system.

Scientists carry out a number of functions in the management plan development system, and they are perhaps best characterised as facilitators. There is an educational and communication role, explaining the concepts the need for objectives and criteria and the selection and meaning of outputs as well as carrying out most of the work.

For local stocks, evaluations can readily form the background for decisions, where fairly rapid discussions with a single decision maker and representative stakeholders can be used to develop criteria for evaluation and a small number of iterations in presentation of results.

For shared stocks, the process may be much more complex with diverse players who have different needs may require a much wider range of scenarios. Here the process is likely to be longer requiring many more meetings and good communication between scientists, stakeholders and managers.

It is important to recognize that development of acceptable management plans may take extensive resources with many man months or years of time required in order to carry out the process. If insufficient resources are available, it may be counterproductive to start the process, raising unrealizable expectations amongst stakeholders. If

ICES is the contractor then it is important that ICES identifies and obtains agreement for appropriate resources from the start.

Where evaluations form the background for negotiations amongst players such as in Coastal States, the process is much more complicated. Here managers may be unwilling to participate in consultations in case aspects of the negotiations are affected by participation. In this case the concept of an open and transparent process involving stakeholders may be perceived by some participants as counter to their interests. In this case there is a need for even clearer communication and for an understanding of the sensitivities of the different players.

ICES' has a dual role, first as neutral unbiased advisor providing an interactive forum to define the criteria and to carry out the analysis. However, ICES may also be asked to participate as a judge as well as a guide by one or more players, as such its important that this role is recognized early and where possible both roles are carried out in harmony. This implies that ICES should participate to develop precautionary plans directly.

During this process there needs to be an awareness that some stakeholders may quite legitimately lobby for specific outcomes. Here it is important for ICES to clearly recognize the need for an independent science boundary.

Some practical issues that have proven to be critical to a successful dialogue process need to be established from the start:

- Identification of sufficient manpower
- Agreement on criteria
- Regular communication
- Iteration in the process of presentation of results
- Effort to present carefully selected options in tables rather than clever graphs.

6 Software

Coding Quality Standards

The adoption of quality control procedures for the development of models and their application in management plan evaluation is a necessary prerequisite for successful implementation and is discussed by the Methods WG (ICES 2006).

The process of coding can generally be broken down into three phases: design, build and test.

The design phase is the most critical. In general, seek to reduce the overall requirement into functional units that can be coded and tested individually. Attempt to write generic code and reuse existing code if it is available. The use of pseudo code or flowcharts can be helpful at this stage. The design phase should also establish the inputs and outputs for the function in terms of both type and value. The identification of these parameters will help in the development of a test plan.

During the coding (build) phase, the design is translated into the appropriate language. Regardless of the language employed, use a naming convention for variables and reduce complexity wherever possible. Employ lots of whitespace, comment the code liberally and use sensible, descriptive variable names. This will aid reuse of the code. Defensive coding is an appropriate method to employ. This implies attempt to identify any exceptions that may occur during execution (e.g. divide by zero) and either test for them prior to execution or trap and handle them. Should the application or function be forced to terminate, it should do so cleanly. In addition, pay attention to possible performance issues and attempt to eliminate any unnecessary or inefficient processes.

There are a number of methodologies for the testing of computer code. Unit testing is a widely used technique appropriate for testing software that can be subdivided into functional units. Ideally, unit test plans consist of a series of tests and should be constructed during the design phase of development. Packages such as RUnit can be helpful for executing unit tests on software written and packaged in R. System testing involves running a number of predefined tests once unit testing of all components has been completed. Should any code be changed, the appropriate unit test and the system tests should be re-run. All tests should be repeatable.

6.1 FLR update and development principles

6.1.1 Principles and issues regarding FLR development and use

The objective of FLR is to implement packages in R to run Management Strategies Evaluation, promote engagement of stakeholders and promote transparency and peer review. FLR aims to be a tool for fisheries scientists, and the feedback from ICES scientists is an important information to improve and extend the framework according to future scientific requirements.

FLR development follows some principles layed down by Eric Raymond on his essay "The cathedral and the Bazaar"

(http://www.catb.org/~esr/writings/cathedral-bazaar/cathedral-bazaar/). In particular "release early, release often and listen to your customers" and "given enough eyeballs, all bugs are shallow". Although well accepted and understood within the open source community, these principles, and the corresponding licensing and openness issues, are far from being fully comprehended and accepted within the ICES community. Those not used to be engaged on the software development cycle expect all releases to be fully functional and, in those cases, FLR development looks chaotic, the packages' features difficult to understand and the documentation outdated.

FLR development follows the common alpha-beta-production cycle. The alpha status is unstable, not functional, with inconsistent code, it works most of times as a container for prototyping and experimental code and may or may not evolve to a beta status. The beta status is still unstable but already functional although some (or lots) of features are still missing and the code is expected to have critical bugs. The production releases are stable, well documented, with all features previewed on the design phase implemented and critical bugs are not expected. However, one must bear in mind that writing bug-free code is impossible.

The expectation from the FLR development team is that if more people get involved with the software and given the opportunity to look into code, the probability of identifying bugs and submit corrections will be higher, ultimately leading to better software.

At the moment of this meeting the latest FLR stable release is "The Golden Jackal" for R 2.4.1 and R 2.5.0 with the following working packages which can be dowloaded from sourceforge:

pkg	R 2.4.1	R 2.5.0
FLCore 1	.4.3	1.4.4
FLAssess	1.4.1	1.4.2
FLBayes	1.4.1	1.4.1
FLEDA 1.4.2		1.4.3
FLSTF 1.4.2		NA
FLXSA 1.4.2		NA

6.1.2 FLR 2.0

At the time of this SGMAS, FLR Version 2.0 is still on beta status but is already functional for most needs, although additional testing is still ongoing for possible remaining bugs and missing features.

Since the early stages, FLR was meant to address MSE problems. However, in practice, much of its use had been both for running stock assessment in ICES WG and management simulations. But the growing focus on MSE has raised new issues, including:

The need to run multiple iterations for stochastic analyses

The diversity of OM and MP addressed, calling for more flexible and extended “lego blocks”

The increased focus on multiple units, e.g. several stocks, several fleets

The increased focus on economic and fleet behavior issues

The diversity and complexity of HCR to be evaluated

The need for improved computing speed and documentation

Accounting for these new issues, and building on the increasing experience of the FLR development team, a complete new design has been proposed for version 2.0, which now is being developed. This imples strengthening the Object Oriented approach and improving the internal consistency and computing efficiency. Some of the new features of version 2.0 are briefly described below :

The basic class for data storage, FLQuant, is now a 6 dimension array including quant, i.e. age or length or other user-defined quantity, year, unit, season, area and iter,

The FLFleet object has moved from a fairly simple tuning-oriented design to a complex bioeconomic design, with a 3-levels hierarchical tree structure related to 1) the Fleet, i.e. the group of vessel, 2) the Metier, i.e. the type of activity of the fleet in terms of gear and mesh size, and 3) the Catch, i.e. the catch of the species obtained by the given fleet using the given metier.

An improved package for forward projection and generic HCR using automatic differentiation, Flash. This package includes extended features for optimizing HCR under any type of constraints and underlying OM, and could ultimately solve simultaneous HCR for several stocks and/or several fleets in a mixed fisheries context.

In addition, some effort is being put in improving the documentation on the various components, in testing them, and in providing some working examples on how to construct simple full feedback MSE. The objective is that FLR 2.0 will be more consistent, more flexible, faster and better documented, and will thus act as a better basis for the users-developers interface.

6.2 FPRESS Update

The FPRESS model and subsequent developments have been documented in previous SGMAS reports (ICES2006, ICES2007a). Since the meeting in 2007, the model has undergone further development, testing and application. The principal developments implemented are

A full simulation audit trail. The version number of each source code file, all simulation options (as specified in the simulation options file) and run statistics (start and finish times and any debug information written to the console) are recorded in a log file. Users should adopt a rigorous approach when modifying source code. If simulations have been completed (and need to be retained) using the current version and users wish to alter the source code files then an new version of the file should be created containing the code updates and an updated version number. Use of version control software is appropriate, although not required, for this purpose.

Further performance improvements have been implemented through code updates and the (optional) ability to operate the model in a parallel framework. The parallel operation on multi processor machines is implemented using DeinoMPI middleware. The setup involved is minimal. A control file containing a list of calls to the simulation execution function is used to schedule the runs. The middleware will initiate the (predefined) number of R processes which will execute the runs specified in the control file. It is not possible to execute a single model run in parallel.

Further development of the options file creator application. Users can now create additional input parameters for use in the model framework.

Version 2 of the software with a full manual is available as an R package. The changes described above will be incorporated into a later version once development and testing has been completed.

6.3 HCS

The program HCS ('harvest control simulation') is a recently developed simple general purpose program for stochastic simulation of management decision rules (harvest control rules). It originates from software made for generic studies, (e.g. Skagen and Dankel (2007), Skagen (2007)), but has been adapted to routine use in HCR simulations. A more detailed description of HCS was presented to SGMAS in a working document (Skagen, WD2008), which also summarizes some experience with its use during the last year.

The program follows the standard layout of a harvest control rule simulation, with a 'true' model population from which noisy observations are generated, decision rules using the noisy observations and an implementation model that derives real catches from those decided by the decision process. These catches are removed from the real stock. The models are age-structured, for single fleet and single area fisheries.

The program is run as a bootstrap (1000 iterations as a standard), with the following stochastic elements:

Initial numbers
Recruitments
Observation noise
Implementation noise
No assessments are included in the loop.

The range of options for each of the stochastic elements, as well as the options for harvest rules are relatively wide, to serve a broad range of needs. The observation and implementation noise is made as a product of random noise and optionally biased year factors, all with several options for their distributions. The decision models include options to cover most rules that have been proposed recently. This includes options for F- rules, TAC rules and Harvest Rate rules, constraints on year-to-year variation in TAC, options for the timing of the advice relative to the 'assessment' year with built in projections if needed and options for the interval between decisions. Hence, the program is intended to imitate the normal advisory process as far as possible without running actual assessments as part of the simulations.

The program is primarily made to allow screening over a large number of management rule options. For several rule options, a range and step size can be specified, and the program is run automatically for all the options. To serve this purpose, high computation speed has been a priority. Typically, 1000 iterations with one choice of rule options take 10-30 seconds to run, depending on the options and the speed of the computer. The results are presented partly as annual means and fractiles, partly as detailed data of the resulting distributions, but also as assembly tables allowing performance measures to be compared across options.

The program is written in Fortran 77 and can be compiled on any standard F77 compiler. No external libraries are needed. Input and output is through ascii-files. Although it does not follow all the standards laid out in Section 5.2.1 completely, the code is strictly modular and the program has been tested quite extensively with real and artificial data.

The code, as well as a user manual with full description of all components is distributed with the program, is freely available from the author (dankert@imr.no).

6.4 SMS

The Stochastic Multi-Species model (SMS) (Levy P. & Vinther M., 2004) has been used by some ICES study groups during last several years (SGMAB, 2006, WKREFBAS, 2008, WGBFAS, 2008).

It provides estimates of estimates stock sizes, fishing mortality and predation mortality from observations of catch at age, survey CPUE and stomach contents data, but can also be used as a tool to evaluate harvest control rules. SMS has a separable model for the fishing mortalities. Parameters are found by the maximum likelihood method, Uncertainty of the parameters and some other values can be calculated by analytical method (inverse Hessian approach) and by MCMC. As a multispecies model, SMS is semi age-length structured where stomach content observations and the food selection model are length based. The difference between XSA and SMS is that SMS fits the model to the catch data, while XSA just uses the catch to estimate the stock numbers from the terminal F (and catches). SMS estimates an exploitation pattern of the commercial catches with an assumption that the pattern has been stable over the year range specified. Based on that assumption the catch data alone can be used to give estimates of the terminal F and stock numbers, the exploitation pattern and year factors. The survey CPUE data are additional data to estimate stock numbers.

SMS model was used to redefine reference point for the Baltic cod stock: In this case, SMS was used to estimate stock sizes, fishing mortality and predation mortality from observations of catch at age, survey CPUE and stomach contents data from 50,000 cod for the eastern Baltic Sea. The model included the predator species cod, and the prey species herring and sprat. Cod cannibalism was also included. Compared to the 4M model presently used for the Baltic Sea, SMS allows for more realistic food selection models and the use of the originally sampled length based stomach data. The SMS for the Baltic Sea has been developed under the EU BECAUSE project and development is continued under the EU UNCOVER project.

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17 - 21 November 2008

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